Occupational Hearing Conservation

American Speech-Language-Hearing Association

American Speech-Language-Hearing Association
10801 Rockville Pike
Rockville, Maryland 20852

HEARING IMPAIRMENT AND THE AUDIOLOGIST

Who is qualified to help persons with hearing impairment?

An audiologist is the person qualified to provide professional assistance concerning communication problems associated with hearing impairment. An audiologist is a person with graduate professional training who specializes in prevention, identification, and assessment of hearing impairment; in habilitation and rehabilitation of persons with hearing impairment, including the use of hearing aids; and in research of normal and impaired hearing.

A person is qualified to provide independent audiology services by either holding the *Certificate of Clinical Competence in Audiology* granted by the American-Speech-Language-Hearing Association (ASHA) or meeting equivalent requirements for such Certificate. ASHA awards Certificates of Clinical Competence to persons upon the successful completion of exacting education and training requirements. Licensure laws in many states establish professional requirements for audiologists similar to those established by ASHA.

If you suspect that you or someone you know has a hearing impairment, be sure to contact an audiologist in your community.

What is a hearing impairment?

Hearing impairment takes a variety of forms:

- It can be an inability to hear speech and other sounds loudly enough and is considered a loss in hearing sensitivity or simply a **hearing loss.**
- It can be an inability to hear speech and other sounds clearly even though the sounds are sufficiently loud. What is heard may be similar to garbled speech from a radio with a broken speaker. This is considered an impairment in **speech discrimination.**
- It can be an inability to understand and use speech in communication even though speech is sufficiently loud and can be heard clearly. This is considered an impairment in **language reception.**
- Finally, a person can experience one or more of these three hearing impairments in combination. For example, a person with a moderately severe hearing loss and impairment in speech discrimination cannot hear speech clearly even with the use of a hearing aid.

Therefore, a hearing impairment is often more complex than simply an inability to hear speech and other sounds loudly enough.

Many hearing impairments are subtle in nature and difficult to recognize. A mild hearing loss or a loss in hearing sensitivity for high frequency sounds may not be noticeable except under adverse listening conditions such as when the background is noisy or when the sound source is some distance away. A high frequency hearing loss may make it difficult for a person to differentiate between words that are the same except for high frequency consonant sounds like **f**, **s**, or **th**. These sounds often are unheard or heard in a distorted way by people with high frequency hearing loss. Thus, words like fit and sit, or math and mass, frequently are confused.

Is hearing impairment a serious problem?

Yes, it can be a serious problem. The ability to communicate is our most human characteristic. When a person cannot communicate, isolation from friends, family, and society often occurs.

Individuals with hearing impairment may encounter this isolation in vocational, social, emotional, and educational areas. Communication problems associated with hearing impairment in adults can affect their social interactions, create emotional problems, and interfere with the ability to earn a living. Children with communication problems associated with hearing impairment may experience difficulties in learning and may find it hard to establish the relationships with other children that are essential in growing into healthy, stable adults. The onset of hearing impairment at birth or during infancy may result in severe delays in the development of speech and language.

Besides affecting a person's ability to communicate, hearing impairment can also be a serious medical problem. For example, an ear infection left untreated may result in a permanent hearing impairment. In many instances, a hearing impairment can be eliminated or reduced by medical treatment.

How many persons have hearing impairment?

Hearing impairment was the most frequently reported disorder in a health interview study conducted by the United States Public Health Service in 1971. For comparison, 7 out of every 100 persons reported having a hearing problem, while only 5 out of every 100 reported having a visual problem.

Based on several studies, hearing impairment affects approximately:

- 16.2 million Americans in one or both ears
- 3 out of every 100 school children
- 30 out of every 100 persons 65 years of age and older
- Approximately one-half of all Americans with hearing impairment are 65 years old or older.

What are some types of hearing impairment?

Hearing impairment is classified according to the location of the problem in the hearing mechanism.

A **conductive** type occurs when the sound is not conducted efficiently through the ear canal, ear drum, or the middle ear into the inner ear (cochlea). A blockage, malformation or damage of these structures may result in a conductive hearing impairment.

A **sensorineural** type occurs when there is damage or malformation in the structures of the cochlea (which converts sound energy into nerve impulses) or of the auditory nerve (which transmits nerve impulses to the brain).

A **central** type occurs when there is damage or malformation of the neural structures in the brain.

A **mixed** type hearing impairment occurs when there is a combination of conductive and sensorineural hearing impairment.

What are some causes of hearing impairment?

Hearing impairment may stem from a variety of causes:

- excessively loud noise
- viral infections
- head injury
- certain drugs
- tumors
- birth defects
- earwax
- heredity
- aging process

- Conduct hearing conservation programs in industry and the Armed Services in order to prevent hearing impairment resulting principally from noise exposure.
- Assess hearing to determine if there is a hearing impairment, the severity of the impairment, and the necessity for any auditory habilitation.
- Provide auditory habilitation including speech (lip) reading, auditory training, orientation to hearing aid use, counseling, speech and language development, and conservation of normal speech and voice.
- Determine if using a hearing aid will help communication, and if so, can help you obtain the appropriate aid. Many persons with hearing impairment can benefit from using hearing aids, although some persons are able to benefit only partially and others are unable to benefit at all from amplification.
- Assess the hearing and communication problems associated with aging and provide any necessary rehabilitation to maintain good communication skills.

Where and how can an audiologist be located?

Audiologists provide services in many different types of facilities such as:

- hospitals
- rehabilitation centers
- colleges and universities
- public and private schools
- state and federal governmental agencies
- private practice
- industry
- nursing care facilities
- health departments
- community clinics

To locate an audiologist in your area, contact such facilities directly or your health department or school district. If you are unable to locate an audiologist, write for a list of clinical facilities in your state from: Audiologist, American-Speech-Language-Hearing Association, 10801 Rockville Pike, Rockville, Maryland 20852.

How can audiologists help persons with hearing impairment?

Audiologists provide many specialized professional services. For example, audiologists:

- Screen and evaluate hearing in infants, particularly those with a high risk of having hearing impairment associated with: (1) a history of hereditary childhood hearing impairment; (2) rubella or other fetal infection early in pregnancy; (3) defects of the ear, nose or throat; or (4) premature birth.
- Screen and evaluate hearing of nursery and school age children. Screening programs are usually conducted by local and state departments of education and health.

What can I do?

Have your hearing tested.

Wear hearing protectors when loud noise cannot be avoided.

Limit periods of exposure to noise.

Identify noisy areas in your home. Lower volume on T.V.'s, radios, and other appliances; carpet floors; and insulate noisy areas.

Buy quiet! Choose carefully, and look for E.P.A. noise rating labels, which will be found on products soon.

Learn quiet! Become aware of community noise standards and of groups in your area that deal with noise.

Advocate quiet in the home, school, workplace, and community.

Think quiet! Do I make unnecessary noise around others?

Spread quiet! Very few people are aware of how noise affects our hearing. You can teach others!

Know your *quiet rights.*

The American Speech and Hearing Association, the Environmental Protection Agency, and many other organizations are working toward preventing noise-induced hearing impairment and reducing environmental noise.

For further information about your hearing, write:

ASHA

The American Speech and Hearing Association
10801 Rockville Pike
Rockville, Maryland 20852

For further information about noise, write:

EPA

U.S. Environmental Protection Agency
Office of Noise Abatement and Control
Washington, D.C. 20460

THINK QUIETLY ABOUT NOISE

Dear Reader:

We're concerned about environmental noise pollution and your hearing health. There are over 40 million Americans working, playing, and living around environmental noise that is dangerously loud.

Noise-induced hearing impairment is **permanent.** It is also hard to recognize, since it is painless and develops slowly. A person suffering from noise-induced hearing impairment often has difficulty understanding what others say, making communication difficult. With special training, a hearing aid may help some people communicate a little better, but it can't bring back what is already damaged or destroyed. Medicine or surgery will not cure noise-induced hearing impairment.

Hearing-impaired children may have problems learning in school. It may be hard for them to talk, play, and establish relationships with other children, which are essential for growth into healthy, stable adults.

Many things we find necessary or convenient or even enjoyable add to today's growing noise problem. These include dishwashers, air conditioners, power tools, trucks, airplanes, hair dryers, construction, loud music, snowmobiles, and toys.

Congress has passed legislation that will require manufacturers to label equipment and toys that may harm your hearing. But this alone is not enough. **Everyone** can help. Make hearing protection and noise reduction a family affair! Ask members of your family what noises bother them at home. Tell your family what noises bother you. Discuss this brochure together. We think you'll learn much about your hearing and how to protect it.

Think quiet!

American Speech and Hearing Association

U.S. Environmental Protection Agency

What is noise?

Noise is **ANY** sound, loud or soft, which makes us irritable, angry, listless, or unable to sleep.

Ringing in the ears, headaches, temporary difficulty in hearing, and pain in the ears are some side effects of excessive noise.

Noise is **any unwanted sound.**

But isn't some noise important?

Yes. Chances are we could not survive without some forms of noise. Railroad crossing signals, horns, and ambulance and police sirens are all important warning sounds in our daily lives. In some situations and in certain moods, loud sounds from concerts, parties, and sports events are enjoyable. However, even these sounds can hurt our hearing.

> *A high school band in Seattle recently took a decibel reading while playing the school fight song. At its loudest crescendo, the music registered 110 decibels, exceeding safe levels. Band members now wear* ***ear protectors*** *while playing loud music.*

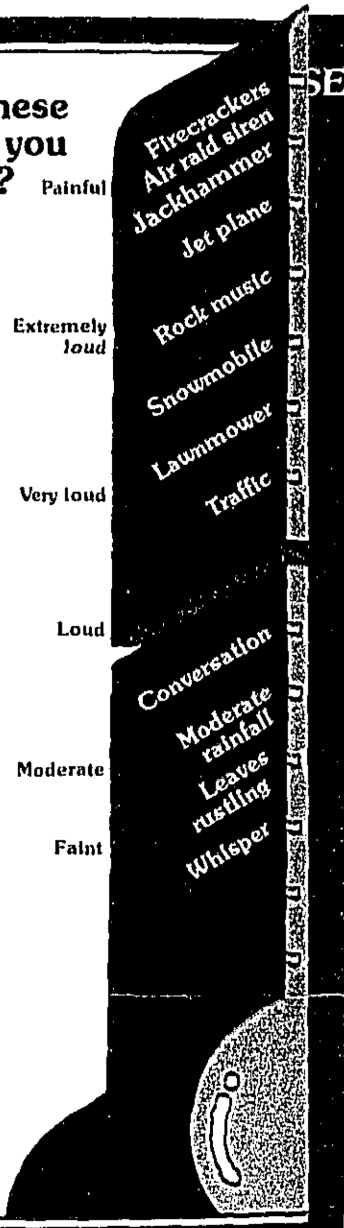
Noise-induced hearing impairment usually occurs slowly and painlessly. Most people don't notice hearing impairment until it becomes advanced and interferes with communication.

Worst of all — noise-induced hearing impairment is permanent.

Hearing impairment was the most frequently reported disorder in a health interview study conducted by the United States Public Health Service. Seven out of every 100 persons reported a hearing problem, while only five out of every 100 reported a visual problem.

Today, over 20 million Americans are exposed to environmental noise that is potentially damaging to hearing.

Which of these sounds are you exposed to?



Decibels (dB)

are units of measurement for noise. The higher the decibel level is, the louder the noise is. Long-term exposure to noise in the danger zone is dangerous to your hearing!

Individuals with hearing impairment may experience isolation in work, play, and school situations. Learning becomes difficult, relationships can become strained, and emotional upsets can occur.

If you have suggestions, questions or requests for further information, they may be directed to your nearest EPA Regional office.

EPA Region 1 • JFK Federal Bldg. • Boston MA 02203 • Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont • 617-223-7223

EPA Region 2 • 26 Federal Plaza • New York NY 10007 • New Jersey, New York, Puerto Rico, Virgin Islands • 212-264-2515

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EPA

Noise and its Measurement

Breaking Noise Into Parts

The noise abatement engineer may need to analyze the noise from a particular source so that he can identify its origin and eliminate the cause.

Using the example of a jet engine, the engineer may determine that the high-pitched whine comes from one part of the engine while learning that other, less bothersome frequencies come from another part. He will then concentrate his work on the part of the engine that makes the most trouble.

To solve the problem, the engineer may use a sophisticated noise analyzer together with a graphic sound level recorder to break the noise down into its individual ingredients.

Summary

With new methods like these, we are coming to grips with the problem of noise and how to reduce it. Accurate noise measuring instruments have made it possible to replace arguments over what is too loud with statements of scientific fact.

These new instruments are proving invaluable to manufacturers who want to make quieter equipment, and to State and local officials who want to reduce noise.

The Environmental Protection Agency, through its ten Regional Offices, offers equipment and technical assistance to State and local governments with noise problems. EPA technicians also consult with manufacturers.

By using noise monitoring equipment of simple design and moderate cost, we can now go a long way toward reducing noise pollution and benefit the health and well-being of all Americans.

The tools are there. It is up to us to use them effectively.

Hearing Protectors

In today's mechanized world it is virtually impossible for an active person to avoid exposure to potentially harmful sound levels.

For this reason, hearing specialists now recommend that we get into the habit of wearing protectors, not only to guard against hearing loss but to reduce the annoying effects of noise.

There are two basic types of hearing protectors: muffs worn over the ears and inserts worn in the ear. Well-fitting protective muffs are more effective, but inserts also do a good job if properly fitted. Since ear canals are rarely the same size, inserts should be separately fitted for each ear. Cotton plugs are virtually useless.

Protective muffs should be adjustable to provide a good seal around the ear, proper tension of the cups against the head, and comfort.

Both types of protectors are available at many sports stores and drugstores. They are well worth the small inconvenience they cause for the wearer.

Hearing protectors are recommended for the following:

At work: Construction, Lumber, Mining, Steel, Textiles.

During recreational and home activities: Target shooting and hunting, Power tool use, Lawn mowing, Snowmobile riding.

Note: These are only some of the jobs and activities where hearing protectors are beneficial. Protectors are also helpful when concentration is necessary in the home or office.

The decibel scale is logarithmic (based on powers of ten), not linear like a ruler. Therefore, a small increase in decibels represents a great increase in intensity. For example, while 10 decibels is 10 times more intense than one decibel, 20 decibels is 100 times more intense (10 x 10, rather than 10 + 10), 30 decibels is 1000 times more intense (10 × 10 × 10) and so on. The sound intensity multiplies by 10 with every 10-decibel increase. The reason for such a scale is simply that the human ear is sensitive over such a wide range of acoustic energy that the numbers involved had to be compressed for convenience.

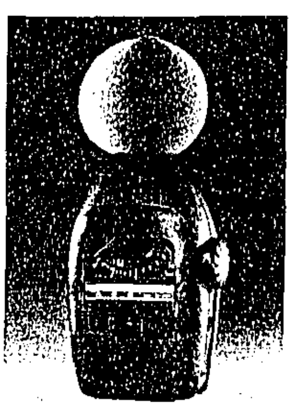
In some ways, the decibel scale resembles the Richter scale for earthquakes. A small numerical increase represents a great increase in intensity.

The ear can detect a very slight change in noise intensity. Even a small reduction in decibels then can make a difference.

Measuring Noise Scientifically

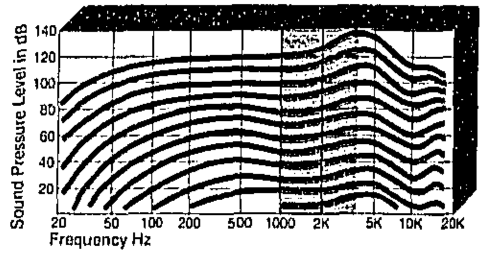
In response to mounting public concern over environmental noise, new and better ways of measuring it have been developed. In the past, typical sound level meters were the size of TV sets. Now they are no larger than pocket transistor radios and measure noise with laboratory accuracy. In addition, their use requires no special scientific training.

This means that the average citizen or city employee can reliably monitor noise, making possible new opportunities for noise abatement and control. Prices for good sound level meters start around $200, a cost within the reach of most municipal budgets.



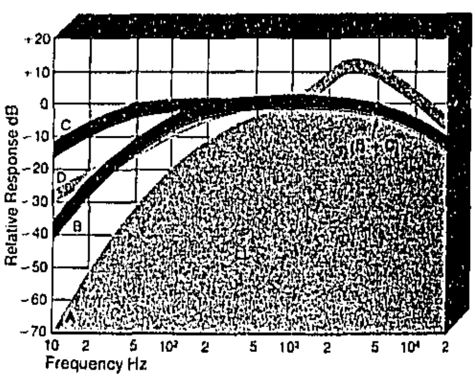
How Meters Work

Sound level meters have three or four scales for measuring noise. The A scale is used most often to measure neighborhood noise. It electronically filters the low and high frequencies and responds to sounds much the same as the human ear. The graph below shows that the ear is most sensitive to sounds in the 1000-4000 Hz range.



Human response to pure tones of equal Sound Pressure Level.

The B, C and D scales on noise meters are used for more specialized noise readings. The D scale, for instance, is the one being considered for use in measuring the noise of jet engines at airports.



The Weighting Curves A, B, C and D

While jet engines generate a great concentration of high frequency noise, diesel locomotives generate noise that is heavily weighted in the lower frequencies, so a different scale may be used to measure their noise, usually the C scale.

The damage done by the pollution of our air and water is widely recognized. The evidence is right before our eyes, in contaminated water, oil spills and dying fish, and in smog that burns the eyes and sears the lungs.

Noise is a more subtle pollutant. Aside from sonic booms that can break windows, noise usually leaves no visible evidence, although it also can pose a hazard to our health and well-being. An estimated 14.7 million Americans are exposed to noise that poses a threat to their hearing on the job. Another 13.5 million of us are exposed to dangerous noise levels without knowing it from trucks, airplanes, motorcycles, hi-fi's, lawnmowers, and kitchen appliances.

Recent scientific evidence shows that relatively continuous exposures to sound exceeding 70 decibels—expressway traffic, for instance—can be harmful to hearing. More than that, noise can cause temporary stress reaction which includes increases in heart rate, blood pressure, blood cholesterol levels and effects in the digestive and respiratory systems. With persistent, unrelenting noise exposure, it is possible that these reactions become chronic stress diseases such as high blood pressure or ulcers.

Knowing the damage that noise is doing, what can we do about reducing it?

First we must identify the noise source and measure its output. Accurate analysis and measurement are the first steps in controlling noise.

What Is Sound?

Sound travels in waves through the air like waves through water. The higher the wave, the greater its power. The greater the number of waves a sound has, the greater is its frequency or pitch.

The strength of sound, or sound level, is measured in decibels (dB). The frequency is measured in Hertz (Hz) (cycles per second). However, the human ear does not hear all frequencies. Our normal hearing ranges from 20 Hz to 20,000 Hz or, roughly, from the lowest note on a great pipe organ to the highest note on a violin.

The human ear also does not hear all sounds equally. Very low and very high notes sound more faint to our ear than 1000 Hz sounds of equal strength. This is the way our ears function.

The human voice in conversation covers a median range of 300 to 4000 Hz. The musical scale ranges from 30 to 4000 Hz.

Noise in these ranges sounds much louder to us than very low or very high-pitched noises of equal strength.

Loudness and Decibels

Because hearing also varies widely between individuals, what may seem loud to one person may not to another. Although loudness is a personal judgment, precise measurement of sound is made possible by use of the decibel scale. This scale, shown below, measures sound pressure or energy according to international standards.

Sound Levels and Human Response

Common Sounds	Noise Level (dB)	Effect
Carrier deck jet operation Air raid siren	140	Painfully loud
	130	
Jet takeoff (200 feet) Thunderclap Discotheque Auto horn (3 feet)	120	Maximum vocal effort
Pile drivers	110	
Garbage truck	100	
Heavy truck (50 feet) City traffic	90	Very annoying Hearing damage (8 hours)
Alarm clock (2 feet) Hair dryer	80	Annoying
Noisy restaurant Freeway traffic Man's voice (3 feet)	70	Telephone use difficult
Air conditioning unit (20 feet)	60	Intrusive
Light auto traffic (100 feet)	50	Quiet
Living room Bedroom Quiet office	40	
Library Soft whisper (15 feet)	30	Very quiet
Broadcasting studio	20	
	10	Just audible
	0	Hearing begins

This decibel (dB) table compares some common sounds and shows how they rank in potential harm to hearing. Note that 70 dB is the point at which noise begins to harm hearing. To the ear, each 10 dB increase seems twice as loud.

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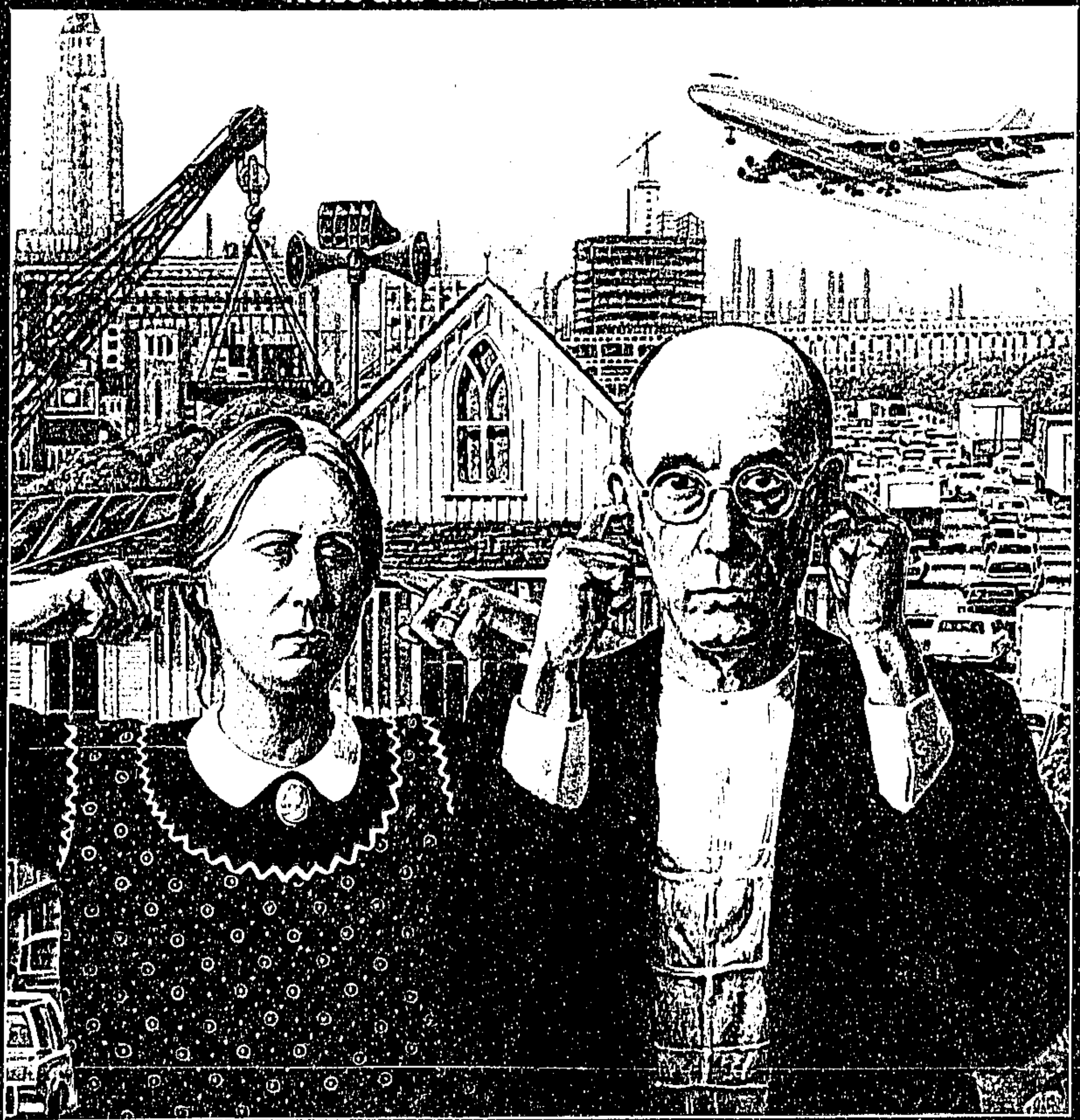
Noise and the Environment



Noise in Our Environment

This issue of EPA Journal reviews the battle against noise—a pollutant that most of us are exposed to at home, at work, at play, and on the streets. Administrator Costle notes that noise control is critical and that ways can be found to keep abatement costs within reason. An article by Deputy Assistant Secretary Hales of the Department of Interior points out that modern noise is an intrusion that can detract from our enjoyment of national parks. Legislative aspects of noise control are outlined by Senator John Culver and Representative James Florio. A former Surgeon General describes the adverse impact noise can have on health. Other articles review the role noise plays in our cities, neighborhoods, and at work. Some of the ways we can deal with the problem of too much noise are described in articles about volunteer organizations, product regulation, and public information. A look at the impact of hearing loss on personal life and conflicting views on the need for sirens also are included. International steps to control noise and EPA's cooperation with Germany on environmental matters round out the issue. □

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Douglas M. Costle, Administrator
Joan Martin Nicholson, Director, Office of Public Awareness
Charles D. Pierce, Editor
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EPA is charged by Congress to protect the Nation's land, air and water systems. Under a mandate of national environmental laws focused on air and water quality, solid waste management and the control of toxic substances, pesticides, noise and radiation, the Agency strives to formulate and implement actions which lead to a compatible balance between human activities and the ability of natural systems to support and nurture life.

Articles

Front cover: This illustration, based on Grant Wood's famous painting "American Gothic," shows many of the sources that add noise to daily life. It was done for EPA Journal by Nathan Davies of the E. James White Design Company.

Opposite: This illustration from the National Archives was a working model for a series of security posters during World War II.

Design Credits: Robert Flanagan, Donna Kazaniwsky and Ron Farrah.

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A Balanced Approach to Noise Control

By Douglas M. Costle
EPA Administrator

A recent poll conducted by the U.S. Bureau of the Census showed that noise is considered to be the most undesirable neighborhood condition—more irritating than crime and deteriorating housing. The poll also pointed out that the proportion of Americans who feel this way has been increasing yearly. This information underscores the need for regulations and programs to abate noise pollution in our society.

Early in 1978, the U.S. Senate held oversight hearings to determine what amendments to the Noise Control Act of 1972 were needed to respond to the growing national constituency against noise. Two things surfaced as being necessary: additional research into the non-auditory health effects of noise, and stronger State and local programs equipped to administer noise administration and enforcement. Out of these hearings, the Congress drafted a set of amendments which became known collectively as the Quiet Communities Act of 1978.

I am pleased that, following the enactment of the Noise Control Act of 1972, research has made significant inroads toward an understanding of the effects of noise. What is too much noise? Research enables us to answer the question in terms of volume, duration, and character of the noise. Research thus provides a basis for regulations that give numerical noise limits. The answer to this question forms the health and welfare justification for local noise control ordinances and Federal product regulation.

There has never been any doubt that excessive noise can cause severe hearing impairment. Studies of the auditory effects of noise abound. There also is no doubt that we live in a world filled with potentially harmful levels of noise. Our jobs, our entertainment and recreation, and our neighborhoods and homes all expose us to excessive levels of noise. It is estimated that 20 million or more Americans are exposed daily to noise that is permanently damaging to their hearing. EPA's research has already established the limits of noise volume and duration above which exposure will result in hearing damage.

Recently, however, EPA's investigation of the health and physiological effects of noise has extended beyond the solely auditory effects. We are currently in the second year of a four-year study which is examining the non-auditory effect of noise on primates. The results to date give us something to worry about. When exposed to noise levels similar to those experienced by millions of Americans in urban areas, the laboratory animals experience a 30 percent elevation in blood pressure. Furthermore, when the primates are withdrawn from the noisy environment, their high blood pressure persists.

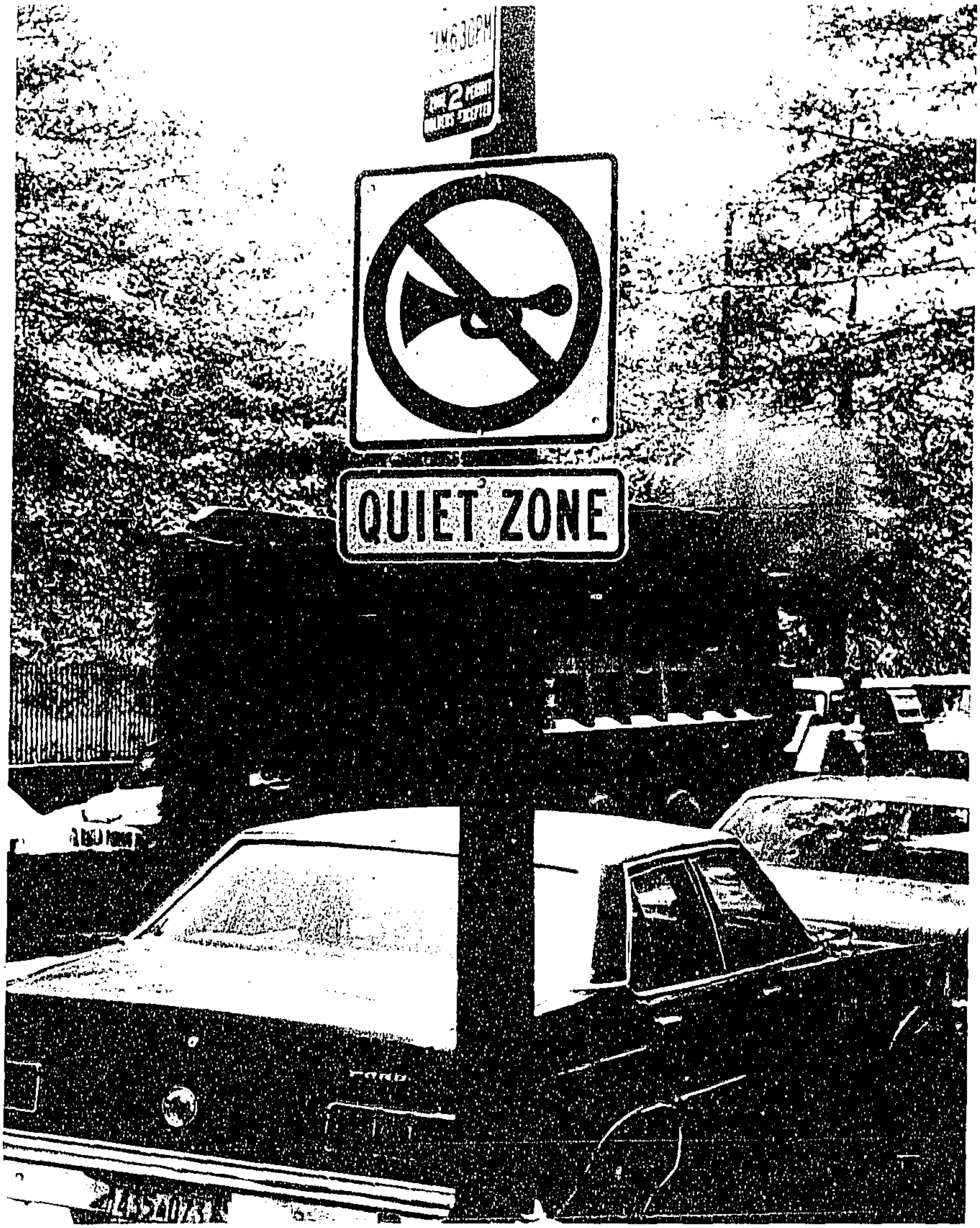
This suggests the possibility of something quite startling. That is, not only might our noisy living and working environments be giving us high blood pressure, but those occasional vacations we take to the country may not be giving us much of a respite from the ravages of noise. Since high blood pressure (hypertension) is a serious risk factor for heart disease and stroke and these two causes account for 48 percent of the deaths in this country each year, the public health implications of this study could be very serious indeed.

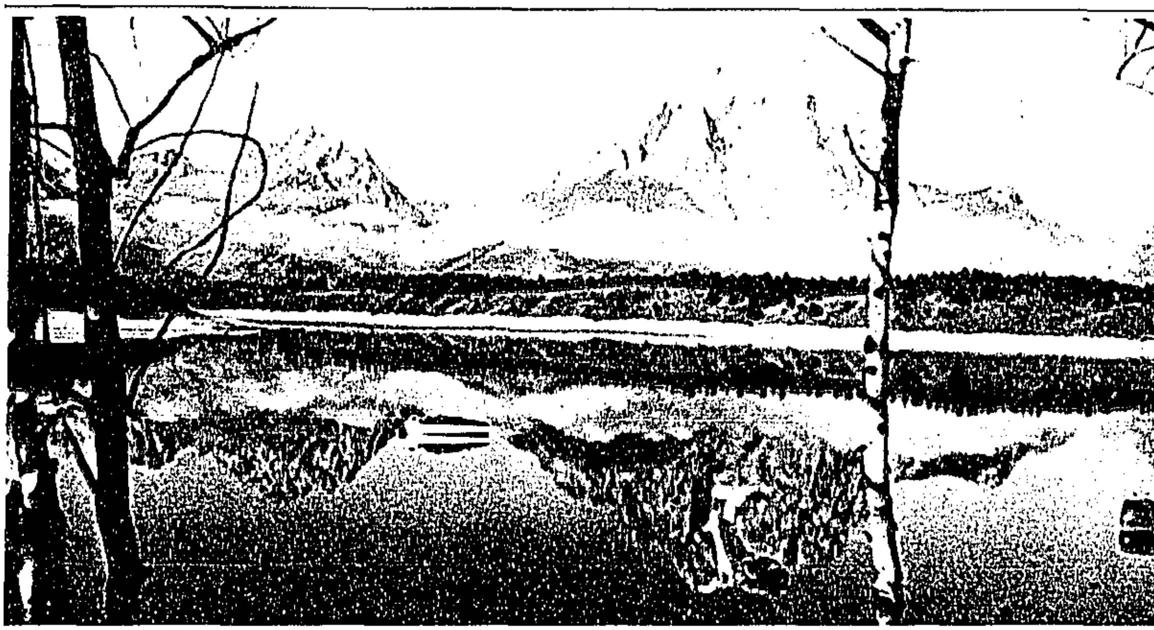
These significant findings correlate well with 40 epidemiological studies in 11 countries, which link noise exposure with cardiovascular disease. These findings highlight the need for noise abatement and for continued research. During the next two years, EPA will continue its research into the physiological effects with emphasis placed on cardiovascular effects, sleep, and reproduction.

The Quiet Communities Act gives us the opportunity to carry out noise abatement that is needed so critically. EPA's noise abatement initiatives have been and will be part of a well-balanced program that emphasizes both national standard-setting and State and local programs. Noise is viewed primarily as a local problem requiring local solutions. It is our intention to use the resources provided by the Quiet Communities Act to foster the development of State and local noise programs throughout the Nation. By so doing, we are using Federal dollars to initiate self-sustaining local programs that can work on their own to control noise in the future.

Principal features of EPA's State and local program initiatives are public education and information. EPA communicates with localities, providing information on the health effects of noise and the need for Federal product regulation. It also provides assistance to communities interested in adopting and maintaining noise control programs. When the information and education programs take hold in the local communities, EPA may follow-up with technical and financial assistance.

Those of us in government must always be aware of the needs, costs, and benefits of regulatory programs. The Agency's research program has amply demonstrated that the need for noise abatement is critical. EPA's reliance on State and local program initiatives should help keep the costs of abatement activities down. The benefits will speak for themselves in a quiet and healthy environment. □


QUIET ZONE



Mount Moran reflected in Jackson Lake is only one of the peaceful scenes to be found in Grand Teton National Park.

Quiet: A National Resource

By David F. Hales

As I was growing up, in what was, for Texas, a large city, I do not recall being bombarded by the noises of civilization. I do recall, however, because I was fortunate enough to spend at least part of my summers away from the city, a sense of joy and wonderment at the natural sounds which seemed to penetrate pleasantly through more rural surroundings.

While I doubt if I could have articulated then the value of the absence of man-made sound, there is no doubt in my mind now that it was this very absence which enriched—in fact, made possible—some of my more treasured memories.

Much has been written of the changes brought about by the technology of the Twentieth Century. Since the beginning of this century, we have consumed more energy, expended more military firepower, artificially impounded more water, produced more written material, and generated more trash than all of our forebears had up until that time.

A perhaps overlooked result of the changes this century has seen is our geometrically expanded ability to make noise and, more significantly, our increased ability to spread that noise into places where the sounds of man were rarely, if ever, heard before.

This is not, of course, in and of itself, pernicious. Few of us would prefer walking from New York to San Francisco to occasionally hearing the sound of an airplane. As President Carter said, in his 1979 Environmental Message, "A certain level of urban noise is tolerable or even agreeable, reflecting the multitude of activities that make a city thrive."

The increasing pervasiveness of noise is, however, one of the reasons that many Americans place increasing importance on escaping to places where quiet and solitude still exist. One of the major responsibilities of the National Park Service is to ensure that such places continue to exist. Each year we host some 300 million visits by people who want to be refreshed and renewed by the historic and natural resources Congress has protected by inclusion in the National Park System. Quiet is one of those resources which deserves protection.

In the Act of Congress which created the National Park System, and in subsequent legislation, some of which applies only to the National Park Service, and some of which is of broader scope, Congress and Administrations of both major political parties have made it clear that the Park Service has the responsibility and authority to regulate sources of noise within National Parks. It also has responsibility to influence other Agencies with authority to control noise emanating outside of park boundaries but impacting resources within them.

The exercise of these duties in a reasonable and responsible way is a complex task, for the production of noise is almost always associated with someone's convenience, and quite often, particularly when the noise emanates from outside a park, with someone's livelihood.

Since one of the basic purposes of having parks is for people's enjoyment, some allowances for convenience should be made if it appreciably increases the individual's enjoyment of the resource without harming it. Allowances cannot be made, however, if the convenience of some significantly impairs the enjoyment of others, or if the very resource which one seeks to enjoy is harmed or endangered. In addition, we have the responsibility to maintain a few places where convenience is not a consideration and where people can address nature face to face, without mechanized buffers.

Although these types of situations (where the convenience of the visitor must be

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weighed against the impact of the noise which accompanies the convenience) are complex, in these instances we can be guided by ample precedent; a history of decisions that have become accepted by the American people and by Congress as the standard which is expected from the National Park Service.

In several instances, however, the conflict between noise and park values is even more complex. Occasionally, the activities that produce noise which impacts directly and adversely on park resources have no relationship to the enjoyment of park resources, yet are important to the communities which are adjacent to the resource. Since it is not particularly useful to generalize about such conflicts, let me take two examples to illustrate the problems and our approach to resolving them.

Grand Teton National Park in northwest Wyoming, established in 1929 and expanded in 1950, encompasses some 500 square miles of breathtaking mountains that rise abruptly from the floor of Jackson Hole Valley.

The stark rocky peaks were formed by a combination of fire and ice—volcanic action caused land to rise and fall along the Teton Fault, then glaciers roamed the valleys shaping the present canyons. The ice sheets cleared soil from areas that now are dominated by sagebrush and deposited it in moraines that support pine, Engelmann spruce, and alpine fir. The Park is home to bighorn sheep, bear, deer, moose, and in fall welcomes a massive migration of elk to feeding grounds in Jackson Hole.

Jackson Hole Airport, located within the boundaries of the Park, evolved from an unpaved landing strip in the 1930's, as over the years a runway and terminal facilities were built on land leased from Federal, State, and private interests. When the land passed into the National Park System in 1950 the airport remained and became the only airport inside a National Park, through a continuing lease arrangement with the Park Service. In 1963, and again in 1967, the Federal Aviation Administration suggested extending the airport runway to accommodate larger propeller-driven planes, then jets. The National Park Service began studies of runway capacity in 1965, and in 1971, Congress appropriated $2 million to study and implement improvements to Jackson Hole Airport. The Service issued a draft environmental impact statement in 1973 on major airport improvements including a wider, longer, and stronger runway, runway lighting systems, an air traffic control tower, and a sewage treatment system. Most of these improvements were approved by reviewing agencies and are now complete, with the exception of runway changes.

In our final Environmental Impact Statement in 1974, the Service recommended denial for the runway extension and jet service to Jackson Hole Airport, and instead advocated the development of a comprehensive regional transportation plan that would meet valid transportation needs without unacceptable impacts on Grand Teton National Park and nearby Yellowstone.

Since 1974, the question not only of whether or not to expand the airport, but also whether it should continue at all within park boundaries has been fully debated and discussed by government agencies at the local, State, and Federal levels, and by concerned interest groups.

The impact of airport-associated noise has been studied by the Environmental Protection Agency and the National Park Service. What we found was that were it not for airplane noise, the quiet in some sections of the park would be so profound that scientists could not register the sound levels. What this meant was that the natural sounds of the Tetons, the murmuring of streams, bird calls, even the sounds of snow falling from the trees, could be heard.

The experiencing of these sounds is as integral to the full enjoyment of the Tetons as is an unobstructed view of the park itself. In a setting such as the Grand Tetons, where visitors actively seek quiet, the sound of airplanes; particularly jet airplanes, passes from being an annoyance into a major intrusion.

We also analyzed the relationship of the airport to the purposes of the National Park and found that only 1 percent of the people who visit the park each year use the airport.

In light of these facts, Interior Secretary Cecil D. Andrus, in August of this year, announced his refusal to approve any runway extension, and called for the implementation of a noise abatement plan for airport activities. The Secretary also indicated his belief that the special use permit for the airport should not be renewed when it expires in 1995, and urged that efforts to relocate the airport be begun immediately.

In announcing his decision, Andrus said: "With this much advance notice, I am confident that the people of Jackson, working with local, State, and Federal assistance, can locate and develop a new airport site or other means to satisfy the transportation needs of the area. This decision reflects our concern that the pristine setting of this beautiful national park should not indefinitely be degraded by unnecessary noise and disturbance."

In another, even more complex, situation, we are concerned about the impact of noise associated with the operations of Washington National Airport in Arlington, Va., on Park Service areas in and around the Nation's Capital.

National Airport is located just across the Potomac River from Washington, D.C., and serves some 13 million people each year. Because of past problems with noise complaints from suburban residents of Virginia and Maryland, air traffic from National is largely routed over the rivers just north and south of the airport.

This means that many of the Capital's most significant and heavily visited memorials and parklands are located either directly under, or immediately adjacent to, National Airport's approach and departure paths. These areas include Arlington Memorial Cemetery and the Iwo Jima Memorial, and Park Service-operated areas such as the Washington Monument, the Memorials to Lincoln, Jefferson, and Theodore Roosevelt, and a number of historic sites and recreational areas. Because of this proximity, aircraft noise effectively disrupts an otherwise moving experience for millions of park visitors each year.

Many of the memorials offer interpretive programs presented by National Park Service guides instead of signs. Park personnel at the Jefferson and Lincoln Memorials must contend with repeated noise interruptions during their talks. Some guides have developed a speak, pause pattern to accommodate the jets. Other guides on Theodore Roosevelt Island have resorted to using megaphones to get their message across. In addition, the intensified effect of the aircraft noise on the hearing of park employees, because of the acoustical properties of those structures, is a matter of some concern to Park officials.

The intrusion of aircraft noise is especially harsh at some of the historical locations. At Arlington House in the heart of Arlington Cemetery, tour guides attempt to recreate the mood of the home when General Robert E. Lee lived there, as jets roar by outside. Turkey Run Farm is a working replica of the farms that fed the residents of the Nation's Capital in the 18th Century. All the accoutrements are authentic except the noise from above.

In the past years, the Park Service has sponsored concerts, plays, and musicals at various places in and around the District of Columbia. The Watergate Concerts, which were held near the famous apartment complex starting in the '60's had to be stopped because of the noise. Symphony concerts at the Iwo Jima Memorial were cancelled when the Navy Band refused to continue playing in competition with the aircraft. Additionally, many possible visitor activities, such as readings and presentations, are automatically ruled out for the Capital area because of the noise interference.

Vacationing visitors are subjected to such extremes of sound at the base of the

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Opportunities in the Quiet Communities Act

By Senator John C. Culver (D-Iowa)

In 1972, Congress passed the Noise Control Act to reduce excessive noise that jeopardizes the health of our citizens, and gave the Environmental Protection Agency the authority to develop noise control methods. In the years that followed, unfortunately, we found that the law did not do enough to help communities to resolve their unique problems.

The need to create community-level noise programs was brought to the attention of Congress when the Senate Resource Protection Subcommittee, which I chair, held oversight hearings on the Noise Control Act in March and April of 1978. This was the first comprehensive set of hearings by the Senate on the Noise Control Act since its enactment, and this examination was revealing.

One finding was that the 1972 Act had, in fact, simply not reduced environmental noise. Indeed, the subcommittee discovered that, despite the efforts of EPA, noise and its adverse health effects were increasing on the whole nationwide.

I took the March, 1978, hearings to Des Moines, Iowa, in order to learn more about problems of cities in dealing with excessive noise. One witness after another emphasized the need for effective noise education and abatement programs on a local level.

Elaine Szymoniak, a member of the Des Moines City Council, for example, stressed the need for public education and said more money should be provided to communities for self-help programs.

Charles Anderson, a professor of audiology at the University of Iowa Hospitals and Clinics, urged that three actions be taken to inform the public: "(1) the development of Federal grant programs supporting innovative research into the effects of noise on human health and welfare, (2) the support of local demonstration projects on public education, and (3) the broad dissemination to the public of information about the known effects of noise on human health and welfare."

Larry Crane, executive director of the Iowa Department of Environmental Quality, said he felt that EPA should do more noise research and should establish "realistic standards which would provide additional guidance to local governments in the kind of options they can implement." He, too, supported a grant program that would be responsive to local needs.

Finally, Ed Ryan, area director for the National Retired Teachers Association/American Association of Retired Persons Title X program, explained the special requirements of our senior citizens for effective noise control programs. He indicated that the elderly represent an outstanding resource to help implement community noise education and control programs.

I was impressed with Iowa's response to the noise problem. Many Iowa cities, like cities in other States, have adopted or are moving toward noise control ordinances. Effective programs are already in operation in Des Moines, Council Bluffs, Dubuque, Sioux City, Davenport, and other mid-sized cities. It has been especially gratifying that Iowa realizes that noise is a pervasive problem which is not confined solely to industrial States, and that programs must be directed at specific regional and local needs.

At the April, 1978, hearings in Washington, D.C., the National League of Cities, the National Association of Counties, numerous State and local noise and health officials, former Surgeon General Dr. Luther Terry, and others all supported greater public education, research, and grant programs for our cities and towns.

The Subcommittee on Resource Protection concluded that few effective programs had been initiated at the Federal level to inform the public about the adverse health effects of noise, and to properly integrate local needs into any control strategies. The solution recommended by the subcommittee was for EPA to place greater emphasis on technical assistance to State and local levels, to begin a vigorous noise research program, and to strengthen the regulatory program.

In response to these problems, the Quiet Communities Act of 1978, which I introduced, authorized EPA to develop a range of programs to help State and local governments combat excessive noise at the local level. It allows communities to be the principal developers of programs that are responsive to their own special needs, desires, and capabilities. In addition, it not only encourages communities to assist one another but also encourages them to solicit the cooperation of volunteers and senior citizens. The Act also provides direct assistance from EPA in the form of grants, training programs, seminars, and a clearinghouse on noise information.

I have been very impressed with several innovative programs of EPA's Office of Noise Abatement Control.

First, *the Quiet Communities Program* was established in 1977 as a pilot project to demonstrate the best available techniques for local noise control. The first Quiet Community, Allentown, Pa., received an EPA grant in September of that year. The Quiet Communities program was made a nationwide, permanent effort with enactment of the Quiet Communities Act of 1978.

This pilot program, emphasizing community involvement in defining the major noise control problems and finding solu-

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Aircraft Noise: An Abatement Priority

By Representative James J. Florio (D-N.J.)

Quiet is an essential element in the quality of our lives. Our citizens are increasingly conscious of the impact of noise and are no longer willing to dismiss it as an annoyance that must be tolerated. However, combatting the increasing onslaught of noise is a frustrating undertaking for even the most highly motivated communities.

Unfortunately, each level of government has unwittingly contributed to this frustration. Though Federal noise abatement and control activities were concentrated in the Environmental Protection Agency in 1972 with the passage of the Noise Control Act, the enforcement of noise standards and regulations is largely a State and local matter. This local emphasis was embodied in the Quiet Communities Act Amendments of 1978. However, with ever-increasing budgetary constraints, local noise abatement and control programs often suffer a low priority. Even at the Federal level, the EPA, charged with leadership responsibility, allots a modest one percent of its total budget for noise control activities.

It is time for us to recognize the impact of noise on the public health and welfare and to be resolved in our attempt to reduce and control its effect on our lives. As Chairman of the Subcommittee on Transportation and Commerce of the House Interstate and Foreign Commerce Committee, I have closely examined the problems and available means to decrease noise pollution in our environment. Testimony before the Subcommittee has persuaded me that prolonged exposure to noise adversely affects human health. The frequent interruption of sleep, high blood pressure, and emotional disorders can be exacerbated by the unrelenting bombardment of noise.

Similarly, high levels of environmental noise are often linked with the economic decline of neighborhoods. In testimony before the subcommittee, witnesses explained that the fiscal well-being of communities located near significant noise sources is threatened by the subsequent exodus of homeowners and shopkeepers seeking quieter surroundings. Though the causal relationship of noise to ill health and urban economic decline requires further investigation, we can agree that noise is certainly not an asset.

In the interest of decreasing environmental noise, preserving the public health and welfare, and observing public budgetary constraints, I am convinced that we must more narrowly focus our noise abatement effort in order to be effective. It is critical that we channel our resources toward reducing those sources of noise that have the greatest impact on the greatest portion of our population. Without doubt, the most widespread and universally experienced noise problem is aircraft noise. I strongly urge that combatting aircraft noise be our Nation's number one noise abatement priority.

Aircraft Noise: The Target of Special Interests

The 1970's have been called the decade of environmental legislation. Unfortunately, we are beginning to experience an all-out effort on the part of special interests to dismantle the intent of these laws. The Federal authority for reducing aircraft noise is no exception. It, too, has been the target of such dismantling.

Specifically, I am referring to the aviation noise abatement bills now under consideration by the Congress. If these legislative attempts are successful, the Federal authority to control aircraft noise will be seriously eroded. These bills would (1) exempt a substantial portion of commercial aircraft from compliance with established noise abatement deadlines; (2) discourage production of quieter aircraft, and (3) severely undercut both the FAA and the EPA's authority to implement noise abatement measures.

These bills represent a flagrant disregard by their supporters for the health and welfare of our communities. Further, I view these legislative proposals as testimony to the unwillingness of the air carrier industry to comply with long-standing regulations intended to provide long-awaited relief promised to communities plagued by aircraft noise.

Communities Take Action

On the basis of testimony, correspondence, and useful information discussions with local officials and citizens, it is clear that the callous dismemberment of existing noise abatement laws and regulations will not be quietly accepted. In lieu of Federal authority, local officials have indicated their willingness to bring noise control matters before city councils and county chambers. In the face of possible revocation of existing Federal aviation noise abatement authority, communities have already begun to pass their own ordinances to control the use of local airports by noisy aircraft. Precisely this sort of action was taken in June of this year by the members of the Los Angeles City Council.

Similar action by other communities near the major airports of our Nation could severely disrupt interstate commercial aviation. However, in lieu of Federal authority, local governments cannot be prevented from adopting their own means for resolving the aircraft noise issue. The supporters of legislation that effectively guarantees the continuation of aircraft noise

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Noise: The Invisible Pollutant

Interview with Charles Elkins, Deputy Administrator for Noise Abatement and Control

You've worked in most of the programs in EPA. How is working in the Noise Program different?

I have a very hard time convincing people that noise pollution is important. In my other assignments in EPA, I've had the task of presenting issues and policies related to virtually all of EPA's programs, but noise is much harder to present. I find it easier to convince people of the hazards of some chemical which they have never heard of than about noise, even though I often have a stronger health case. We all seem to have an instinctive fear and respect of the unknown and, in contrast, a cavalier disinterest about those risks which we think we understand. I know. I used to have these very same views about noise until I took a closer look and realized how people's unconscious attitudes were getting in the way of their understanding of the hazards of noise. Noise is something we grow up with, and it is very difficult to believe that such a common pollutant could be doing anything serious to our health or environment.

EPA has a legal mandate to protect public health. Where does noise as a pollutant fit into the health picture? Is hearing loss the principal effect?

Hearing loss is one of the best understood harmful impacts of noise. Loss of hearing occurs at noise levels which most people would believe are completely harmless. With the limited monitoring we have done, we find that even some housewives are being exposed to noise on a 24-hour basis that could be hazardous to their hearing. This puts into perspective the risk of hearing loss to factory workers and other people subjected to high noise levels. Unfortunately, once a person loses hearing from over-exposure to noise, a hearing aid will usually not help.

Except for hearing loss, though, isn't noise something we can get used to?

No, in fact this is not the case. People who think they can get used to noise are deceiving themselves. If a child comes up behind you and shoots off a cap gun, you might stay in your seat and appear to be calm and undisturbed. But you cannot control your heart rate and adrenalin secretion and other internal reactions. These will increase, and your body will react because of your instinctive fear response. We can consciously control many of our reactions to noise, but some of the body's systems are not controlled by our consciousness. I am confident this kind of bodily response to noise will be recognized more in the future, as stress-related physiological studies are completed. Perhaps then we will recognize that we must take steps to protect ourselves from an overdose of noise, and we will begin to feel frustrated, as many citizens already do, because in our society it is so difficult to escape from noise.

I've heard that noise may contribute to cardiovascular disease. Has this been proven yet?

The evidence is not all in yet but 40 epidemiological studies conducted in Europe show a link between noise and cardiovascular disease. In addition, EPA and the National Institutes of Health (NIH) are now conducting a study of rhesus monkeys to determine the reactions of their cardiovascular systems to noise. We find that when exposed to levels of noise which many Americans receive day in and day out, these monkeys develop high blood pressure. After the noise was shut off this high blood pressure continued. These studies suggest that noise may be a contributing cause of cardiovascular disease. Thirty-eight percent of the people in this country die from cardiovascular disease, another ten percent die from stroke. Hypertension (high blood pressure) is a major cause of these diseases. In the next few months, we expect to expand our research on the link between cardiovascular effects and noise. If these studies continue the trend of previous studies, noise control may develop into one of EPA's major health protection programs.

Isn't one of the difficulties with noise the fact that some people like to make noise, that in some instances we equate noise with power?

Yes. We see this in our children's love for really noisy toys, such as the ubiquitous "Big Wheel." Region 5's Noise Program Chief, Horst Witschonke, came up with an excellent observation on this point. He was awakened at 2 a.m. one night by a motorcycle going by. Instead of counting sheep he lay there calculating how many people this one motorcyclist could wake up or disturb in one hour, driving at a normal speed through the streets of Chicago. He estimated it would affect something like fifteen or twenty thousand people.

How long will it take to bring noise down to an acceptable level?

Unfortunately under current programs I don't see a time when an acceptable level will be reached. Take traffic noise for instance: if there were no Federal regulations, the number of people exposed to traffic noise would double by the year 2000, as compared to when the Act was passed in 1972. With a very ambitious Federal regulatory program by the year 2000 we might be successful in holding down the noise exposure to the same number of people affected in 1972. But this assumes that the products will not degrade and that no one will modify or tamper with them. We all know, however, that people seem to enjoy modifying cars and motorcycles, so the outlook is not encouraging.

Is airplane noise a major problem?

Aviation noise seems to aggravate people more than any other source of noise even though it affects a smaller number of people than traffic noise. One reason is that airplane noise intrudes into peoples' homes—their refuge from the world—

and for many there is no escape because they cannot afford to move. The regulatory authority for controlling aviation noise lies with the Federal Aviation Administration. Recently they have put out some regulations that will result in a substantial reduction in the number of people exposed to aviation noise by 1985. That's the good news. The bad news is that immediately thereafter the number of people exposed will begin to rise again because of the expected increase in air traffic.

Is there anything that planners can do to minimize noise in residential areas?

There certainly is. In fact, prevention is a lot cheaper than trying to abate the noise after it is already there. Homes can be insulated and designed to shut out noise, if we know they are going to be exposed to a high noise level. Land bordering a noisy industrial site can be put to compatible use instead of being residential. Highways, of course, can be routed away from residential areas. There can be spacing between the highway and the homes themselves and barriers can be erected. It's easier and more cost-effective to erect a barrier along the highway or at the edge of a community at the time the original highway or community is being built. If we install barriers after the fact, as Virginia is now doing around the beltway in Washington, D.C., we find it's very difficult to buy the proper land and to place the barriers where they can be most effective. Prevention is really the best answer to noise problems for the future.

In the past Congress has sometimes been critical of the performance of some of the Agency's noise efforts. How is the Agency responding to this?

The Congress has been critical really on two points. One is the speed with which we put out regulations, and the other is the lack of emphasis on State and local programs. In the time since the criticism was originally voiced regarding the regulations, we have proposed a number of additional regulations and we expect to promulgate them very shortly. The question of State and local programs is more difficult because the 1972 act did not give us any real responsibility to deal with States and localities. That has been corrected and we feel that the performance that Congress will now see under the Quiet Communities Act will be responsive to their criticism.

Do we have any important noise standards that will be coming into existence in the immediate future?

At the present time, large trucks, rail cars and locomotives, and air compressors are regulated. Shortly we will promulgate final regulations on garbage trucks, buses, motorcycles, and other railroad equipment. In addition, we are initiating a labeling program to help consumers make informed choices about the products they buy. This is important because consumers can control the amount of noise pollution to which they are exposed more so than in the other pollution areas. Noise is such a pervasive pollutant, perhaps the most pervasive that this Agency deals with, that it would be impossible for us to protect people from all serious exposures. Individuals must help protect themselves.

We've found people complaining about disco noise. Do some feel that the Federal Government should say you can't go to a disco because the noise is too high and it will damage your hearing even though discoing is an individual choice?

Yes, but there really is a limit to what the Federal Government can and should do with regard to many noises including disco noise. EPA can inform people that their hearing can be damaged. But they must decide for themselves. We have also informed local communities about what other communities have done. For instance, in Montgomery County, Md., school dances are controlled below certain decibel levels and in a few communities signs are posted outside discos to warn people of possible harm to their hearing. Rock music performances could be handled in the same manner.

Do we have any indications that industries and manufacturers are interested in cooperating with the labeling program? Are there some that will voluntarily label their products in the near future?

Yes. Some manufacturers recognize that they can build quieter products and that this could be an excellent selling point, particularly for some consumer products. Consumers must let the manufacturers know that quieter products are more desirable.

We are working now with several industry groups on the development of voluntary labeling programs. The offer which the Agency has held out to them is that if they develop a voluntary program that meets our criteria, then EPA will postpone imposing a Federal labeling requirement on their product until their program has a chance to prove itself.

Are there any segments of our society that we can say are getting quieter? Do we have cause for optimism?

The neighborhoods around many airports will get significantly quieter by 1985. Unfortunately, the noise will start back up at a fairly rapid rate unless further steps are taken. Noise is no different from all the other pollutants that EPA controls. If we want to make the year 2000 clean or quiet, steps must be taken now to change the design of products and factories, since long lead-times are involved. With the present Federal effort in noise we are not able to promise that the year 2000 will really be any quieter than the year 1972, the year the Congress directed EPA to launch an attack on this pollutant.

If EPA is vigorous in its implementation of the Quiet Community Act, we may be able to hold the line on noise exposure. Of course, without a Federal program, the situation would be much worse.

Where do you see the noise program going in the next five years?

We see a tremendous enthusiasm for noise control at the State and local level. In fact, a recent Gallup poll showed that next to water pollution, noise was mentioned more often as a serious pollution problem than any other. The number of local noise ordinances has skyrocketed in the last several years. Therefore, we predict a very rapid growth in State and local programs to control noise.

I began my career in the Federal Government working on air pollution. Back in the 60's air pollution was viewed primarily as an irritant which made people's eyes water in Los Angeles, and few people recognized air pollution's more serious heath effects. The air pollution program and the public's understanding of the problem have grown tremendously. The noise control program is still at the "Los Angeles" irritant stage in terms of public awareness. The Noise Program is lucky to be in EPA, which has had the experience of these other growing programs. The noise program can profit from the insights gained. □

This interview was conducted by Chris Perham, Assistant Editor, EPA Journal.

Health and Noise

By Luther L. Terry, M.D.

The realization that noise is a pollutant has been very slow in coming to the general public. Yet it is clear that we are now fighting the same battle against noise pollution that we fought 10 to 15 years ago over air and water pollution.

As a physician, I am very concerned about this problem because of its insidious quality. First of all noise is invisible and its impact on our total environment, including people, has proven to be more difficult to define than that of other environmental pollutants.

Most of the scientific evidence available supporting the fact that noise is harmful to human beings is in the auditory area. At the recent Model Symposium on Community Noise, held last May in Washington, D.C., Dr. David Lipscomb reminded us that the cochlea in the inner ear is completed in the developing fetus by the third month of pregnancy and it is virtually of adult size and complexity by that time. This would indicate that the auditory mechanism is designed to serve an extremely vital part in a person's livelihood.

The insidious character of high level exposure is such that it may be weeks, months, years, or decades before the total influence and reaction is felt by the person so exposed. Dr. Lipscomb also brought out the fact that we don't have "earlids." We can't effectively close off our ears from the sound around us. Therefore, it is imperative that our ears have some quiet time because community noise levels are increasing. Our ears are more susceptible or predisposed to damage from high intensity sound because they are not rested but remain under continued assault.

Hearing is our major social and learning sense. The ear is a magnificent microcosm of creation. It may be small in size but it is mighty in its impact on the totality of human life. I believe that we should eliminate exposure to high level sound, which can destroy the structure and function of this beautifully engineered receiver of vital outside information.

There is another auditory effect from excessive noise and that is in speech interference. A good deal of study has been undertaken to discover what kind of speaking voice is necessary for an individual to be able to carry on an intelligent conversation with another person from various distances in the presence of noise. We now have a good feel for what happens when noise interferes with a person's communicating ability. Adequate communication has a bearing on everything including safety and the quality of life.

What has not been investigated but certainly should be, is whether the decrease in hearing sensitivity in response to noise exposure is a protective mechanism of our bodies against a perhaps greater danger—physiological damage resulting from noise exposure. We know that noise can constrict blood vessels, speed the heart rate, stimulate the outpouring of adrenal cortical hormones, and elevate the blood cholesterol level. And Dr. Robert Cantrell, Chairman of the Committee on the Medical Aspects of Noise, American Academy of Otolaryngology, feels very strongly that since noise enters the body through the ear, the body may wish to protect itself from greater damage by sacrificing the sense of hearing, which is not absolutely necessary for human survival.

In addition, there are other very important non-auditory effects of excessive noise. A partial list would include cardiovascular constriction, elevated blood pressure, increased heart rate, more labored breathing, measureable changes in skin resistance and skeletal muscle tension, digestive system changes, glandular activity altering the chemical content of blood and urine, vestibular effect, balance sense effect, changes in brain chemistry, and so forth.

Recent research has also indicated that excessive noise exposure during pregnancy can influence early embryo development. A very careful set of studies done at Research Triangle Park, N.C., attributed this fact to overproduction of corticosteroids, which induces congenital defects, and so we are beginning to see that noise can be a negative influence to coming generations. There are correlations also, which still are not well understood, between more noisy environments and mental disorders.

I am very much interested in a recent animal research report presented by Dr. Ernest Peterson of University of Miami, at the Model Symposium on Community Noise. He has exposed rhesus monkeys (whose cardiovascular system operates on the same general principle as human beings) to a noise exposure sequence resembling the exposure pattern that an industrial worker in the western world might experience on a daily basis. Various forms of household noise, transportation noise, cafeteria noise, work-place noise, air conditioner drone, aircraft fly-overs and noise from passing vehicles bombarded these animals for nine months.

The test showed an immediate rise in their blood pressure when the noise was turned on. Over a period of time blood pressure was elevated 30 percent, *which percentage was sustained over the nine month period.* But the most interesting result was the fact that their blood pressure remained at the 30 percent increased level long after the noise was turned off. If one chooses to translate this information to the human condition (although at present there are no clinical studies on people to confirm the hypothesis) it becomes evident that if you as a person are exposed to high noise levels and you wish to escape them for a few days by relaxing and allowing the effects of the noise to dissipate, you will be disappointed because the effects are going to last much longer than the noise.

Although it is a normal physiological response for a person to have elevated blood pressure during periods of stress, under most circumstances the blood pressure returns to normal when the stress is removed. Continued stress can lead to hypertension and be a contributing cause in decreasing life expectancy. Excessive noise in the environment falls into the category of "continued stress" and actually poses a safety danger as regards a person's ability to hear important warnings in our everyday pattern of life.

Even in the area of recreational activities, noise is important. A recent survey done by the Environmental Health Administration of Washington, D.C. measured the noise level of 18 discos in the District. Measurements were made at the edge of the dance floor, at the disc jockey station, and at the bar. On the basis of accepted standards it was found that: (1) Fifty percent of the discos constituted an occupational hazard to disc jockeys and bartenders, and that in three discos, the noise level was such that the exposure time for the disc jockey should be limited to one hour or less, and (2) if occupational limits are applied in the case of patrons, then at the noisier discos, the patrons should not be permitted to remain for more than two hours.

There are numerous reasons for stressing the need for a quieter environment. First, the human body is a wondrous device which uses a complicated set of counter-relevant forces that are kept in balance in order to maintain body health and equilibrium. Any unnecessary influence which interferes with the normal body function should not be tolerated.

Second, one most important human need is for a desirable quality of life. This is not possible in the case of half the citi-

zens of this country because of excessive noise in their work, recreational, or home environment.

And, third, "home" should be a place for rest and quiet after the labor and cares of each day. Community noise deprives most people of access to such a retreat. This is an unfortunate and unnecessary by-product of our industrialized society which may in fact be taking an unrecognized toll on human physical and mental health.

We need a great deal more research in the public health and welfare area of noise pollution. We need to fill in the voids that are still left. There is a definite need in this country for tight prospective studies dealing with the problem of noise and cardiovascular function in human beings and the effects of noise on the unborn. We need to know the effects of noise on children and infants, especially their susceptibility to hearing loss. There is an enormous need to understand immunologic mechanisms and their relationship to excessive noise.

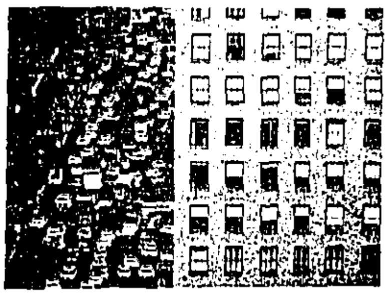
The Environmental Protection Agency has the mandated responsibility and authority to pursue the research to gain the knowledge needed for meaningful progress in achieving a more healthy environment. Especially in the areas of secondary health effects, it is a complicated task calling for the very best in scientific design and talent. It also calls for informed, creative leadership at the governmental and professional levels as well as cooperation between public and private agencies. This is a challenge to the Environmental Protection Agency. We hope the Agency will be able to demonstrate its capacity to offer the leadership needed.

The Environmental Protection Agency can give the leadership, but the final result will depend upon the aroused community concern and corrective actions at the local level. We simply cannot continue to accept the increased noise level without appreciation of its destructive effects on our lives. □

Dr. Terry is former U.S. Surgeon General and President of HEAR Foundation, Inc., a nonprofit organization that works to overcome hearing impairment in children.

Urban Noise and Neighborhood Organizations

By Milton Kottler



Tom and Janet Ross live in Queens, New York. For them, New York is a different city every Sunday morning. "It's not that there are no people around, but there is no noise," Tom said. "We can sit on the porch and have coffee and good conversation. You would never be able to do that during the week."

What Tom and Janet Ross discovered about their neighborhood is similar to what people around the country are discovering: neighborhoods are a lot more fun when they are quieter. While EPA is taking steps on a national level to reduce noise through a combination of regulatory and planning approaches, neighborhood organizations from Alaska to Florida are finding that they can be successful in reducing noise in their community by working together. The current noise control programs of the Federal Government will contain and reduce the escalation of noise, but a major portion of the solution to the problem of noise rests with local communities and neighborhood organizations.

There are many kinds of community organizations. Some have paid staff members. Some receive outside funding. Some primarily advocate neighborhood interests. Many operate programs such as food co-ops, health programs, and other services. A community organization must serve a small neighborhood or be a coalition of neighborhood organizations incorporating the entire city.

The one thing that all community organizations have in common is that they are controlled by the residents of the community. People become involved with community organizations to help themselves and their neighbors. By joining together in community organizations, residents concerned over the quality of life in their neighborhoods can have a pronounced impact on improving their surroundings.

Neighborhood organizations represent a growing force in American life. They are unique because they transcend politics in the traditional sense. They express the common interests of the average people of any community, and they are led by highly motivated and deeply concerned people who are playing leading roles in revitalizing American cities

Noise control and city revitalization go hand in hand. Noise is the unwanted companion of modern technology and urbanization. It insults and intrudes into people's lives, and it comes from a variety of sources —street traffic, aircraft, rail yards, construction activity, industry, the neighbor's lawnmower, and even barking dogs. Such noise is not only unwanted—in many cases it is unnecessary.

Noise is a leading cause of neighborhood dissatisfaction among residents in urban areas. Attempts to escape the noise are often given as reasons for moving out of the city. Noise is therefore a blighting influence as well as a health problem.

City vitality and noise seem to be practically synonymous. Yet, excessive noise can be harmful to city residents and serves to inhibit common patterns of behavior. Moreover, certain types of noise are especially irritating and can have an adverse effect on people. Noise reduction efforts will not lead to a quiet, dormant city. City noise is an integral element of a vibrant city lifestyle, and city patterns of commerce and communications need to be preserved and enhanced. But neighborhood noise programs can reduce, control, and/or eliminate those noises which are in actuality serving to retard urban living and the revitalization of cities.

While it is clear that vibrant, developing and expanding cities will not be silent, noise should not reach the point where the sound itself inhibits growth, where jackhammers drown out conversation, where trucks and buses and airplanes drown out all talk, where street noise hinders commerce, and where not even one's home is immune from eternal blaring noise.

Public concern has begun to find political expression at the local level. The number of local ordinances designated to control community noise levels has increased from 275 to over 1,000 in the last six years. These ordinances reflect the increasing frustration people feel from noise that is significantly disrupting their lives.

But it takes more than an ordinance to reduce noise in a neighborhood. The shelves at any City Hall are filled with ordinances that have never been enforced. In part, the reason has been because people have assumed that city neighborhoods have to be noisy. Many are now discovering that this need not be the case and are consequently turning to neighborhood organizations to develop or enforce city noise statutes.

Allentown, Pa., is a prime example. Allentown was the first city to receive Federal assistance for a demonstration program for noise reduction under the "Quiet Communities" program. The Community of Neighborhood Organizations (CNO) was the driving force that provided constant and sustaining grass-roots support to obtain and carry out this grant.

In addition, the organization worked closely with the city government in the development of Allentown's noise ordinance. Groups from various neighborhoods worked to ensure that their specific noise problems (motorcycles, nightclubs, industry, etc.) were addressed in the ordinance. Through its Environmental Issues Committee, the group was also a leader in the ultimate adoption of an effective ordinance.

On a smaller scale, the Basset Neighborhood Association serves a twelve-square block area in the central city of Madison, Wis. The area is made up primarily of small apartment buildings, housing mostly students and senior citizens. The population of the area is about 2,500.

The Association has been working for the past two years on a comprehensive neighborhood plan. A major component of the plan is a proposal to divert through-traffic away from interior neighborhood streets. Arterial streets would take traffic around the neighborhood and barriers and weight restrictions would keep traffic within the neighborhood to a minimum. The Association has worked to mobilize support for the plan among residents. The plan has made it through the city planning review process, and is now before the City Council. Association leaders feel that it will be enacted soon.

In Sarasota, Fla., Project Traffic was organized by a single neighborhood organization to deal with traffic noise problems throughout the city. The Project is presently completing research on the problem. A study of Federal, State, and local noise laws has been done and a draft noise ordinance developed. In addition, a consultant has just completed a city-wide traffic plan that calls for better signaling to improve traffic flow on major streets and the restriction of through-traffic on other roads. Project Traffic is initiating efforts to have the proposals for traffic noise reductions implemented by the city.

In Anchorage, Alaska, citizens have organized the Federation of Community Councils, which is a coalition of neighborhood organizations. Anchorage is a medium-sized city which has undergone tremendous growth in the past few years. Along with the growth has come an alarming increase in noise levels. After having worked closely with the city government in the four-year process of developing a city noise ordinance, the Federation is now working toward its enactment. Inasmuch as the proposed ordinance would operate on a citizen complaint-responsive basis, the community would play an integral part in its implementation.

In Baltimore, Md., the Greater Homewood Community Corporation has taken on a large and long-range project to reduce noise and congestion from traffic. The organization serves a number of neighborhoods ranging from wealthy to very poor and from single-family homes to large apartment and commercial buildings. The total population of the neighborhoods is 44,000.

The organization has been most active in the area of traffic. Residents were concerned about the noise, air pollution, and congestion resulting from traffic on arterial streets that run through the neighborhood. Greater Homewood was instrumental in setting up a coalition of organizations in neighborhoods affected by arterial street traffic. The coalition, Streets for People, led a two-year fight which resulted in an experimental traffic reduction plan.

The experimental plan allows 24-hour parking in one lane of each four-lane street. An additional lane is reserved for buses. The lane reduction is intended to divert traffic to other routes and to encourage people to use public transportation. The plan will be evaluated this year, and the coalition will work to make the change permanent.

These are just a few of the examples in which active and concerned residents working through neighborhood organizations have made their community a quieter place to live. The role of EPA in this process is to encourage the initiative of neighborhood organizations in reducing excessive urban noise and to provide the technical assistance these organizations need to be successful.

Few urban residents would enjoy their city if every day were as quiet as an early Sunday morning. But like Tom and Janet Ross, they would like to sit on their porch and carry on a conversation without the sound of a jackhammer or a diesel engine drowning out their discussion. Neighborhood organizations around the country are helping to make this happen. □

Milton Kottler is the Executive Director of the National Association of Neighborhoods and author of Neighborhood Government: The Local Foundations of Neighboring Life.

Memo from President Carter to Federal Department Heads

In my Environmental Message of August 2, 1979, I recognized that city noise is an integral part of a vibrant city lifestyle, reflecting city patterns of commerce that must be preserved and enhanced, but that much urban noise is harmful to urban living and could be abated.

I am initiating a program to reduce urban noise by making existing programs work better through interagency and intergovernmental cooperation. I am directing you, in consultation with other Federal agencies, to:

- initiate programs to achieve soundproofing and weatherization of noise-sensitive buildings, such as schools and hospitals;
- promote the use of quiet-design features in the planning, design, and operation of proposed urban transportation projects;
- encourage noise-sensitive developments, such as housing, to be located away from major noise sources;
- help Federal, State, and local agencies buy quiet equipment and products; and
- support neighborhood self-reliance efforts seeking to identify and address local noise problems.

The Federal Interagency Committee on Noise, chaired by the Administrator of the Environmental Protection Agency, shall coordinate the implementation of this program. The Chairman of my Interagency Coordinating Council will assist the Interagency Committee and other intergovernmental cooperative efforts to assure that this program is carried out fully and promptly, including consultation with State and local governments.

The Administrator of the Environmental Protection Agency will report to the Chairman of the Council on Environmental Quality and the Director of the Office of Management and Budget on the progress of this new program on February 1, 1980, and on August 1, 1980.

Quiet Comes to Evansville

By Nancy Shulins
Associated Press Writer

Evansville, Ind.—It's 3 a.m. before the lone lawman finally gets his man within range.

He springs from his wooded hiding place and before the outlaw can make a move, he draws and aims.

Zap! Eighty-five decibels at 50 feet. "Sorry, buddy," drawls deputy sheriff Buster Gordon. "You are gonna hafta get you a new muffler."

So ends another suburban showdown between Gordon and the enemy—the faulty mufflers, wailing stereos, and buzzsaw lawnmowers that keep his neighbors awake at night.

With his visored helmet, dusty boots, and police motorcycle, the 45-year-old Evansville native looks like a California highway patrolman who has taken a wrong turn on his way to L.A.

But he packs a noise detector, not a pistol, and he'd be the first to tell you that there's nothing he loves better than peace and quiet.

In the nine months that Gordon has been enforcing Vanderburgh County's noise ordinance, more than 300 offenders have been brought to justice, and Gordon has risen to the rank of hero among local insomniacs.

"Go get them, Buster," crowed an editorial in a local newspaper. "Buster made me a believer," pronounced Mayor Russell G. Lloyd. "We need more Buster Gordons in our society today," extolled an Evansville radio station.

Who is Buster Gordon?

He's a former Hell's Angel and a registered nurse, a disabled iron worker and an airplane pilot. By day, he's a mild-mannered field enforcement officer for the local environmental protection agency.

By night, he's a volunteer vigilante in this southwestern Indiana county's war against noise.

His dedication is unwavering, and his law is simple: "Thou shalt not make noise." If thou dost, thou shalt pay—from as little as $25 up to $1,000 for a single violation.

To determine whether a citation is warranted, Gordon stands 50 feet from the source of the disruption and turns on his noise detector. If it registers 85 decibels or more, it is deemed unlawful.

Asking Buster Gordon what's so bad about noise is like asking a Ford dealer why he doesn't drive a Chevy.

"Noise pollution destroys hearing; and it can cause neurosis and psychosis," he begins. "It makes you irritable and it makes you mean. And people are getting meaner all the time."

If that argument doesn't sway you, he'll pull out his calculator and try the scientific approach.

"Suppose it's 2 in the morning and one loud motorcycle is cruising the streets. Suppose there are 12 houses to a block and at least two people to a house.

"In the course of three hours, that biker is going to drive 17,400 people bananas. And one of them could be you."

Why do people make noise?

Gordon will tell you that, too.

"A lot of kids have nothing else to do. They drive around on a new motorcycle or in a $9,000 van and they're saying, 'Look at me.'

"They want to draw attention to themselves, to be different, to be special. That's why they put heel plates on their boots and why they rev their engines."

Gordon looks down at his own boots and flashes his engaging grin. "The reason I know so much about it is because I'm describing myself. You see," he confides, "I got heel plates on my shoes, too."

That, says one of Gordon's advocates, is one reason why he succeeds.

Gary Winn, a legislative analyst for the Ohio-based American Motorcycle Association, is trying to spread the word about Gordon's program.

"Buster Gordon has singlehandedly cleaned up the streets of Evansville, and it's not because he's running around in a cop suit," Winn says.

"The reason is because he knows motorcycles and he knows motorcycle language. When he talks to the bikers, they understand him. He's a 25-year member of the association, for God's sake."

Winn says that most cities fighting noise pollution "try to cure the disease by killing the patient."

"They either try to ban motorcycles outright or they try to solve the problem by throwing money at it. All they really need is someone like Buster."

City officials from as far away as Anchorage, Alaska, apparently are beginning to agree. Cambridge, Mass., Louisville, Ky., and Saginaw, Mich., also number among the cities that have requested information about the Evansville program.

Meanwhile, Gordon, with the help of State Rep. Gregory Server, an Evansville Republican, is hatching a plot to take his ordinance to the Indiana legislature with an eye toward seeing it implemented statewide.

"It's a good, fair ordinance, and it's directed at people like me," says Gordon, who likes to think of himself as a champion of the little people.

"I love bikes and I love bikers. All they do wrong is make noise. And I love to bust the noisy ones, because they're giving people like me a bad name."

The pickings are getting slim for Gordon, who describes Evansville streets as "99 percent quieter than they used to be." But he says his work in the city is far from over.

Next on his hit list are firecrackers, faulty air compressors, and loud parties.

The people of Evansville are applauding. Very quietly. □

Noise in Our Cities

John P. Rousakis
Mayor of Savannah, Georgia. President of the National League of Cities

This past summer *Time* magazine offered an essay on the subject of urban noise pollution; specifically those "surly troops" who manage a symbiotic relationship between roller skates and 90 decibels of non-stop disco while aimlessly meandering down our city streets. It noted that many cities are responding to this newest form of urban noise pollution by enforcing existing noise ordinances "to hold the volume down." Frank Trippet, a *Time* senior writer who authored the editorial, thought it remarkable that cities would single these people out for attention amidst the "incessant horn bleats—the ingenious cacophony of screaming sirens, screeching tires, shattering jackhammers, clangorous garbage cans, raucus trucks and roaring buses." He concludes from his observations that "still, the city dweller, though besieged by chronic noise among other civic abominations, is not indifferent to his plight. Certain noises, those of traffic for instance, are inherent in city life, essential and irreducible, they must be borne. The music of the (radio) boxes is not in that category."

I can only partially agree with this conclusion. Clearly the city dweller is not indifferent to his plight. On that point we agree. A recent Gallup survey conducted for the National League of Cities showed that forty percent of urban residents think noise pollution is a serious problem. Half believe urban noise levels have grown in the last five years and a similar number believe that not enough is being done to solve the noise problem in cities. The most astonishing of the Gallup results indicates that 1 out of 5 people see noise as a serious threat to health. All of these public perceptions of the problem are in fact true to a large extent.

However, Mr. Trippet classifies most urban noise as "essential and irreducible . . . inherent to city life." On that point we differ. Many of us have been led to believe this. We are victims of conditioning. The fact is none of these noises *must* be borne by the public. Like all types of pollution, noise has a manufactured source and people are involved along every step of the way from production to operation. People cause noise pollution and people can prevent it. None of us can deny the fact that urban noise levels are on the upswing. None of us can deny that not enough is being done about noise in our cities. The question is what is being done to reverse these current trends? Despite seven years of experience with Federal legislation to control noise (the Noise Control Act of 1972), noise seems to be becoming worse. Part of this current dilemma, I believe, rests with the previous focus of the Noise Act where accountability, authority, and responsibility to solve our Nation's problems were bestowed solely upon EPA.

The view was that Washington regulations would solve our noise problems. It's clear that this approach failed, that Washington could not solve the noise problem, that the problem refused to surrender to uniformity and central governance solutions.

The Quiet Communities Act of 1978, authored by Senator John Culver (D-Iowa), recognized the inadequacies of that Washington-based approach and embraced the notion of local solutions to local problems. In fact, the new law directs EPA to refocus its efforts toward local governments, since local leaders hold the key to quiet. Senator Culver said, ". . . The Quiet Communities Act may be the forerunner of future urban policies, which can be expected to place greater emphasis on the role of local communities with less dependence on the Federal Government."

Rather than solving our problems with nationally legislated solutions, Congress is recognizing that cities are qualified to solve urban noise problems, and are the level of government most likely to do so. This is American federalism in action. Unfortunately, it is an exception to the norm, which today views local government as an "extension service" of the Federal Government. This partnership approach is one which the National League of Cities supports to the fullest extent, since it recognizes the capability of local governments.

Helping, not regulating, is the most effective way the Federal Government can aid municipalities. There is a move afoot in Congress to ensure that such help is available to cities. Some members of Congress hope that EPA will divorce itself from its regulatory agenda and begin supporting and encouraging local noise efforts through partnership activities. Applying local resources and local institutions to reduce noise pollution is clearly the most logical step at this time, a course which Congress has quite wisely charted under the leadership of Senator Culver.

Cities and people want action on noise, not reams of shelf-sitting research reports and *Federal Register* reprints. No one needs to be told time and time again that noise is a health problem and that it causes stress. For the average person who wants quiet, researching and contemplating the noise problem doesn't reduce it. Positive action by applying resources to abatement and control at the local level is the answer.

It must begin now or our cities are apt to devour themselves with noise. Let's not wait until we can prove beyond a doubt that noise causes cardiovascular disease. Let's act now to reduce noise and prevent it from becoming a clear-cut contributor to health problems. Active prevention, not remedial reaction, should be the goal of a national strategy for noise control.

How EPA's noise program is structured in the future will either enhance or nullify efforts at the local level. I believe that EPA's efforts will positively demonstrate that an equal partnership between cities and the Federal Government can succeed in the Eighties . . . a partnership consistent with the President's articulated urban policies.

My good friend, Barbara Blum, summed it up quite clearly when she said, "Noise from a variety of urban sources is helping destroy the neighborhoods which the President is seeking to save under this urban program." In his Environmental Message to Congress *this* year President Carter spoke of an urban noise program and its importance, highlighting not regulatory programs, but substantive self-help programs aimed at accomplishments, not wishful thinking. Any partnership efforts between cities, States, and the Federal Government will recognize that cities and their people provide the decisive and critical difference between action and inaction, and between success and failure. □

Curbing Construction Noise

By Paul N. Howard, Jr.

We are subject to a multitude of wide-ranging sounds at home, work, and play.

But what differentiates everyday sounds from what we call "noise"? Noise is a distraction, an agitation, an inconvenience. Noise is rarely appreciated and, at best, only tolerated.

Over the years, construction noise has been tolerated as a necessary but temporary inconvenience attendant to progress. But today, government agencies at the Federal, State, and local levels are undertaking serious efforts to reduce or eliminate noise at construction sites. These efforts have produced mixed results.

Two principal types of noise—occupational and ambient—are the targets of the government's attention. Occupational noise is related to the safety of the worker, while ambient noise relates to the impact of noise on the community.

The Associated General Contractors of America, recognizing the benefits of protecting the health of its workforce, has long supported efforts to reduce noise at the construction site and has worked with assorted agencies to develop the most practical ways of achieving noise abatement.

Construction noise should be, and is, a serious concern to contractors. An industrial insurance survey reported that hearing loss is the largest compensable health problem today. In addition, nearly half of the American population experiences aggravating and potentially harmful environmental noise, according to the Environmental Protection Agency.

The most important question, then, is how best to achieve the goal of noise abatement in construction?

The Associated General Contractors of America support the inclusion of contractual requirements to reduce noise levels during construction provided the requirements are practical, feasible, and capable of accomplishment. This means that measures to control noise should be realistic and free of conflict. Unfortunately, this is not always the case.

For example, a conflict exists in the requirement that back-up noise devices on vehicles and equipment must be heard above the noise generated by the vehicles or equipment. This is a requirement of the Occupational Safety and Health Act and the Safety and Health Regulations for construction.

The necessarily high level of the warning signal, however, often disturbs residents nearby. In order to lower the noise level of the warning signal, the noise made by the equipment must be lowered.

Therein lies the principal problem for contractors. Few source controls (those built in with the equipment) for industrial equipment are now available. But, it is source controls which provide the best long-term approach to the problem of reducing noise.

Source controls are more economical in the long run than "retrofit" measures, which are extremely expensive to implement and seldom work as well as source controls. For example, while a contractor may build barriers, enclose equipment operations, and substitute equipment to reduce noise, these temporary, expensive measures often fail to adequately protect workers and construction requirements may require operations that cannot be accomplished without raising environmental noise levels.

Economic research has indicated that noise abatement regulations will significantly increase construction costs. Because no increases in productivity will accompany the higher costs of equipment with noise controls, regulations at all levels will be inflationary. (It has been estimated that built-in noise controls will add about three percent to present costs of new equipment. By contrast, retrofit controls designed to reduce noise levels by five decibels will add up to 10 percent to the equipment's initial cost.)

What should be the role of the Federal Government in the noise abatement process? Initially, government agencies should establish final equipment noise regulations. Any other role by the government should be extremely limited and directed at specific, well-defined problems such as the risk of hearing impairment, reduction of the number of people exposed, and the rate of progress in noise abatement by industry.

The Associated General Contractors recognize that some regulation is necessary and beneficial and we are committed to providing the most cost-effective product possible—whether it is a sewage treatment plant, a highway or subway, a building, a dam, or a power plant. The government must also recognize that increased costs are associated with virtually every government regulation.

Activities of the Federal Government should always complement those of the private sector, which must be responsible for furnishing the direction in noise abatement. The private sector possesses the necessary knowledge of what problems must be solved in order for the goals to be achieved. And, there are obvious incentives for a contractor to achieve noise abatement goals.

Most important of these is that reduction of noise in construction means complying with federally imposed occupational noise standards. In addition, the contractor has a concern for the health, safety, and welfare of his employees; wants to reduce costs associated with worker's compensation claims; and increase worker productivity. Finally the contractor wants to be as good a neighbor as possible to those who live around the construction site.

For these reasons, contractors believe that a market for efficient noise-controlled products currently exists. Manufacturers have said that they cannot invest in developing quieter equipment until there is an adequate market or until the noise factor is a strong selling factor. Contractors are convinced that the market does, indeed, exist.

While EPA should establish noise standards for newly manufactured equipment and require that those standards be met, certainly a reasonable lead time must be allowed to develop and produce this equipment. And, noise regulations should apply only to equipment produced after a specific date.

While more research is necessary to develop noise controls on many types of equipment, current technology exists to control noise levels on others. Some equipment—air compressors, for example—has already been so developed. But, until reasonable uniform standards and requirements are developed, manufacturers will not produce and contractors will not have available to them, equipment with reduced noise levels.

In the long run, substantial noise reduction at the construction site is attainable, provided the Federal Government, manufacturers, and contractors work in unison toward this goal.

The Association of General Contractors encourages the Federal Government to realistically assist the private sector in the research and development of noise-controlled equipment and calls upon manufacturers to accept the challenge of producing efficient, reliable, and quieter construction equipment.

By working together we can enhance the environment for the worker as well as the community, while continuing our Nation's progress through construction. Let's do just that and let's be realistic about it. ☐

Paul Howard is President, Associated General Contractors of America.

Noise in the Workplace

By Jeff Stansbury.

Some work place hazards crush and kill instantly. Noise doesn't. It wreaks its havoc slowly through the years in ways workers seldom notice.

Noise doesn't get the front page coverage that air pollution does. It doesn't create the fear in people that nuclear waste does. It doesn't get the research dollars that water pollution does. Nevertheless, of all the countless types of pollution, it is unquestionably the most pervasive and varied—it is literally everywhere.

Nowhere is it more prevalent or more dangerous than in the work place. Not too long ago the National Institute for Occupational Safety and Health estimated that over 2.5 million U.S. industrial workers were exposed to harmful levels of noise. This, they said, was a conservative estimate.

The Occupational Safety and Health Administration (OSHA) and EPA are responsible for Federal noise control initiatives. OSHA is responsible for noise control in the work place. It sets and enforces decibel standards, for example. EPA reinforces OSHA's activities by establishing standards for hearing protection devices and for industrial equipment that have a direct impact on the environment. In addition, EPA establishes noise limits on certain occupation-related processes such as trash compaction.

American industrial workers—and industrial workers everywhere, for that matter—have always had to fight for health protection in the work place. We are currently locked in such a struggle to bring about noise control measures in America's manufacturing plants.

Why is it so important to us that noise is abated in the work place? Well, I think we have to look at the health effects of exposure to excessive levels of industrial noise.

Certainly, the most easily observed of these health effects is hearing loss. Researchers have found that excessive noise wears out the nerve cells of the inner ear. If the exposure is long-term, as it is for thousands of UAW workers, noise destroys the cells, and the hearing loss not only becomes permanent but grows worse. At what level does continuous noise become dangerous to hearing? There is no definite answer; however, the consensus is 80 decibels. In the U.S. the allowable industrial noise level is 90 decibels for 8 continuous hours. At this level, one-fifth of the work force will eventually suffer disabling loss of hearing.

Jeff Stansbury is a staff writer of Solidarity, *the official magazine of the United Auto Workers (UAW).*

When confronted by workers on this issue, most companies propose the use of hearing protectors. Why? Simply because ear plugs or ear muffs are inexpensive and put the burden of noise control on the workers. It is the opinion of the UAW health and safety staff, and many OSHA specialists, that personal hearing protectors should be used only as a last resort. Ear plugs readily work themselves loose, often cause infections, and can mask warning shouts and signals.

While we recognize that hearing protectors must sometimes be used for temporary protection, UAW insists that the long-term solutions to excessive occupational noise must be engineering and work-procedure controls. OSHA can recommend various operational and engineering procedures within the work place, and it can enforce them where necessary. EPA contributes to in-plant noise controls by setting standards for equipment manufacturers.

Hearing loss is by no means the only negative health effect that workers suffer from noise. Noise creates stress which causes blood vessels to constrict. Pulse rate, blood pressure, and breathing rate increase, and there are marked changes in blood chemistry. A German study has documented a higher rate of heart disease in noisy industries. In Sweden, several researchers have noted more cases of high blood pressure among workers exposed to high levels of noise.

In addition to heart disease problems, the increased flow of adrenalin and other hormones makes workers prime candidates for illnesses caused by stress. In the words of Leonard Woodcock, former President of UAW, the auto workers "find themselves unusually fatigued at the end of the day compared to their fellow workers who are not exposed to much noise. They complain of headaches and inability to sleep and they suffer from anxiety. . . . Our members tell us the continuous exposure to high levels of noise makes them tense, irritable, and upset."

Research is continually identifying the contribution of noise to other physical disorders. A five-year study of two manufacturing firms in the United States found that workers in noisy plant areas showed greater numbers of diagnosed medical problems, including respiratory ailments, than did workers in quieter areas of the plants.

The health and safety of industrial workers is jeopardized also by noise loud enough to mask warning signals. The effects of masking and speech interference can be dramatic, as in the case of an accident in an auto glass manufacturing plant. Noise levels were so high that a worker whose hand was caught in manufacturing equipment received no aid since no one heard his screams. And in a noisy Ohio plant, two pressroom auto workers were permanently disabled when they failed to hear approaching panel racks and warning shouts.

One point we try to make to management is that noise can interfere with work. When noise is particularly loud or unpredictable, errors in people's observation increase, perception of time is distorted, and greater effort is required to remain alert. Loud noises also can lead to breaks in concentration sometimes followed by changes in work rate.

A coal industry study indicated that intermittent noise conditions during mining are likely to cause distractions leading to poorer work. Other studies have confirmed additional effects of noise exposure, including exhaustion, absentmindedness, mental strain, and absenteeism—all of which increase the risks of accidents and injuries.

UAW has been intensifying its fight against workplace noise. We stiffened the health and safety provisions of our latest national contracts. At many locations we have won noise-monitoring rights. In addition, we have pressured a growing number of plants to work out noise-abatement schedules in consultation with local union health and safety representatives.

We also are aware that to truly protect our union members, we must inform them that noise does not necessarily stop when the workday ends. UAW supports EPA's programs to reduce environmental noise and to educate people about its associated health effects. A noisy environment only aggravates the effects of work place noise. We do not want to let this situation continue.

I am often asked by union leaders what they can do to protect their members from excessive noise. My advice is, first and foremost, to educate their whole membership about noise hazards and how to abate those hazards. They can then work with management to adopt comprehensive programs to engineer out noise on a definite timetable. OSHA can be called in to bring added pressure on companies. In addition, help can be obtained from their unions' regional offices, their national bargaining departments, and their health and safety staffs.

Noise can never be completely eliminated from manufacturing plants, but it can certainly be reduced to safe levels. It is management's responsibility to provide effective noise control engineering and procedures. But management seldom carries out its responsibility without a push from workers. For this reason, workers and their unions must remain ever-vigilant against noise hazards in the work place. □

By Chris Perham

The Sound of Silence

Jack G., a heavy equipment operator, and his wife Mary are arguing in their front yard again. He accuses her of mumbling so that he can't hear her over the noises of the neighborhood. She replies that he's just not paying attention. Mary knows perfectly well that when she talks to Jack in the house he hears her.

Sarah P. has been working in the mills for many years. Lately her family finds that she's cranky and irritable. She won't go along on outings, avoids social gatherings, and has even stopped going to church. She accuses them of talking about her behind her back and often makes comments that aren't relevant to the conversation going on around her.

Tommy L. is a drummer in a teenage rock group. He and his friends play for hours in family garages and basements. He sometimes notices a ringing sound in his ears for hours after practicing. His mother says he never listens to her any more and wonders what all that music is doing to his hearing. He discounts her fears, saying hearing loss is only for old people.

Hearing loss is one of America's most common chronic disorders. Some researchers estimate that approximately 19 million Americans have measurable hearing losses, and 13 percent of the U.S. population have hearing losses described as handicapping. How much of the damage can be attributed to noise exposure? Nobody knows for sure, but EPA research shows that workers, students, homemakers, and people in all walks of life are regularly assaulted by sounds that border or exceed the limits above which hearing is damaged.

Unfortunately when the ear is injured it often shows no visible signs, so few people realize the damage they suffer until it is too late. Hearing loss from noise is irreparable. Scientists note that a hearing aid cannot compensate for lost hearing the way glasses can improve poor eyesight. For a noise-induced hearing loss, the impact is especially profound because no operation or amplification can restore total sense to the jumble of sounds that the injured person hears in place of normal conversation.

What sounds are dangerous to hearing and why? According to EPA research the danger zone begins when the daily noise level averages about 70 decibels. This means that certain traffic sounds, power lawnmowers, jet planes, chainsaws, and jackhammers are all hazardous to healthy hearing if you are exposed to them for extended periods of time. What many people do not recognize is the danger posed by household appliances as well; food processors, mixers, hair dryers, and vacuum cleaners often exceed the safe noise limits.

The reason for concern is that prolonged and excessive exposure to noise can damage or destroy the hair cells in the inner ear, disrupting the sound transmission mechanism. While there are many thousands of hair cells in the inner ear, beyond a certain point the damaged cells will not heal. Under continued high level noise exposure damages accumulate and will eventually affect enough frequencies that a person's ability to comprehend speech is impaired. At this point the listener has trouble not only with the volume but also the clearness of speech.

There is as much variation in sensitivity to sound as there is in the sensitivity of skin to sunlight. Just as some people sunburn at the first exposure to sun and others can frolic at the beach endlessly without pain, so some people flinch at the sound of a car horn while others revel in the hair-raising blasts at discos. There is no way of predicting what a person's sensitivity to sound will be, and many people only find out when it's too late.

Dr. George W. Fellendorf, director of the EPA-sponsored National Information Center for Quiet, says, "The American public needs to have an awareness of the existence of hard-of-hearing persons. These are people who are not deaf, who do not use sign language, but who need an extra measure of consideration when it comes to sounds and communication. During conversations hard-of-hearing people may comprehend clearly only one or two of every ten words. Trying to communicate under those conditions is like being in a foreign country where you know only a fraction of the language. It's extremely frustrating."

Exposure to loud noises generally affects the high-frequency hearing range first. The people affected can lose the ability to hear things like clocks ticking, crickets chirping, the ring of telephone bells, and certain portions of speech, especially consonants. The sounds of **s**, **sh**, **ch**, **p**, **m**, **t**, **f**, and **th** are some of the first speech sounds to be lost, depriving spoken conversation of its meaning. Speech begins to sound like a meaningless string of vowel sounds.

Other hearing phenomena caused by excessive noise include ringing in the ears, distortion and discomfort associated with even moderately loud sounds.

Scientists report that the impact of this hearing loss is psychological as well as physical. People who cannot hear the

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Fighting Noise Pollution Around the World

By Dr. Ariel Alexandre

In Sweden, some city officials are deliberately spending extra money to purchase quiet buses.

In Japan and France, proceeds of airport taxes are used to finance noise insulation of nearby buildings.

In Europe, major efforts are underway to standardize noise emission limits for motor vehicles and other equipment.

In Germany, buyers of exceptionally quiet lawnmowers and noncommercial aircraft are exempted from certain restrictions on use. Germany is studying how to apply this principle to traffic noise control.

In Lausanne, Switzerland, a police anti-noise brigade has enforced a vehicle noise emission law and educated the public on noise control since 1959.

In Darlington, England, school children participating in a project sponsored by the Noise Advisory Council and the Advisory Center for Education are measuring noise in the town and conducting simple social surveys on noise effects.

These are just a few of the technological, legislative, and incentive measures to control the growing menace of worldwide noise pollution that are cited in the 1978 report of a two-year study by the Paris-based Organization for Economic Cooperation and Development (OECD). Member countries are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States (and Yugoslavia as an observer).

The report, *Reducing Noise in OECD Countries*, was compiled as a result of some staggering projections made by the OECD's Ad Hoc Group on Noise Abatement Policies. A sample of some of their findings include: total noise energy output in OECD countries has doubled in the past 15 years; between 15 and 20 percent of OECD inhabitants (more than 100 million people) are now exposed to outdoor noise in excess of the 65 decibels often considered the upper limit of acceptability; by next year, the world's motor vehicle population will exceed 300 million units; air traffic worldwide (USSR and China excluded) will probably double between 1975 and 1985. And if stringent measures are not adopted, forecasts suggest that the number of people exposed to excessive noise will increase, as has been stated during the recent OECD meeting of the Ministers of the Environment (May, 1979).

The concern of the OECD member countries is reflected in the observations made in the report, which are meant to act as blueprints for fighting noise pollution through cooperation by government, industry, and the public at local, national, and international levels. The following are summaries of a few of these key task force action proposals; they include examples of measures already in force or being considered by different OECD countries.

Standardization of Noise Measurement

OECD countries are in agreement that it would be highly desirable to have a universal, standardized, simple method of measuring total noise received and compatible noise emitted from sources such as road vehicles, aircraft, and machinery. Work is under way to develop a standard measurement that would be practical, accurate, and useful for planning and enforcement procedures. Such a standard also would prove valuable for evaluating pervasive long-term noise in various areas under prescribed conditions.

Standardization measurements would have the additional benefit of minimizing barriers to trade by providing manufacturers with a universal "language." They also would help international organizations working in noise abatement, such as the International Civil Aviation Organization, the World Health Organization, and the International Standards Organization, to recommend standards and practices.

Noise Abatement: At the Source and Through Operation Regulations

OECD countries unanimously agree that noise abatement at the source is essential, particularly control through emission standards. Most countries have emission standards for motor vehicles. Many countries have, in addition, various regulations for aircraft, trains, construction, and light and heavy equipment. For example, Germany and the Netherlands are preparing noise emission standards for rail transport; a number of OECD countries have established reference limits for construction equipment; and some countries impose noise emission constraints during the planning or licensing process of light and heavy industrial plants.

When source regulations are not sufficient or applicable, regulations on operation are used in many countries. Restrictions in time are the most widespread operating regulation: for example, Switzerland prohibits driving of heavy trucks at night and on Sundays, and night curfews are imposed on many airports around the world.

Restrictions in place, common for mobile noise sources, are used mainly to regulate traffic or construction equipment near noise-sensitive areas (homes, churches, schools, hospitals). Care is taken in establishing such restrictions so that they do not merely lead to a transfer of noise from one critical area to another.

Another method is noise zone regulations which restrict the levels of noise allowable in land areas surrounding major industrial or transportation facilities. Regulations of this sort are already in effect in areas near Japanese and French airports, and have been recently advocated by Switzerland, the Netherlands, and Germany.

Noise-Related Charges Can Complement Other Forms of Control

Such noise-related fees as charges on aircraft designed to motivate product manufacturers and operators to develop, manufacture, and use quieter equipment are becoming popular in several OECD countries. Revenue from noise-related charges can finance comprehensive noise abatement programs, including research and development, and pay for building insulation and land acquisition.

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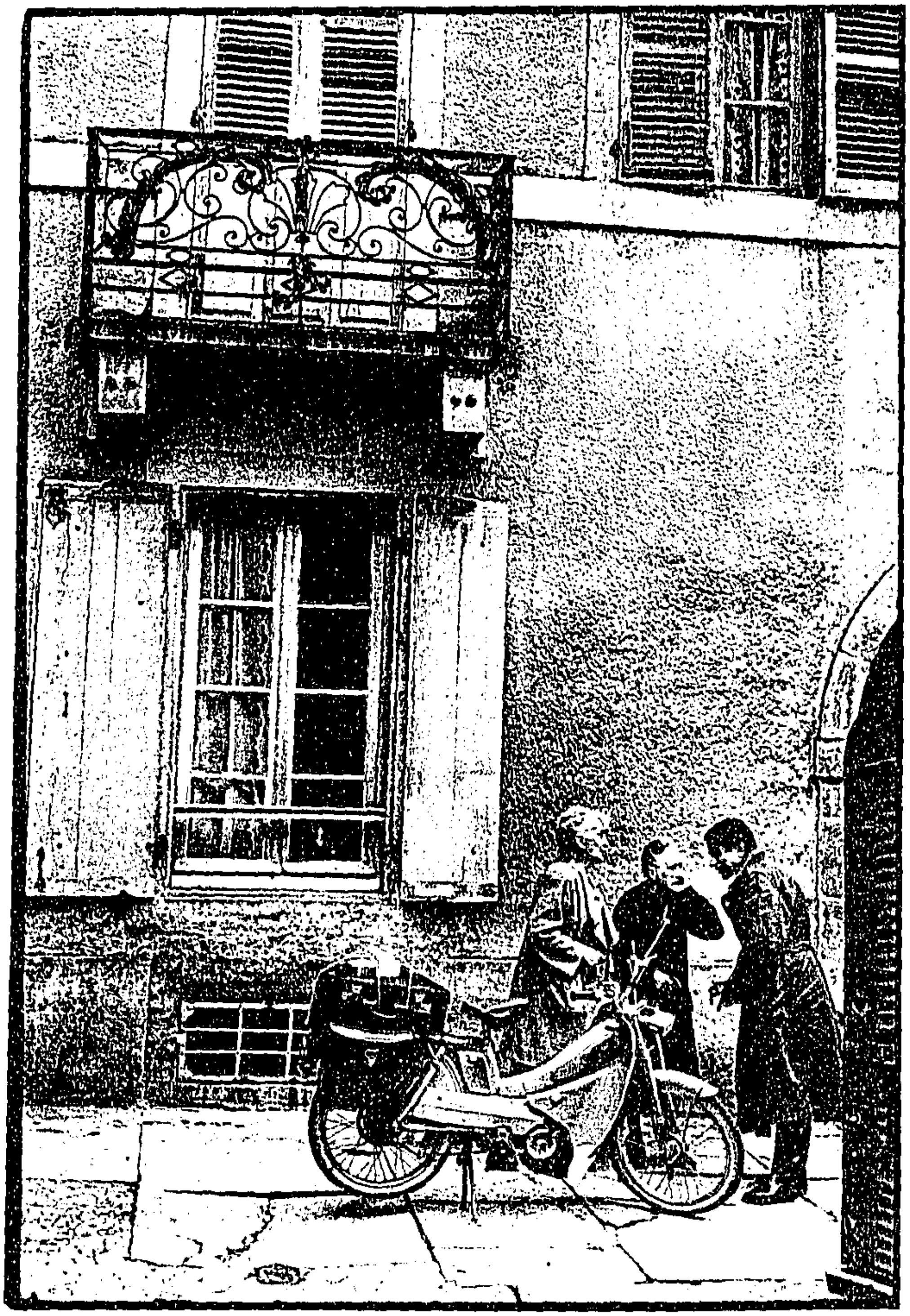

Do We Need New Product Noise Regulations?

Jesse O. Borthwick
Executive Director, National Association of Noise Control Officials

With the passage of the Quiet Communities Act of 1978, Congress has recognized the importance of comprehensive State and local programs in the overall national noise control effort. Through the establishment of the Quiet Communities Program which authorizes noise control grants for the first time and through the expansion of technical assistance made available to State and local noise control agencies, Congress has finally filled the void in its program to curb this most pervasive pollutant.

State and local noise control officials couldn't be happier! For while the Noise Control Act of 1972 declared that the primary responsibility for control of noise rests with State and local governments, only 7 out of the Act's 921 lines of text supported State and local controls. More was said about what State and local governments could not do than what was to be done to support them. Therefore, it should be easy to understand why State and local officials are openly supportive of the new Quiet Communities Act and the resultant shift in EPA program direction away from new product noise regulation to State and local programs.

With all the emphasis now being placed on the new Federal grant program and the renewed national noise control effort stemming from the Act, we have perhaps lost sight of the fact that the Quiet Communities Act amended and strengthened the Noise Control Act of 1972 rather than abolished it. In all the furor, we seem to have forgotten the need for and the importance of new product noise regulations in the overall national noise control strategy.

Why Are New Product Noise Emission Standards so Important?

It seems that we have gotten along fine without them. Since the passage of the Noise Control Act of 1972, the EPA Office of Noise Abatement and Control has promulgated standards for two products, portable air compressors (January, 1976) and medium and heavy trucks (April, 1976). During the same time only a handful of States and cities have promulgated new product standards with most opting for in-use type standards. Why—is it because it was presumed that the Feds would handle new product standards and since such standards would preempt State regulations, they opted to put their resources elsewhere?

When one considers the investment required to get a standard out in terms of time, money, manpower, and politics it is a miracle that any ever get promulgated! Promulgating national standards has become even more difficult as a result of the new Federal philosophy of encouraging "non-regulatory strategies." The easy thing to do would be to ignore the need for new product regulations and concentrate on those sources which can be easily and quickly controlled by in-use ordinances. However, while in-use controls can offer immediate relief from worst case problems, the only way we will ever realize a reduction in general community noise levels in this country will be through the adoption of comprehensive new product regulations for major noise sources.

What Effect Can New Product Regulations Have On Our Future Acoustic Environment?

In controlling any noise at its source there are three basic approaches: (1) you can require that sources be manufactured to operate as quietly as possible (2) through anti-tampering provisions require that sources be properly maintained so as not to increase their sound level above that as originally manufactured and (3) through in-use controls require that they not be used in any manner as to create excessive and unnecessary noise. Anti-tampering and in-use controls affect only those individual sources which are considered to be excessively noisy when compared with the general population. However by establishing noise emission standards for new products the entire source population can be affected with average noise emissions dropping as the new quieter products are introduced. This is the type of change that will be needed if average community noise levels are to be reduced.

One source in particular will have to be controlled if we as Americans are ever to achieve EPA's goal of an environment free from noise that jeopardizes our health or welfare. That source is the automobile. As a result of its extensive use, over 87 million Americans are currently being exposed to environmental noise above those levels identified by EPA as required to protect public health and welfare. The number of people affected could increase to over 110 million over the next decade if diesel powered vehicles and subcompacts with high power-to-weight ratios become the backbone of our automobile population. Again, our only hope is to successfully reduce sources of noise through new product regulation.

Have Existing New Product Regulations Had Any Effect On Current Noise Levels?

Yes, as a result of new product regulation initiated by the State of California in 1967, supported by other States and communities in the early 1970's, and by EPA in 1976, average motor vehicle noise emissions appear to be dropping.

In 1967 California amended its Vehicle Code to make provisions for vehicle noise control. The law established this country's first sound level standards for new motor vehicles (applicable to vehicles manufactured after January 1, 1968). The new limits were a compromise between what was desired in terms of noise reduction and what was economically practical at the time. Under specified wide-open-throttle acceleration tests, limits were set at 88 decibels for trucks and buses, 86 decibels for passenger cars and pickups, and 92 decibels for motorcycles. In 1971 the California Legislature adopted a schedule of decreasing levels (see Table 1) with the following three objectives: (1) establish an eventual limit that was low enough to practically eliminate public annoyance and complaints (2) allow sufficient lead time so manufacturers could do necessary research and design and tool up to meet production deadlines and (3) allow the

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TABLE 1.

	Trucks and Buses	*Passenger Cars Pickups, and Motor driven Cycles*	*Motorcycles*
1970	88	86	88
1973	86	84	86
1975	83	80	80
1978	80	75	75
1988	70	70	70

Initial vehicle sound level limits (in decibels) established for new motor vehicles sold in California.

Noise Control Through Education

By Martha Pennino

Excessive noise is the most frequently identified undesirable condition in urban neighborhoods. Moreover, neighborhood residents show increasing dissatisfaction about noise levels with each passing year. This alarming trend emphasizes the need for concerted effort at all levels of government to reduce intrusive noise levels.

As an elected official, I am keenly aware that legislation directed toward control of environmental problems is only a partial answer to reducing pollution. In my view, an effective public education and information program can contribute to significant noise reduction. Fortunately, in recent years the information available to assist in public education about noise pollution has grown. Increased public awareness leads to both implementation of individual and community noise control mechanisms and more effective communication with elected officials and administrators about noise concerns.

In the Metropolitan Washington area, I have observed a definite increase in public concern about noise issues in the past five years. During this period, most of the major jurisdictions have implemented noise control programs. In each case public concern and pressure have been instrumental. The noise pollution issues in our region range from aircraft, highway, and construction noise impact to noisy home air-conditioning systems.

The issue of aircraft noise from National Airport has consistently generated the greatest public concern. Residents and elected officials are both knowledgeable about this noise issue and equally frustrated by the complexity of attempting to reduce the noise impact. Citizens groups throughout the region have organized special committees and groups to monitor the situation and exert pressure to ease this growing noise problem. Through the Metropolitan Washington Council of Governments, the regional organization for this area's elected officials, we have had a noise monitoring system installed. Also, in August a test of a new flight pattern was initiated at National Airport. Area residents are participating in evaluating the impact of this noise control approach through a telephone survey and a hotline.

School children represent a vital link in noise reduction through public education and information.

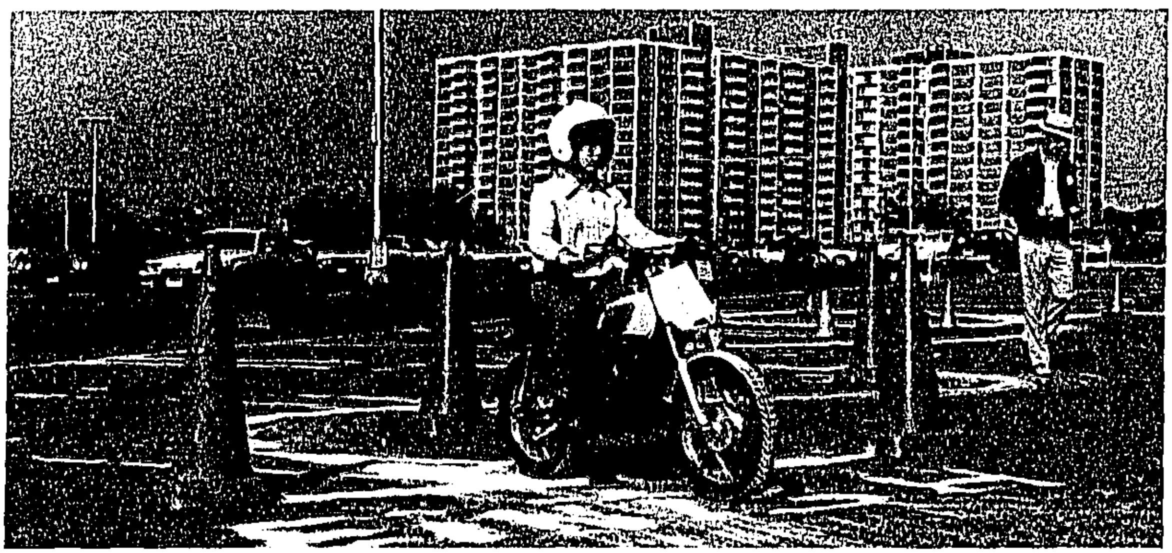
It is important for young people to develop an appreciation of quiet as an environmental right and an understanding of the adverse effects that excessive noise exposure can have on their health and welfare. In recognition of the need to reduce noise exposure in the schools, two local school systems, Arlington County, Va., and Montgomery County, Md., have developed noise control policies that set decibel limits for school activities such as dances. In Montgomery County, student volunteers are involved in the monitoring process too.

Last year the Montgomery County School system also participated in the field testing of three brochures developed by the American Speech-Language-Hearing Association for EPA. The brochures, *Noise and Your Hearing, Hear Here!,* and *Think Quietly About Noise* were developed for distribution at the time of school hearing tests. The booklets provide students from kindergarten through high school and their parents with information about the effects of noise pollution on hearing. These brochures now have been incorporated into a complete hearing test package that will be available from EPA for use by educators, school nurses, and audiologists in the near future.

In 1974, the Metropolitan Washington Council of Governments initiated an Area-wide Environmental Noise Program that was sponsored initially by the area's local governments and the U.S. Department of Housing and Urban Development. A major focus of this program has been to develop and disseminate information about noise pollution to the public, citizens associations, elected officials, and local government staffs.

Two years ago, the Council received funding from EPA to develop educational modules for elementary and secondary school levels. This year the author, Dr. Donna Dickman, will give seminars for teachers on the use of these units. Numerous school systems throughout the Nation have shown interest in these noise educational units.

Classroom discussions about noise pol-



Complaints about minibike noise decreased after youngsters in Montgomery County, Md., were counseled on how and where to ride without disturbing others.

lution can help inform parents on ways to control noise.

As the tools available for noise assessment are rapidly expanding, there is a continuing need for educational programs to help State and local governments develop and implement noise control programs. Three years ago, 90 area planners attended a workshop on Noise Control and Land Use Planning sponsored by the Metropolitan Washington Council of Governments and EPA Region 3. Six members of the Fairfax County, Va., Office of Comprehensive Planning were there.

Since then, noise has received increased attention from our planning staff. Specific guidelines for analysis of noise impacts have been developed and applied. When potential problems are identified, the staff assists the developer in creating a compatible noise control plan.

To assist developers and builders in planning noise reduction projects, the Montgomery County, Md., noise staff arranged a seminar on building noise. It was attended by 30 area builders and developers. They received information on site planning, acoustical, and architectural approaches to noise control. Again, application of this information in future developments will result in quieter homes and offices for area residents.

Recently, local and regional purchasing officers met at the Council of Governments to discuss noise reduction through specifying (at the time of requests for bids) the acceptable noise levels for various products. A pilot project conducted by the Federal Government to acquire quieter lawnmowers was successful. Many of these quieter lawnmowers are loaned to local governments for use by groundskeepers in noise sensitive areas such as hospitals and schools. Local governments represent a substantial market and emphasis on the desirability of quieter products should not be ignored. But the push for quieter products must come from a concerned public which makes quiet a priority for local government officials.

In the past year, noise control personnel in this area have received frequent calls from people about specific home noise control problems. *Quieting in the Home*, a National Bureau of Standards publication that has been reprinted by EPA, gives valuable aid in solving many home noise problems. This "quiet it yourself" book and other materials on noise are now being distributed through the National Information Center for Quiet in Rosslyn, Va. The EPA-funded center has been created to serve as a resource for people who want a quieter personal and community environment. The center for noise information will aid public participation in noise reduction efforts.

For several years, I have seen the effectiveness of an information sharing concept through the work of the Council's Noise Technical Committee. In this program, noise staff from the region's major jurisdictions meet monthly to discuss noise issues and to help one another develop plans to ease noise problems.

It has been my experience that maximum public commitment and support for almost any issue result from going to the people rather than waiting for them to come to you. For example, several years ago EPA sponsored a Noise Exposition in a large area shopping center. Locally, Montgomery County has held two "Noise, Sound and You" Expos. Each of these has sensitized thousands of people to noise pollution as an environmental problem.

Last fall the Council of Governments sponsored a Minibike Roundup for youngsters in Montgomery County. Minibike noise was a frequent cause of complaints in the County. The youngsters received noise and air pollution analyses for their minibikes, participated in a skills contest, and received information about areas where they could ride minibikes without disturbing others. At last check minibike noise complaints were less frequent in the County. Similar educational efforts directed toward other noise problems could be equally successful.

Two other efforts in the Metropolitan area show the potential for noise reduction through user education. Both were developed in cooperation with the Council of Governments. In a pilot inspection program, Prince George's County, Md., noise control officials conducted noise measurements on refuse collection vehicles. Owners and operators were then counseled about the use of quieter trucks in residential areas. The State of Maryland noise control staff developed brochures on air conditioning and refrigeration condensing noise and grain dryers, which were distributed throughout the State. The brochures tell how to quiet these noise sources. The pilot inspection counseling program and the brochures are ways to augment noise control efforts beyond a program of individual responses to complaints.

As an elected official, I recognize the concerns of my constituents in governmental regulation to foster environmental change. There is both an aversion to overregulation and understanding of the limits of regulation as an effective control. I strongly support public education and information programs as an adjunct and an alternative to legislative restraint. An educated public can help achieve a quieter tomorrow. □

Martha Pennino is Vice Chairman of the Fairfax County, Va., Board of Supervisors and President of the Metropolitan Washington Council of Governments.

Volunteers Against Noise

EPA scientists record sound levels along highways and in other areas as part of research into the effects of noise.

The major part of the struggle for a quieter society is carried on by private citizens working through voluntary local organizations. While EPA's Office of Noise Abatement and Control plays an essential role in coordinating noise control efforts nationwide and providing technical support and advice to local communities, the success of any local noise control program depends on the support of that community's citizens. Indeed, if it were not for the vigorous efforts of local volunteer groups, most local noise control programs would not exist.

EPA's efforts to reduce noise pollution involve giving support to local communities to help them develop and enforce their own noise control efforts. One aspect of this is the ECHO program (Each Community Helps Others), in which EPA reimburses out-of-pocket expenses to enable experienced local noise control officials to travel to other communities to provide advice and assistance in developing an effective, enforceable noise control program. The "local" orientation of these experts is important, because a thorough familiarity with the workings of local government units is essential to develop effective local noise control efforts.

In authorizing EPA's noise activities, Congress recognized that excessive noise is essentially a local problem demanding local solutions. Every community is unique and requires a noise control program tailored to its specific needs. No one is better qualified to determine what those needs are than residents of the community, and no one is in a better position to see that things "get done."

Noise in Paradise

Getting things done can require some "informed nagging," according to Joan Hayes, president of Citizens Against Noise, a voluntary citizens' group with over 1,200 members in Honolulu, Hawaii. Hayes has led the campaign against noise in Hawaii since 1970 when a "screeching" air-conditioner unit near her apartment proved beyond the power of the local government to handle. There was a city noise code but no enforcement, a common condition. Put off by the bureaucracy, Hayes slipped notices under the doors of neighbors saying "Let's start a Citizen's Campaign Against Noise (CAN)." Within 10 days, 70 people had contributed a dollar each and CAN began. Since that time, CAN has worked steadily to raise the community's concern about noise, promote legal action against chronic offenders, and carry out public education programs about noise. In the past 10 years, CAN has:

- Pioneered a noise education program in the Oahu school system, which one principal called "one of the most successful innovations" he had seen at his school
- Brought a San Francisco Police Community Noise Control Officer to Honolulu to show city and State officials how to handle noise problems
- Placed noise awareness posters on buses and in schools and libraries
- Distributed radio public service announcements about noise
- Purchased noise films which CAN loans to interested parties
- Purchased sound level meters which CAN loans to private citizens for testing noise levels
- Achieved extensive newspaper coverage for noise control activities

"Our experience suggests more than volume motivates people," Hayes said. "Another is awareness of what noise really does to people. Third is disappointment with enforcement." Hayes added that the best thing that can happen for noise control is for enough people to become concerned, thereby creating a voting constituency for noise control that elected officials will respond to.

Mobilizing Older Americans

The Hawaii group is the largest of its kind in the country. However, a nationwide volunteer effort for noise control being developed by the American Association of Retired Persons may eventually outstrip it.

The Association is a non-partisan association of older Americans with approximately 12 million members and more than 3,000 local chapters. Membership is open to people over the age of 55, though associate memberships are available to those over 45. It has been involved in environmental issues for years through the Senior Community Service Employment Program in which older citizens receive training and are placed in community service jobs with various government agencies and non-profit organizations.

The Association is currently managing a Noise Counselors Program, an outgrowth of its general environmental effort, in which senior citizens receive training in noise control and are then assigned to work in their local communities. Currently, there are about 20 Noise Counselors.

Of the Noise Counselors now at work, some receive part-time compensation with funding provided by the Department of Labor under the Older Americans Act. The remainder are volunteers. EPA provides technical equipment and educational materials for the Noise Counselors.

The Association plans to use the experience gained in this "pilot program" to determine exactly how much training and technical support is necessary to enable the Noise Counselors to be effective in dealing with noise issues. Once this evaluation is complete, it anticipates developing a complete training package for use as a national program activity, setting up noise control committees in many of its 3,000 chapters, and providing necessary assistance and support so that each chapter can contribute to the development of effective local noise control programs. While some of the current Noise Counselors receive part-time compensation, the Association plans to develop a completely volunteer program mobilizing thousands of members.

According to the Association's Sandra Sweeney, experience gained so far indicates that older citizens can be especially effective in dealing with noise problems. They need some encouragement and direction to get started, she said, but once started, they "go like mad." The Noise Counselors handle a tremendous volume of noise complaints. They seem to have an advantage over younger people, Sweeney said, especially in the resolution of noise complaints that require negotiation in potential adversary situations. The Noise Counselors are more readily accepted, especially by business operators, and the result is usually an amicable settlement of the noise problem. If the Association's plans are successful, within a few years there should be a tremendous increase in the number of local noise control programs spearheaded by a group of volunteer Noise Counselors.

The National Urban League embarked on a similar program in July of this year. This initiative, targeted toward inner-city residents, will address the noise problems associated with urban environments.

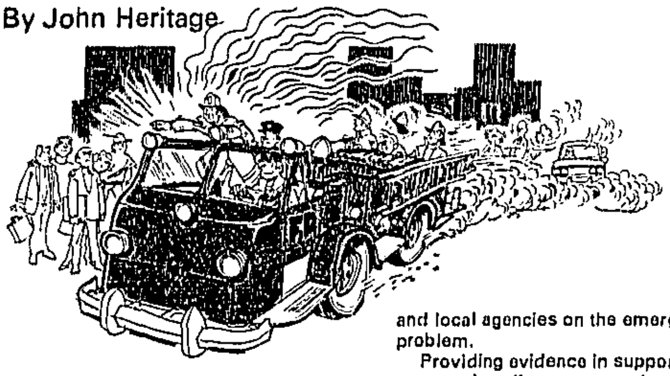
A National Coalition

A national coalition of volunteer citizens' organizations concerned with noise issues, the National Alliance for Quieter Communities, has just been formed. According to Frank Sordyl, treasurer, more than 30 organizations across the country have been contacted, and virtually all of them expressed enthusiasm for the concept of a national coalition, and willingness to participate in its development.

As presently envisioned, the alliance will play a vital role in assisting and supporting efforts of volunteer groups to deal with noise problems. □

Sirens

By John Heritage



"There's the road noise—the tires screeching. There's the sirens and the air horn. It's all quite devastating." —a description of a firetruck ride by Vincent Riccordella, fireman with Ladder 81 of the New York City Fire Department.

"Over the past 20 years, it's been one of the most profoundly pervasive noise abatement problems that we have—the virtually endless proliferation of emergency warning signals," says Dr. Thomas H. Fay, an audiologist who has advised the New York City Fire and Police Departments and is a member of the Council on the Environment of New York City .

"It's been enormously hazardous to the hearing of the men that have to ride on these vehicles," says Dr. Fay. "The general public is simply tortured by all this, particularly those that live near the medical centers."

Fay's view is supported by Joan Hayes, Chairperson of the Board of Citizens Against Noise, a nationally-concerned public interest group. Noise control is a jigsaw puzzle and the siren piece is an important part of the whole picture, she says.

Fireman Riccordella describes the effects from his own personal experience. He starts his workday "pretty relaxed." Then, as the number of trips on the fire engine builds, he describes it this way: "I get a little hyper. We have to talk louder to hear. The TV goes up. After upwards of 40 to 45 runs, we've got to talk up to each other. Our tolerance for noise decreases. Our sleep is interrupted."

"Noise makes you sick in many, many ways," Riccordella comments. As a result of this, he was instrumental in setting up a meeting in February, 1978, with New York City labor groups and Federal, State, and local agencies on the emergency noise problem.

Providing evidence in support of adverse noise effects, a recently published study by three University of California researchers found that firefighters appear to suffer greater hearing loss than the general population.

Such research has convinced Howard McClennan, president of the International Association of Firefighters, that siren noise is a problem, and he is now bringing the issue up during meetings with the Occupational Safety and Health Administration.

Sirens affect everyone, adds Norman Waitzman, author of "Siren City USA," a report for Ralph Nader's Public Interest Research Group of Washington, D.C., on sirens in the Nation's Capital. "I can't even sit down and read this report without some siren blaring outside," he says.

Advocates of stiffer controls on emergency warning noise see several possible steps.

As one measure, Waitzman believes 50 percent of ambulance noise could be eliminated. A siren can be shielded, he says, making it more precise and effective and reducing the noise for the hundreds of thousands of people who hear it.

In most cases flashing lights are adequate, says Hayes, who believes there should be a maximum decibel limit for sirens as well as the minimums that are often set.

Ear muffs help for firemen, says fireman Riccordella.

There could be a different kind of warning system, says New York audiologist Fay. He suggests a radio signal with receivers on all vehicles.

Limits could be set on the use of sirens depending on how serious the call, Waitzman says. Sirens could be prohibited between 11 p.m. and 7 a.m., according to a 1976 recommendation of a Washington, D.C., health and environment advisory committee.

While there may be steps that can be taken to reduce emergency warning noise, how to implement them is another concern.

Putting solutions into effect is a local matter, says Hayes of Citizens Against Noise. "But I think suggesting to a local community how it can be done effectively could be a very appropriate national undertaking.

"A Federal organization could do some testing easily and see what makes sense and put out a simple, easy to understand flyer," Hayes explains.

But there is another side in the emergency warning noise issue. Some don't believe the noise is a problem needing tighter controls. Even louder signals may be justified, they add.

In fact, emergency warning signals are actually getting noisier, not quieter. This trend is acknowledged by Harry Foster, northeast region district manager of Federal Signal Corporation, one of the biggest siren makers in the country.

Louder equipment is necessary, he says, because automakers are making their cars tighter and tighter to keep out noise and provide a seal for air conditioning.

Siren noise isn't a problem, Foster continues. "The easiest and best way to give the alert is the siren and the air horn. They save many millions of dollars a year and many lives."

Louder signals aren't justified, counter those concerned about emergency warning noise. The continuing push for more volume is due to tradition and economic interest, they argue.

"Noise is a vastly overused tool," says Hayes of the citizens group. "I think it's an old fashioned solution, one that does more harm than good."

Foster of the Federal Signal Corp. denies that his company encourages louder signals to make a dollar. "The marketplace has asked for it. Fire, police, and other emergency departments have said that people don't see or hear. So they've asked for better light and sound, both of which we have responded to."

Several observers agree that many emergency departments favor louder warning equipment, because they may feel that the more noise they make, the more people will get out of the way.

If trends and old attitudes are going to be changed, two key problems need to be solved, several of those concerned about emergency warning noise say.

First, says fireman Riccordella, there isn't enough education on the problem and the answers. Second, says audiologist Fay, basic auditory principles haven't been applied when left up to industry itself, and when restrictions have been imposed, those principles have only been used within certain limits. □

John Heritage is an Assistant Editor of EPA Journal.

The Hummer's Voyage

Hundreds of tiny and remarkable ruby-throated hummingbirds often fly at this time of year across the Gulf of Mexico to their winter homes in Latin America.

They are carried on this remarkable flight by wings beating at a furious rate of 60 strokes a second or better. The wings move so rapidly that they are seen only as a blur and the thrumming sound of their motion gives the bird its nickname of "hummer."

The ruby-throated hummingbird, the only species of this type of bird that nests east of the Mississippi River, sometimes migrates as much as 2,000 miles from its breeding site to winter quarters.

Some of these tiny creatures starting their migratory flights are being caught in almost invisible mist nets erected in the Dolly Sods area of the Monongahela National Forest on the Allegheny Front, some 200 miles west of Washington. The Brooks Bird Club members who tend these nets as part of a bird banding operation always swiftly release the fragile hummingbirds so they can resume their journey without injury.

These birds have proportionately immense wing muscles and, for their size, the hummers outperform any other warm-blooded animals. Their daily intake of sugar, a principal food, may amount to half the bird's weight. These creatures take food 50 to 60 times a day and use their tubular tongues to suck up nectar from flowers such as gladioli.

They also frequently visit glass feeders hung by bird lovers for free sugar water often colored red with a food

dye to help attract their attention. Thousands of these birds summer on the East Coast and many visit feeders in the Washington area.

When two or more hummingbirds gather at a feeder, they often engage in mock aerial combat, darting at each other at speeds of up to 30 miles an hour. However, they never seem to actually make physical contact, contenting themselves with playing an aerial game of "chicken."

In order to sip sugar water from feeders, they hover in the air in one position until their hunger has been sated. The hummingbird must be refueled every 10 to 15 minutes. Scientists have found that in order to save energy these birds will sometimes pass into a state of torpor at night instead of sleeping. In this condition, the bird's body temperature drops and its energy output sinks to only one-twentieth that of normal sleep.

For a tiny creature weighing only about one-tenth of an ounce, the hummingbird shows a remarkable lack of fear of people. It will often fly or perch within 15 or 20 feet of humans and, in some cases, these birds have been induced to take sugar water from hand-held feeders and to alight on a finger. This may reflect their confidence in their ability to make a quick escape if they see danger.

Yet the hummers are wary of the bees that often find the sugar water dispensers appealing and cling to the feeder tip. Since hummers frequently refuse to visit when a bee is at the sugar water, some feeders come equipped with "bee guards" which permit only the stiletto-like beak of this bird to gain access to the fluid.

The ruby-throat is only one of more than 300 species of hummingbirds. The family includes the smallest bird in the world, the 2¼-inch Cuban "bee."

Until the discovery of America, no European had ever seen a hummingbird. All members of this family are found in the western hemisphere only.

Most of the 300 types are tropical. Like many beautiful birds, they often were slaughtered for their feathers. Before such commerce was outlawed, a total of 40,000 skins reportedly were sold to a London firm in one year.

In courtship, the male ruby throat puts on an aerial circus as he dives in front of his future mate. The male's resplendent red throat consists of iridescent feathers, which glow with astonishing intensity when struck by sunlight. The female perches on a branch, her head turning from side to side as she watches the display.

The nests are walnut size and are tied to a branch with spider silk woven by the needle-like bill of the female. Two pea-sized white eggs are laid in the nests, which have been camouflaged with lichen and are often lined with thistle down. The mother bird feeds newly hatched young by thrusting regurgitated food into the gaping mouths with her long bill.

Although hummingbirds are relatively safe from non-human predators, there have been reports of bass, frogs, and hawks occasionally swallowing them. A more significant cause of death for hummingbirds is the unexpected storms they sometimes encounter while migrating over the Gulf of Mexico.

Workers stationed on off-shore oil rigs and sailors on vessels in the Gulf occasionally report the arrival of large numbers of starving and exhausted small birds such as hummers and warblers.

Like all living creatures they are vulnerable to an environment that can sometimes be unpredictable and lethal.—C.D.P.

Cooperating With Germany on the Environment

By David H. Strother

Administrator Douglas M. Costle will greet an old friend of EPA this month when his counterpart in the Federal Republic of Germany, State Secretary Guenter Hartkopf, arrives in Washington.

Dr. Hartkopf is attending a meeting of NATO's Committee on the Challenges of Modern Society, which is rounding out its tenth year. CCMS was initiated in 1969 by the United States in cooperation with the other 14 NATO member countries to seek solutions of pressing environmental problems. Costle is scheduled to address the CCMS meeting.

Dr. Hartkopf last year presented Costle with the special German Environmental pin, only the second foreigner ever to receive this symbolic award, as a measure of the cooperation between the two countries in environmental matters.

The United States and the Federal Republic of Germany as two of the most advanced industrialized nations share many environmental problems. In recognition of this, Dr. Hartkopf represented his country five years ago in signing an "Agreement between the Government of the United States of America and the Government of the Federal Republic of Germany on Cooperation in Environmental Affairs."

Today the two countries are not only jointly pursuing several projects under the Agreement but also are working together in environmental programs under the auspices of the Organization for Economic Cooperation and Development (OECD) and the CCMS.

The most active and productive project under the U.S.-German agreement deals with emission control technology for energy processes. Five subprojects under way in this category are flue gas desulfurization, utilization of products from this desulfurization, control of nitrogen oxide, of particulates, and other control technologies.

Both countries are faced with increasing demand for the use of easily accessible supplies of coal which is relatively high in sulfur content. EPA and the German Ministry of Interior and Ministry of Research and Technology are carrying out ambitious programs to control pollution from this source in order to help their countries use domestic supplies of coal effectively.

In another area, EPA is now in the process of providing a grant for an evaluation of the Andco-Torrax pyrolysis process to convert solid waste to useful resources. The facility, located in Frankfurt, makes use of high temperature in a vertical shaft furnace to convert municipal refuse into a burnable fuel gas. The noncombustible materials are converted to a glassy aggregate which may be used by industry. The $100,000 investment by EPA will provide valuable technical information which is otherwise unobtainable since there are no identical facilities in the U.S. Test results will be available to both countries.

Another project involves the exchange of information by the two countries on successful enforcement of environmental laws. The German legal decisions on the feasibility of existing technology for control of emissions from coke ovens and casting houses, for example, already have been useful to EPA. The comparison of monitoring and enforcement philosophies and practices helps to identify both strong and weak aspects of each country's approach.

Each time a new pollutant is identified as hazardous, one of the major problems facing scientists is the lack of information about the pollutant prior to the time that they began focusing attention on it. Existing specimen banks of pollutants don't always help because the new chemical compounds often are subtle, and their existence may be masked by preservatives used in storage of tissues and other specimens in these banks.

To solve this problem, EPA in cooperation with the National Bureau of Standards and the German Federal Environmental Agency has undertaken to create a specimen bank to identify samples which will be of the greatest potential use, and then devise a foolproof method of storing them where they are unaffected by preservatives.

EPA and its German counterpart maintain close contact in order to harmonize their positions on toxic substance regulation and to address problems not covered by international organizations. Last May Steven D. Jellinek, Assistant Administrator for Toxic Substances, met with his counterparts in Bonn and Berlin to study the question. As a result, it is now likely the U.S. inventory of existing commercial chemicals will be adopted as the *de facto* international inventory, with great savings for international trade in these products.

A key aspect of an effective environmental program is the availability and exchange of pertinent information. The importance of this was recognized in a memorandum of understanding signed by Administrator Costle and Dr. Hartkopf last May. Policies and practices for establishing and maintaining useful data systems are now under constant review by the two countries' environmental agencies.

A problem linked with industrial growth is air quality planning and maintenance. As a U.S.-German project this has been focused on new source siting. Other common concerns such as long range transport measurement and control of pollutants are being addressed by the OECD and the Economic Commission for Europe.

Although not the subject of a formal project, both auto emissions including diesel fumes and problems in radiation also are being jointly studied by the two agencies. □

David Strother is the European Program Manager in EPA's Office of International Activities. Edward Olson and Jeffrey Gallup of the Department of State also contributed to this article.

Helping Preserve Greek Temples

It was a celebrated 19th century German, Heinrich Schliemann, who investigated the origins of Greek civilization and in the process put classical archaeology on a more scientific basis.

Today the Federal Republic of Germany is playing a new environmental role in helping to preserve ancient Greek architectural works and statues. It is one of the leaders in a new pilot study by NATO's Committee on the Challenges of Modern Society on the conservation and restoration of monuments. The project seeks to combat deterioration of such classical treasures as Greek temples, along with medieval cathedrals elsewhere, from the ravages of 20th century air pollution.

This and numerous other environmental problems will be the subject of a CCMS conference at the State Department in Washington, D.C. October 22-24. Of its 14 pilot studies, West Germany leads two, on air pollution assessment methodology and modeling, and hazardous waste disposal, and is an active participant on half a dozen others.

In addition to being "co-pilot," in the Committee's phrase, of the study of monuments, West Germany also plays the same role in projects on flue gas desulfurization and drinking water.

News Briefs

Gas Mileage

The EPA recently released gasoline mileage figures for 1980 cars and trucks. The ten cars with the best mileage ratings were four Volkswagens, two Japanese Hondas, and four Chrysler cars made in Japan. EPA expects all of the major manufacturers to meet or exceed the 1980 corporate average fuel economy standard of 20 mpg for passenger cars. Under the Energy Policy and Conservation Act, manufacturers must increase the efficiency of their passenger car fleets each year until they meet the final fleet average of 27.5 mpg in 1985. For the 1980 cars tested through August 29, 1979, the top ten miles per gallon ratings are:

Estimated MPG	Manufacturer	Car Line	Engine*
42	Volkswagen	Rabbit (Diesel)	90 CID**
40	Volkswagen	Rabbit (Diesel)	90 CID
37	Dodge	Colt	86 CID
37	Plymouth	Champ	86 CID
36	Honda	Civic	91 CID**
36	Volkswagen	Dasher (Diesel)	90 CID
36	Volkswagen	Dasher Wagon (Diesel)	90 CID
35	Dodge	Colt	86 CID***
35	Honda	Civic	91 CID
35	Plymouth	Champ	86 CID***

*Cubic-inch-displacement **5 speed manual transmission
***Dual range manual 4 speed transmission.

Joan Z. Bernstein

EPA General Counsel Joan Z. Bernstein has decided to accept the General Counsel position at the Department of Health, Education, and Welfare. Ms. Bernstein has served at EPA since July 1977, and also was briefly Acting Assistant Administrator for Enforcement.

States Served by EPA Regions

Region 1 (Boston)
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
617-223-7210

Region 2 (New York City)
New Jersey, New York, Puerto Rico, Virgin Islands
212-264-2525

Region 3 (Philadelphia)
Delaware, Maryland, Pennsylvania, Virginia, West Virginia, District of Columbia
215-597-9814

Region 4 (Atlanta)
Alabama, Georgia, Florida, Mississippi, North Carolina, South Carolina, Tennessee, Kentucky
404-881-4727

Region 5 (Chicago)
Illinois, Indiana, Ohio, Michigan, Wisconsin, Minnesota
312-353-2000

Region 6 (Dallas)
Arkansas, Louisiana, Oklahoma, Texas, New Mexico
214-767-2600

Region 7 (Kansas City)
Iowa, Kansas, Missouri, Nebraska
816-374-5493

Region 8 (Denver)
Colorado, Utah, Wyoming, Montana, North Dakota, South Dakota
303-837-3895

Region 9 (San Francisco)
Arizona, California, Nevada, Hawaii
415-556-2320

Region 10 (Seattle)
Alaska, Idaho, Oregon, Washington
206-442-1220

Around the Nation

Region 1

Grants Awarded

EPA's Boston office has awarded a total of $519,700 for studies of the effects of urban runoff on three New England waterways. The Massachusetts Department of Environmental Quality Engineering will receive $334,200 to study the Mystic River and $110,500 to study Lake Quinsigamond in Worcester, Mass. The Mystic River project will assess the impact of urban runoff on a highly urbanized stream and lake. The Lake Quinsigamond project will look at what contribution runoff makes to the eutrophication of the lake, in conjunction with a study funded through the Clean Lakes program. Region 1 also has given the New Hampshire Water Supply and Pollution Control Commission $75,000 for a project on the Oyster River in Durham to find cost-effective runoff controls, which can be applied to a statewide program of permits.

US/USSR Water Symposium

Region 1 recently held a symposium on "River Basin Water Quality Planning and Management" for 200 American and Russian scientists in Cambridge, Mass. The meeting revolved around the water protection planning techniques of both countries with emphasis on technological, regulatory, and institutional constraints. The American scientists prepared a river basin water protection plan for a segment of the Severski-Donet River in the Ukraine Republic, applying U.S. laws, regulations, and technologies. The Soviet scientists prepared a similar water plan for a segment of the Connecticut River in Massachusetts, based on Soviet constraints and planning approaches. The Russians discussed some of their treatment technologies and pollution abatement procedures, which are not used in this country. Research and design of water pollution control systems in the USSR is the responsibility of the All-Union Scientific Research Institute for Water Protection, an equivalent of EPA, which sent researchers to the symposium.

Region 2

Sludge Dumping Cut

Nine municipalities in Region 2 plan to stop dumping their sewage sludge into the ocean during the next year. Sewage sludge from the ten treatment plants involved, some 95,000 wet tons, will not go into the waters off New York and New Jersey as in the past. The communities are using environmentally acceptable alternatives for sludge disposal. In Lincoln Park, N.J. the Two Bridges sewage authority has completed an incinerator. The Modern Transportation Company's facility in Kearny, N.J. has completed a sludge/septic tank waste treatment plant. Other municipalities involved, all in New Jersey, are Atlantic Highland, Cedar Grove, Pequannock Township, West Paterson, Totowa, Washington Township, West New York, and Wanaque.

Burn Permit Stalled

EPA's New York office will not issue a permit to Rollins Environmental Services, Inc. for incineration of wastes containing polychlorinated biphenyls (PCB's) at its waste disposal facility at the present time. The company must have the permit before it can handle PCB wastes. Speaking to local officials in Logan Township, N.J., where the facility is located, Region 2 Administrator Chris Beck said, "I do not intend to issue a PCB permit to Rollins until all the environmental questions have been thoroughly assessed to my satisfaction, and the company's problems with meeting its current operating conditions have been corrected." Beck added that there will be no test burning of PCB's at the Rollins site until EPA is satisfied that the company can operate its incinerator properly.

Region 3

Reclamation Project Initiated

Builders broke ground recently for an EPA-supported resource recovery system in New Castle County, Del. The system, called the Delaware Reclamation Project, will convert solid waste and sewage sludge into energy and marketable products. EPA's Office of Solid Waste Management is contributing an $8.25 million demonstration grant toward the construction. Region 3 will add approximately $21.5 million from the Agency's grants program for construction of municipal sewage treatment facilities. The remainder of the more than $60 million cost will come from State and local funds. The project will handle all of the county's recyclable solid waste, some 1,000 tons per day. It also will process 250 tons per day of sewage sludge from Wilmington's treatment plant, which handles most of the county's sewage. The resource recovery system will separate combustible materials from the waste stream, to burn in a nearby commercial power plant for electricity production. The remaining waste will be separated into marketable metals and glass, which will be sold. Any solid waste left after this step will be mixed with the sludge, composted in closed digesters, and processed into a high-grade humus material that can be used as a soil conditioner or a light burning fuel. The project is expected to ease the pressure on New Castle County's dwindling landfill capacity and result in near-complete recycling of municipal wastes.

Region 4

Florida Fish Kill

A major fish kill occurred in the Hillsborough River in Tampa, Fla., after large quantities of untreated sewage from the city were dumped into the sewer. The decomposing sewage depleted oxygen in the river below the level needed by the fish. Officials blamed heavy summer rains for overloading the main north-south sewage line, which is already in bad repair. Federal funds for improving the sewage system were approved in late 1977 but equipment shortages have caused a delay in delivery for construction. During the summer, bacteria counts reached 115 times the maximum level allowed by the State. County officials posted warning signs along the banks of the river, due to their concern about the threat of disease to people drinking or touching river water. During the week just before the fish kill as many as two to three million gallons of raw sewage a day were overflowing the system into the river.

Clean Air Program Promoted

Region 4 Public Awareness Branch has completed a slide/cassette show on the Clean Air Act. The 22-minute program outlines important provisions of the law and shows the contrast between scenic beauty and pollution-filled skies in the Southeast. The program shows the impact of pollution control on stationary source emissions. It also describes the health effects of air pollution. Copies of the slide presentation have been furnished to EPA-funded local and State air agencies throughout the Region.

Region 5

Noise Ordinance Enforced

EPA's Chicago office has developed a noise control ordinance that is being enforced by police officers in several Midwestern cities. The policemen tell Region 5 Noise chief Horst Witschonke that they like the ordinance because it can be integrated quickly with radar speed checking. They report that rather than diverting personnel to direct noise control enforcement, police forces can continue to perform their regular duties and enforce noise control ordinances as the need arises. Witschonke and the Region 5 noise staff have built up an inventory of sound-measuring equipment for vehicle noise control, which they lend to local police departments on a trial basis. One officer told EPA personnel that because the equipment is unusual the noise monitoring has more impact than radar equipment on slowing down speeders. The Chicago Regional Office also offers a noise control sign, which can be used to notify residents that a local noise control ordinance is in effect.

REGION 6

Oil Spill Response

Region 6 personnel joined other Federal and State agencies in a massive effort to ease the impact of oil on the Texas Gulf Coast from the runaway Mexican oil well in the Bay of Campeche. The Coast Guard is On-Scene Coordinator, with the Dallas Regional Response Team and the EPA National Response Team active. Contingency funds have been made available for the containment and cleanup effort. EPA provided staffing for the Regional News Office set up in Corpus Christi, Texas, to answer media inquiries from around the world. The Agency sent its new research vessel, the Antelope, to help track the oil slick. The ship will locate and protect environmentally sensitive areas, and determine the condition of oil that hits the coast. Beneficial winds and currents helped keep much of the oil offshore. But oil is known to be mixed with water as deep as 40 feet below the surface. Scientists fear that much ecological damage may be done to the Gulf even if the coast is spared. The first oil blobs reached the Texas coast two months after the blowout occurred, and experts feel that the threat will continue for a similar period after the well is capped.

REGION 7

Inspection and Maintenance Discussed

The Kansas City, Kan., police cars were among the vehicles tested when EPA Region 7 brought the Inspection and Maintenance emission van to town. The Agency provided this service in conjunction with a public meeting being held by the Kansas Special Legislative Committee on Air Quality and Pollution Control. The Committe sought public views on proposed legislative amendments to State air quality laws. One bill under consideration provides for a mandatory inspection and maintenance program for vehicles in areas that do not meet Federal air quality standards. EPA staff at the testing van answered questions about air pollution and gave free emissions inspections. Despite very hot weather interest was high. More than 100 cars took the test and over half of them passed.

REGION 8

Oil Shale Permit Set

EPA's Denver office approved a crucial air pollution permit for Colony Development Operation, a joint venture of Atlantic Richfield Co. and Tosco Corporation, which plans an oil shale development on Colorado's Western Slope. The proposed facility will mine and process 66,000 tons per day of oil shale and will produce nearly 15 million barrels of oil, more than a million barrels of liquid propane, and more than 50,000 tons of ammonia and sulfur each year. The "prevention of significant deterioration" permit contains air pollution limits far more stringent than the national standards, as is required when air quality in an area is cleaner than national standards. The permit process is designed to protect pristine air in places like the energy-rich West. Several environmental organizations were involved in the permit review process. According to Kevin Markey of Friends of the Earth, which was involved in the process, the EPA review was "hard-hitting and well done." He added "Informed public participation can help produce approvable permits."

REGION 9

Radiation Support

Region 9 provided technical assistance and support in the case of an application to the Arizona Atomic Energy Commission by the American Atomics Corporation for termination of its license to handle radioactive materials. The San Francisco Regional Office coordinated the participation of technical staff from EPA's Office of Radiation Programs and the Office of Research and Development. Agency scientists found tritium in samples of food, water, and urine collected in Tucson and analyzed at the Nevada lab. American Atomics Corporation produced tritium-filled tubes used to illuminate watch dials and exit signs, and the company had been emitting unacceptably high levels of radioactive tritium gas. The State Atomic Energy Commission has accepted the company's application for termination of its license pending agreement to certain conditions, which include the closure and decontamination of the Tucson manufacturing plant. Dr. Al Moghissi of EPA's R&D program testified in hearings that, while individual exposure would probably be low, the plant had emitted more tritium in one year than all 72 nuclear power plants in the U.S. American Atomics Corporation is currently negotiating the relocation of its operations to an unpopulated area of southern Nevada.

Water Pollution Seminar

The San Francisco office recently hosted a seminar for U.S. attorneys, State attorneys general, and FBI personnel from Regions 8, 9, and 10 to create an awareness and understanding of the Water Pollution Control Act. The increased knowledgeability will help EPA to better cooperate with these law enforcement agencies to fight fraud and abuse in the construction grants program. Several hundred law enforcement officials from 15 Western States attended the seminar.

REGION 10

Fuel Switching Penalties

Region 10 has proposed penalties totalling more than half a million dollars in response to charges by the Agency Enforcement Division that 114 motor vehicles were illegally fueled with leaded gas. The vehicles were operated by the Loomis Courier Service, Inc. and Gelco Courier Service Inc. EPA alleges that the vehicles, designed for unleaded fuel, were supplied with leaded gasoline in Seattle and Portland from pumps that were equipped with nozzles made for use only on pumps that contain unleaded gasoline. Region 10 proposed penalties of $245,200 against Loomis and $297,700 against Gelco.

Drinking Water Advisory

EPA's Seattle office found excessive levels of bacteria in water supplies of two Oregon communities, Cove and Haines, and advised residents to boil their water before drinking it. The Agency made the discovery during spot checks of water supplies in 13 communities. EPA's frequent spot checks are designed to augment the monitoring and reporting performed by water system operators throughout Oregon, which has not yet assumed enforcement responsibility for the Safe Drinking Water Act of 1974. □

Opportunities in the Quiet Communities Act

Continued from page 6

tions, was the guide for the Quiet Communities Act. The Act enhances this effort by authorizing:

- grants to States, local governments, and regional authorities for identifying noise problems, developing abatement plans, and evaluating control techniques.
- loan of equipment to State and local governments and:
- studies to determine the needs of State and local governments for noise control.

Second, *Each Community Helps Others* (ECHO) enables communities to obtain assistance from other communities which are already dealing effectively with noise problems. Local officials from communities with successful noise control programs volunteer to assist other areas requesting technical help.

Two examples of local initiatives assisted by the ECHO program are Des Moines and Council Bluffs, Iowa. Both of these cities received help through ECHO from noise officials in Lincoln, Neb., and Des Moines is now preparing to aid other Midwestern communities in establishing local noise abatement strategies.

Ultimately, noise can only be controlled by having a strong constituency willing to devote time and effort to local programs. The Quiet Communities Act offers many opportunities for communities to receive technical and material assistance from EPA for their own initiatives. EPA is marshalling the efforts of volunteers dedicated to enhance this country's quality of life.

The Senate intends to maintain close oversight responsibility in this environmental area to guarantee that the Quiet Communities Act is implemented according to the desires of Congress. I hope that our noise abatement programs will not be given a low priority in the budgeting process now that research is beginning to show that excessive noise has adverse implications for our health. The noise programs, especially those assisting communities, are already understaffed, and budget cuts could leave them unable to function effectively.

Nevertheless, I am optimistic about the future. Noise has been a neglected environmental concern both in research and control programs. The Quiet Communities Act and further health research, however, are helping to make the public aware of the need to control the Nation's growing noise problems, and to provide communities with the tools to fight local noise problems. □

Implementing the Act

EPA's Noise Program recently began funding cooperative agreements to State, city, and local entities to implement the provisions of the Quiet Communities Act.

State Cooperative Agreement Awards		
California	California Department of Health Services	$28 000
Colorado	Department of Health	$27,990
Connecticut	Department of Environmental Protection	$35,644
Delaware	Department of Natural Resources and Environmental Control	$25,000
Florida	Department of Environmental Regulation	$45,000
District of Columbia	Metropolitan Washington Council of Governments	$42,750
Minnesota	League of Minnesota Cities	$38,000
Nebraska	Department of Environmental Control	$26,473
New Hampshire	Bureau of Occupational Health	$25,000
New Jersey	Department of Environmental Protection	$35,109
New Mexico	Health and Environmental Department	$17,000
North Dakota	Department of Health	$28,008
Ohio	Ohio Department of Health	$27,293
Oregon	Department of Environmental Quality	$28,414
Utah	Department of Social Services	$25,000
Washington	Department of Ecology	$30,000
Local Cooperative Agreement Awards		
Brookline/Newton, Massachusetts	Brookline Conservation Commission	$12,000
Stamford, Connecticut	Health Department	$12,170
Teaneck, New Jersey	Teaneck Health Department	$14,250
York, Pennsylvania	Office of the Mayor	$9,279
Kingsport, Tennessee	City of Kingsport	$9,500
Mentor, Ohio	City of Mentor	$2,200
Akron, Ohio	City of Akron Health Department	$12,000
Norman, Oklahoma	City Manager's Office	$12,000
St. Louis County, Missouri	Department of Community Health and Medical Care	$10,000
National City, California	Planning Department	$12,000
Boise, Idaho	Department of Community Development	$14,172
Thornton, Colorado	City of Thornton	$7,800
Demonstration Cooperative Agreements		
New Orleans, Louisiana	Office of the Mayor	$49,774
Des Moines, Iowa	Building Inspection Department	$28,297
Massachusetts	Massachusetts Port Authority	$31,610
National Association of Neighborhoods	Washington, D.C. 20009	$35,474
Portland, Oregon	City of Portland	$11,414
National Institute of Governmental Purchasing	Washington, D.C. 20036	$60,000
State of New Jersey	Department of Environmental Protection	$34,440
State of Oregon	Department of Environmental Quality	$33,978
City of Chicago	City of Chicago	$24,035
Delaware Valley Regional Planning Commission	Philadelphia, Pennsylvania	$130,000
Regional Noise Technical Assistance Centers		
Region 1	University of Hartford Hartford, Connecticut 06117	$90,000
Region 2	Rutgers University New Brunswick, New Jersey 08902	$90,000
Region 3	University of Maryland College Park, Maryland 20742	$90,000
Region 4	North Carolina State University Raleigh, North Carolina 27650	$90,000
Region 5	Illinois Institute of Technology Research Institute Chicago, Illinois 60616	$90,000
Region 6	University of Texas at Dallas Richardson, Texas 75080	$90,000
Region 7	University of Iowa Iowa City, Iowa 52242	$90,000
Region 8	University of Colorado Boulder, Colorado 80309	$90,000
Region 9	University of California at Berkeley Berkeley, California 94720	$90,000
Region 10	University of Washington Seattle, Washington 98195	$90,000

Aircraft Noise: An Abatement Priority *Continued from page 7*

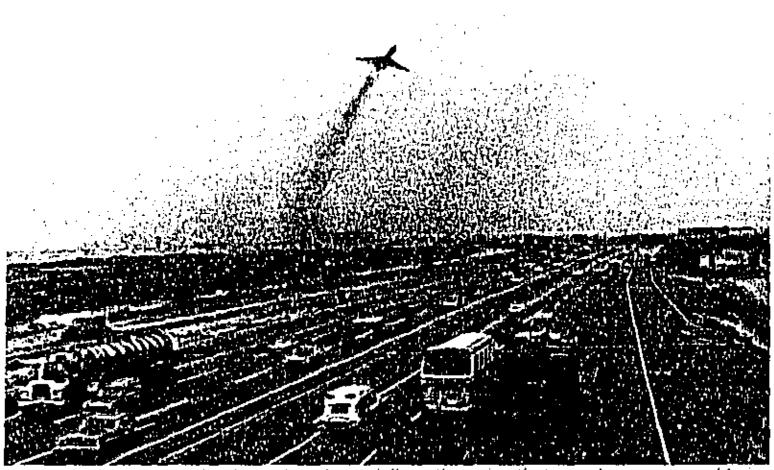
would do well to carefully reconsider the benefits of dismantling existing Federal authority in this area.

The National Noise Abatement Effort

Of course, aircraft are not the only source of noise in our environment. The Noise Control Act authorizes the EPA to identify and control other major sources of environmental noise as well. However, aircraft noise does affect a substantial portion of our population as represented by increasingly well-organized citizen groups protesting such noise.

More important, however, is that the aircraft noise issue represents the symbolic battle between interest groups pitted against one another in the legislative arena. Some parts of the commercial aviation industry continue to stall efforts to comply with existing regulations in the hopes that the authorizing laws will be adjusted in their favor. Other members of the airline industry have already complied, or intend to comply with noise regulations, in the expectation that regulations will be enforced. At the same time, community groups have mounted increasing pressure on lawmakers to preserve, at the very least, if not strengthen laws that have been held up to them as the source of relief from ever present aircraft noise.

It is crucial that the existing authority to reduce aircraft noise, as well as other sources of environmental noise, be upheld and fulfilled as Congress intended in the passage of the Noise Control Act. □



Aircraft on takeoff and landing add substantially to the noise that people are exposed to in many urban areas.

Quiet—A National Resource *Continued from page 5*

Washington Monument that conversation can be all but impossible.

There is also concern for the continuing architectural integrity of the monuments we have built to honor our country's leaders. The possibility of accelerated structural deterioration due to noise-induced vibrations has not been sufficiently investigated, but is a matter of major concern.

When the Federal Aviation Administration last year issued a Draft Environmental Impact Statement on proposed policies for the future of National Airport, we recommended that the plan include development of all possible measures to minimize harm from aircraft noise. These should include the enforcement of strict flight regulations to reduce noise: site specific means to reduce noise impacts inside national monuments and memorials, and provision of an adequate mechanism to handle public complaints about aircraft noise.

While the public has for the most part tolerated the existing noise levels as an inevitable nuisance, I disagree with the premise that these noise levels should be allowed to continue without close examination of their impacts on the visitors to the Nation's Capital and upon the monuments themselves.

At the very least, the conflict must be publicly acknowledged and addressed, and responsible officials must work cooperatively to develop and implement all possible measures to reduce and mitigate this conflict. While these measures may not, for various valid reasons, include the rerouting of most traffic to Dulles Airport or Baltimore's Friendship Airport, a solution similar to that which many cities across the Nation have resorted, we should definitely consider suggestions such as that of the National Capital Planning Commission to limit the annual allowable passenger volume to present numbers. This approach, combined with extensive use of wide-bodied jets, could result in the maintenance of present levels of service and convenience while reducing the number of flights, noise exposure time, and negative impacts on parklands and memorials.

In the case of National Airport, two things appear obvious at this point. First, the future operating regime at National must consider many factors, including environmental ones; and secondly, we do not now have enough objective information to allow us to responsibly balance competing values. The National Park Service has increased its efforts to gather necessary information within its realm of expertise, and continues to encourage other agencies to do so as well.

The cases of Jackson Hole and National Airports only highlight the complexities of weighing the advantages of activities which produce sound against the impact of the sound which is produced. The task will not be easy, but it is necessary.

Of one thing, however, I am certain. A most appropriate, in fact, necessary role of the National Park Service in years to come will be the preservation of some special places which are not polluted by sound, just as we would not allow them to be polluted by dirty air or water. In these places, the artificial and unnecessary introduction of sound into a natural environment is more than just an irritation caused by what you can hear. It is, in essence, an act of robbery, a theft of those sounds which naturally belong in these environments, and which are part and parcel of the natural and cultural heritage of this Nation.

I think back to moments of my childhood when my father had me convinced that if I listened very carefully, I could hear the music made by the stars as they travelled across the sky. It is a legend as old as written language. What a shame it would be if we could only pass this legend on to our children by beginning it with "If it weren't for all this noise, you could hear. . . ." □

Update

A review of recent major EPA activities and developments in the pollution control program areas.

AIR

Conditional Approvals
The EPA recently agreed to conditionally approve the sale of 228,000 Fords, Lincolns, and Mercurys equipped with an electronic engine control system known as "EEC-III."

The conditional approval means the cars can be sold pending additional tests on the electronic engine control system.

The EEC-III functions as an onboard computer that controls the emission control system and other aspects of the engine operation. While Ford Motor Company expects that this computer will function properly in use, the durability of this system has not yet been fully demonstrated in the certification program as required by the Clean Air Act.

Also, EPA recently said that, pending the successful completion of tailpipe emission tests, it has agreed to conditionally approve the sale of General Motors' 1980 diesel cars equipped with 5.7 liter (350 cubic inch, V-8) engines. This accounts for all of GM's currently planned diesel passenger car production for this engine.

EPA said the diesel cars could not be fully certified because of failure of an emission control device to pass the 50,000 mile durability tests as required by the Clean Air Act.

The conditional approval means the cars can be sold pending additional tests of an exhaust gas recirculation valve.

ENFORCEMENT

Steel Agreement
The EPA and Copperweld Steel Company have reached agreement on a program to completely eliminate water pollution discharges from the firm's Warren, Ohio, plant.

Copperweld, headquartered in Pittsburgh, has agreed to totally eliminate discharges of oil, grease, and suspended solids (big particles of dirt that do not degrade in water) from its Warren plant into the Mahoning River by June 1, 1980.

The company, which currently employs about 2,500 people, serves a nationwide market and is one of the largest specialty steel firms in the U.S.

Additive Okay
The EPA recently announced that it has granted a waiver to Suntech, Inc. (Sun Oil Company) permitting the sale of a new anti-knock fuel additive.

The Suntech additive has high anti-knock qualities and can be used in unleaded gasoline without adversely affecting automobile emissions, according to EPA. This additive has the potential to slightly increase gasoline supplies, and Sun states its use will significantly increase the percentage of customers satisfied with gasoline anti-knock performance, the Agency says.

The 1977 Clean Air Act Amendments banned the use of certain fuel additives unless a waiver is granted. Suntech requested a waiver on December 19, 1978.

Parts Review
A regulation designed to make it easier for automobile owners to know which parts will not cause emissions to increase when used in the maintenance and repair of pollution controls on cars has been proposed by the Environmental Protection Agency.

This voluntary regulation provides a simple procedure for parts manufacturers to certify that the use of their parts will not cause automobile emissions to increase. Manufacturers who are now producing parts which are the equivalent of parts installed on a new car will be able to comply with the proposed regulations with only minimal adjustments in their present operations, according to EPA.

Motor Homes
The EPA has denied a request by the manufacturers of motor homes to exempt these vehicles from the Agency's noise regulations for new medium and heavy trucks.

Under the EPA ruling, motor homes must be in compliance with the regulations a hundred and twenty days after publication in the *Federal Register*. Motor homes manufactured before this compliance date are not required to comply with the regulation.

In turning down the manufacturers' petition, EPA said no burdens in the regulation are placed upon motor home manufacturers that are not placed upon similarly situated manufacturers in the rest of the truck industry.

PESTICIDES

Citrus Fruits
EPA Administrator Douglas M. Costle has ordered a ban on most uses of the pesticide chlorobenzilate but is allowing treatments on citrus fruits to continue, provided farmers and others using the pesticide take certain safety precautions.

Costle found the pesticide a suspect cancer agent capable of causing testicular effects in men. But he also determined that its use on oranges, grapefruit, and other citrus can be done safely provided it is sprayed by certified applicators wearing protective clothing and respirators, or applying it from tractors with enclosed cabs.

At the same time, Costle ruled that an environmental group, the Environmental Defense Fund (EDF), is not "adversely affected" by the restrictions on the citrus use of the pesticide, and that EDF cannot use this action to request a total ban on chlorobenzilate.

"On the other hand," Costle explained, "as my decision emphasizes, EDF is not precluded from challenging the original determination not to propose a total ban on the citrus uses. EDF may petition the Agency to initiate a separate proceeding to consider a total ban, and if the petition is judged to be meritorious, an evidentiary hearing will be held with full rights of cross-examination and opportunities to present supporting evidence. If the petition is denied, FIFRA (Federal pesticides law) also gives EDF the right to have that decision judicially reviewed. Consequently, my ruling does not mark a departure from the past Agency commitments to provide for public participation in pesticide decisions."

Endrin
The EPA has decided to allow growers to continue to use the pesticide endrin on such crops as wheat, apples, and some cotton.

In doing so, however, the Agency has placed certain restrictions on the way it is used to help protect the health of field workers and the general public, as well as the environment. These include special protective clothing in some instances, and precautions on the product label.

To prevent contamination of waterways, EPA cancelled endrin's use on cotton crops in areas where contamination of water is most likely to occur. Specifically, EPA's decision does not allow spraying on cotton in Louisiana, Arkansas, Missouri, the eastern parts of Texas and Oklahoma, and any State east of the Mississippi River.

Granular Pesticides
Farmers must be certified to use most of the widely-used granular pesticides under a new proposal by the EPA.

The proposed regulation, which would classify certain uses of these granular pesticides for restricted use, is necessary to protect the users, children, pets, farm animals, and birds and other wildlife from potentially harmful exposure, according to EPA.

Granulars are solid particles larger than dust, and consist of carrier compounds such as clay that are mixed or impregnated with a pesticide. Most farmers using them on such crops as corn, cotton, tobacco, and soybeans already have been certified during a nationwide EPA-State-USDA Cooperative Extension Service program of applicator training which instructed users of potentially hazardous pesticides in correct ways to mix and apply these products. Training also included instruction in recognizing pests, calibrating equipment, assessing environmental hazards, and recognition and treatment of pesticide poisonings.

SOLID WASTE

EPA Guidelines

The EPA has issued guidelines for use by State and local governments in planning and managing solid waste programs.

After their plans have been approved, States will be eligible to receive financial and technical assistance to improve their management of solid waste.

To be approved by EPA, State plans must aid the recovery of materials and energy from solid wastes and provide for environmentally acceptable disposal for unrecoverable wastes.

State plans, covering at least a five-year time period, will be developed within the next eighteen months and must be adopted by the States.

Resource Savings

The Resource Conservation Committee recently sent its final report on beverage container deposits and nine other conservation-related policies to the President and Congress.

The Resource Conservation Committee is a Cabinet-level committee established by the Congress to study Federal incentives and disincentives to materials conservation. The report is entitled *Choices for Conservation.*

"While we do not appear to be facing an imminent shortage of material resources similar to that which we face with energy resources," said EPA Deputy Administrator Barbara Blum in transmitting the report, "we have no cause for complacency about the rate at which we consume our natural endowment. Our materials use practices affect environmental quality, energy consumption, waste generation, the balance of trade, and other important national concerns. Individuals, private companies, local governments, and the Federal Government all make choices every day which affect our use and conservation of resources."

TOXICS

Asbestos

The EPA plans to develop regulations to reduce or eliminate hazards in public schools from walls and ceilings containing asbestos material.

EPA will consider several options to reduce asbestos hazards in the nearly 10,000 public schools nationwide that are estimated to contain asbestos materials, the Agency reports. As these materials deteriorate, or if they are damaged, they release asbestos fibers into the air—which in turn may be inhaled by school children and others. Inhaled asbestos fibers remain in the lungs and can cause lung cancer and mesothelioma, a cancer of the lining of the chest and abdominal cavities.

Last March, EPA asked the States to inspect public schools for asbestos-containing materials. The Agency has provided States with technical assistance to assess the degree of hazard and select the most appropriate remedy. At the moment, State compliance with EPA's request is not mandatory.

"We are prepared to require immediate action to substantially reduce asbestos hazards in schools not examined or repaired under our technical assistance program," said EPA Deputy Administrator Barbara Blum.

WATER

Savings

EPA recently announced new regulations that will save industries up to $200 million in water pollution control costs. These savings represent about 50 percent of previously estimated future clean-up expenditures for affected industries.

EPA's decision is a key part of the Agency's continuing effort to review and reform its regulatory programs. By eliminating some future clean-up requirements, the action will help to ensure that industrial water pollution control expenditures are cost-effective in improving the Nation's water quality.

Regulations are being withdrawn for 64 industry groups, which affect hundreds of individual companies in such industries as food processing, glass manufacturing, and ferro-alloys. This rulemaking will save money for industries by eliminating future clean-up requirements which EPA found to be unreasonably stringent, or which require further review.

Ocean Dumping

Thirty-two communities and companies stopped dumping sewage sludge and industrial wastes into waters off the United States during 1978. This is the largest number of dumpers to be phased out during any one year, an EPA report shows. In addition, 38 more dumpers are scheduled over the next two years to cease using the ocean to dispose of their wastes.

This information is contained in EPA's 7th Annual Report to Congress on the status of the Agency's program to regulate waste dumping in waters off the United States. The 48-page report covers activities in 1978.

Health Aid

High blood pressure patients could benefit from new EPA proposals calling for the periodic measurement and announcement of sodium levels in municipal water supplies.

The sodium monitoring proposal is but one of several health-related issues addressed by the new regulations. They also call for a program to limit water's corrosiveness, which can add contaminants and ruin pipes. In addition, the rules provide further Federal endorsement of the fluoridation of water as a safe and effective dental health measure.

The new EPA rules are proposed amendments to the Agency's interim primary (health-related) drinking water regulations, which went into effect in June, 1977. Under the 1974 Safe Drinking Water Act, EPA has the authority to establish and amend water purity rules that are necessary to protect public health.

Other issues covered in the new regulations are designed to help small communities.

Taste and Odor

EPA has issued final regulations to guide the States in controlling drinking water contaminants which normally are not dangerous to human health, but which may make water less palatable or useable.

The new rules are intended to deal with those contaminants which can cause aesthetic problems for the consumer, even though they are generally harmless to health. Such problems include offensive taste or odor, the staining of fabrics and plumbing fixtures, precipitations in cooking utensils, and the accelerated deterioration or encrustation of pipes and plumbing fixtures.

"The existence of a taste, odor or color problem does not always mean that a health threat exists, but it can be a warning signal," said EPA Deputy Administrator Barbara Blum. "Even though these regulations are not enforceable by the Federal Government, controlling these types of problems is important. If a drinking water system has such problems, for example, they can cause consumers to lose confidence in the healthfulness of their public water supply. This could result in their choosing an alternate source of water that is ultimately less safe to use."

Tuna Fish

EPA recently announced a change in the water pollution clean-up rules for tuna processing plants. Based on new information, one aspect of the industry's clean-up regulation is being relaxed.

EPA's action formally cancels that specific part of existing clean-up rules that limits the amount of tuna processing wastes that would reduce dissolved oxygen in receiving waters.

AGENCYWIDE

An American Indian programs staff has been established within EPA's Office of Environmental Review. Working together with EPA's Regions and programs offices, the staff will help make Agency programs responsive to the status of Indian tribes and lands and will serve as an overall Agency contact point for Indian environmental matters. The establishment of this function formalizes EPA's commitment to work with Indian tribes to protect the vast areas of the Nation occupied by Indian Reservations.

Eckardt C. Beck

He will join the Administrator's staff to help direct the Water and Waste Management Program. Beck has been Regional Administrator in EPA's New York office since 1977. During his tenure in Region 2 he was selected by President Carter to chair the Federal Regional Council there. Beck was Deputy Assistant Administrator for Water Planning and Standards in the Office of Water and Hazardous Materials from 1975 to 1977. Before joining EPA he was Deputy Commissioner of the Connecticut Department of Environmental Programs for several years. Earlier he helped to establish the State energy agency, acted as the agency's first administrator, and was chief energy advisor to the Governor. Beck graduated from Emerson College in Boston, did graduate work there in communications, and earned a Master's Degree in public administration from New York University in 1972, where he is a doctoral candidate. He attended the Yale University Graduate School of Epidemiology and Public Health and holds a Graduate Certificate in Air Pollution Administration from the University of Southern California Graduate School of Public Administration.

- Administrator Douglas M. Costle has announced the appointment of James Smith and Swep Davis as Associate Assistant Administrators for Water and Waste Management. Their appointment follows the resignation of Thomas C. Jorling as Assistant Administrator for the Water program. Jorling held the post since 1977, when he came to EPA from the Center for Environmental Studies at Williams College. As Associate Assistant Administrators, Davis will focus chiefly on strategy development and the superfund for dealing with hazardous wastes and Smith will concentrate on program operations. The Administrator noted that these appointments will ensure strong program leadership until a new Assistant Administrator for Water and Waste Management is named and given Senate confirmation.

- A reception and inauguration ceremony was held recently at EPA Headquarters for the 131 people in the Agency's Washington, D.C. offices who are part of the Senior Executive Service. After an introduction by Bill Drayton, Assistant Administrator for Planning and Management, Administrator Costle, Deputy Administrator Blum, and Office of Personnel Management Director Scotty Campbell addressed the group. Each member of the Senior Executive Service received a membership certificate at the ceremony. The Service is a new position/pay system established by the Civil Service Reform Act of 1978, which includes all executive type supervisory and managerial positions in the Federal Government that were previously in pay grades GS-16 through Executive Level IV.

David M. Rosenbaum

He has been appointed Deputy Assistant Administrator for Radiation Programs at EPA. In this post Rosenbaum will oversee the development of all Agency radiation standards, as well as criteria and recommendations that establish guidelines for other government agencies to follow when developing their own regulations. He will direct a staff of 175 people with a budget of $13.7 million. Administrator Costle said, "The environmental and health impact of radiation exposure constitutes one of this Nation's most pressing priorities. David Rosenbaum is a radiation expert who can give us excellent guidance as we deal with crucial radiation programs."

Rosenbaum has been a consultant in the nuclear field since 1976, previously serving as a management consultant to the Comptroller General at the General Accounting Office. He helped prepare GAO studies on the safety of liquefied energy gases and on the health effects of ionizing radiation. From 1974 to 1976 he was Senior Staff Analyst with the MITRE Corporation, where he supervised a conference on Nuclear Energy Centers and directed a study on the threat to licensed nuclear facilities. In 1973 he was a consultant at the U.S. Atomic Energy Commission. He has also served as Assistant Director, Office of Narcotics Intelligence in the U.S. Department of Justice, was president of his own firm, Network Analysis Corporation, and worked with the Office of Emergency Preparedness and the Institute for Defense Analysis. Rosenbaum earned a BS from Brown University in 1956, a Master's degree from Rensselaer Polytechnic Institute in 1958 and a Ph.D. from Brandeis University in 1964.

Cooperative Education

The Western Florida University students who are part of EPA's Cooperative Education Program (Co-op) met recently with their supervisors: EPA officials and representatives of the university, to review their program.

The Co-op program began at EPA in 1971 and is run by Amy Kearns, Chief of Headquarters Employment Center; Tom Wyvill, EPA Program Coordinator; and Thelma Jones, Headquarters Program Coordinator. Students in the Co-op program alternate periods of related study and work experience in a cooperative curriculum. The work experience is closely tied to the student's major field of study and provides the student with learning opportunities.

The program is available to students from a variety of backgrounds, permitting them to test their career choices through work experience. Students may receive credit toward their degrees while helping to finance their educations. Once Co-op students have graduated, they need not compete for a rating, but are listed directly on the Civil Service Register.

Since EPA hopes to retain these Co-op students after their graduation, Personnel is increasing its efforts to find students who are interested in protecting the environment. Presently, 35 to 40 percent of the Co-op students convert to full-time, permanent EPA employees after graduation.

Jan Geiselman

She has been named director of the Air and Hazardous Materials Division in Region 2. She will oversee 60 employees charged with carrying out Federal laws governing air pollution, asbestos, pesticides, radiation, and other hazardous materials. Geiselman joined EPA in 1975 as an attorney in the Headquarters Division of Stationary Source Enforcement. In 1977 Geiselman moved to the New York Regional Office and organized its first Office of Congressional and Intergovernmental Relations. She won an EPA Special Achievement Award in 1975. Geiselman has her degree from the University of Texas at Austin Law School, where she received a teaching excellence award in environmental law.

Herbert Barrack

He has been appointed Assistant Regional Administrator for Planning and Management in EPA's New York office. In this position he will be responsible for analyzing the success of Regional programs and integrating their activities to ensure that policies and programs are consistent. Barrack began his government service with the U.S. Atomic Energy Commission in 1960. He joined EPA in 1971 and has held positions of increasing responsibility with the Agency. In 1975 Barrack received an EPA Gold Medal for Exceptional Service. He holds an MBA from the Graduate School of Business Administration at New York University.

Loretta Stevenson

She has been nominated by EPA's Kansas City Regional Office for the Outstanding Handicapped Federal Employee of the Year Award. Mrs. Stevenson was diagnosed as having multiple sclerosis in 1969. The disease affected her mobility balance, motor coordination, hearing, and sight. She persevered with plans for a college degree, despite the problems posed by her illness. During summers and college breaks she worked part-time for EPA as a student aide in the Region 7 office. In 1974 Mrs. Stevenson received a BS in Elementary Education from the University of Kansas. After graduation she continued to work for the Agency. "I wanted to teach very much, but I realized I couldn't give 100 percent," said Mrs. Stevenson. "I knew I couldn't run down the court with the children when they wanted to play basketball. Then I decided that since EPA has been so good to me while I was in college that I would see what I could do for them. I believe it has been good for both of us." She is work leader in the Enforcement Division Data Section, and is responsible for maintaining the automated Permit Compliance System. In 1977 she received an Outstanding Performance Rating. The ten Outstanding Handicapped Federal Employees of the Year will be announced later this month in Washington.

Lewis Hughes

He has been appointed Acting Associate Administrator, Office of International Activities.

Dr. Hughes had served for the past year as Deputy Associate Administrator of the Office, with responsibilities for development of policies for EPA's overseas activities, coordination with the State Department, and other foreign relations with U.S. Government organizations, and management of bi- and multilateral environmental programs.

Previously he was Acting Chief of the Institutional Operations Office of the National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif. He received a Ph. D. from the University of California at Berkeley in 1972 and was Radiological Safety Officer there. He is the author of 34 scientific reports and manuals.

Fighting Noise Pollution

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Since noise is an important social cost produced by motor vehicles, certain countries (such as the Netherlands) are considering charges on motor vehicle noise based either upon emission levels established under test conditions or upon the vehicle's estimated noise impact. These could be levied as a purchase charge, an annual charge, or combination of both.

The Dutch Noise Nuisance Law relates the amount of noise fee as closely as possible to the potential nuisance of the noise source, and thus takes into account the total amount of noise emission, duration of noise production, and quality of noise. It anticipates noise charges on industrial plants to cover noise emitted outside the plant. Such charges are to be based on the severity of the noise impact which will be determined through scientific measurements taken of each plant's noise "footprint."

Noise Control Enforcement

OECD countries vary considerably in the comprehensiveness of their noise abatement legislation and in the extent to which control and implementation are centralized. In fact, while some countries have found that legislation which sets national standards is most effective, others have discovered that their most positive noise abatement results have come when local authorities have had the power to establish limits.

A good example of local enforcement is the United Kingdom's system in which local authorities can establish noise abatement zones where increasing noise levels from industrial, commercial, or entertainment sites are lowering the quality of the environment. Such establishments must first not increase their noise level and later take steps to reduce it.

Of concern to all countries is that enforcement be as simple, inexpensive, and straightforward as possible. Since police workloads and budget constrictions are often cited as problems in noise abatement enforcement, some OECD countries have started using civilians to enforce noise laws, and have adjusted the laws if necessary to grant the civilians appropriate authority.

Compensation for Unacceptable Noise-Control Damage

While OECD countries believe that compensation for damage caused by noise should be a last resort, some countries have found that this tactic motivates public developers to consider ways to soften noise generated by public works. The potential cost of compensation is an incentive both to reduce noise at its source and to improve noise control measures at the design stage.

Germany's Federal Pollution Control Act provides for compensation in kind to owners of buildings where traffic noise from a new road, highway, or railroad exceeds the limits defined in the implementing regulation. The regulation stipulates the required quality of sound insulation and that the cost of insulation be borne by the authority responsible for the new traffic way.

Dutch noise legislation will soon provide for the possibility of compensation in kind (noise insulation of buildings) and in cash (acquisition of buildings and land) for noise caused by aircraft, rail traffic, road traffic, and industry.

Other countries will not provide financial assistance to projects that would result in unacceptable noise. The Netherlands has enacted legislation that prohibits the construction of industrial plants, airports, and roads unless such structures conform with noise exposure standards.

Noise and Acoustical Education

Many OECD countries believe that educating children is the most promising long-range solution to the noise problem. Since children schooled in noise control may educate their parents in noise abatement, this approach has short-term benefits as well.

The Swiss Institute for Research into the Built Environment prepares school courses on environment protection that include noise control. Swiss police courses on road traffic focus primary school children's attention on the need not to cause noise. The French government plans to distribute, through the national education service, booklets educating children about noise, including the need for young motorcyclists to respect other people's desire for peace and quiet.

Public education is at the heart of almost all the noise abatement proposals made in the OECD report. To date, public awareness of noise and public commitment to noise reduction have been modest. In urging that all possible low-cost measures be taken to increase public awareness and commitment, the report concludes with the statement:

"By making people more aware of their rights, of the technical problems and of the progress with research and development, low-cost measures might pave the way for more stringent legislation as controls which might otherwise be considered unacceptable. They can also make possible better living conditions by making people more noise conscious." ☐

Dr. Ariel Alexandre is an Urban Environment and Land Use Specialist in the Environment Directorate of the OECD. Opinions expressed in this article are those of the author and do not necessarily reflect the views of the Organization.

EPA Deputy Administrator Barbara Blum Comments on the Problem of Noise Pollution.

During the past few years, the level of noise that Americans are exposed to daily has increased alarmingly. Not merely an urban phenomenon, it has spread to the suburbs and rural areas as well. The situation has become so serious that the May, 1979, report on the State of the Environment by the Organization for Economic Cooperation and Development suggests that if the entire U.S. population slept with its windows open, 13 percent would be awakened by aircraft noise, 40 percent by road traffic.

According to international experts, noise pollution in the U.S. is far worse than in other Western countries. Noise that can permanently damage hearing is twice as likely to happen in the U.S. as in Canada or Japan. By 1985, it is possible that the number of people exposed to harmful levels of noise could triple or even quadruple because so many live near major transportation facilities.

Considering that the noise problem has worsened in the past 15 years, the task of effectively controlling it becomes urgent, especially in view of what we already know about the range of adverse health effects of noise. The situation cries out for effective Federal action. We also need viable State and local noise programs. Even more important are effective public education programs that will help the American people recognize the dangers and what can be done about them. Without public involvement, no noise program can be successful. The Environmental Protection Agency, realizing the need for Federal, State, and local action and the importance of public awareness, will be using the authority of the Noise Control Act to launch meaningful programs.

Noise is not something which has to be tolerated as a consequence of the modern world. The U.S. is joining the Western European countries to develop innovative solutions to the world noise problem. There is plenty we can do, and a role for each of us to play in the effort. It's a responsibility none of us should take lightly.

The Sound of Silence

Continued from page 19

speaker at a convention or their table partner at a company dinner because of the interference from other sounds are at a distinct disadvantage. They can become reluctant to take part in activities necessary for a successful career because of the insecurity caused by impaired hearing.

A recent EPA report, *"Occupat.onal Hearing Loss: Worker Compensation Under State and Federal Programs,"* notes that occupational hearing loss can have a profound effect on social and work life. The report notes that one study of weavers, who had a slight hearing handicap by U.S. medical criteria, showed that the vast majority of the workers had trouble hearing in public, talking with friends, or conversing with strangers on the phone. Most had seriously restricted their social lives and more than half used lip-reading to aid understanding.

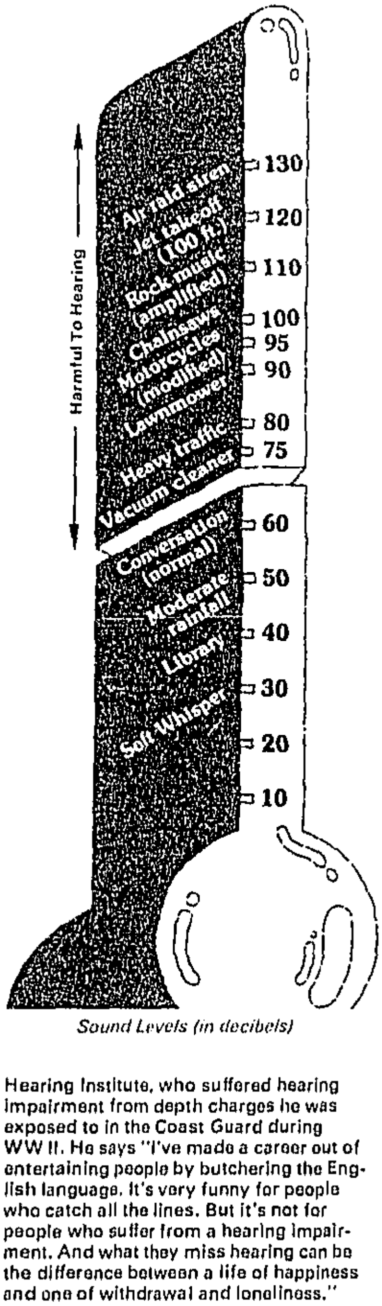
Humanitarian Helen Keller, who was both blind and deaf due to a childhood disease, said that of the two handicaps she felt the loss of her hearing most keenly because it shut her off from human social interaction.

A worker who can hear well enough to do the job at hand may be cut off from promotion or transfer possibilities because of impaired communication ability. Some researchers feel that the level of noise in a worker's job can serve to mask the seriousness of a hearing loss. A man who says, "I can talk to the guys at work OK," may be discounting the limited nature of much workday conversation where brief exchanges occur in tones raised to carry over the noise of machines. Such persons can find themselves totally lost in conversations that involve a large group of people and get beyond the "How are you doing? Nice day" stage.

Hearing conservation workers note that people with hearing losses can have feelings of isolation that are directly related to the degree of difficulty comprehending conversation. The inability to hear or understand what is going on around them can lead people to withdraw socially or to believe that others are talking about them.

People with certain degrees of perceptive hearing loss do not hear normal sound even with amplification. What they hear can sound like a short-wave radio that is not properly tuned in. Gaps in sound, distortion, and muffling accompany the transmission of sound. This can make it very difficult for them to translate the noises they hear into something meaningful.

One point of view on these problems is expressed by comedian Norm Crosby, National Honorary Chairman of the Better



Sound Levels (in decibels)

Hearing Institute, who suffered hearing impairment from depth charges he was exposed to in the Coast Guard during WW II. He says "I've made a career out of entertaining people by butchering the English language. It's very funny for people who catch all the lines. But it's not for people who suffer from a hearing impairment. And what they miss hearing can be the difference between a life of happiness and one of withdrawal and loneliness."

Former Governor George Wallace of Alabama has a hearing impairment. He says, "Loss of hearing is not only an invisible handicap, but it is burdened with centuries of half-truths and outright myths. It is often mistakenly associated with senility, yet some three million school-age children suffer from hearing problems. Many people feel there is a terrible stigma attached to losing one's hearing, to wearing a hearing aid. I was no exception. But because I value good hearing, I am no longer a reluctant hearing aid wearer. I continue to enjoy the marvelous sounds of life, thanks to hearing help."

Hearing experts point out however, that amplification will not completely correct all hearing losses. In some cases increasing the sound can be a source of annoyance because of a phenomenon called recruitment. Recruitment is abnormal sensitivity to sounds in a certain range that occurs in people with hearing impairment. People with recruitment reach a pain level with noise much sooner than most, even unaided, and a hearing aid can compound the problem. This causes difficulty in finding the "comfort range" for hearing aids. An aid that is uncomfortable will not be used, and does no good sitting in a drawer.

It is important for people who already have hearing losses to protect their remaining hearing. Even if you have lost some hearing, continued exposure to loud noise can erode it further. Lower sensitivity can mean that the hearing loss is slowed but still occurs.

Another problem that can accompany hearing loss is that of head noises or tinnitus. Many people notice a ringing in their ears after periods of exposure to loud noise. The ringing is tinnitus, which scientists believe usually indicates some damage to the auditory pathway.

After exposure to loud noise the ringing noises will usually fade and normal hearing return within several hours. However, hearing researchers warn that with repeated and prolonged exposure it takes longer for the ears to recover, and a permanent impairment in hearing can occur.

The continued presence of tinnitus is very disturbing to many people. While ear noises are not always caused by hearing loss (they can be a sign of arteriosclerosis or Meniere's disease), they often accompany it. The American Tinnitus Association reports that some 36 million Americans suffer from ringing, buzzing, and roaring sounds in their heads. Such an affliction can interfere with sleep, distract from conversation, and generally wear out its hapless victims. Some sufferers obtain relief with masking devices, tiny receivers that fit into the ear like a hearing aid and emit sound sometimes called "white noise," which is somewhat like hissing, to mask or cover up the intruding internal noise. But many people continue to suffer with "racket inside the head" in addition to their hearing impairment.

EPA is working with a number of organizations to present information to the public

Continued

about the hazards of noise and to reduce environmental noise so that noise-induced hearing impairments might be prevented. If such efforts are successful, perhaps fewer people will find themselves in the predicament of writer Jonathan Swift, the author of Gulliver's Travels, who in his later years described himself as "Deaf, giddy, helpless, left alone, To all my friends a Burden grown." □

Further information on hearing impairment available from:

American Council of Otolaryngology
1100 17th St. NW
Washington, D.C. 20036

The American Speech-Language-Hearing Association
10801 Rockville Pike
Rockville, Maryland 20852

American Tinnitus Association
P.O. Box 5
Portland, Oreg. 97207

Better Hearing Institute
1430 K St., NW Suite 600
Washington, D.C. 20005

The National Information Center for Quiet
Box 57171
Washington, D.C. 20037

Chris Perham is an Assistant Editor of EPA Journal.

Hearing Protectors

People who wish to conserve their hearing in noisy situations have had to choose protection from among the many and various types of protective devices that are both readily available and relatively cheap. Protective devices have widely varying noise-reducing effectiveness.

Earplugs fit into the ear canal to block the entry of sound, and are found as moldable, putty-like material that can be re-used several times, ear-down that is intended to be used only once, universal fit pre-molded plastic available in several sizes, and custom-fitted pre-molded plastic inserts.

Ear-muffs fit over the entire outer ear and cling tightly to the head to block out noise, and are basically two cup-like covers joined by a metal or plastic headband.

Ear-caps are a combination of the two previous devices, and fit into and on the ear.

Up to the present time, for people to choose hearing protection that is adequate for the noise situation in which they find themselves, they would have to have had some prior use or knowledge of protectors and the perceived variations in their ability to reduce noise; have had the aid of someone directly involved in a hearing conservation program; or have done some personal library research. However, approximately one year from now, all protective devices that are sold wholly or even in part on the basis of their effectiveness in reducing noise will have a label on them stating—in decibels—the noise reducing effectiveness of the particular model of protector. This will occur because EPA has issued a regulation requiring manufacturers of hearing protectors to uniformly test and label their products.

The label will have on it the Noise Reduction Rating for the particular model of protector, and the range of ratings for all presently available protectors for the purpose of product comparison.

The intent of this regulatory action is to provide notice to a prospective user of these devices of the effectiveness of a device *before* it is purchased or used, and that others are available.

Noise Regulations

Continued from page 22

Legislature to consider in an orderly manner any needs that might arise for future revisions of the time-table.

The 1988 requirement of 70 decibels for all classes of new vehicles was included because it seemed to be an acceptable limit below which further quieting of vehicles would not be necessary to eliminate general complaints. Information was not available to indicate that far in advance whether it would be an acceptable low limit for the public and whether it would be economically feasible for the manufacturers.

The 70 decibel limit was not technically feasible with then-current type of trucks, tires, and engines, but it would allow manufacturers a lead time of at least 16 years to attempt to meet the goal. This philosophy of "holding industry's feet to the fire" until they either come up with the solutions or can convince the regulatory body why the solution can't be reached has proven to be an effective approach. As a matter of fact the little progress that we have made to date in the area of new vehicle noise control is primarily the result of a few strong programs which weren't willing to accept current vehicle noise levels as acceptable. Truck noise levels appear to be dropping as a result of the new product regulations which have been in effect since 1968.

How Effective Has EPA Been in Regulating New Noise Sources?

Unfortunately, the philosophy adopted by State and local programs as described earlier has reversed itself in EPA. As a result of legal and administrative problems we see industry holding EPA's feet to the fire until they back off enough on their standards to protect industry. EPA instead of industry has the onus of proving whether or not a standard is technologically and/or economically feasible. As a result we're seeing EPA propose and promulgate standards which may be weaker than some of those currently enforced by State and Local noise control agencies. In such cases these standards would do little more than "legalize noise pollution" and preempt States and cities from dealing with the problem.

How Can Noisy Products Best Be Controlled in the Future?

Many noise control officials feel that State and local governments can best regulate new product noise. Their feelings are based largely on the initial success of State and local regulatory efforts and perhaps more out of frustration with the lack of a strong Federal program.

Unfortunately, regulating major manufacturers at the State and local level is becoming increasingly difficult. The use of "bluffing tactics" which work initially when decisions are easy, prove to be less effective as standards become more stringent and serious technological and economic questions are raised. In recent years, State and local governments have been backing down. For example, new motor vehicle standards have been holding at the 1975 California levels with further reductions doubtful.

Only the Federal Government, with EPA in the lead role, has the capability of adequately addressing the technology and economic issues and establishing an appropriate accounting system for compliance. In order to more effectively regulate, EPA should:

1. Concentrate its limited resources on the most important products,

2. Be willing to force industry to expend money in search of "quiet" technology, and

3. Base future noise emission standards more on public health and welfare and less on economic impact.

The fate of our Nation's acoustic environment is heavily dependent upon a strong Federal new product noise regulatory program—without which we are fighting a losing battle. □

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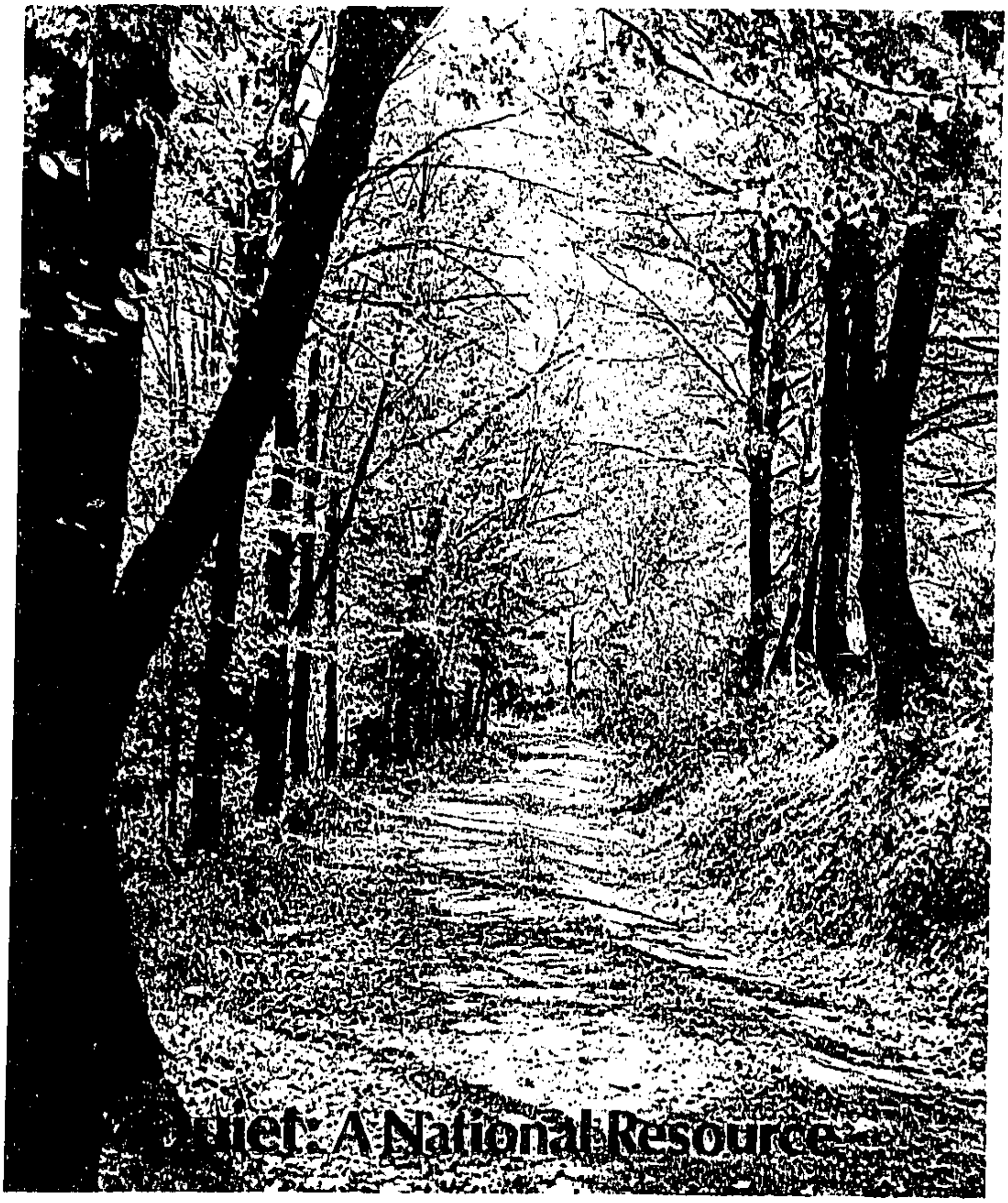
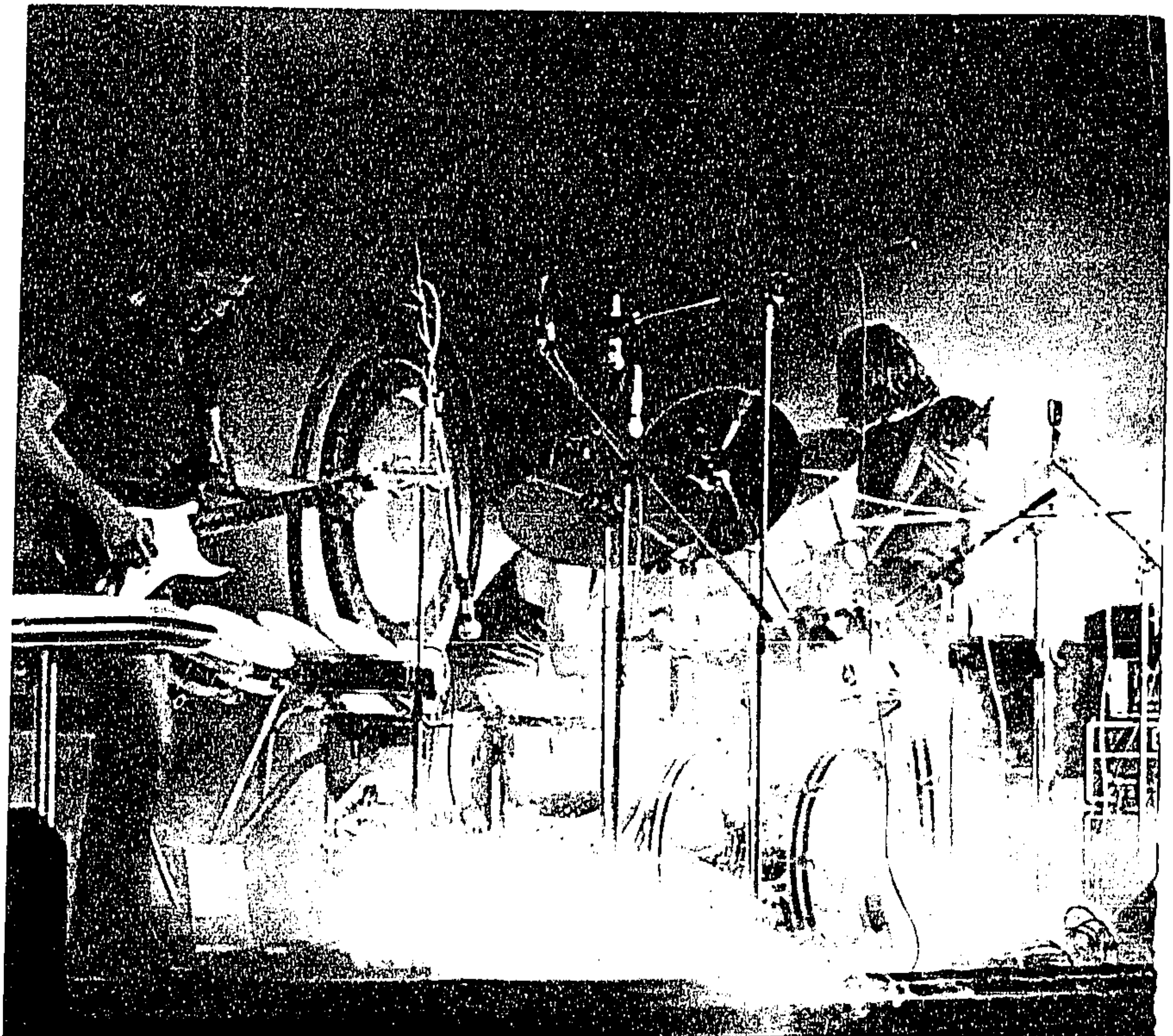


Above: Copies of this poster will be available late this year from the National Information Center for Quiet, Box 57171, Washington, D.C. 20037 (See story on P. 4.)

Back cover: The sound level at rock concerts is often high enough to endanger the hearing of the musicians and audience.



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E·A·RLOG 11

Eleventh in a comprehensive series of technical monographs covering topics related to hearing and hearing protection.

The Hearing Conservation Amendment (Part I)

BY ELLIOTT H. BERGER,
Manager Acoustical Engineering, E·A·R Division

Since October of 1974, OSHA has been working on revisions to the occupational noise exposure standard. After years of oral and written public testimony, resulting in an unwieldy public record of almost 40,000 pages, OSHA promulgated revisions[1] to the noise standard in January, 1981. This was followed by deferrals, stays[2], revisions, further public hearings, and a multiplicity of lawsuits, all of which culminated in the *Occupational Noise Exposure; Hearing Conservation Amendment; Final Rule*[3], issued March 8, 1983, with an effective date of April 7, 1983. The purpose of this EARLog, #11[4], is to summarize briefly principal components of this important new noise regulation, elucidate its key aspects, and clarify issues it has raised that are often misunderstood.

Background Information

It is estimated by OSHA[1] that there are 2.9 million workers in American production industries with equivalent 8-hour noise exposures in excess of 90 dBA and an additional 2.3 million whose exposure levels exceed 85 dBA. The Hearing Conservation Amendment (HCA) applies to all those 5.2 million employees except for those in oil and gas well drilling and servicing industries which are specifically exempted. Additionally, the Amendment does not apply to those engaged in construction or agriculture, although a construction industry noise standard exists (29 CFR 1926.52 and 1926.101) which is essentially identical to paragraphs (a) and (b) of the general industry noise standard described below.

The Occupational Noise Standard

Prior to promulgation of the HCA, the existing noise standard [29 CFR 1910.95 (a) and (b)] set a permissible exposure level of 90 dBA for eight hours, and required the employer to reduce employee exposures to that level by use of feasible engineering or administrative controls. In all cases where the sound levels exceeded the permissible exposure, regardless of the use of hearing protection, "a continuing, effective hearing conservation program" was required, but the details of such a program were never mandated.

Paragraphs (c) through (p) of the HCA supply OSHA's definition of an "effective hearing conservation program." They replace paragraph (b)(3) of 1910.95, but do not alter the law as defined in paragraphs (a), (b)(1), and (b)(2). As long as the permissible exposure level for unprotected ears is exceeded, feasible engineering and administrative controls must still be implemented regardless of the existence or quality of a company's other hearing conservation efforts.

Terminology

The noise standard and the HCA define the **permissible exposure level (PEL)** as that noise dose that would result from a continuous 8-hour exposure to a sound level of 90 dBA. This is a dose of 100%. Doses for other exposures, either continuous or fluctuating in level, are computed relative to the PEL based upon a 5 dB trading relationship of level vs. duration (see Table I).

The **8-hour time-weighted average sound level (TWA)** is the sound level that would produce a given noise dose if an employee were exposed to that sound level continuously over an 8-hour workday. This is true regardless of the length of the actual workshift. For example, workday exposures of 4 hours at 90 dB, 8 hours at 85 dB, or 12 hours at 82 dB, all correspond to a TWA of 85 dBA or a noise dose of 50%. If a noise level is constant for an entire 8-hour workshift, the TWA is simply equal to the measured sound level. The procedure for converting doses to TWAs is demonstrated in Table II.

A noise dose of 50% is designated as the **action level**, or the point at which the HCA requires implementation of a continuing, effective hearing conservation program.

Summary of the HCA

All workers receiving noise exposures at or above the action level are to be included in a hearing conservation program comprised of five basic components: exposure monitoring, audiometric testing, hearing protection, employee training, and recordkeeping. The requirements of the standard are primarily performance oriented, allowing the employer to use judgement in selecting the best methods of compliance.

MONITORING: Employers shall monitor noise exposure levels in a manner that will accurately identify employees who receive daily noise doses at or above the action level. All continuous, intermittent, and impulsive sound levels from 80 - 130 dBA must be integrated into the computation. Noise levels must be remeasured whenever any change relating to production is suspected of increasing exposures to the extent that additional employees may receive doses at or above the action level, or the attenuation provided by the selected hearing protectors is rendered inadequate.

Monitoring may be accomplished by an area survey technique in which sound level meter readings are combined with estimates of the length of exposure of individuals to particular sound levels in order to calculate the TWA (as in Table I), or may be measured by personal sampling methods via the use of a noise dosimeter. However, employers must justify the particular monitoring technique they choose to utilize. OSHA inspections will in most cases be conducted via the personal noise dosimetry approach. All initial noise surveys were to have been completed by April 7, 1983, but in general, properly executed and documented existing surveys are an acceptable alternative.

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Eleventh in a comprehensive series of technical monographs covering topics related to hearing and hearing protection.

The noise dose that is to be reported for compliance purposes is the daily noise dose that could be measured by an OSHA inspector on a particular survey day. It is not permissible to average doses over a number of days to compute a long term average noise dose. Unless an employer can fully document the infrequent nature of particular exposures, and unless management wishes to rely upon the latitude that might be permitted by a particular inspector, the prudent course of action and the one that would be more protective of the employees' hearing, would be to account for infrequent higher level exposures by using such values to compute noise doses.

The noise standard [paragraphs (a) and (b) and Table G-16] does not permit exposures to steady sound levels above 115 dBA, regardless of duration (although the exact meaning of "steady sound" and the types of impulsive or impact noises that might be excepted from this prohibition are unclear[5]). OSHA still considers the 115 dBA limitation to apply even though Table G-16a of the HCA, which is to be used for computation of employee noise exposures, incorporates levels up to 130 dBA. Those higher levels were listed in Table G-16a to indicate explicitly that they be accurately assessed and included in the dose computation, but they were italicized to avoid giving the impression that levels above 115 dBA are permitted.

AUDIOMETRIC TESTING: Audiometric testing not only monitors employee hearing acuity over time, but also provides an excellent opportunity to (re)educate employees about their hearing, (re)motivate them to protect it, and (re)train them in the use of their hearing protectors. The audiometric program consists of baseline audiograms against which future tests are compared, and annual audiograms which are the tests used to identify changes in hearing acuity in order to take protective actions.

All current employees must have baseline audiograms taken by March 1, 1984, or six months from their first exposure at or above the action level, whichever is longer. An exception is provided when mobile test vans are used to meet the audiometric testing obligation, in which case the employer has one year to obtain a valid baseline. When this exception is invoked, employees must wear hearing protectors for any period exceeding six months after their first exposure, until the baseline audiogram is obtained.

Baseline audiograms must be preceded by 14 hours without exposure to workplace noise; however, hearing protectors may be used as a substitute for this requirement. Annual audiograms may be obtained at any convenient time during the workday. Although an audiologist, otolaryngologist, or physician must supervise the audiometric testing and must review problem audiograms, testing and evaluation in general may be conducted by a technician who has been certified by the Council for Accreditation in Occupational Hearing Conservation,

TABLE I

Abbreviated version* of Table G-16a for computation of employee noise exposure.

Sound Level (dBA)	Permissible Time (hrs.)
80	32
85	16
90	8
95	4
100	2
105	1
110	0.5
115	0.25
120*	0.125*
125*	0.063*
130*	0.031*

*Exposures above 115 dBA are not permitted regardless of duration (see Table G-16), but should they exist, are to be included in computation of the noise dose.

Dose (D) = 100 [$C_1/T_1 + C_2/T_2 + \ldots + C_n/T_n$] where C_n is the time exposed at a specific level and T_n is the time permitted at that level.

Example (1): Workday consists of 7 hours exposure to a constant level of 95 dBA; D = [7/4] = 175%

Example (2): Workday consists of 1 hour @ 95 dBA
2 hours @ 90 dBA
4 hours @ 85 dBA

$$D = 100\,[1/4 + 2/8 + 4/16] = 75\%$$

TABLE II

Abbreviated version* of Table A-1 for conversion from Dose to TWA.

Dose (%)	TWA (dBA)*
10	73
25	80
50 (action level)	85
75	88
100 (PEL)	90
115	91
130	92
150	93
175	94
200	95
400	100

*Values rounded to the nearest dB. The exact conversion from Dose to TWA is given by:

$$TWA = 16.61 \log_{10}[D/100] + 90$$

or who has otherwise demonstrated competency to the supervising professional.

Changes in hearing acuity that exceed an average of 10 dB or more at 2000, 3000, and 4000 Hz in either ear, relative to the baseline audiogram, are considered to be a standard threshold shift (STS). In determining whether an STS has occurred, allowance may be made for the contribution of aging to the change in hearing level (presbycusis) by correcting the annual audiogram as described in Appendix F of the Amendment. When an STS is detected, the employee must be notified, and unless a physician determines that the shift is not work related or aggravated by occupational noise exposure, the employee must be fitted or refitted with hearing protection as needed, and referred for a clinical evaluation as appropriate.

It is important to distinguish between an STS and a compensable hearing loss, the latter being defined according to each state's workers' compensation formula. The presence of an STS indicates a change in hearing acuity as defined by the HCA, but it has no relevance with respect to the determination of hearing impairment or handicap. It is possible for an STS to develop for employees whose hearing threshold levels are still considered "normal," and conversely, it is possible for persons to develop considerable hearing loss at the frequencies of 4000 and 6000 Hz before being detected by the STS criterion.

The necessity of reporting STSs on OSHA Form 200 is unclear at this time. Although 29 CFR 1904.2 clearly specifies that "work related" injuries and illnesses are to be recorded on Form 200, OSHA has not stated whether an STS is to be considered a work related injury, and the HCA has specifically relieved the employer of the burden of determining the "work relatedness" of particular hearing losses.

HEARING PROTECTORS: Hearing protectors must be made available to all workers exposed at or above the action level. Additionally, for those exposed at or above the PEL, and for those exposed at or above the action level who either incur an STS or who have been exposed in excess of six months without having had a baseline audiogram established (due to the mobile test van exception), hearing protector utilization is mandatory. Hearing protectors must reduce exposures to 90 dBA, or to 85 dBA for those exhibiting an STS. Attenuation is calculated according to methods outlined in Appendix B of the Amendment.

The employer must provide a "variety of suitable hearing protectors" from which the employee can choose, and must provide training in the use and care of those devices, as well as ensuring proper initial fitting and supervision of continued correct use. OSHA interprets "variety" to mean at least one type of plug and one type of muff, although a somewhat larger selection is considered preferable[1,6]. The hearing protectors are to be furnished to the employees at no cost, and replaced as necessary. However, employers are not expected to pay for an unlimited supply of protectors or to replace devices that are lost or damaged due to employee negligence or irresponsibility.

TRAINING: Employees exposed at or above the action level must be trained at least annually regarding the effects of noise; the purpose, advantages, disadvantages and attenuation of the hearing protectors being offered; the selection, fitting, and care of protectors; and the purpose and procedures of audiometric testing. This training does not have to be accomplished all in one session, and in fact portions of it may be ideally reviewed during the employee's annual audiometric test.

RECORDKEEPING: Noise exposure records must be retained for two years, but data older than two years should not be discarded unless remonitoring has been performed. Audiometric test records are to be retained for the duration of the employee's service. However, consideration of future possible compensation claims suggests the advisability of maintaining such data for an indefinite duration.

Comments
An alternative, but still nontechnical summary of the HCA, may be found in the 1983 Federal Register[3] on pages 9738-9739, and in a similar, but separate document[7,8] which is available from OSHA and from E-A-R Division. Additionally, E-A-R has prepared a single sided reproduction of paragraphs (a) through (p) of the Standard[9] so that they may easily be posted in order to comply with the Amendement's requirements for access to information [paragraph (l)(1)].

In the next EARLog we will conclude this review of the HCA with additional discussions of the hearing protector portions of the Amendment, especially Appendix B and the often misunderstood "7 dB correction."

References and Footnotes

1. Occupational Safety and Health Administration (1981a). "Occupational Noise Exposure; Hearing Conservation Amendment," Fed. Regist. 46(11), 4078-4181.
2. Occupational Safety and Health Administration (1981b). "Occupational Noise Exposure; Hearing Conservation Amendment," Fed. Regist. 46(162), 42022-42639.
3. Occupational Safety and Health Administration (1983). "Occupational Noise Exposure; Hearing Conservation Amendment," Fed. Regist. 48 (46), 9738-9783.
4. The EARLog Series, #1 - #11, is available upon request from E-A-R Division, Cabot Corporation.
5. See OSHA Bulletin 334 (1970), "Guidelines to the Department of Labor's Occupational Noise Standards for Federal Supply Contracts," for additional discussion.
6. Berger, E. H. (1981). "EARLog #7 - Motivating Employees to Wear Hearing Protection Devices," available upon request from E-A-R Division, Cabot Corporation.
7. Occupational Safety and Health Administration (1983). "Hearing Conservation," OSHA 3074, U.S. Dept of Labor, Washington, D.C.
8. Noise Standard/Hearing Conservation Amendment Poster, and Reproductions of OSHA 3074, are available free from E-A-R Division, attention Ms. Minkner.
9. For actual computation with respect to compliance, see Table G-16a and Table A-1 of Appendix A of the Amendment (footnote 3, above).

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February 18, 1982

Possible Activities by Noise Control Technology In Hearing Conservation Programs

1. Prepare/provide tutorial/training materials for:
   - o Management - a simplified manual for establishing and conducting hearing conservations programs with simple forms.
   - o Employees - simplified text/graphics illustrating need for hearing conservations, benefits of participating/ cooperating; hints) instructions for proper use of hearing protectors.
   - o Selection of hearing protectors.
2. Consult with company management in instituting a hearing conservation program.
3. Perform noise surveys, monitor area exposure, assist in selection and use of personal dosimeters.
4. Recommend inexpensive ways of reducing noise exposure including noise control treatments, barries, enclosures, use of functional sound absorbers, etc.
5. Cooperate with/help to select audiologists/technicians to make audiometric measurements, interpret audiograms, assess potential presence of NITS (P or T).
6. Develop/provide standard forms for recording data to meet OSHA requirements and for file/reference purposes.

OCCUPATIONAL HEARING CONSERVATION:

A Challenge to the Profession

A Continuing Education Program
of
The American Speech-Language-Hearing Association

American Speech-Language-Hearing Association
10801 Rockville Pike • Rockville, Maryland 20852 • (301) 897-5700 (Voice or TTY)

March 25, 1982

Dear Workshop Participant:

In current discussions of health care delivery systems, an ever-increasing number of professionals advocate those systems that are prevention-oriented. You, as professionals invested in hearing health care, have such a forum for the implementation of occupational hearing conservation programming. Supported by federal regulatory policy, audiologists have a rare opportunity to impact on the prevention side of a burgeoning health management movement. To this end, the American Speech-Language-Hearing Association is pleased to offer this continuing education program in OCCUPATIONAL HEARING CONSERVATION: A Challenge to the Profession. In response to repeated requests from the membership for related specific information and training, Evelyn Cherow, Director of the Audiology Liaison Branch, has coordinated this program offering.

The workshop manual enclosed is a compilation of outlines, articles, chapters, and references designed to complement program content prepared by our expert faculty. I would like to gratefully acknowledge those publishers who generously agreed to our inclusion of their copyrighted materials:

Asha
Council for Accreditation in Occupational Hearing Conservation
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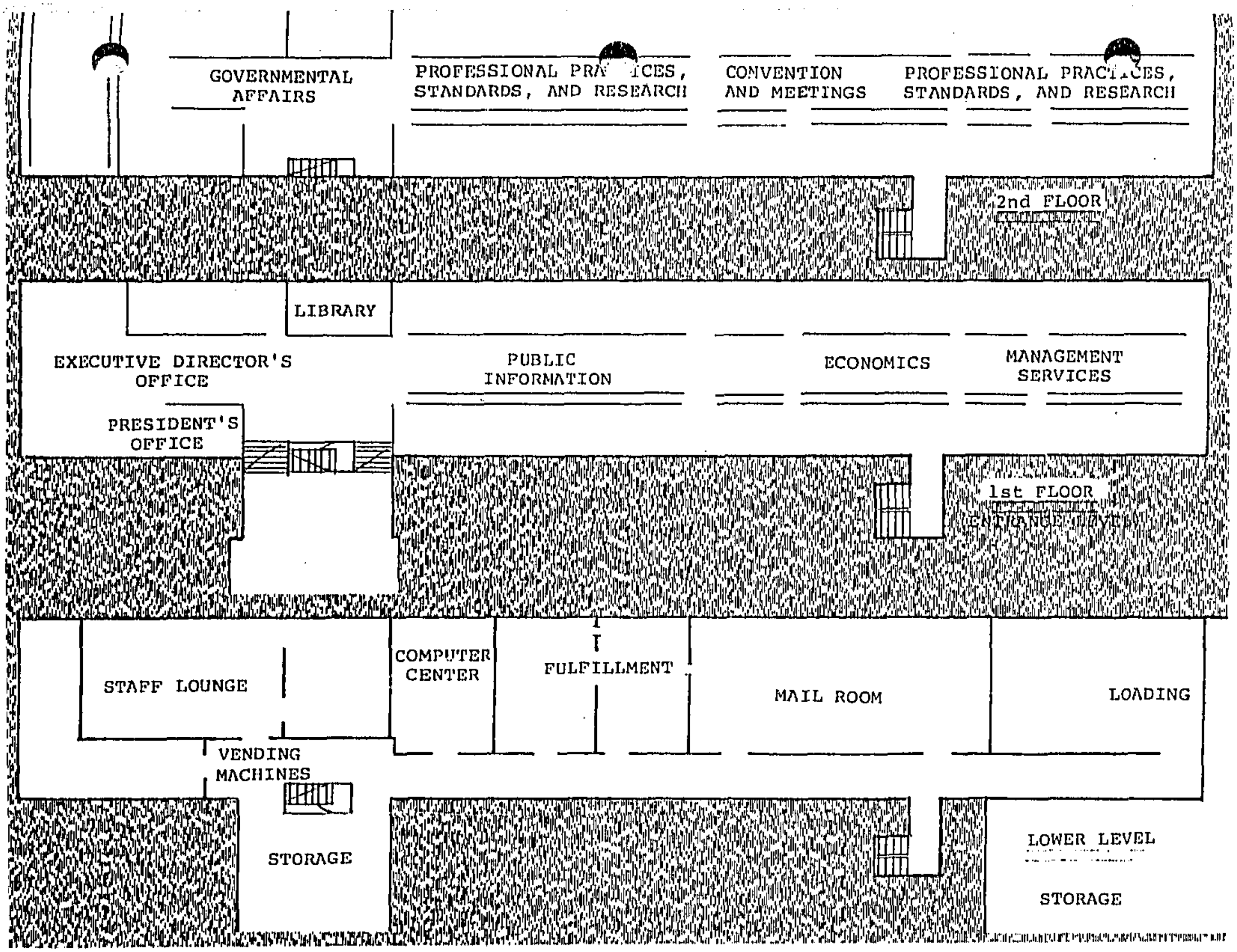
University Park Press

I hope that your workshop participation foretells a growing trend not only toward diversification of audiological service delivery to that segment of our population in industrial workplaces at risk for hearing impairment, but also reflects your willingness to be at the forefront of professional involvement in hearing health care for over 5 million Americans.

Sincerely,

Frederick T. Spahr, Ph.D.
Executive Director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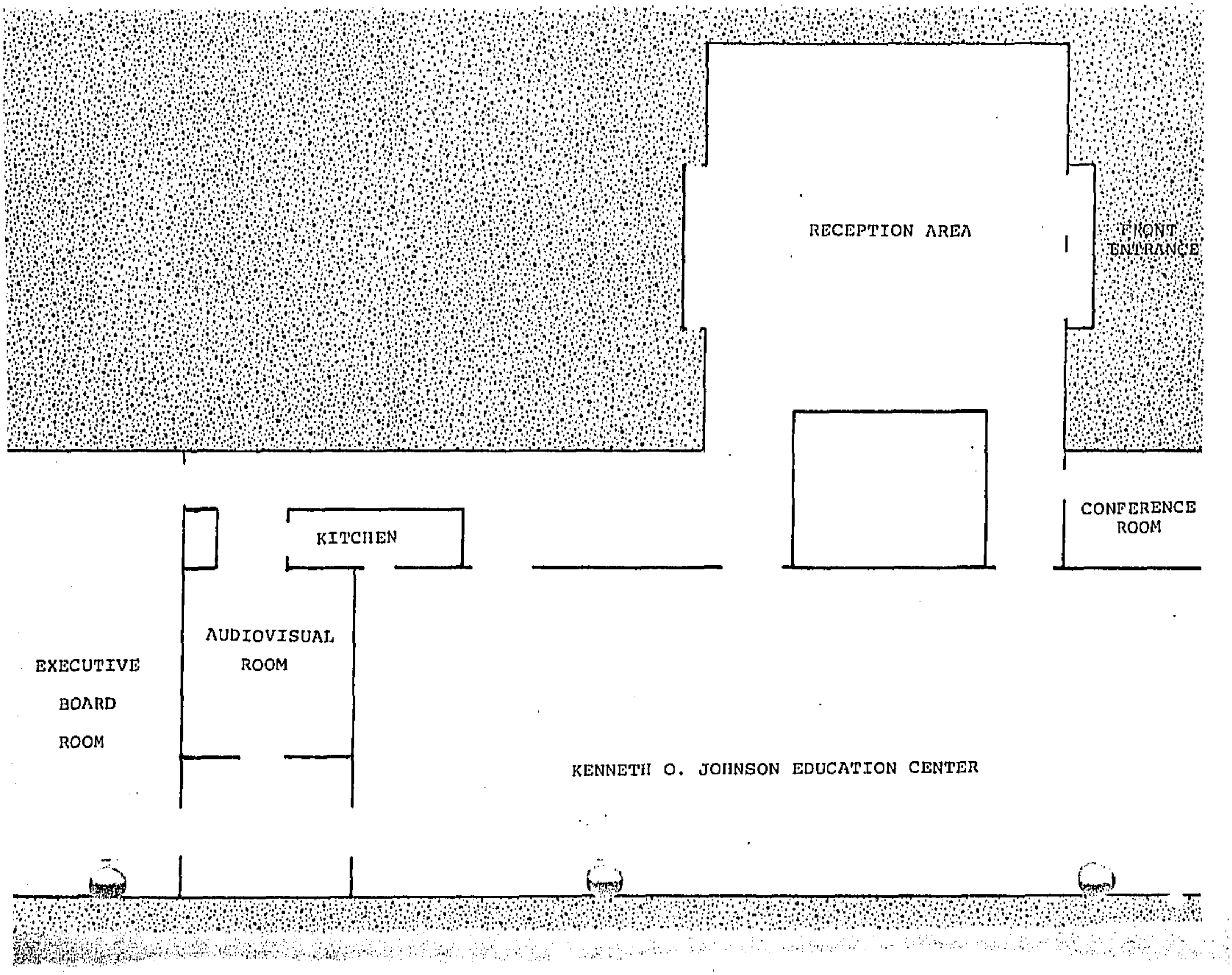
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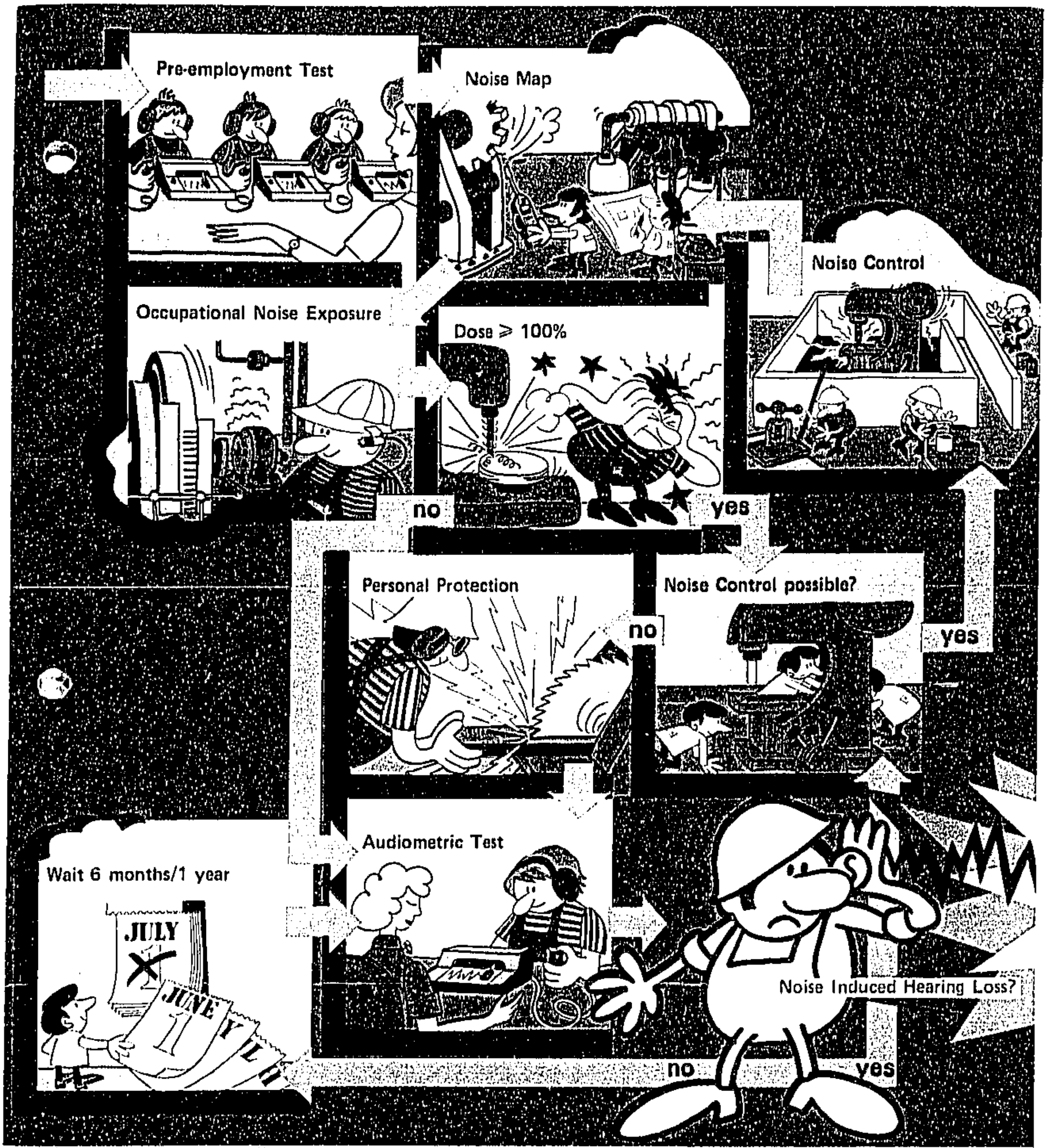


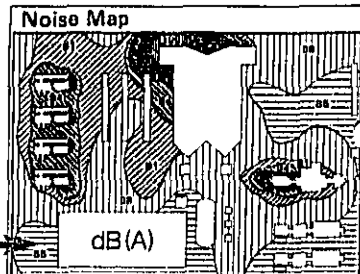
Industrial Noise Hearing Conservation Programme

USA English

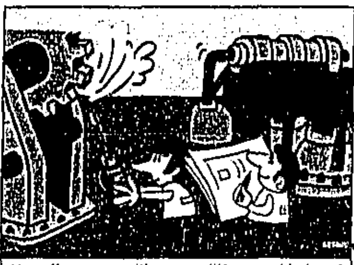
Brüel & Kjær

Noise in industry poses problems which are not always easy to solve. Before launching a noise abatement programme which may entail an appreciable investment, the prudent health and safety officer should consider all aspects of the problem and inquire about the various methods of measurement which would enable the best solutions to be found.

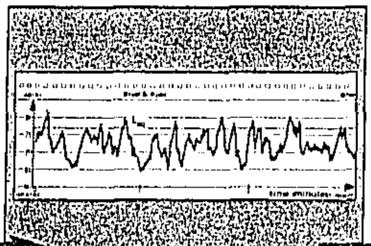
The aim of the whole programme is to preserve the hearing faculty of the employees. Tests at the beginning of employment would enable the employer to avoid placing people who are particularly sensitive to noise in high noise areas and to compare periodically the condition of the hearing faculty with the initial test. Moreover they protect employers from assuming responsibility for hearing damage incurred in a previous job.



The next stage consists of making a scaled map of the particular workshop or building site showing all the noise sources. On this map lines can then be traced connecting points of equal noise levels. These noise countours or "isobels" clearly define any hazardous areas and allow to identify locations where the most effective steps can be taken for noise reduction. The map can also be used to inform employees where ear protectors must be worn.

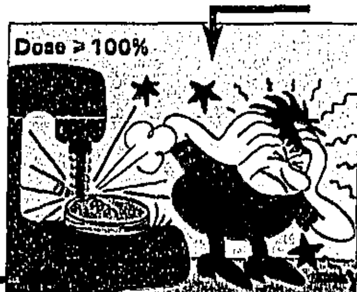


Usually, you will meet different kinds of noise in the same factory. Different methods need to be used to measure the continuous noise from a rotating machine, the fluctuating noise from an automated production line or the impulse noise from a punch press. Therefore, you have to be sure when selecting your sound level meter that it is versatile enough and conforms to your country's recommendations for sound level measurements. The table on the last page summarizes the principal features of the various B & K sound level meters.



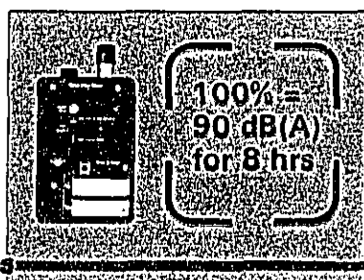
In cases where noise levels vary with time during the working day, it is necessary to measure a quantity which takes into account both the noise levels and their duration. This quantity is the "Equivalent Continuous Level, L_{eq}" which has the same energy content and hearing damage potential as the noise of varying level. Impulse noise such as punch press noise can be measured by a sound level meter having a special "Impulse" response or the facility to retain the maximal peak value of the impulse noise.

The third stage consists of quantifying the noise exposure experienced by the employees. It is obvious that the risk of hearing loss will not only depend on the noise levels themselves but also on their duration. The employees usually experience time-varying noise exposure because noise varies unpredictably at their work location or because they move around the site in performing their job.



The total amount of noise to which the individual is exposed during the working period is known as the Noise Dose. The Noise Dose is simply the L_{eq} value of the noise experienced by one person during the whole working period, expressed in % of the allowed exposure. This corresponds, depending on the standard to which one refers, to a level of 90 dB(A) during 8 hours for a working day or during 40 hours for a working week.

yes



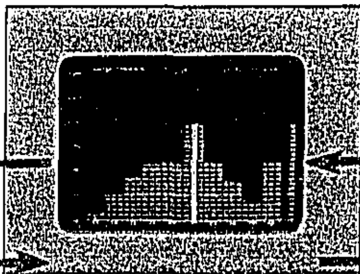
The instrument used to measure the individual's exposure to noise is known as a Noise Dose Meter. It is carried by the person all through the working day and it gives an indication of the dosage directly in % of allowed daily exposure. If the dosage indicated at the end of the day is greater than 100% then the following problem should be asked: Is it possible to reduce the noise?

no

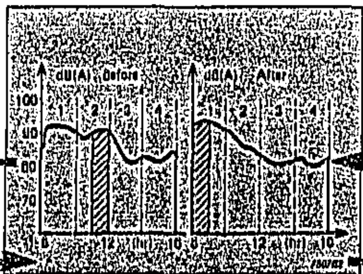
yes

The answer to this question is, almost without exception, YES. Of course, although it may be possible to reduce the noise, it may not be feasible to do so in practice due to the inordinate cost involved. The first few dB of noise reduction may perhaps cost nothing at all and may even save money in the long run. There comes a point, however, where further noise reduction involves appreciable investment.

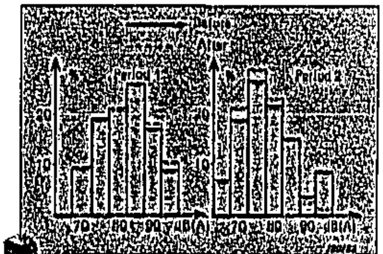
One way of investigating a noise problem is to analyse the frequency composition of the noise in octave or third octave bands. This method is very useful, for example, for detecting the most harmful noise sources, for selecting suitable absorbant material or for determining the necessary dimensions for an acoustic enclosure. One could use a combined sound level meter and octave analyser or a precision sound level meter in conjunction with an octave or a third octave filter set.



If a real time analysis is needed in order to observe instantaneous changes in spectra, for example, following a change in the speed of a motor or a change in the cutting tool used by a lathe, then the Digital Frequency Analyzer Type 2131 can be employed. Subsequent modifications lead to noise reduction and often to an extension of the working life of the machines.

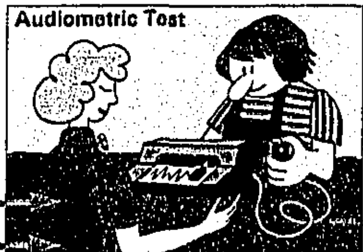


The two curves shown here represent the noise level in a workshop during a working day. The only difference between the two is that a particularly noisy machining process has been advanced 3 hours to coincide with the beginning of the day, when the noise level is already relatively high. Although the total acoustic energy in the two cases is the same this modification means that there is a period of relative quiet later in the day allowing the hearing faculty of the staff to recuperate.

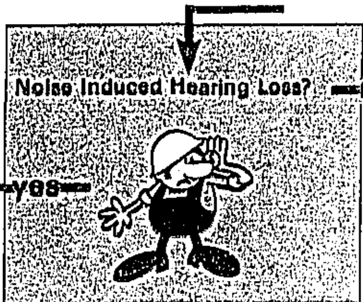


This improvement is the result of comparing the histograms of noise levels obtained for the first two periods of the day. Statistical analysis is performed by the Noise Level Analyzer Type 4426. It allows hearing damage potential of a noise to be assessed in a more extensive way than with only one L_{eq} value of a relatively long duration. Samples of the measured noise may be divided into a number of level classes which can be used to express e. g. peak noise levels or ambient noise levels.

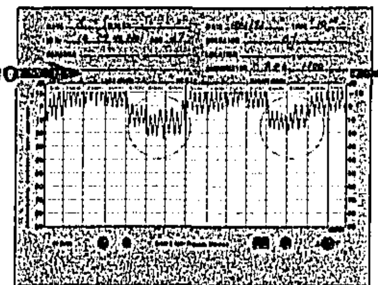
In the situation where it is no longer possible to reduce the noise, it is necessary to ensure the protection of the people whose noise dosage was found to be above 100%. This may be done, for example, by prescribing wearing of earplugs or ear muffs or rotation of personnel working at the most noisy posts with personnel working in quieter areas.



Even at this point of the hearing conservation programme not all noise problems are entirely solved. The limit corresponding to a dosage of 100% will protect most of the workers, but not necessarily all. The means of protecting the individual may not be perfect or are not used properly. The only way to obtain a guarantee of the success of the programme is to test the hearing ability of the employees periodically.



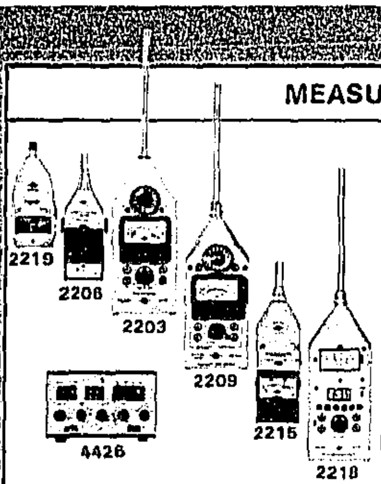
The interest in these tests is twofold: firstly, they are a means of directly verifying the efficacy of the methods used to reduce the noise or to protect the personnel, and secondly they allow hearing damage to be detected before the person being tested has difficulties in comprehending normal speech. The periodical use of such tests is therefore an effective preventative method.



Prolonged exposure to excessive noise levels leads to damage of the inner ear, which is often evident on an audiogram as a characteristic "hollow" in the region of 4 to 6000 Hz. Audiograms such as these can be automatically recorded by the B & K Audiometer Type 1800. The Audiometer measures the hearing threshold level of a person at 7 selected frequencies for each ear and gives the result as a sawtoothed line calibrated in dB of hearing loss.

Whatever the results, it is necessary to repeat the tests every 6 months or every year, according to the risk of hearing damage because the noise climate in a particular establishment may be constantly changing.
Further information enabling a noise reduction programme to be established following the general plan described here may be obtained from your local B & K representative.

MEASURING NOISE LEVELS (dB(A) and L_{eq})



FEATURES		2219	2206	2203	2209	2215	2218	4426
Meet SLM Standards	IEC DIN 45 ANSI Type	123 634 S2	179 633' S1	179 633' 1	179A 633¦ 1	179 633' S1	179A 633¦ S1	179A 633¦ S1
Weighting Networks		A	A C	A B C	A B C D	A C	A	A
Impulse Noise								
L_{eq}							*	
Optional ext. Filters								
Built-in octave Filters								
Digital Readout							**	

*) And L_{AX}, Single Event Exposure Level **) L_{eq} only

MEASURING NOISE EXPOSURE (DOSE and L_{eq})

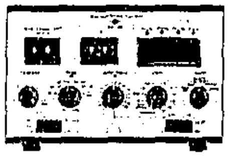
Noise Dose Meters 4424 (ISO) 4425 (OSHA)

- Rugged 1/2" condenser microphone
- Cover plates for concealed or visible readout
- Lamp indicates exposure greater than 115 dB(A), "Slow"
- Accelerated mode for quick evaluation of cyclical noise environments
- Digital readout of noise dosis from 0 to 9999% of the permitted noise exposure
- Battery life 80 hours (8 h/day)

Precision Integrating Sound Level Meter 2218

- Liquid crystal display of L_{eq} and L_{AX}
- Preselection of integrating period up to 27.8 h
- L_{eq} ranges 25 to 105, 45 to 125 and 65 to 145 dB(A)
- Sound level display on linear 50 dB meter scale
- "Fast", "Slow", "Impulse" and "Peak Hold"
- Linear and A-weighting
- Performs as vibration meter with appropriate accessories
- AC and DC outputs

STATISTICAL ANALYSIS



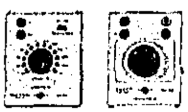
Noise Level Analyser 4426

- Direct readout of L_N, L_{eq}, propability distribution and cumulative distribution
- Digital indication of sound level
- Sampling intervals selectable 0.1 to 10 seconds
- Preset measurement time up to 180 hours
- 64 dB measuring ranges
- 256 amplitude cells of 1/4 dB resolution
- Internal battery power supply
- Amplitude distribution in 2 dB intervals on the Printer 2312 or on a Level Recorder

FREQUENCY ANALYSIS

Sound Level Meter and Octave Analyser 2215

- 10 octave filters
- 20 Hz to 20 kHz
- 26 to 140 dB(A)
- 30 dB linear scale
- A and C weighting + Linear

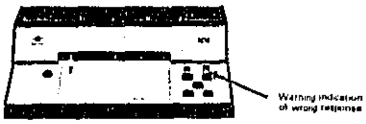


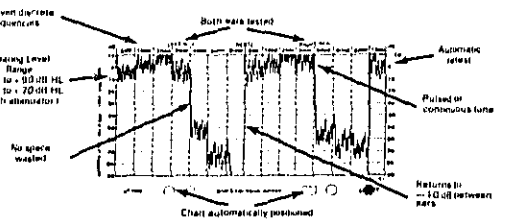
Octave Filter Set 1613
1/3 Octave Filter Set 1616

- attach directly on 2203, 2209 and 2218

AUDIOMETRIC TESTING

Automatic Recording Audiometer 1800





U.S. Department of Labor

Occupational Safety and Health Administration
Washington, D.C. 20210

Reply to the Attention of:

MAR 18 1982

MEMORANDUM TO: PERSONS REQUESTING COPIES OF INTERPRETATIONS OF HEARING CONSERVATION AMENDMENT

FROM: ALICE SUTER AS

Enclosed is a copy of the interpretations which were mailed to OSHA's Regional Administrators on March 11, 1982. If you have any questions about them you can contact Deborah Feldman at 202-523-7151 or Mary Ann Garrahan at 202-523-8031. Thanks for your interest.

ATTACHMENT

Interpretations

1. Q: (j)(8)(iv)(a)--The follow-up procedure for the audiometric testing program requires the employer to inform the employee in writing, within 21 days of the determination, of the existence of a significant threshold shift (STS).

   (a) Is it 21 calendar days?

   A: Yes.

   (b) From what point does the 21-day period begin?

   A: The amendment specifies 21 days from the determination. For companies with in-house testing capabilities, the determination of STS could occur at the time of testing, or at the time the annual audiogram is compared to the baseline. In cases where the company sends its test results to a professional reviewer, the determination would occur when the employer receives the results of the review.

2. Q: Should we consider issuing a citation for failure to provide audiograms where the only time employee noise exposures exceeded a TWA of 85dB was during an isolated incident, such as a process breakdown?

   A: Evaluate the individual circumstances and use professional judgment to determine if the condition may warrant a de minimis violation instead.

3. Q: Should an employer be cited for not posting a copy of the noise standard if the employer made copies available to each affected employee?

A: No. The intent of the requirement is to ensure that employees are able to read the standard without having to ask for it. Therefore, compliance efforts should not be concentrated on citing such an employer, who clearly met the intent of the standard. Likewise, the intent of the posting requirement is met where there is a good training program and the standard is readily available to affected employees.

4. Q: Must noise-induced hearing losses be reported on the OSHA 200 form?

A: Yes. 29 CFR 1904.2 sets forth the requirement for reporting occupational illness (e.g., noise-induced hearing loss) and injuries. For enforcement purposes, generally consider a citation where an employer failed to report on the OSHA 200 form a hearing loss equal to or greater than 20 dB at any test frequency, and where that employee's TWA noise exposure is 85dB or greater. If the employee was referred to a physician and it was determined that the loss was not work-related, then the loss does not have to be reported.

5. Q: Who pays for audiometric test referrals required by (j)(8)(iv)(b)?

A: The employer must pay for the initial referral to an audiologist or physician, as appropriate, regardless of the final diagnosis, where the professional determined that additional testing was necessary to ascertain the validity of the test results, or if the professional suspected that a medical pathology of the ear was caused or aggravated by wearing hearing protectors.

For example: The physician determined on a referral visit that the professional's suspicion was incorrect: that, in the physician's judgment, the protective device is not causing or aggravating the employee's medical condition. The employer must, however, assume the cost of the initial visit of such a referral.

6. Q: Are there any situations where the employer does not have to pay for a referral?

A: Yes. If the professional determines that the audiometric test results are consistent with a medical problem that is not related to the wearing of hearing protectors (such as an upper respiratory infection), then the employer does not have to pay for the referral. In such cases, however, the employee should be told about the problem and should be advised to see a physician (1910.95(j)(8)(iv)(c).)

7. Q: Since follow-up measures are only triggered upon identification of STS, must the employer pay for a referral where it is determined that the validity of the baseline results is questionable?

A: The amendment requires the employer to establish a valid baseline audiogram for each employee who is exposed at or above an average level of 85 dB. If the professional reviewer determines that the results are suspicious and feels that further testing is necessary, the employer must bear the expense of this referral, because it is incidental to the duty to obtain a valid baseline audiogram (1910.95(j)(5)(i).)

8. Q: Are employers required to maintain noise exposure measurement records and audiograms performed prior to the effective date of the new amendment?

A: Yes. All historical employee exposure and medical records (e.g., audiograms) existing as of July 19, 1978, are subject to the Access to Employee Exposure and Medical Records standard (29 CFR 1910.20).

9. Q: Does OSHA accept baseline audiograms taken before the effective date of the amendment?

A: Yes. We should accept or "grandfather" older baseline audiograms that reflect reasonable compliance with the audiometric test requirements of the amendment. To be acceptable, baseline audiograms should be administered by a trained technician, taken at the required test frequencies (500, 1000, 2000, 3000, 4000, and 6000 Hz) in a reasonably quiet room, and with calibrated equipment.

In choosing the appropriate baseline, the professional (or employer) should screen the old baselines to identify the ones that are reasonably in compliance. Out of those, the audiogram with the best (lowest) threshold should be selected as the baseline audiogram.

10. Q: Is a company allowed to disregard old audiograms that are acceptable as a baseline audiogram, and instead elect to perform a new baseline?

A: It was never the intent of the new amendment to allow employers to disregard any valid audiograms administered prior to the effective date. In fact, the preamble to the amendment (46 F.R. 42626) explains why it is more protective to allow the use of valid, older audiograms. Thus, document in the case file any evidence of such a practice, and use it to support why reduced credit for "good faith" may be necessary when calculating penalties for any noise violations.

11. Q: When should the annual audiogram be performed if a "grandfathered" audiogram--i.e., one obtained before August 22, 1981, the effective date of the amendment--is used as the baseline?

A: The annual audiogram must be performed by August 22, 1983, when a "grandfathered" audiogram is used as the baseline.

Employers who chose to obtain new baselines must complete annual audiograms within 1 year of the baseline date.

12. Q: When do baselines have to be conducted for new employees (after August 22, 1982)?

A: As soon as possible (e.g., pre-employment), but no later than 1 year from the date of the employee's first exposure to noise levels at or above an 8-hour TWA of 85 dB.

13. Q: Can results of noise monitoring performed prior to August 22, 1981, be used towards complying with the new amendment?

A: Yes. Any past monitoring results may be used which identify employees who must be included in the hearing conservation program. Additional monitoring may be necessary where:

a. There has been a change in production, process, control, or personnel which may result in new or additional noise exposure; or

b. Additional employees who were not originally identified (because past monitoring did not take into consideration all continuous, intermittent, and impulsive sound levels from 80 dB to 130 dB, and so these levels were not integrated into the computation) may need to be included in the program.

14. Q: If an employer decides to include all employees, regardless of their exposure, in the hearing conservation program, is monitoring still required?

A: Yes, some monitoring may be necessary to assure that workers are adequately protected. The intent of the requirement for workplace noise monitoring is to identify employees who need to be included in the hearing conservation program. Employers have some flexibility in how they achieve this regulatory goal.

Thus, an employer may choose to include all workers (regardless of individual noise exposure level) in the hearing conservation program, as long as all of the other provisions of the standard are followed for each employee. Some of these provisions may require some monitoring of the noise levels to assure that workers are adequately protected. For example:

a. Hearing protectors must attenuate employee noise exposure at least to a time-weighted average (TWA) of 90 decibels. (29 CFR 1910.95(m)(2).)

b. For employees who have experienced a significant threshold shift, hearing protectors must attenuate employee noise exposures to a TWA of 85 decibels or below. (29 CFR 1910.95(m)(3).)

c. Hearing protectors are mandatory for employees who are exposed to a TWA of 85 decibels or greater and who have experienced a significant threshold shift. (29 CFR 1910.95(l)(2)(i).)

d. An employee's audiogram record shall include the employee's most recent noise exposure assessment. (29 CFR 1910.95(q)(2)(ii)(f).)

15. Q: Is the 85 decibel "action level" adjusted for workshifts greater or less than 8 hours?

A: Yes. The concept of "action level" used in this amendment relates to employee noise exposures that equal or exceed an 8-hour TWA of 85 dBA, or a dose of 50 percent. Thus, the "action level" could be greater than 85 dB for exposures less than 8 hours, or less than 85 dB for shifts greater than 8 hours. Appendix A to the amendment must be used to adjust the "action level" for workshifts greater or less than 8 hours.

16. Q: Can an employer allow an employee to work in an area where noise exposures exceed a TWA of 85 dB when such an employee elects not to participate in the audiometric testing program?

A: Yes. OSHA does not make it mandatory for an employee to participate in the testing program. However, the employer may, on his own prerogative, make taking the audiometric test a condition of employment.

Where an employee elects not to participate, the employer must still be in compliance with the following:

a. The audiometric testing is offered annually (1910.95(j)(6)(i)) and at a time and location convenient to the employee (1910.95(j)(6)(ii)); and

b. The employer has informed the employee of the purposes of audiometric testing, explained the test procedures, and described the effects of noise on hearing (1910.95(n)(j)).

17. Q: What method should compliance officers use to determine the adequacy of hearing protector attenuation?

A: The most convenient and simple method to determine whether the specific hearing protector offers sufficient attenuation for the employees' working environment is based on the NRR (Noise Reduction Rating), which appears on the hearing protector package. See Appendix G. of the amendment.

18. Q: Can records required by the amendment be stored in a central location?

A: Yes, if they are available and accessible when necessary.

19. Q: Is a referral automatically triggered when an STS is identified?

A: No, a referral is only required when the professional determined that the results are questionable and that wearing hearing protectors is aggravating or causing a medical condition of the ear. (See 1910.95 (j)(8)(b).)

20\. Q: Can a film or newsletter alone constitute training?

A: Yes, as long as the employer was able to meet the requirements of (n)(2), which states that training must be repeated annually for each affected employee and must be updated to be consistent with changes in protective equipment and work processes. OSHA, however, encourages employers to be available during the training session so that any questions employees may have could be addressed.

21\. Q: How is STS defined in the August amendment?

A: STS is defined as a 20 dB shift at any frequency, as stated in the IHFOM. However, for employers who already have ongoing programs, any definition that is as protective as a 20 dB shift at any frequency can be used. In the preamble (46 FR 42628) employers are made aware that OSHA will use the definition of 20 dB at any frequency in their enforcement procedures.

22\. Q: Can hearing protectors be worn to substitute for the quiet period prior to a baseline audiogram?

A: Yes. If the correct use of hearing protectors is well supervised on the day of the baseline test, hearing protectors can be used to substitute for the quiet period. Employers should be encouraged to issue ear muffs on the day of the baseline test.

EDUCATION PROGRAMS

Subjects: A. Effects of Noise on Hearing
B. Purpose of Hearing Protectors
C. Purpose of Audiometric Testing
} Same communicated during fitting of HPD's

Purpose to gain employees support & cooperation

ESSENTIALS Evidence; Reasoning (analogy); Motivation; Suggestion (emphasize positive)
authority (concrete examples) — grass — detriments, effects of hrg. loss (security, social acceptance - self expression/participation (give choice) recognition + respect

Identify problem; explain remedial measures; recommend specific corrective action

- Visual aids; practice actions or talk about it (e.g., inserting ear plugs)
- Look at audience; try to relate to them - understand their value system; make contact (visual)
- Employee has instinctive defense against new ideas; limit emphasis to key points
  - Program has to be simple
  - Protection of hearing - through use of HPD. RECAP
- Stay within time allowed

- Gibson's film SOS is good. DEEP EAR also good.

Sound of Sound - AO

- Handouts should be catchy, picturesque, use visual aids

AUDIOMETRIC TESTING

1. Establish BASELINE AUDIOGRAM ; identify prior noise exposure
(manual audiometry deprecated)

Audiogram Review & Interpretation : computer (screened) ; technician (screening) ; professional review
- interpreter should know whether subject has relevant history - knowledge of hrg. loss, previous tests, exposure, etc.

Referral Criteria of subject is marginal, give in-house counseling, notice of referral
- note abnormal hearing loss patterns (e.g., low-freq loss - sudden)

Significant Threshold Shift (STS) (doesn't say anything quantitative)
(20 dB or more at any frequency or
15 dB or more at any 3 adj. freqs)
A.I - 10 dB or more in either 5, 1 + 2
or 3, 4 + 6

Employee Notification -

R E S T A U R A N T S

Chateau Gesundheit
(Continential Cuisine)
7141 Wisconsin Avenue
Bethesda, Maryland
(301) 657-8080

Diplomat Restaurant
(Greek Cuisine)
7345 Wisconsin Avenue
Bethesda, Maryland
(301) 657-3058

Bish Thompson's
(Seafood)
7935 Wisconsin Avenue
Bethesda, Maryland
(301) 656-2400

Michelle's
(French Cuisine)
7904 Woodmont Avenue
Bethesda, Maryland
(301) 656-0720

O'Donnells
(Seafood)
8301 Wisconsin Avenue
Bethesda, Maryland
(301) 656-6200

Poor Richard's
Chevy Chase Holiday Inn

Szechuan Peking Restaurant
7944 Wisconsin Avenue
Bethesda, Maryland
(301) 652-6460

Japanese Steak House
7845 Wisconsin Avenue
Bethesda, Maryland
(301) 656-1344

Benihana of Tokoyo
7315 Wisconsin Avenue
Bethesda, Maryland
(301) 652-5391

3/25/82

Notes on Feldman's Talk

· Occupational Hearing Conservationist - supplement for Audiometric Testing Technician (see Feldman paper under "Model Hrg Cons. Prog")

Suter · no change in current provisions of reg likely in near future
· NIOSH is part of DHHS (formerly DHEW)

re the Reg (Standard). p. 4131 starts summary & explanation
p. 4161 starts real amendment - sections (c) thru (s).
(This is of Jan. 16th 1981 publication)
originally effective 90 days after publication.

Aug. 21 - version - as a result of stay & review

ANPRM is coming out - to establish what is best "trigger" level for requiring HCP. - soliciting data on dose/response for effects on hrg.

was there a proposal before final rule?
90 dB leaves 20-25% of pop unprotected
85 dB " abt 10%
80 dB " practically nobody unprotected

what is appropriate fence? (25 dB) - which frequencies use? add 4 kHz or 500 Hz

Looking for dose-response on extra-auditory effects.

Fletcher: NOISE SURVEY: (Type 2 SLM adequate)
EQPMT Needed: SLM & Calibrator; plus perspective & organization (logical) / technique
· Report summarizing, interpreting results & providing recommendations

Organization of Noise Survey
1. Know plant layout, operations, staff assignments and related attributes, e.g. working materials (stock); machine operation schedule
(Need as guide plant manager, dept foremen, etc.)

Personally fit HPD's - & simultaneously indoctrinate worker
· Supervision in use is problematical with insert HPD's -
· Inserts not good for intermittent use; muffs not so good for long-time use
· muffs can be defeated - spring tension, drilled holes, heavy glass frames.
· Combined muff & plug don't help much.

ROCKVILLE/GAITHERSBURG AREA
MAY WE SUGGEST:

RESTAURANTS
(To Name a Few)

JASON
The Sheraton Potomac Inn's own incomparable dining room
x583

Harvey's
"Restaurant of the Presidents"
258-9670

Victoria Station
"Purveyor of Prime Rib & Potable Spirits"
948-5775

Claude's Bistro
"Fine French Cuisine"
258-0405

Red Lobster
"For the Seafood Lover in You"
840-0380

Valles
Varied, inexpensive menu
948-1755

La Gondola
Atmosphere, fine service, inexpensive Italian dinner
977-6944

THEATRES

Harlequin Dinner Theatre
Broadway Shows, Sumptuous Buffet
340-8515

Six Movie Theatres at White Flint Mall
881-5207

MALLS

Montgomery Mall

White Flint Mall

Lakeforest Mall

GOLF COURSES

Montgomery Village Golf Course (Private Club.) Sheraton Potomac Inn guests have playing privileges.

Red Gate Golf Course (Public)

Taxi Fares to the above are less than $4.00, except to White Flint and Montgomery Malls.

Negotiate Contract

1. Personnel + SERVICES PROVIDED - who, where + how supervised ?
2. Testing Specifications
3. Test Unit
4. Equipment /Calibration
5. Scheduling Requirements - Yours and Theirs   max. no. of people per hr, per day . contingencies
6. Record Keeping - Who - What - How   - Lab keeps originals; sends copies to employer
7. Confidentiality - What is Specified   - How releasable?
8. Standards - What is expected from company, vendor   - employees delivered after 14 hrs. noise-free (note violations on record)
9. Indemnity
10. Insurance   - vendor must have liability insurance
11. Subcontracting - is or is not available
12. Term of contract: Open, renewable, etc.
13. Cancellation privileges
14. Cost
15. Payment Schedules

Feldman
Schedule

- Education of employees - at audiometric test area - visual aids, handouts, audio aids, direct speech.
- Make convenient arrangements for re-test of subjects who have bizarre audiograms (maybe subcontract to local clinic)
- Have to train technicians to run audiograms - too expensive for audiologist to do them.
- (Feldman has recently charged about $7 per test in van)

→ • The important thing is to sell a whole package of services, not just the cheap testing.
  - perhaps by annual retaining

Hearing Conservation: A Legislative Challenge
to the Profession

Tentative Agenda

<u>Thursday, March 25, 1982</u>

		8:30	Registration/Coffee
		9:00	Welcome and Introductions
Chairman - E. Cherow	<u>Professional Growth: A Point of View</u>		
	Feldman	9:10 - 9:30	The Audiologist and Industry
Chairman - A. Feldman	<u>The Legislative Mandate</u>		
	Suter	9:30 - 10:45	The Status of the OSHA Hearing Conservation Amendment - Implications for Audiology Practice
		10:45	COFFEE BREAK
Chairman - J. McCallum	<u>The Physiological Threat</u>		
	Suter	11:00 - 12:00	Noise Exposure and Damage
		12:00 - 1:00	Luncheon
Chairman - M. Kramer	<u>A Model Hearing Conservation Program</u>		
	Fletcher	1:00 - 2:00	Conducting Noise Survey and Monitoring Programs
Chairman - M. Kramer	Fletcher	2:00 - 3:00	Hearing Protection Devices
		3:00	BEVERAGE BREAK
Chairman - M. Miller	McCallum	3:15 - 4:00	Employee and Management Education
	Feldman	4:00 - 4:30	Audiometric Testing, Review and Referral
	Kramer	4:30 - 5:00	Recent Advances in Equipment
		5:00 - 5:30	Exhibitors Forum
		5:30 - 6:30	Reception

to USI

<u>Friday, March 26, 1982</u>

Chairman - J. Fletcher	<u>Training</u>		
	Miller	8:30 - 9:30	The Council for Accreditation in Occupational Hearing Conservation

Marketing Services

(besides items on other page

- Exhibits
- Industrial Hrg Conservation Courses
- Visit plants – (from Mfg Assoc) – knock on doors
- Stress uniqueness of service/company.
- Use "show & tell" machine – audio-visual – slides w- voice-over
- Professional (Health Screening – Hearing Conservation) at lowest cost

Chairman - J. McCallum	**Medicolegal Matters**		
	Feldman	9:30 - 10:15	Workers Compensation
		10:15	COFFEE BREAK
	Kramer	10:30 - 11:15	Forensic Audiology: A Responsibility
		11:15 - 12:00	Recordkeeping
		12:00 - 1:00	Luncheon
Chairman - A. Suter	**Service Delivery Models**		
	McCallum	1:00 - 1:30	The Audiologist Full-Time Within Industry
	Kramer	1:30 - 2:00	Private Practice Consultation
	Feldman	2:00 - 2:30	Perspectives from Other Clinical Settings
		2:30	BEVERAGE BREAK
Chairman - A. Suter	**Academic Training**		
	Miller	2:45 - 3:30	Curriculum/Practicum: Academic Program Expansion
Chairman - E. Cherow	**A Panel Discussion**		
	Feldman; Miller	3:30 - 4:00	How to Market Your Services ✓
	All Faculty	4:00 - 4:30	Questions/Evaluation/Closing ✓

to EPA

- Use "prospectus" - who work for Finley's Fee
  - check companies that have gotten citations

- Package what you have to sell - conjure up an image (maybe develop tape with hi-freq. missing to show what conversation sounds like with hi-freq loss)
- Reasons for us
  - Workers compensation - increased awards
  - Compliance w. Federal regulations
  - Humanitarian - improved health of employee
  - (Reynolds Alum - reduced workers compensation after HCA)

Techniques: • Advertise (Occupational Hazards mag)
- Flyers - describe services - Tear-off returns

Kramer — Services to provide:

1. Noise / exposure measurements
2. Audiometric testing
   - pre-employment
   - baseline
   - periodic
   - forensic
   - diagnostic
   - who will run tests? · where?
   - recommend in-plant testing / facilities?
   - computerized records / files / data processing
     - notification of employees
3. · Recordkeeping - noise data, audiometric tests, etc.
4. Hearing protection
   - evaluation, selection
   - Fitting of employees - acceptability, aesthetics, etc.
5. Education
   - employees - risks, value of HPD's
   - source of materials: commercial (e.g. Belson)
   - management
   - contents / reqmts of OSHA regulations

   (re. act as source of info)
6. Knowledge of Regulatory / Enforcement policies, procedures, developments
7. Qualify as Expert Witness
8. General Consultation
   - know when to bring in other experts.
   - assist attorney in developing case, brief
   - validity of workmen's compensation claims

If plant has 150-175 people, it pays to set up their own test equipment & facility

Feldman: · Having audiograms atyelly office is too expensive for employer, because of employee travel time.
· Doesn't recommend mobile test van - too expensive for supplier
(FM note: Maybe collapsible booth)

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BL Individual Noise & Hearing Conservation
Carl Harford

Dove-Lipscomb, Noise & Audiology
Univ. Park Press

ASHA, Noise as a Public Health Problem

Hearing Conservation: A Legislative Challenge
to the Profession

Thursday, March 25, 1982

		8:30	Registration/Coffee
		9:00	Welcome and Introductions
Chairman - E. Cherow	Professional Growth: A Point of View		
	Feldman	9:10 - 9:30	The Audiologist and Industry
Chairman - A. Feldman	The Legislative Mandate		
	Suter	9:30 - 10:45	The Status of the OSHA Hearing Conservation Amendment - Implications for Audiology Practice
		10:45	COFFEE BREAK
Chairman - J. McCallum	The Physiological Threat		
	Suter	11:00 - 12:00	Noise Exposure and Damage
		12:00 - 1:00	Luncheon
Chairman - M. Kramer	A Model Hearing Conservation Program		
	Fletcher	1:00 - 2:00	Conducting Noise Survey and Monitoring Programs
Chairman - M. Kramer	Fletcher	2:00 - 3:00	Hearing Protection Devices
		3:00	BEVERAGE BREAK
Chairman - M. Miller	McCallum	3:15 - 4:00	Employee and Management Education
	Feldman	4:00 - 4:30	Audiometric Testing, Review and Referral
	Kramer	4:30 - 5:00	Recent Advances in Equipment
		5:00 - 5:30	Exhibitors Forum
		5:30 - 6:30	Reception

Friday, March 26, 1982

Chairman - J. Fletcher	Training		
	Miller	8:30 - 9:30	The Council for Accreditation in Occupational Hearing Conservation

Chairman - J. McCallum	<u>Medicolegal Matters</u>		
	Feldman	9:30 - 10:15	Workers Compensation
		10:15	COFFEE BREAK
	Kramer	10:30 - 11:15	Forensic Audiology: A Responsibility
		11:15 - 12:00	Recordkeeping
		12:00 - 1:00	Luncheon
Chairman - A. Suter	<u>Service Delivery Models</u>		
	McCallum	1:00 - 1:30	The Audiologist Full-Time Within Industry
	Kramer	1:30 - 2:00	Private Practice Consultation
	Feldman	2:00 - 2:30	Perspectives from Other Clinical Settings
		2:30	BEVERAGE BREAK
Chairman - A. Suter	<u>Academic Training</u>		
	Miller	2:45 - 3:30	Curriculum/Practicum: Academic Program Expansion
Chairman - E. Cherow	<u>A Panel Discussion</u>		
	Feldman; Miller	3:30 - 4:00	How to Market Your Services
	All Faculty	4:00 - 4:30	Questions/Evaluation/ Closing

Volume 3, Number 1

Occupational Hearing Conservation:
State of the Art
Maurice H. Miller Ph.D.

Comprehensive descriptions of the current state of knowledge in audiology and related disciplines.

Monographs in Contemporary Audiology

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Correspondence may be sent to the editors at the address below. Permission to quote material contained in this issue is hereby granted if permission is also obtained from the author(s) and if credit is given to the author(s) and this journal.

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Occupational Hearing Conservation: State of the Art

By

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Monographs in Contemporary Audiology

Volume 3, Number 1 November, 1981

REGULATIONS

federal register

Friday
August 21, 1981

Part III

Department of Labor

Occupational Safety and Health Administration

Occupational Noise Exposure; Hearing Conservation Amendment; Rule and Proposed Rule

DEPARTMENT OF LABOR

Occupational Safety and Health Administration

29 CFR Part 1910

Occupational Noise Exposure; Hearing Conservation Amendment

AGENCY: Occupational Safety and Health Administration (OSHA), Labor.

ACTION: Partial lifting of administrative stay; request for comments; clarification and interpretation of rule; corrections.

SUMMARY: On January 16, 1981 OSHA published an amendment to its occupational noise exposure standard (46 FR 4078) requiring hearing conservation programs for all employees whose noise exposures equal or exceed an 8-hour time-weighted average sound level (TWA) of 85 decibels (dB). The amendment was to become effective on April 15, 1981, with various provisions being phased in over a two year period. OSHA deferred the effective date of the amendment until August 22, 1981 in order to give the Agency time to evaluate numerous requests for clarification and petitions for administrative stay.

By its action today, OSHA is (1) lifting the administrative stay as to many portions of the amendment, (2) making certain technical corrections, (3) inviting public comment on the continuation of the stay for other provisions, (4) inviting new information and comments on the merits of many provisions in the hearing conservation amendment and (5) clarifying various provisions of the amendment.

DATES: Except for those provisions that continue to be stayed, the amendment is effective August 22, 1981. See Supplementary Information for details. Comments on the continuation of the stay must be received by September 22, 1981. Comments on the provisions which are reopened must be received by November 23, 1981.

ADDRESSES: Written comments should be submitted to the OSHA Docket Office, Docket No. H-011, Room S-6212, U.S. Department of Labor, 200 Constitution Avenue, NW., Washington, D.C. 20210, telephone 202-523-7894.

FOR FURTHER INFORMATION CONTACT: Dr. Alice Suter, Office of Physical Agents Standards, Occupational Safety and Health Administration, Room N-3718, U.S. Department of Labor, 200 Constitution Avenue, N.W., Washington, D.C. 20210, Telephone (202) 523-7151.

SUPPLEMENTARY INFORMATION:

I. Background

On January 16, 1981 (46 FR 4078) OSHA promulgated an amendment to its occupational noise exposure standard (29 CFR 1910.95 (a) and (b)).[1] The new hearing conservation amendment requires employers to provide an effective hearing conservation program for all employees exposed to an 8 hour TWA of 85 dB.[2] This amendment supplements the existing standard and specifies the essential elements of an effective hearing conservation program. Briefly, the amendment contains requirements for monitoring employee noise exposure, annual audiometric testing for those employees exposed at or above a TWA of 85 dB, the proper selection of hearing protectors such as ear plugs, education and training of employees, warning signs and the keeping of records pertaining to exposure monitoring and audiometric testing.

The amendment covers all employees who work for employers covered by the Act except those engaged in construction or agriculture. OSHA estimated that at least 5.1 million employees in as many as 300,000 establishments have noise exposures above 85 dB and are therefore covered by the amendment. The amendment was estimated to cost approximately $254 million per year[3] or $53 per worker per year.

Employers were given 90 days in which to become familiar with the standard. Various provisions of the standard were to be phased in over a two year period. For example, employers were given 6 months from the effective date of the standard to do initial determinations and to monitor the employee exposures (originally this was to be done by October 15, 1981). Baseline audiograms had to be completed within a year of the effective date of the standard (April 15, 1982) and employers were given an additional year in which to obtain certain equipment such as audiometric test booths and dosimeters meeting the requirements of the standard.

After the amendment was promulgated the Agency received numerous requests for clarifications and interpretations of various provisions of the standard. A number of objections based on misunderstandings of certain portions of the standard or preamble were also received. In addition, there were petitions for administrative stay and a number of requests that the entire amendment be reconsidered pursuant to Executive Order 12291 (46 FR 13193) which was issued on February 17, 1981. Over 250 comments, petitions, and requests for clarification were received and it was necessary for the Agency to defer the effective date of the standard several times (see 46 FR 21365, 4/10/81, 46 FR 28845, 5/29/81 and 46 FR 39137, 7/31/81) in order to evaluate the merits of the numerous petitions and comments. Petitions for judicial review under section 6(f) of the Act have been filed by the Chocolate Manufacturers Association, Chamber of Commerce, American Iron and Steel Institute, Flock Industries, Inc., and the AFL-CIO.

OSHA has very carefully reviewed and analyzed all of the comments, petitions, and requests for clarifications in light of the lengthy preamble to the amendment and consistent with the requirements of E.O. 12291 to evalute the cost-effectiveness of agency regulations. Based on this review, OSHA has decided that major portions of the amendment which are outlined below should be allowed to go into effect. The underlying rationale for these requirements can be found in the preamble to the January 16, 1981 rule (see 46 FR 4078 *et seq.*), which is hereby reaffirmed for those portions going into effect. A Regulatory Impact Analysis conforming to the requirements of Executive Order 12291 has been prepared and is summarized briefly below. The petitions for administrative stay are therefore denied insofar as they relate to the portions of the amendment which are being put into effect. More detailed reasons for denying those parts of the petitions will be sent to the petitioners shortly. OSHA concludes that the provisions which are going into effect on August 22 constitute a coherent and protective hearing conservation amendment.

Many of the petitions, comments and objections were based on misinterpretations of the meaning and

[1] The existing standard sets a permissible exposure level for noise of 90 dB as an 8 hour time weighted average and requires the employer to reduce employee exposure to within this level by the use of feasible engineering controls or administrative controls. In addition, the existing standard requires that a "continuing effective hearing conservation program" be implemented when employee exposure exceeds 90 dB without regard to the use of hearing protectors, but the standard does not spell out the elements of such a hearing conservation program.

[2] Assuming an exchange rate of 5 dB, a TWA of 85 dB is approximately half a TWA of 90 dB.

[3] The actual cost of the amendment was estimated to be about $270 million per year, but this figure was adjusted to $254 million per year in recognition of the ongoing hearing conservation programs some employers have established. Therefore, the $254 million dollar estimate contained in the Regulatory Analysis represents the amount of new cost that would be incurred by industry as a result of the amendment. This cost has subsequently been recalculated, based on new information, to $234.0 million.

purpose of certain portions of the amendment. Where this was the case, the discussion below provides explanations and clarifications in response to these comments. In addition, in some instances comments pointed out clear errors in the standard. These errors in the standard are also discussed and corrected below.

As to certain other provisions, the Agency is reopening the record for additional comment. Generally, the record has been reopened for substantive comment where there is reason to believe, based on the comments received to date, that there may be a more cost effective way of accomplishing the desired result of saving employee hearing, or where new information as to the feasibility or desirability of a requirement has been submitted which deserves further evaluation.

For most of the provisions on which the record is being reopened, comments are also requested on whether these provisions should continue to be stayed while the public is given an opportunity to submit their substantive comments and these comments are evaluated. A short period of time (30 days) is being given in which to comment on whether these provisions should continue to be stayed. In the meantime, these provisions are stayed. After considering all timely public comments on whether the interim stays should be allowed to remain in effect pending consideration of the substantive comments, the Assistant Secretary will make a decision on the stays which will be published in the Federal Register.

This procedure is considered to be the most practical way of resolving the stay matter and to comply with all procedural requirements which may apply. The alternative of allowing these provisions to go into effect for the brief period of time necessary to solicit public comment and then possibly reinstituting the stay would be confusing to employers and employees. In addition such a course of action would not result in any increased employee protection since essentially no action need be completed within the time period given for comments on the stay. Where public comment has been requested as to whether the stay should continue, substantial questions have been raised concerning the extent to which these provisions contribute to occupational safety and health and whether their inclusion in the standard is necessary or appropriate. Therefore, at least until the public comments on the stay can be evaluated, it is inappropriate to allow these provisions to go into effect. Good cause is therefore found for continuing the administrative stay of these provisions whil epublic comments on the stay can be considered.

To assist the public in determining which portions of the standard are in effect and which portions are stayed, a copy of the amendment, with only those portions which are in effect, has been reprinted below.

II. Public Participation

A. Interim Stays

Interested persons are invited to submit written views and arguments as to whether the interim stay of any of the paragraphs discussed below should be allowed to continue pending reconsideration of the substantive requirements contained in these paragraphs. These comments must be submitted in quadruplicate to the Docket Officer, Docket H-011, Room S-6212, Department of Labor, 200 Constitution Avenue, N.W., Washington, D.C. 20210 and must be received in the Docket Office no later than September 22, 1981. Comments on the stays should be marked "stay" at the top of the first page. All submissions will be available for public inspection and copying at the above address.

B. Substantive Provisions

Interested persons are requested to submit written data, views and arguments on the provisions that are reopened below. Any hearing requests submitted will be given appropriate consideration. These comments must be submitted in quadruplicate to the Docket Officer, Docket H-011, Room S-6212, Department of Labor, 200 Constitutions Avenue, N.W., Washington, D.C. 20210. These submissions must be received in the Docket Office no later than November 23, 1981. The submissions will be available to the public for inspection and copying at the above address. All timely submissions received, as well as all post-promulgation comments and petitions which have already been submitted to the Agency, will be made part of the record of this proceeding and will be considered by the Assistant Secretary in making any modifications to the hearing conservation amendment.

III. Summary and Explanation of Actions Taken

The material below details and discusses the provisions of the hearing conservation amendment for which the interim stay is continuing. Several non-substantive or technical amendments and corrections are included. Also, specific questions are posed and substantive comments requested on the various provisions on which the record is being reopened. In addition, clarifications and interpretations which are responsive to comments received are given for many of the provisions which are going into effect.

Permissible Exposure Limit

The subject of the permissible exposure limit (PEL) was mentioned frequently in the comments and petitions. Many commenters confused the action level concept with the PEL and interpreted the amendment as lowering the PEL to 85 dB. The amendment does not lower the PEL to 85 dB; the PEL is still 90 dB (see 29 CFR 1910.95 (a) and (b)). The 85-dB TWA referred to in the amendment is an *action level* which triggers the initiation of hearing conservation programs. The issue of the appropriate PEL, including the appropriate exchange rate, will be considered in the near future when 29 CFR 1910.95 (a) and (b) are reviewed. This review will include consideration of the appropriate method of compliance with the permissible exposure level.

Hearing Conservation Program—Paragraph (c).

Paragraph (c) will be corrected by inserting the words "slow response" after "an 8-hour time-weighted average sound level measured on the A scale", in the first sentence. These words were inadvertently left out of the amendment and have been added to conform paragraph (c) with § 1910.95(a) and with the original intention as expressed in the preamble (see 46 FR 4137, 1/16/81).

Exposure Monitoring—Paragraphs (d)-(h).

The hearing conservation amendment required that employers make an initial determination concerning the need for monitoring. If the initial determination was positive, employers were required to measure *personal* noise doses for representative employees using equipment meeting minimum specifications and calibrated to ensure accuracy. This monitoring was required to be conducted at least every two years and within 60 days of a change of process which changed noise exposures to the extent that employees previously exposed below 85 dB would be exposed above 85 dB, or if the change was such that it rendered inadequate the hearing protectors issued.

The Agency received a number of requests to administratively stay and to reconsider the requirements for noise exposure monitoring. Probably the most serious objection came from employers who believed that personal exposure monitoring was unnecessary for purposes of hearing conservation programs. They stated that area monitoring is sufficient to identify the employees who need to be included in the program, and that area monitoring is simpler and less costly. The adequacy of hearing protector attenuation would be computed from sound levels obtained for the various areas in which employees worked.

Some employers maintained that the requirement for initial determination was unnecessary, and that the specific bases from which a positive determination could result were unnecessarily complicated and might lead to labor-management conflict. Other commenters objected to the requirement that the employee with the highest exposure be selected (if one employee was to represent the others), saying that the effect of such a requirement was to force employers to monitor all employees. In addition, comments objected to the periodic remonitoring requirement, stating that remonitoring every two years was costly and unnecessary, and that remonitoring when there was a change in process or equipment should be sufficient. Objections were raised to requiring employee exposure notification; also to the idea of notifying workers of their measured exposure levels since exposure levels might vary considerably for day-to-day. Moreover, notifying workers of their actual exposure levels would be difficult for employers using area monitoring. Commenters believed that individual notification was unnecessary and that posting a notice of exposure should suffice.

OSHA received many adverse comments on the requirements of paragraph (g), *Method of measurement*. Commenters questioned the accuracy of noise dosimeters, especially in impulsive noise conditions, and objected to setting the dosimeter's lower threshold at 80 dB. Some questioned the technical feasibility of dosimeters meeting the crest factor test specified in the standard. Rather than requiring the ANSI S1.25, Section 7.5 test for measuring a crest factor capability as high as 30 dB, it was suggested that the frequency, duration and repetition of the test signal be stated. Many comments were opposed to the inclusion of Appendix B, *Temporal Sampling Procedures for Use with a Sound Level Meter*. They stated that it was unnecessarily complex and rigorous. The sampling strategy outlined in Appendix B would be unnecessarily stringent if area monitoring procedures were to be used. The requirements for microphone placement would also be incompatible with the concept of area monitoring. The Agency also received comments objecting to the calibration requirements, stating that they were unnecessary.

The many objections to specific noise exposure monitoring requirements have persuaded OSHA to reconsider these provisions and seek further comment on their appropriateness. In the meantime, OSHA will require employers to monitor noise exposure where employees are exposed at or above an 8-hour time-weighted average of 85 dB, and the stay of all of the detailed monitoring requirements published in January will continue. Paragraphs (d) through (h) therefore are being stayed for further comment, with the exception of parts of paragraph (e) and paragraph (g)(2)(ii)(*b*). Thus, the monitoring obligation will consist of two sentences:

(e)(1) When information indicates that any employee's exposure may equal or exceed an 8-hour time-weighted average of 85 decibels, the employer shall obtain measurements for employees who may be exposed at or above that level.

(g)(2)(ii)(*b*) All continuous, intermittent, and impulsive sound levels from 80 dB to 130 dB shall be integrated into the computation.

As it now reads, the requirement for monitoring is a performance requirement. This change allows employers to use an area monitoring or a personal monitoring approach, with whatever measurement procedure they consider appropriate. While monitoring must be completed within 6 months, remonitoring may be done as often or as seldom as employers consider to be warranted by the circumstances. All continuous, intermittent and impulsive sounds between 80 dB and 130 dB must be included in the measurement, although the employer is free to use any instruments or measurement technique that will do this. While the standard which is going into effect does not require the employer to calculate each employee's noise dose, the standard does require all employees exposed at or above a TWA of 85 dB to be included in a hearing conservation program. Therefore, when enforcing the standard, OSHA will inspect to determine whether employers have failed to include in the hearing conservation program all employees whose exposures equal or exceed a TWA of 85 dB.

Comments are requested on whether the interim stay of the monitoring provisions should continue. In addition, in order to evaluate the monitoring provisions, OSHA is requesting comments, information, and data on the following:

1. The need for monitoring to achieve a successful hearing conservation program.
2. The need for an initial determination, to help focus on whether monitoring is necessary, in addition to general monitoring requirements.
3. The advantages and disadvantages of area monitoring or personal exposure monitoring for hearing conservation purposes.
4. Criteria for selecting a representative employee to monitor.
5. The circumstances under which remonitoring is necessary.
6. The need for notifying employees of their actual exposures.
7. The appropriateness of requiring measuring instruments to conform with consensus standards such as ANSI.
8. The ability of sound level meters and dosimeters to measure impulsive, intermittent, and continuous noise accurately, including criteria for determining accuracy.
9. The need for specifying a test for dosimeter crest factor capability, and if so, suggestions as to the content of such a test.
10. The availability and cost of dosimeters with a dynamic range of 80 dB to 130 dB.
11. Appropriate sampling procedures for use with a sound level meter for purposes of area monitoring or personal monitoring, and the need for requiring such procedures.
12. The need for standardized microphone placement for purposes of area monitoring or personal monitoring, and if so, suggestions as to appropriate microphone placement.
13. The need for field and laboratory calibration requirements for noise measuring instruments.
14. The need for requiring specific monitoring practices that employees must be allowed to observe, and if so, the nature of these practices.

Observation of Monitoring—Paragraph (i).

Employees must be able to observe the monitoring process since the right to observe monitoring is mandated by section 8(c)(3) of the Occupational Safety and Health Act. Paragraph (i)(1), which merely restates the observation right given by the Occupational Safety and Health Act, will go into effect.

Some comments expressed concern that allowing employees to observe monitoring would disrupt production because employees would leave their work stations en masse to watch the procedure. It has not been OSHA's experience that employee observation of monitoring is disruptive since in most cases a representative of the employees acts as an observer. The stay is being continued on paragraph (i)(2) which specifically entitles observers to receive an explanation of the measurement procedures, observe all steps related to the noise exposure measurements and record the results obtained. Comments indicated confusion as to the amount of explanation necessary. Therefore, the stay of paragraph (i)(2) will continue on an interim basis and comments are solicited as to whether paragraph (i)(2) is necessary to assure that employees are afforded a meaningful opportunity to exercise their statutory right to observe monitoring, or whether the performance language of paragraph (i)(1) is sufficient.

Audiometric Testing Program—Paragraph (j).

Qualifications of personnel administering audiometric tests. One commenter interpreted the amendment to provide that only audiologists or medical doctors can test employees' hearing. The standard, however, in paragraph (j)(3) allows trained technicians to perform audiometric tests if they demonstrate competency in administering tests and in the use and care of audiometers. Questions were also raised as to whether nurses could do audiometric testing. All persons who can demonstrate competency in administering tests and in the use of audiometers may administer audiometric tests required by the standard.

Another request was to clarify the requirement that a technician must have "satisfactorily demonstrated competence" in audiometric testing. The proof of competence is left up to the professional who supervises the technician. A certificate of the satisfactory completion of a recognized training program would be one way of meeting the requirement; the Agency believes that on-the-job training may also be effective and technicians may also qualify by this route.

Qualifications of supervisors. One comment addressed the statement in the preamble that the amendment requires certain functions to be carried out by an audiologist, otolaryngologist, "or in the absent of one of these specialists, a qualified physician." However, the standard does not use the words "in the absence of one of these specialists". Therefore, for compliance purposes, the audiologist, otolaryngologist, and other physician are on an equal footing. While the Agency believes that audiologists and otolaryngologists will be in the best position to make judgments about testing procedures and about the validity and interpretation of audiograms, physicians with specialities other than otolaryngology may be quite capable of making these judgments. Also, as explained below, OSHA is considering deleting the word "qualified" as it applies to physicians, since in this context it adds nothing to the meaning or effectiveness of the standard.

Paragraph (j)(3) and paragraph (j)(7)(iii). In the first sentence of paragraph (j)(3) the amendment requires that audiometric tests be performed by a licensed or certified "audiologist, otolaryngologist, or other qualified physican * * *." The same words are used in paragraph (j)(7)(iii), which specifies the qualifications of personnel who review audiograms. Comments to the Agency have requested a clarification of the word "qualified" which precedes "physician". OSHA intended the word "qualified" to mean any licensed physician who believes that he or she has adequate training or knowledge to administer audiometric tests and interpret the results. The Agency believes that the word "qualified" is unnecessary and that adequate professional judgment and responsibility can be assumed. Therefore the Agency is considering deleting the word "qualified" in paragraphs (j)(3) and (j)(7)(iii), and requests comments on the issue.

Also in paragraph (j)(3), the Agency is changing "a *person* who is certified by the Council of Accreditation in Occupational Hearing Conservation" to "a *technician* who is certified by the Council of Accreditation in Occupational Hearing Conservation * * *." This substitution conforms the wording to a sentence later in the same paragraph that reads, "A technician who performs audiometric tests must be responsible to an audiologist, otolaryngologist or qualified physician." It was suggested that one might interpret this paragraph as meaning that a *person* who is certified by the Council to perform audiometric tests need not be responsible to a professional. OSHA's intent was that all non-professionals engaging in audiometric testing must be responsible to a professional. Therefore non-professionals will be referred to a "technicians" for purposes of the amendment. In addition, the Agency is deleting the words "by an audiometric technician" which precede "who has satisfactorily demonstrated competence * * *", since these words are now redundant. This deletion does nothing to change the meaning of the requirement.

Baseline audiogram—Paragraph (j)(5). Paragraph (j)(5)(i) required employers to perform baseline audiograms (after the initial phase-in period) within 4 months of an employee's first exposure to noise at or above the action level. Ideally, the baseline audiogram should be conducted before employment, or before exposure to hazardous noise levels in order to avoid contamination by threshold shifts. Any hearing loss, temporary or permanent, that is caused by an employee's work in a noisy area would contaminate the baseline audiogram, making it appear as though the worker had a preexisting hearing loss. Such losses can occur in a matter of months or even days depending on the susceptibility of the individual to noise and the level of exposure. This could result in measuring future losses against a false baseline. Thus the true extent of hearing threshold shifts that have been caused by noise exposure would not be detected.

Pre-employment audiometric testing would be generally feasible for large companies that carry out their own audiometric test programs, or for small companies that send employees to local clinics or doctors' offices for testing. Although the Agency was aware of the need for prompt baseline testing, the principal reason for selecting the 4-month period was that it allowed employers to exclude most seasonal and temporary workers, for whom continued testing and follow-up would be extremely difficult. This 4-month provision took into account the need to take audiograms as soon as possible to reflect the employee's true hearing ability before exposure to workplace noise; and the problems of requiring baseline audiograms on a pre-employment basis. However, such a requirement would probably result in added expenditures for companies that generally rely on mobile test services that come to the plant once a year since these employers would have to send new employees who need baseline audiograms to a local clinic or physician, where the cost per employee would be higher.

In order to investigate more thoroughly the feasibility of obtaining baseline audiograms relatively soon after an employee's initial exposure, the Agency will continue the stay of paragraph (j)(5)(i) insofar as the 4-month period is concerned. Specifically OSHA requests data and information on:

1. Factors precluding baseline testing within 4 months of initial exposure to noise.
2. Whether the requirement to obtain baseline audiograms within 4 months of the initial exposure is unnecessarily stringent.
3. Recommended time periods within which baseline audiometric testing should be conducted for specified TWA's between 85 dB and 110 dB.

Paragraph (j)(5)(ii) requires employers to perform baseline audiograms after employees have been away from workplace noise for at least 14 hours. Paragraph (j)(5)(ii) (*a*) prohibits employers from using hearing protectors as a substitute for the 14 hours without exposure to workplace noise. The reason for the prohibition was that hearing protectors are often fitted and worn improperly, allowing the worker to be exposed to levels of noise that could cause a temporary hearing loss. As discussed above, any temporary hearing loss caused by an occupational noise exposure would contaminate the baseline audiogram; the baseline would be misleading in that the worker would appear to have less hearing ability than he or she actually does have. Since the first test might not be truly representative of the employee's hearing ability, this could result in measuring future losses against a false yardstick; actual future hearing loss would therefore be understated. OSHA received many objections to the prohibition on the use of hearing protectors for this purpose. Comments stated that many companies would experience a significant hardship, trying to schedule all baseline audiograms before the workshift or paying employees overtime for coming in for testing on days when they were not scheduled to work. Some comments suggested that if the wearing of ear protectors was particularly well supervised on the day of the baseline audiogram (and especially if employees wore ear muffs, which are clearly visible to the supervisor), employees could work in noise for a few hours before being tested without incurring temporary threshold shift. While this is still an open issue, OSHA has decided to stay the prohibition against using hearing protectors to satisfy the 14 hour quiet rule before the baseline audiogram is taken. In addition, the Agency is considering adding language to the standard that explicitly allows the use of hearing protectors to provide the required quiet. The Agency is reopening the record on this issue and requests data, evidence and comments on:

1. Whether hearing protectors will be effective in preventing temporary threshold shift before baseline audiograms.

2. Any steps that are necessary to ensure hearing protector effectiveness on the day of baseline audiometry.

3. The level of quiet and the length of the quiet period before the baseline audiogram which is necessary to insure the integrity of the baseline audiogram.

4. Any experience on the part of those administering or evaluating audiometric examinations that indicates that some baselines may contain temporary threshold shift.

Paragraph (j)(5)(ii)(*b*) requires employers to notify employees of the need to avoid high levels of non-occupational noise exposure during the 14-hour period preceding their baseline audiogram. This requirement was included because the Agency acknowledges the fact that employers cannot be held responsible for hearing loss that is incurred away from the workplace. However, employers could help to minimize the contribution of non-occupational noise exposure to the baseline audiogram by counseling workers ahead to time as to the need for avoiding such exposures. It has been suggested, however, that paragraph (j)(5)(ii)(*b*) may be unnecessary because this kind of notification would normally occur during training which is already required by the standard. Since the paragraph may constitute an unnecessary and redundant requirement, OSHA has decided to continue the stay of this requirement, and to request any comments and information that would justify retaining it in the standard.

Grandfathering of pre-existing baseline and audiograms. Many commenters asked whether or not OSHA would accept the validity of baseline audiograms taken before the effective date of the amendment. Most comments urged the acceptability of audiometric tests that were performed using hearing protectors as a substitute for 14 hours away from workplace noise. Since the prohibition against the use of hearing protectors to achieve the quiet hours is being stayed, OSHA will accept baseline audiograms that were taken using hearing protectors as a substitute for 14 quiet hours. The Agency will continue to accept these audiograms in the future as valid baseline audiograms regardless of the outcome of the stay, and will accept or "grandfather" older baseline audiograms that reflect substantial compliance with the audiometric test requirements of the amendment. For example, to be acceptable, baseline audiograms should be administered by a trained technician, taken at the required test frequencies (500, 1000, 2000, 3000, 4000 and 6000 Hz), in a reasonably quiet room, and with calibrated equipment. The Agency is prepared to be flexible in accepting or grandfathering old baseline audiograms because in most cases this would be more protective of the employee since old baselines will allow the true extent of the hearing loss over the years to be evaluated. Obtaining a new baseline audiogram after many years of noise exposure might be less protective since the new audiogram might show higher thresholds and the true extent of future losses would appear smaller than when compared with the original baseline.

Evaluation of audiogram—Paragraph (j)(7). Paragraph (j)(7)(ii) of the amendment states that audiogram evaluation must be performed by an audiologist, otolaryngologist, or qualified physician. The Agency has combined this section with paragraph (j)(7)(iii), so that it now reads "An audiologist, otolaryngologist, or qualified physician shall review the audiograms to determine whether there is a need for further evaluation." The original first sentence in paragraph (j)(7)(ii) will be deleted since it suggests that a professional must review each audiogram. Professionals do not need to review *every* audiogram. Some comments assumed that the amendment prohibited technicians from reviewing a routine audiogram. Technicians may review audiograms and give only problem audiograms to the professionals for review. The preamble did state that computers could be used to compute shifts shown on audiograms so long as an appropriate professional provided input in the development of the computer program. Although the text of the amendment may have been unclear, it was the Agency's intention that technicians, once they have been adequately trained, could perform the same function, and let the professional review audiograms where the audiogram's validity was in question, or where there might be a medical problem or other problem that would indicate a need for further evaluation.

The Agency has decided that the requirement for the reviewer to determine work relatedness of a significant threshold shift, which is contained in paragraph (j)(7)(iii), should be stayed pending further public comment. A number of comments objected to the requirement, stating that occupational and non-occupational hearing loss can appear to be identical on the audiogram. In some cases it may be very difficult even for an audiologist or physician to determine the cause, or work relatedness, of a threshold shift. This objection also applies to two other portions of the amendment. In paragraph (j)(8)(iv)(*b*), which requires referral for further evaluation as necessary, the words "to determine the cause of the permanent significant threshold shift" will be stayed pending further consideration. Also, paragraph (j)(8)(iv)(*d*) will be stayed pending further public comment. The latter paragraph requires employers to record the existence of a permanent significant threshold shift on the OSHA Form 200 when the professional reviewer determines that the shift is work related. In addition to difficulties in making the determination, the need for such a requirement is questionable since it duplicates the requirements for reporting occupational illnesses and injuries set forth in 29 CFR 1904.2. With respect to these provisions, OSHA is requesting comments and information on the following:

1. Whether it is necessary to determine the cause of a significant threshold shift in order to protect a worker's hearing.

2. Methods or guidelines for distinguishing between occupational and non-occupational hearing loss.

Paragraph (j)(7)(iv) requires that where annual audiometric testing reveals the presence of a significant threshold shift, a new audiogram shall be given within 60 days to determine if the shift is permanent. There were objections to this provision on the basis that it is extremely difficult to discern if a significant threshold shift is permanent; that the definition of significant threshold shift used in the amendment might result in as many as 30–40% of those tested showing significant threshold shifts and having to be re-tested, and that the burdens of re-testing would be substantial for those employers using mobile audiometric test services. Some of the provisions included in paragraph (j)(7)(iv), such as the requirement that hearing protectors not be used to obtain the necessary quiet hours before re-testing, are inconsistent with the continued stays of other parts of the amendment (see, for example, discussion of paragraph (j)(5)(ii)(*a*)). Moreover, it might not be worthwhile to require retesting without including the requirement for 14 hours away from workplace noise, in that in most cases without this requirement the retest results would be the same. Any benefit that the retest requirement might have is further clouded by the continuing stay of the significant threshold shift definition discussed below. The stay of all the requirements contained in paragraph (j)(7)(iv) will therefore continue. Comments and data are requested on the following issues:

1. Whether retesting within a short period of time to confirm the presence of a significant threshold shift is necessary to the protection of employee hearing.

2. If retesting is necessary, is the requirement that such retesting be accomplished within 60 days appropriate?

Follow-up procedures—Paragraph (j)(8). Paragraph (j)(8)(iv)(*b*) required that employees be referred for a clinical audiological evaluation or an otological examination, as appropriate, under certain circumstances. Some commenters wanted to know who pays for audiometric test referrals. Since employers are responsible for providing employees with a safe and healthful working environment, they must pay for examinations to discover whether or the extent to which a harmful agent in the workplace is affecting employees' health or safety. In addition, they must pay for examinations to discover whether a protective device, which is worn to mitigate adverse effects, is in itself having an adverse health effect. Consequently, employers must bear the expense of referral in cases where the validity or the significance of the test results is questionable or when a pathology of the ear is caused or aggravated by wearing hearing protection. This requirement that employers pay for medical examinations is mandated by section 6(b)(7) of the Act. When the reviewer suspects a medical problem that is not related to the wearing of ear protection (such as an upper respiratory infection), the employer need not assume the cost of further testing or treatment.

Employees who refuse follow-up examination or treatment. Where the standard requires referral for further evaluation, some commenters were concerned that employers would be held responsible for the worker's refusal to go. However, the requirement was phrased in terms of "refer" rather than "require." As long as the employee is referred for further evaluation, the employer has carried out his or her responsibility even if the employee refuses the medical treatment. This is consistent with all OSHA requirements for medical surveillance, which only require that employers make medical examinations available to employees.

Employee notification of significant threshold shift—(STS). Paragraph (j)(8)(iv)(*a*) requires notification of employees within 21 days of the determination of the existence of a significant threshold shift. A number of commenters wanted to know from what point the 21-day period began. The amendment specifies 21 days *from the determination.* For companies with in-house testing capabilities, the determination of STS could occur at the time of testing or at the time the annual audiogram is compared to the baseline. In cases where the company sends its test results to a professional reviewer, the determination would occur when the employer receives the results of the review. Employers should not delay the review of audiograms, since the existence of an STS should be identified as quickly as possible so that protective measures may be initiated.

Revised baseline: Paragraph (j)(9). This paragraph requires baseline audiograms to be revised when subsequent testing reveals either a significant threshold shift, or an improvement in hearing at two or more test frequencies. Some comments requested further guidance on the amount of improvement in hearing thresholds needed to trigger a revision of the baseline. Other questions were submitted concerning whether a revision should be done where an annual audiogram shows improvements at some frequencies and losses at others. The Agency has determined that this section needs to be stayed to be consistent with the stay of the retest requirement. If retests are not performed, professional reviewers will not be able to tell whether a hearing loss is temporary or permanent. If baselines are revised on the basis of a temporary hearing loss, future comparisons would be invalid, and baselines might continually need to be revised, resulting in confused recordkeeping and insufficient protection of employees because of invalid audiogram comparisons. Therefore any requirement for revision of baseline audiograms will be stayed until a decision is made on the subject of retesting.

Consequently the Agency is requesting comments on the following:

1. The need for revising baseline audiograms, when either improvement in hearing or a significant threshold shift occurs.

2. The amount of improvement needed before baseline audiograms should be revised.

Significant threshold shift—Paragraph (j)(10). This paragraph defines significant threshold shift in a manner that becomes progressively more stringent as an employee's hearing loss becomes greater. Unlike the proposal, the amendment allows employers to make a specified correction to the audiogram for aging in determining whether a significant threshold shift has occurred. The Agency received a number of comments requesting that OSHA reconsider the definition of significant threshold shift. Most commenters agreed that a definition of significant threshold shift is necessary. However, many commenters objected to the complexity of the definition chosen, asserting that it would be difficult to evaluate audiograms using the complicated multi-part criteria without a computer and asserting that it would not function as intended. Specifically, some commenters felt that the definition was so stringent that it would result in identifying "normal people" as having significant threshold shifts; others felt that the definition was too lenient to adequately protect young workers with good hearing. OSHA did not intend to require that computers be used to evaluate audiograms. This might place an undue burden on small or medium-sized companies that have their own testing programs. OSHA agrees that the definition of STS should be reevaluated in light of these comments. For these reasons the Agency has stayed the paragraph defining significant threshold shift, and is reopening the record on this issue. For many employers, this stay will have little effect since it is contemplated that the rulemaking will be completed and that there will be a definition of significant threshold shift in the standard before the first annual audiogram needs to be compared with the baseline. Employers who have ongoing hearing conservation programs with established employee baselines, and who may be taking annual audiograms in this interim period may use any reasonably protective definition. The Agency in its enforcement activities will rely on the definition currently used in its Industrial Hygiene Field Operations Manual, which is 20 dB at any frequency.

Paragraph (j)(10)(v) allows a correction for presbycusis, (hearing loss from aging), when making the determination of significant threshold shift. Non-mandatory Appendix F contains tables of presbycusis values and instructions on how to use them in the determination of significant threshold shift. The effect of allowing these corrections is to reduce the amount of threshold shift. OSHA believes that paragraph (j)(10)(v) and Appendix F should be stayed until the final decision is made on the definition of significant threshold shift. Since employers will be using various interim definitions, corrections for presbycusis may be inappropriate for use with certain definitions. Also, OSHA's final decision on the best definition of significant threshold shift may preclude corrections for presbycusis.

To help resolve the question of the appropriate definition of significant threshold shift, OSHA is requesting the following data and information:

1. The need for any standardized definition of significant threshold shift.
2. Audiograms of noise exposed employees taken over a period of years showing individual hearing histories.
3. Explanations and evidence as to why the amendment's definition of significant threshold shift is too stringent or too lenient.
4. Suggestions of simpler definitions of significant threshold shift that are as protective as the one in paragraph (j)(10).
5. The necessity and appropriateness of presbycusis corrections in combination with definitions of significant threshold shift.
6. The appropriateness of statistical trend analysis in assessing threshold shift of individual employees, as suggested in post promulgation comment number 213.

Audiometric Test Requirements—Paragraph (k).

Audiometer specifications. One comment questioned why references to manual type and computer audiometers were not contained in Appendix C. Use of these types of audiometers is permitted under the standard.

Appendix C was included specifically for pulsed-tone and self-recording audiometers because the ANSI standard S3.6-1969 which is referenced in the amendment does not contain requirements for these instruments. The ANSI standard which is referenced in the amendment does prescribe performance specifications for manual audiometer so there was no need to refer to the manual audiometers in Appendix C. Microprocessor audiometers are allowed by the amendment if they meet the requirements of ANSI S3.6-1969. In order to clarify this point, OSHA is considering adding specific language allowing the use of microprocessor audiometers.

Paragraph (k)(4) states that audiometric examinations must be given in a room meeting the requirements listed in Appendix D, *Audiometric Test Rooms.* In order to obtain accurate audiograms, it is necessary to use a quiet booth or room for testing. Appendix D contains tables that list maximum allowable sound pressure levels in audiometric test rooms. Table D-1 is essentially the same as the current ANSI standard, with a relaxation of 5 dB at 500Hz. Table D-2, taken from the 1960 ANSI standard, contains requirements that are considerably less stringent than those of Table D-1. The amendment allowed background sound pressure levels to be within the limits listed in Table D-2 until April 15, 1983, at which time audiometric test rooms would have to meet the more stringent levels in Table D-1. The reason for the requirement was to enable employers to test employees' hearing to at least 0 dB (referenced to ANSI 1969 audiometric zero) at all test frequencies except 500 Hz.

The Agency received a variety of comments on the issue of whether or not the sound levels in Table D-1 are necessary or feasible for industrial audiometric test programs. Some comments stated that the requirement meant that large rooms with double walls would need to be used, which would take up a considerable amount of space and would be very costly. Others said that compliance with Table D-1 would be extremely difficult for mobile test units, because of the occasional need to park in noisy locations. Some comments also maintained that the levels specified in Table D-1 were appropriate for clinical testing but not for industrial testing. For these reasons OSHA is staying the requirement for complying with Table D-1 in Appendix D. However, employers wishing to purchase audiometric test booths in the near future should bear in mind that the issue of the appropriate background sound pressure levels has not been finally decided. Therefore, in order to avoid potentially costly retrofit or replacement, new purchasers may wish to come as close to meeting the levels in Table D-1 as is practical. With respect to audiometric test rooms, OSHA is requesting information and comments on:

1. Octave band sound pressure levels in existing test rooms used for industrial audiometry.
2. Feasibility of retrofitting rooms not meeting the levels in Table D-1.
3. Criteria for establishing differences between clinical and industrial audiometric test programs, including rationale for selecting the lowest non-masked threshold test levels.

Audiometer calibration—Paragraph (k)(5). Paragraphs (k)(5)(i) and (k)(5)(ii) contain requirements for more extensive calibrations when an audiometer's output deviates from its stated level by more than a certain amount (5 dB or 10 dB). Comments pointed out that the phrase "deviations of more than 5 dB" could literally mean a deviation of only 6 dB, which is a very stringent requirement for triggering an acoustic calibration. Likewise, "deviations of more than 10 dB" could literally mean that a deviation of only 11 dB would trigger an exhaustive calibration. In establishing these requirements, the Agency assumed the use of manual audiometry, which is conducted in 5-decibel increments. Therefore the phrases "deviations of more than 5 dB" or "deviations of more than 10 dB" as used in the above paragraphs were intended to mean deviations of 10 dB and 15 dB respectively. It was pointed out, however, that when self-recording audiometry is used, thresholds can be calculated in 1-decibel increments, in which case 6 dB or 11 dB deviations may appear. Therefore, in order to treat both types of audiometers equally, OSHA will, as an interim measure, interpret the words "more than 5 dB" in these paragraphs to mean 10 dB or greater, and "more than 10 dB" to mean 15 dB or greater. In addition, OSHA requests comments on whether the language of the standard should be changed to explicitly incorporate this interpretation.

One comment interpreted the procedure prescribed in the preamble for checking the functional operation of the audiometer to preclude use of the electroacoustic ear. The standard's requirement for a daily functional check is twofold; a person with known stable hearing must be tested, and a listening check must also be performed. The electroacoustic ear can be used in place of the testing requirement, but the listening check still must be performed to make sure that the signal is free of unwanted sounds or distortion, and that the general functioning of the audiometer is satisfactory.

Performance Criteria. Post promulgation comment #266a recommended that OSHA consider the analysis of audiometric data as an indicator of the effectiveness of the hearing conservation program. The Agency is interested in exploring this kind of approach, and requests data, information, and comments on the following:

1. Methods of evaluating the effectiveness of hearing conservation programs.

2. Criteria for judging program effectiveness through audiometric test data.

a. Where hearing threshold shift is the criterion, the amount of threshold shift deemed to be acceptable, the length of time over which the shift occurs, and the percentage of the population exhibiting such shifts.

b. Where hearing level is the criterion, the amount of occupational hearing loss deemed to be acceptable in a population, the non-occupational hearing loss data used for comparison purposes, and the duration of exposure.

Hearing Protectors—Paragraph (1).

Hearing protectors above 85 dB. One commenter mentioned that his company requires the use of hearing protectors by all employees exposed to sound levels of 85 dB regardless of the duration of the exposure. Similarly, others believed that OSHA should require the use of protectors for all employees exposed to a TWA of 85 dB or greater. Under the standard, the wearing of protectors is mandatory for workers whose exposures exceed 90 dB and for workers who have experienced a significant threshold shift, but only voluntary for other workers whose exposures exceed 85 dB. This combination of requirements is designed to provide necessary protection, but not require hearing protector use where the risk of material impairment is relatively small.

If an employer finds it more efficient and easier to promote employee use of hearing protectors by requiring hearing protector use by all employees exposed to levels of 85 dB or greater, this is permissible since it is more protective than the OSHA requirement. OSHA considers its requirement to be a minimum, and employers are free to require measures that are more protective than those specified in the standard.

Hearing protector replacement—Paragraph (1)(i). One comment interpreted the amendment's requirement that "hearing protectors shall be replaced as necessary," to mean that employers have to pay for lost or mutilated protectors. The Agency believes that employers should not have to pay for an unlimited supply of protectors or replace protectors that have been lost due to employee negligence. Employers may formulate their own reasonable policies as to how many free replacement protectors to supply. Although employers must replace worn out protectors, they should not have to bear the expense in cases where employees have been irresponsible.

Hearing protector attenuation—Paragraph (m). The amendment requires employers to evaluate hearing protector attenuation for the specific noise environments in which the protector will be used. Employers may use any of the methods listed in Appendix G to do this. The easiest method involves the use of the Noise Reduction Rating (NRR) which is printed on the hearing protector package.

One comment expressed concern that employers who wish to use the NRR because of its simplicity would be penalized because of its conservative correction factors. Others, however, noted that the NRR may not be nearly conservative enough. Research has shown that hearing protectors are not as effective in real life conditions as they are in the laboratory. OSHA believes that because of its simplicity the NRR is the best method available at this time, and employers are encouraged to use it. The Agency does, however, caution employers that the NRR values may be unrealistically high. Employers should use extra care in fitting and supervising the use of hearing protectors when the full amount of the NRR is needed. Some recent information submitted to the Agency suggests that only about half the attenuation predicted by the NRR is actually obtained in field use (see post-promulgation comment 266).

In addition, OSHA has recently learned that the Environmental Protection Agency's Office of Noise Abatement, which required the labelling of hearing protectors with the NRR, will soon be abolished. OSHA does not know at this time whether the EPA labelling regulation will be rescinded, and if so whether hearing protector manufacturers will continue to use the NRR voluntarily. Therefore the Agency may need to amend Appendix G so that estimations of hearing protector attenuation more adequately predict the attenuation received in actual use. Consequently the Agency is reopening the record and is requesting data and information on:

1. Ear muff and ear plug attenuation in field conditions.

2. Simple field methods for evaluating hearing protector attenuation.

3. Suggested corrections to the NRR.

Certain portions of Appendix G (which gives various methods of determining the attenuation of hearing protectors) have been stayed insofar as they make reference to Appendix B, which has also been stayed. After evaluating the comments, the Agency may delete the second part of Appendix G's paragraph (iii)(A), the second part of paragraph (iv)(A) and its accompanying footnote, and paragraph (iv)(B), all of which refer to Appendix B, or identified time segments which are described in Appendix B. In addition, procedures for estimating attenuation using sound level meters and area monitoring may be added to Appendix G. For example, the following types of provisions may be added:

(v) When using area monitoring procedures and a sound level meter set to the A-weighting network:

(A) Obtain a representative sound level for the area in question.

(B) Subtract 7 dB from the NRR and subtract the remainder from the A-weighted sound level for that area.

(vi) When using area monitoring procedures and a sound level meter set to the C-weighting network:

(A) Obtain a representative sound level for the area in question.

(B) Subtract the NRR from the C-weighted sound level for that area.

Comments are invited on the above and similar suggestions.

Hearing protector selection—Paragraph (1)(3). Some comments reflected a misunderstanding of the intent of the requirement for giving employees an opportunity to choose hearing protectors from a variety of protectors. Some suggested that the requirement entailed providing employees with a shopping list of different brands and types of protectors. The intent of the requirement is that workers should have more than one type of device, more than one size (where the devices come in different sizes), and preferably three or more devices to choose from. The reason for this requirement is that ear canals come in many shapes and sizes, and even the same person can have two differently sized ear canals. Characteristics of the noise environment, such as temperature, humidity, and presence of dust, grease, or metal particles, also have a bearing on the choice of protectors. A protector that is suitable for a hot environment may not be the best one in a greasy environment. Once employers and employees have settled on the types and sizes of protectors that will be worn, there is no need to keep a varied selection always available.

One commenter interpreted the requirement as meaning that employees alone would make the hearing protector selection. This was not the intention of the Agency. The Agency believes that the employee and the employer (who should have some knowledge of the fundamentals of hearing protection), should work together in selecting the right protector. While the employer may know about attenuation values and other technical considerations, the employee is the best person to judge the protector's comfort. If the protector is uncomfortable, it is not likely to be worn properly, and may not be worn at all.

Training Program—Paragraph (n).

The Agency received a number of requests to reconsider the training requirements. Comments objected to the specificity of the requirements, saying that it would impede the employer's flexibility to conform the program to the needs of his own employees. Some pointed out that some of the training requirements exceed the information that employees need to know to protect their hearing. Therefore OSHA has made effective only those requirements for training that it believes are essential to the success of the hearing conservation program. The remaining requirements are stayed pending consideration of further comments on their necessity.

Paragraph (n)(3)(i) has been stayed because the Agency believes that the requirements may be redundant. Employees have access to the noise standard under paragraph (o)(1), concerning access to information and training materials.

Paragraphs (n) (3) (iii), (n) (3) (iv), and (n) (3) (v) are stayed since information about engineering and administrative controls and the employer's compliance plan may not be relevant to the employee's understanding of or cooperation in the hearing conservation program. In light of these stays, employers may be able to avail themselves of pre-prepared training materials such as pamphlets or films, which are professionally prepared and which may be more effective and less expensive than individually developed programs.

OSHA requests comments and information on the necessity of the above stayed training requirements for effective hearing conservation programs. In addition, comments are requested on whether there are any *disadvantages* in including such provisions in a regulation for hearing conservation programs.

Warning Signs—Paragraph (p).

Comments objected to the requirements for warning signs, stating that the signs would be costly and inconvenient, and that confusion would result as to whether hearing protection was advisory or mandatory in certain areas. In light of these comments, the requirements for warning signs will be stayed pending further comment.

OSHA is requesting information on the following:

1. Educational value of warning signs.
2. Necessity of requiring warning signs to have an effective hearing conservation program.

Recordkeeping—Paragraph (q).

OSHA received numerous requests to reconsider the amendment's recordkeeping requirements. Comments objected to the detailed nature of the provisions, the burden on small and medium-sized companies, and the redundancy of some of the requirements. OSHA has therefore decided to reduce the extent of the recordkeeping requirements in the interim by staying certain provisions. Comments are invited on whether these provisions are necessary for the hearing conservation amendment or whether they should be deleted.

Exposure measurements—Paragraph (q)(1). The Agency is staying and seeking comment on all of paragraph (q)(1) except for the general requirement in paragraph (q)(1)(i) to " maintain an accurate record of all employee exposure measurements required by * * * [paragraph (c) of] this section". The bracketed words in paragraph (q)(1)(i), as well as all of paragraph (q)(1)(ii) are also being stayed to be consistent with the interim stays affecting most of the specific monitoring requirements in paragraphs (c) through (h). These paragraphs require the retention of detailed information such as names of persons whose exposures were actually measured, date of last laboratory calibration, the type of measuring equipment used, and the date and location of measurements. Comments are requested on whether any of the information required by the paragraphs covered by the interim stay is necessary to achieve a successful hearing conservation program.

Audiometric tests—Paragraph (q)(2). OSHA is also staying and inviting further comments on the second part of paragraph (q)(2)(ii)(*c*), which requires records of the qualifications of the person who administered the audiometric test, and paragraph (q)(2)(ii)(*d*), which requires records of the manufacturer and model of the audiometer. While employers may wish to keep this information to help them to evaluate various aspects of their own programs, the Agency believes that it may not be necessary for the standard to require that such information be kept.

In addition, OSHA is staying and inviting comment on the possible deletion of paragraph (q)(2)(ii)(*g*), which requires a statement as to whether the sound pressure levels in the test room meet those specified in Tables D-1 or D-2 of Appendix D. This is consistent with the stay of Table D-1. In addition, this provision is redundant with the requirement in paragraph (q)(3) to record the background sound pressure levels in audiometric test rooms. Some envisioned that employers would have to list background sound pressure levels on each and every audiogram. The Agency's intention was merely that the background sound pressure levels be kept with the audiometric test record, not necessarily *on* each record. The stay of this provision will focus attention on the similar requirement in paragraph (q)(3) and clarify the issue.

Audiometric test rooms—Paragraph (q)(3).

OSHA is staying and considering the deletion of paragraph (q)(3)(ii), which specifies the audiometric frequencies for which sound pressure level measurements are to be kept, and requires noting the date of the measurement. OSHA has stayed these requirements because they are not believed to be necessary in view of the fact that Table D-2 in Appendix D already gives the pertinent frequencies. In addition, the Agency believes that employers will note the date of measurement as a matter of course. The Agency requests comments on the necessity of retaining such a provision.

Calibration of audiometers—Paragraph (q)(4).

Similarly, since the date of the last acoustic or exhaustive calibration of the audiometer also must be kept with the employee's audiometric test record, keeping a separate record of calibration results is unnecessary. OSHA is therefore considering deleting paragraph (q)(4) in its entirety.

Record retention—Paragraph (q)(5).

The Agency is staying and is considering deleting paragraphs (q)(5)(iii) and (q)(5)(iv), requiring that records of test room sound pressure levels and audiometer calibrations be kept for 5 years, to be consistent with the deletion of the requirement that such information be kept as a separate record. The provisions for record retention in paragraph (q)(5)(i) requiring the retention of noise exposure measurement records for 2 years are going into effect. Paragraph (q)(5)(ii) is being partially stayed insofar as employers have to retain such records for 5 years after termination of employment. Employers will, however, be required to retain audiometric test records for the length of employment. OSHA invites comments on whether the retention period for audiometric test records (length of employment plus 5 years) in paragraph (q)(5)(ii) is necessary for a successful hearing conservation program. Since audiometric test records can be valuable to employees after they have left a company, OSHA also invites comments on whether employers should be required to offer a departing employee his or her audiometric test records.

Recordkeeping Clearance. As noted above, this standard contains recordkeeping requirements, some of which are going into effect now and some of which are being stayed pending receipt and review of further comments on the necessity of the requirements. The recordkeeping requirements in the amendment have been approved by the Office of Management and Budget pursuant to the Paperwork Reduction Act of 1980, Public Law 96-511, 44 U.S.C. Chapter 35. The OMB approval number is 1218-0048.

Custody of Records. The question was raised as to whether the amendment requires employers to keep records at the workplace. The Agency recognizes that some employers, especially small companies, may prefer to hire contractors to fulfill their hearing conservation requirements, and may choose to have the contractors keep the records. This is acceptable to OSHA as long as all records are readily available in case they are needed by the employer, employees, designated representatives, or by OSHA.

Appendices—Paragraph (r).

In paragraph (r)(2) reference to Appendix B (Temporal Sampling Procedures for Use With a Sound Level Meter) and Appendix F (Calculations and Application of Age Corrections to Audiograms) has been stayed to be consistent with the stays of Appendix B and Appendix F.

Effective dates—Paragraph (s).

Since the amendment will become effective on August 22, 1981 instead of April 15, 1981, the start-up dates contained in paragraphs (s)(2) and (s)(3) for completion of monitoring and baseline audiograms are being adjusted to reflect the same amount of time given in the January 16, 1981 amendment. Accordingly, monitoring must be completed by February 22, 1982, and baseline audiograms must be completed by August 22, 1982. In paragraph (s)(2), references to the initial determination and to paragraph (d) have been stayed to be consistent with the stay of paragraph (d), requiring initial determinations.

Paragraphs (s)(4) concerning the effective date for the more stringent requirements for background sound pressure levels in audiometric test rooms and (s)(5), concerning the effective date for the more stringent requirements for noise dosimeters, are being stayed to be consistent with the staying of these substantive requirements in Table D-1 of Appendix D and paragraph (g) respectively.

Other Alternatives. Possible alternatives to the hearing conservation standard have been suggested to the Agency. These alternatives might include the following provisions:

1. Employers shall conduct audiograms annually of every employee exposed to noise in excess of an 8-hour time weighted average sound level (TWA) of 85 dBa,[1] according to standards on audiometers and audiometric test rooms established by the American National Standards Institute,[2] and under the supervision of a qualified technician;

2. Such audiograms shall be reviewed annually by a qualified audiologist, otolaryngologist or physician to identify employees whose hearing acuity has diminished more than normal;

3. Employers shall instruct all employees identified under paragraph 2 in the proper use of hearing protection when working in noisy areas and shall take appropriate measures to enforce the use of suitable protective devices for these employees when they are exposed to noise levels in excess of an 8-hour time weighted average sound level (TWA) of 85 dBa.

The purpose of this suggestion is to determine whether the goal of hearing conservation could be achieved by a performance standard that does not contain detailed compliance requirements but rather leaves implementation to physicians and other experts in the field. One of the benefits of the suggestion, for example, may be that more employees would read and fully understand the standard. In addition, small employers whose resources may be limited might themselves be better able to comply because of the brevity and simplicity of this alternative. As a result of a greater understanding on the part of both employees and employers, more effective compliance with the standard may be encouraged.

OSHA invites comments on the above alternative, especially with respect to the following points:

1. Do the above provisions constitute an adequate hearing conservation program? Would the protection provided to workers against noise-induced hearing loss by the above provisions be comparable to the protection provided by the hearing conservation amendment as issued? What evidence supports the conclusions of comparability or non-comparability?

2. How would the employer's compliance with the above provisions differ from the actions necessary for compliance with the hearing conservation amendment? What would be the impact of those differences on costs of compliance?

3. How would OSHA enforcement of the above provisions differ from enforcement of the hearing conservation amendment?

OSHA will consider the comments submitted on these alternative provisions and the responses to the questions listed in deciding whether any further rulemaking activity on the matters included in the alternative is warranted.

IV. Summary of Regulatory Impact Analysis

A Regulatory Impact Analysis, consistent with the requirements of Executive Order 12291 has been prepared. The document discusses, *inter alia*, the costs of the hearing conservation provisions published in January and the costs of the provisions going into effect on August 22, presents information on relative cost-effectiveness between the two sets of provisions, and describes the impact on small business, consistent with the Regulatory Flexibility Act.

As mentioned in the background section of this Federal Register notice, the total cost of the amendment published in January was estimated to be $269 million or an average of $53 per worker included in hearing conservation programs mandated by the amendment. The Regulatory Impact Analysis also presents recalculated costs of $234.6 million for the January amendment. This adjustment was based on new information. The provisions going into effect on August 22 are considerably less costly; these provisions are estimated to result in total costs of $181.5 million or an average of $30 per worker per year. After adjusting for current compliance activities, the

[1] See Appendix A.

[2] American National Standards Institute (ANSI) Specification for Audiometers, S3.6-1969, and the Institute's Specification for Audiometric Test Rooms, ANSI S3.1-1977. Audiometers shall be calibrated annually to ensure the standard is met. ANSI S3.1-1977 must be followed for testing performed at frequencies of 1,000 Hz and above; for testing below Hz, ANSI S3.1-1960 may be used.

provisions going into effect on August 22 will result in $170.6 million in new costs.

The Regulatory Impact Analysis relies on the benefits calculations of the Regulatory Analysis which was prepared for the amendment published in January 16, 1981. OSHA estimated that hearing conservation programs for all employees exposed above 85 dB would eliminate 212,000 cases of material impairment of hearing after 10 years, 698,000 after 30 years and 898,000 cases at equilibrium. Even assuming full compliance with the present standard which requires hearing conservation programs for all employees exposed over 90 dB, the amendment would prevent 38,000 additional impairments within 10 years, 143,000 within 30 years, and 189,000 at equilibrium. Therefore the standard would significantly reduce the risk of hearing impairment present in many workplaces. The original benefits estimates assumed that the provisions in the amendment formed a system of checks and balances to assure that employees who were highly susceptible to noise would be identified and prevented from incurring material impairment by intervening at an early stage with counseling, training, retesting and professional evaluation where necessary. Because of the interrelated nature of the hearing conservation provisions, it is very difficult to predict what effect the relaxation of any requirement or group of requirements will have on the benefits predicted.

Copies of the Regulatory Impact Analysis can be obtained from the Docket Office, at the address listed in the "Address" section at the beginning of this Federal Register document. Comments, including analysis and data to support any conclusions drawn, are invited on the following issues:

1. Whether it is appropriate to assume that the provisions going into effect on August 22 will be adequate to achieve the benefits predicted.

2. Whether the continued stay of certain provisions has lowered the costs and simultaneously diminished the benefits likely to be realized.

3. Whether general performance requirements for noise exposure monitoring are sufficient to identify all employees who need to be included in hearing conservation programs so that they will receive the benefits of such programs.

4. Whether the provisions going into effect August 22 represent a cost-effective alternative to the January 16 amendment.

V. Environmental Impact

On February 19, 1974 OSHA announced in the Federal Register its intention to prepare an Environmental Impact Statement assessing the impact of a standard that would be proposed for occupational noise exposure (See 39 FR 6119). Information was solicited from the public on a variety of environmentally related issues including possible environmental impacts of the recommended standard and any irreversible commitments of resources which would be involved if the standard should be implemented.

A draft Environmental Impact Statement was made available to the public on June 16, 1975 (40 FR 25525) and environmental impact was specifically an issue at the first hearing held in 1975.

A Final Environmental Impact Statement was prepared in accordance with the Council on Environmental Quality (CEQ) Guidelines (40 CFR 1500 *et seq.*) and the Department of Labor's regulations setting out procedures to be used by Department of Labor agencies to insure compliance with the National Environmental Policy Act (29 CFR Part 11). The final Environmental Impact Statement was made available to the public at the time the final rule was published. The Final Environmental Impact Statement concluded that the hearing conservation amendment would beneficially impact the workplace environment by reducing both the incidence and the degree of hearing loss among workers. It also concluded that the incidence of other adverse health effects associated with noise exposure might also be reduced.

OSHA does not believe that staying various provisions of the amendment will have any significant environmental impact. Therefore, no revised Environmental Impact Statement is necessary. Comments and data are requested on whether the Agency's action today will have any significant environmental impact.

VI. Conclusion

Comments and data are hereby requested in response to the specific questions posed in the discussion above. In addition, interested persons are invited to submit any other relevant comments and data on any of the provisions which have been reopened for comment. These substantive comments must be submitted in accordance with the procedures outlined in the Public Participation section (see section II. B), and be received by November 23, 1981.

The stay is still in effect for all or part of the paragraphs listed below. Comments are specifically requested as to whether the interim stay of these provisions should remain in effect pending the submission and evaluation of substantive comments on these provisions. Comments on the interim stays must be submitted in accordance with the procedures outlined in the Public Participation section (see section II. A), and must be received by September 22, 1981.

A. Provisions Stayed

Paragraph (d).
Paragraph (e), except for part of (e)(1).
Paragraph (f).
Paragraph (g), except for part of (g)(2)(ii)(*b*).
Paragraph (h).
Paragraph (i), except for part of (i)(1).
Part of paragraph (j)(5)(i).
Paragraph (j)(5)(ii)(*a*).
Paragraph (j)(5)(ii)(*b*).
Part of paragraph (j)(7)(i).
Part of paragraph (j)(7)(ii).
Part of paragraph (j)(7)(iii).
Paragraph (j)(7)(iv).
Part of paragraph (j)(8).
Paragraph (j)(8) (iii) and (iv).
Part of paragraph (j)(8)(iv) (*a*) and (*b*).
Paragraph (j)(8)(iv)(*d*).
Paragraph (j)(9).
Paragraph (j)(10).
Part of paragraph (1)(2)(i).
Paragraph (n)(3) (i), (iii), (iv) and (v).
Paragraph (p).
Part of paragraph (q)(1)(i).
Paragraph (q)(1)(ii).
Part of paragraph (q)(2)(ii)(*c*).
Paragraph (q)(2)(ii)(*d*).
Paragraph (q)(2)(ii)(*g*).
Paragraph (q)(3)(ii).
Paragraph (q)(4).
Part of paragraph (q)(5)(ii).
Part of paragraph (q)(5) (iii) and (iv).
Part of paragraph (r)(2).
Part of paragraph (s)(2).
Paragraph (s)(4).
Paragraph (s)(5).
Appendix B is stayed in its entirety.
Part of appendix D, including Table D-1.
Appendix F.
Part of Appendix G.

B. Technical Amendments

§ 1910.95 [Amended]

For the reasons set out in the preamble, Part 1910 of Title 29, Code of Federal Regulations, is amended as set forth below.

1. Paragraph (c) of § 1910.95 is amended by inserting the words "slow response" after "85 decibels measured on the A scale".

2. Paragraph (j)(3) of § 1910.95 is amended by deleting the word "person" in the first sentence and inserting the word "technician" in its place. Also in the first sentence, the words "by an audiometric technician" are removed.

3. Paragraph (j)(7)(ii) of § 1910.95 is amended by removing the first sentence which states "such evaluation shall be performed by an audiologist, otolaryngologist, or qualified physician"

and inserting in its place paragraph (j)(7)(iii) as amended below.

4. Paragraph (j)(7)(iii) of § 1910.95 is amended by removing the word "the" before "audiologist" and inserting the word "an" in its place; in addition, the word "also" is removed.

5. Paragraph (k)(5)(iii) of § 1910.95 is amended by inserting the words "and above 6000 Hz" after the words "below 500 Hz" in the second sentence.

6. Paragraph (r)(2) of § 1910.95 is amended by removing the words "appendices B, F and" before "H"; the word "are" which appears twice in the sentence is removed and the word "is" is inserted in its place.

7. Paragraph (s)(1) of § 1910.95 is amended by removing the words "April 15, 1981" and inserting "August 22, 1981" in its place.

8. Paragraph (s)(2) of § 1910.95 is amended by removing the words "October 15, 1981" and inserting "February 22, 1982" in its place.

9. Paragraph (s)(3) of § 1910.95 is amended by removing the words "April 15, 1982" and inserting "August 22, 1982" in its place.

10. Paragraph I. (1)(ii) in Appendix A of § 1910.95 is corrected by removing "C_nT_n" and inserting "C_n/T_n" in its place.

11. Table E-2 in Appendix E of § 1910.95 is corrected by changing "TDH-39" in the middle column heading to read "TDH-49".

12. In Appendix H of § 1910.95, the address given for the Superintendent of Documents in the right hand column of the chart is corrected by changing the zip code from "20404" to "20402".

C. Provisions Going Into Effect August 22

The text of the hearing conservation amendment contained in § 1910.95(c)-(s) and appendices A-I to § 1910.95 currently in effect is shown below.

§ 1910.95 Occupational noise exposure.

* * * * *

(c) *Hearing conservation program.* The employer shall administer a continuing, effective hearing conservation program, as described in paragraphs (c) through (s) of this section whenever employee noise exposures equal or exceed an 8-hour time-weighted average sound level (TWA) of 85 decibels measured on the A scale slow response or, equivalently, a dose of fifty percent. For purposes of the hearing conservation program, employee noise exposures shall be computed in accordance with Appendix A and Table G-16a, and without regard to any attenuation provided by the use of personal protective equipment.

(e) *Monitoring.* (1) When information indicates that any employee's exposure may equal or exceed an 8-hour time-weighted average of 85 decibels, the employer shall obtain measurements for employees who may be exposed at or above that level.

(g)(2)(ii)(*b*) All continuous, intermittent and impulsive sound levels from 80 dB to 130 dB shall be integrated into the computation.

(i) *Observation of monitoring.* (1) The employer shall provide affected employees or their representatives with an opportunity to observe any measurements of employee noise exposure which are conducted pursuant to this section.

(j) *Audiometric testing program.* (1) The employer shall establish and maintain an audiometric testing program as provided in this paragraph by making audiometric testing available to all employees whose exposures equal or exceed an 8-hour time-weighted average of 85 decibels.

(2) The program shall be provided at no cost to employees.

(3) Audiometric tests shall be performed by a licensed or certified audiologist, otolaryngologist, or other qualified physician, or by a technician who is certified by the Council of Accreditation in Occupational Hearing Conservation, or who has satisfactorily demonstrated competence in administering audiometric examinations, obtaining valid audiograms, and properly using, maintaining and calibrating audiometers. A technician who performs audiometric tests must be responsible to an audiologist, otolaryngologist or qualified physician.

(4) All audiograms obtained pursuant to this section shall meet the requirements of Appendix C: *Audiometric Measuring Instruments.*

(5) *Baseline audiogram.* (i) The employer shall establish for each employee so exposed a valid baseline audiogram against which subsequent audiograms can be compared.

(ii) Testing to establish a baseline audiogram shall be preceded by at least 14 hours without exposure to workplace noise.

(6) *Annual audiogram.* (i) At least annually after obtaining the baseline audiogram, the employer shall obtain a new audiogram for each employee exposed at or above a time-weighted average of 85 decibles.

(ii) Annual audiometric testing may be conducted at any time during the workshift.

(7) *Evaluation of audiogram.* (i) Each employee's annual audiogram shall be compared to that employee's baseline audiogram to determine if the audiogram is valid and if a significant threshold shift has occurred.

(ii) An audiologist, otolaryngologist, or qualified physician shall review the audiograms to determine whether there is need for further evaluation. The employer shall provide to the person performing this evaluation the following information:

(*a*) A copy of the requirements for hearing conservation as set forth in paragraphs (c) through (r) of this section;

(*b*) The baseline audiogram and most recent audiogram of the employee to be evaluated;

(*c*) Measurements of background sound pressure levels in the audiometric test room as required in Appendix D: *Audiometric Test Rooms.*

(*d*) Records of audiometer calibrations required by paragraph (k)(5) of this section.

(8) *Follow-up procedures.* If a comparison of the annual audiogram to the baseline audiogram indicates a significant threshold shift the employer shall ensure that the following steps are taken:

(i) Employees not using hearing protectors shall be fitted with hearing protectors, trained in their use and care, and required to use them.

(ii) Employees already using hearing protectors shall be refitted and retrained in the use of hearing protectors and provided with hearing protectors offering greater attenuation if necessary.

(iv)(*a*) Inform the employee in writing, within 21 days of the determination, of the existence of a significant threshold shift;

(*b*) Refer the employee for a clinical audiological evaluation or an otological examination, as appropriate, if additional testing is necessary or if the employer suspects that a medical pathology of the ear (as defined in Appendix I) is caused or aggravated by the wearing of hearing protectors;

(*c*) Inform the employee of the need for an otological examination if a medical pathology of the ear which is unrelated to the use of hearing protectors is suspected.

(k) *Audiometric test requirements.* (1) Audiometric tests shall be pure tone, air conduction, hearing threshold examinations, with test frequencies including as a minimum 500, 1000, 2000, 3000, 4000, and 6000 Hz. Tests at each frequency shall be taken separately for each ear.

(2) Audiometric tests shall be conducted with equipment that meets the specifications of, and is maintained

and used in accordance with, American National Standard Specification for Audiometers, S3.6–1969.

(3) Pulsed-tone and self-recording audiometers, if used, shall meet the requirements specified in Appendix C: *Audiometric Measuring Instruments.*

(4) Audiometric examinations shall be administered in a room meeting the requirements listed in Appendix D: *Audiometric Test Rooms.*

(5) *Audiometer calibration.* (i) The functional operation of the audiometer shall be checked before each day's use by testing a person with known, stable hearing thresholds, and by listening to the audiometer's output to make sure that the output is free from distorted or unwanted sounds. Deviations of more than 5 dB shall require an acoustic calibration.

(ii) Audiometer calibration shall be checked acoustically at least annually in accordance with Appendix E: *Acoustic Calibration of Audiometers.* Test frequencies below 500 Hz and above 6000 Hz may be omitted from this check. Deviations of more than 10 dB necessitate an exhaustive calibration.

(iii) An exhaustive calibration shall be performed at least every two years in accordance with sections 4.1.2; 4.1.3; 4.1.4.3; 4.4.1; 4.4.2; 4.4.3; and 4.5 of the American National Standard Specification for Audiometers, S3.6–1969. Test frequencies below 500 Hz and above 6000 Hz may be omitted from this calibration.

(l) *Hearing protectors.* (1) Employers shall make hearing protectors available to all employees exposed to a time-weighted average of 85 decibels or greater at no cost to the employees. Hearing protectors shall be replaced as necessary.

(2) Employers shall ensure that hearing protectors are worn by all employees:

(i) Who are exposed to a time-weighted average of 85 decibels or greater and who have experienced a significant threshold shift; or

(ii) Who are required by paragraph (b)(1) of this section to wear personal protective equipment.

(3) Employees shall be given the opportunity to select their hearing protectors from a variety of suitable hearing protectors provided by the employer.

(4) The employer shall provide training in the use and care of all hearing protectors provided to employees.

(5) The employer shall ensure proper initial fitting and supervise the correct use of all hearing protectors.

(m) *Hearing protector attenuation.* (1) The employer shall evaluate hearing protector attenuation for the specific noise environments in which the protector will be used by one of the methods described in Appendix G: *Methods for Estimating the Adequacy of Hearing Protector Attenuation.*

(2) Hearing protectors must attenuate employee exposure at least to a time-weighted average of 90 decibels as required by paragraph (b) of this section.

(3) For employees who have experienced a significant threshold shift, hearing protectors must attenuate employee exposures to a time-weighted average of 85 decibels or below.

(4) The adequacy of hearing protector attenuation shall be re-evaluated whenever employee noise exposures increase to the extent that the hearing protectors provided may no longer provide adequate attenuation. The employer shall provide more effective hearing protectors where necessary.

(n) *Training program.* (1) The employer shall institute a training program for all employees who are exposed to noise at or above a TWA of 85 dB, and shall ensure employee participation in such program.

(2) The training program shall be repeated annually for each employee included in the hearing conservation program. Information provided in the training program shall be updated to be consistent with changes in protective equipment and work processes.

(3) The employer shall ensure that each employee is informed of the following:

(ii) The effects of noise on hearing;

(vi) The purpose of hearing protectors, the advantages, disadvantages, and attenuation of various types, and instructions on selection, fitting, use, and care; and

(vii) The purpose of audiometric testing, and an explanation of the test procedures.

(o) *Access to information and training materials.* (1) The employer shall make available to affected employees or their representatives copies of this standard and shall also post a copy in the workplace.

(2) The employer shall provide to affected employees any informational materials pertaining to this standard that are supplied to the employer by the Assistant Secretary.

(3) The employer shall provide, upon request, all materials related to the employer's training and education program pertaining to this standard to the Assistant Secretary and the Director.

(q) *Recordkeeping.* (1) *Exposure measurements.* (i) The employer shall maintain an accurate record of all employee exposure measurements required by this section.

(2) *Audiometric tests.* (i) The employer shall retain all employee audiograms obtained pursuant to paragraph (j) of this section;

(ii) This record shall include:

(*a*) Name and job classification of the employee;

(*b*) Date of the audiogram;

(*c*) The examiner's name;

(*e*) Date of the last acoustic or exhaustive calibration of the audiometer;

(*f*) Employee's most recent noise exposure assessment;

(3) *audiometric test rooms.* (i) The employer shall maintain accurate records of the measurements of the background sound pressure levels in audiometric test rooms.

(5) *Record retention.* The employer shall retain records required in this paragraph (q) for at least the following periods:

(i) Noise exposure measurement records shall be retained for 2 years.

(ii) Audiometric test records shall be retained for the duration of the affected employee's employment.

(6) *Access to records.* All records required by this section shall be provided upon request to employees, former employees, representatives designated by the individual employee and the Assistant Secretary. The provisions of 29 CFR 1910.20(a)–(e) and (g)–(i) apply to access to records under this section.

(7) *Transfer of records.* If the employer ceases to do business, the employer shall transfer to the successor employer all records required to be maintained by this section, and the successor employer shall retain them for the remainder of the period prescribed in paragraph (q)(5) of this section.

(r) *Appendices.* (1) Appendices A, C, D, E, G, and I to this section are incorporated as part of this section and the contents of these Appendices are mandatory.

(2) Appendix H to this section is informational and is not intended to create any additional obligations not otherwise imposed or to detract from any existing obligations.

(s) *Effective dates.* (1) Paragraphs (c)–(r) of this section shall become effective August 22, 1981 unless otherwise noted below.

(2) Monitoring conducted pursuant to paragraph (e) of this section shall be completed by February 22, 1982.

(3) Baseline audiograms required by paragraph (j) of this section shall be completed by August 22, 1982.

Appendix A: Noise Exposure Computation

This Appendix Is Mandatory

I. Computation of Employee Noise Exposure

(1) Noise dose is computed using Table G-16a as follows:

(i) When the sound level, L, is constant over the entire work shift, the noise dose, D, in percent, is given by: D=100 C/T where C is the total length of the work day, in hours, and T is the reference duration corresponding to the measured sound level, L, as given in Table G-16a or by the formula shown as a footnote to that table.

(ii) When the workshift noise exposure is composed of two or more periods of noise at different levels, the total noise dose over the work day is given by:

$D=100\ (C_1/T_1+C_2/T_2+\ldots+C_n/T_n)$,

where C_n indicates the total time of exposure at a specific noise level, and T_n indicates the reference duration for that level as given by Table G-16a.

(2) The eight-hour time-weighted average sound level (TWA), in decibels, may be computed from the dose, in percent, by means of the formula: $TWA=16.61\ \log_{10}\ (D/100)+90$. For an eight-hour workshift with the noise level constant over the entire shift, the TWA is equal to the measured sound level.

(3) A table relating dose and TWA is given in Section II.

Table G-16a

A-weighted sound level, L (decibel)	Reference duration, T (hour)
80	32
81	27.9
82	24.3
83	21.1
84	18.4
85	16
86	13.9
87	12.1
88	10.6
89	9.2
90	8
91	7.0
92	6.2
93	5.3
94	4.6
95	4
96	3.5
97	3.0
98	2.6
99	2.3
100	2
101	1.7
102	1.5
103	1.4
104	1.3
105	1
106	0.87
107	0.76
108	0.66
109	0.57
110	0.5
111	0.44
112	0.38
113	0.33
114	0.29
115	0.25
116	*0.22*
117	*0.19*
118	*0.16*
119	*0.14*
120	*0.125*
121	*0.11*
122	*0.095*
123	*0.082*
124	*0.072*
125	*0.063*
126	*0.054*
127	*0.047*
128	*0.041*
129	*0.036*
130	*0.031*

In the above table the reference duration, T, is computed by

$$T=\frac{8}{2^{(L-90)/5}}$$

where L is the measured A-weighted sound level.

II. Conversion Between "Dose" and "8-Hour Time-Weighted Average" Sound Level

Compliance with paragraphs (c)–(r) of this regulation is determined by the amount of exposure to noise in the workplace. The amount of such exposure is usually measured with an audiodosimeter which gives a readout in terms of "dose." In order to better understand the requirements of the amendment, dosimeter readings can be converted to an "8-hour time-weighted average sound level" (TWA).

In order to convert the reading of a dosimeter into TWA, see Table A-1, below. This table applies to dosimeters that are set by the manufacturer to calculate dose or percent exposure according to the relationships in Table G-16a. So, for example, a dose of 91 percent over an eight hour day results in a TWA of 89.3 dB, and, a dose of 50 percent corresponds to a TWA of 85 dB.

If the dose as read on the dosimeter is less than or greater than the values found in Table A-1, the TWA may be calculated by using the formula: $TWA=16.61\ \log_{10}\ (D/100)+90$ where TWA=8-hour time-weighted average sound level and D=accumulated dose in percent exposure.

Table A-1.—*Conversion From "Percent Noise Exposure" or "Dose" to "8-Hour Time-Weighted Average Sound Level" (TWA)*

Dose or percent noise exposure	TWA
10	73.4
15	76.3
20	78.4
25	80.0
30	81.3
35	82.4
40	83.4
45	84.2
50	85.0
55	85.7
60	86.3
65	86.9
70	87.4
75	87.9
80	88.4
81	88.5
82	88.6
83	88.7
84	88.7
85	88.8
86	88.9
87	89.0
88	89.1
89	89.2
90	89.2
91	89.3
92	89.4
93	89.5
94	89.6
95	89.6
96	89.7
97	89.8
98	89.9
99	89.9
100	90.0
101	90.1
102	90.1
103	90.2
104	90.3
105	90.4
106	90.4
107	90.5
108	90.6
109	90.6
110	90.7
111	90.8
112	90.8
113	90.9
114	90.9
115	91.1
116	91.1
117	91.1
118	91.2
119	91.3
120	91.3
125	91.6
130	91.9
135	92.2
140	92.4
145	92.7
150	92.9
155	93.2
160	93.4
165	93.6
170	93.8
175	94.0
180	94.2
185	94.4
190	94.6
195	94.8
200	95.0
210	95.4
220	95.7
230	96.0
240	96.3
250	96.6
260	96.9
270	97.2
280	97.4
290	97.7
300	97.9
310	98.2
320	98.4
330	98.6
340	98.8
350	99.0
360	99.2
370	99.4
380	99.6
390	99.8
400	100.0
410	100.2
420	100.4
430	100.5
440	100.7
450	100.8
460	101.0
470	101.2
480	101.3
490	101.5
500	101.6
510	101.8
520	101.9
530	102.0
540	102.2
550	102.3

Table A-1.—*Conversion From "Percent Noise Exposure" or "Dose" to "8-Hour Time-Weighted Average Sound Level" (TWA)*—Continued

Dose or percent noise exposure	TWA
560	102.4
570	102.6
580	102.7
590	102.8
600	102.9
610	103.0
620	103.2
630	103.3
640	103.4
650	103.5
660	103.6
670	103.7
680	103.8
690	103.9
700	104.0
710	104.1
720	104.2
730	104.3
740	104.4
750	104.5
760	104.6
770	104.7
780	104.8
790	104.9
800	105.0
810	105.1
820	105.2
830	105.3
840	105.4
850	105.4
860	105.5
870	105.6
880	105.7
890	105.8
900	105.8
910	105.9
920	106.0
930	106.1
940	106.2
950	106.2
960	106.3
970	106.4
980	106.5
990	106.5
999	106.6

Appendix C: Audiometric Measuring Instruments

This Appendix is Mandatory

1. In the event that pulsed-tone audiometers are used, they shall have a tone on-time of at least 200 milliseconds.

2. Self-recording audiometers shall comply with the following requirements:

(A) The chart upon which the audiogram is traced shall have lines at positions corresponding to all multiples of 10 dB hearing level within the intensity range spanned by the audiometer. The lines shall be equally spaced and shall be separated by at least ¼ inch. Additional increments are optional. The audiogram pen tracings shall not exceed 2 dB in width.

(B) It shall be possible to set the stylus manually at the 10-dB increment lines for calibration purposes.

(C) The slewing rate for the audiometer attenuator shall not be more than 6 dB/sec except that an initial slewing rate greater than 6 dB/sec is permitted at the beginning of each new test frequency, but only until the second subject response.

(D) The audiometer shall remain at each required test frequency for 30 seconds (±3 seconds). The audiogram shall be clearly marked at each change of frequency and the actual frequency change of the audiometer shall not deviate from the frequency boundaries marked on the audiogram by more than ±3 seconds.

(E) It must be possible at each test frequency to place a horizontal line segment parallel to the time axis on the audiogram, such that the audiometric tracing crosses the line segment at least six times at that test frequency. At each test frequency the threshold shall be the average of the midpoints of the tracing excursions.

Appendix D: Audiometric Test Rooms

This Appendix is Mandatory

Rooms used for audiometric testing shall not have backgound sound pressure levels exceeding those in Table D-1 when measured by equipment confoming at least to the Type 2 requirements of American National Standard Specification for Sound Level Meters, S1.4-1971 (R1976), and to the Class II requirements of American National Standard Specification for Octave, Half-Octave, and Third-Octave Band Filter Sets, S1.11-1971 (R1976).

Table D-2.—*Maximum Allowable Octave-Band Sound Pressure Levels for Audiometric Test Rooms*

Octave-band center frequency (Hz)	500	1000	2000	4000	8000
Sound pressure level (dB)	40	40	47	57	62

Appendix E: Acoustic Calibration of Audiometers

This Appendix is Mandatory

Audiometer calibration shall be checked acoustically, at least annually, according to the procedures described in this Appendix. The equipment necessary to perform these measurements is a sound level meter, octave-band filter set, and a National Bureau of Standards 9A coupler. In making these measurements, the accuracy of the calibrating equipment shall be sufficient to determine that the audiometer is within the tolerances permitted by American Standard Specification for Audiometers, S3.6-1969.

(1) Sound Pressure Output Check

A. Place the earphone coupler over the microphone of the sound level meter and place the earphone on the coupler.

B. Set the audiometer's hearing threshold level (HTL) dial to 70 dB.

C. Measure the sound pressure level of the tones at each test frequency from 500 Hz through 6000 Hz for each earphone.

D. At each frequency the readout on the sound level meter should correspond to the levels in Table E-1 or Table E-2, as appropriate, for the type of earphone, in the column entitled "sound level meter reading."

(2) Linearity Check

A. With the earphone in place, set the frequency to 1000 Hz and the HTL dial on the audiometer to 70 dB.

B. Measure the sound levels in the coupler at each 10-dB decrement from 70 dB to 10 dB, noting the sound level meter reading at each setting.

C. For each 10-dB decrement on the audiometer the sound level meter should indicate a corresponding 10 dB decrease.

D. This measurement may be made electrically with a voltmeter connected to the earphone terminals.

(3) Tolerances

When any of the measured sound levels deviate from the levels in Table E-1 or Table E-2 by ±3 dB at any test frequency between 500 and 3000 Hz, 4 dB at 4000 Hz, or 5 dB at 6000 Hz, and exhaustive calibration is advised. An exhaustive calibration is required if the deviations are greater than 10 dB at any test frequency.

Table E-1.—*Reference Threshold Levels for Telephonics—TDH-39 Earphones*

Frequency, Hz	Reference threshold level for TDH-39 earphones, dB	Sound level meter reading, dB
500	11.5	81.5
1000	7	77
2000	9	79
3000	10	80
4000	9.5	79.5
6000	15.5	85.5

Table E-2.—*Reference Threshold Levels for Telephonics—TDH-49 Earphones*

Frequency, Hz	Reference threshold level for TDH-49 earphones, dB	Sound level meter reading, dB
500	13.5	83.5
1000	7.5	77.5
2000	11	81.0
3000	9.5	79.5
4000	10.5	80.5
6000	13.5	83.5

Appendix G: Methods for Estimating the Adequacy of Hearing Protector Attenuation

This Appendix Is Mandatory

For employees who have experienced a significant threshold shift, hearing protector attenuation must be sufficient to reduce employee exposure to a TWA of 85 dB. Employers must select one of the following methods by which to estimate the adequacy of hearing protector attenuation.

The most convenient method is the Noise Reduction Rating (NRR) developed by the Environmental Protection Agency (EPA). According to EPA regulation, the NRR must be shown on the hearing protector package. The NRR is then related to an individual worker's noise environment in order to assess the adequacy of the attenuation of a given hearing protector. This Appendix describes four methods of using the NRR to determine whether a particular hearing protector provides adequate protection within a given exposure environment. Selection among the four procedures is dependent upon the employer's noise measuring instruments.

Instead of using the NRR, employers may evaluate the adequacy of hearing protector attenuation by using one of the three methods developed by the National Institute for Occupational Safety and Health (NIOSH), which are described in the "List of Personal Hearing Protectors and Attenuation Data," HEW Publication No. 76-120, 1975, pages 21-37. These methods are known as NIOSH methods #1, #2 and #3. The NRR described below is a simplification of NIOSH method #2. The most complex method is NIOSH method #1, which is probably the most accurate method since it uses the largest amount of spectral information from the individual employee's noise environment. As in the case of the NRR method described below, if one of the NIOSH methods is used, the selected method must be applied to an individual's noise environment to assess the adequacy of the attenuation. Employers should be careful to take a sufficent number of measurements in order to achieve a representative sample for each time segment.

Note.—The employer must remember that calculated attenuation values reflect realistic values only to the extent that the protectors are properly fitted and worn.

When using the NRR to assess hearing protector adequacy, one of the following methods must be used:

(i) When using a dosimeter that is capable of C-weighted measurements:

(A) Obtain the employee's C-weighted dose for the entire workshift, and convert to TWA (see Appendix A, II).

(B) Subtract the NRR from the C-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.

(ii) When using a dosimeter that is not capable of C-weighted measurements, the following method may be used:

(A) Convert the A-weighted dose to TWA (see Appendix A).

(B) Subtract 7 dB from the NRR.

(C) Subtract the remainder from the A-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.

(iii) When using a sound level meter set to the A-weighting network:

(A) Obtain the employee's A-weighted TWA.

(B) Subtract 7dB from the NRR, and subtract the remainder from the A-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.

(iv) When using a sound level meter set on the C-weighting network:

(A) Obtain a representative sample of the C-weighted sound levels in the employee's environment.

(C) Subtract the NRR from the C-weighted average sound level to obtain the estimated A-weighted TWA under the ear protector.

Appendix H: Availability of Referenced Documents

Paragraphs (c) through (s) of 29 CFR 1910.95 and the accompanying appendices contain provisions which incorporate publications by reference. Generally, the publications provide criteria for instruments to be used in monitoring and audiometric testing. These criteria are intended to be mandatory when so indicated in the applicable paragraphs of Section 1910.95 and appendices.

It should be noted that OSHA does not require that employers purchase a copy of the referenced publications. Employers, however, may desire to obtain a copy of the referenced publications for their own information.

The designation of the paragraph of the standard in which the referenced publications appear, the titles of the publications, and the availability of the publications are as follows:

Paragraph designation	Referenced publication	Available from—
§ 1910.95(g)(1)(i)	"Specification for Personal Noise Dosimeters," ANSI S1.25-1978. (ASA 25-1978).	Back Numbers Department, Dept. STD, American Institute of Physics, 333 E. 45th St., New York, NY 10017. American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.
§ 1910.95(g)(1)(ii)	"Specification for Sound Level Meters," S1.4-1971 (R1976).	American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.
§ 1910.95(k)(2), appendix E.	"Specifications for Audiometers," S3.6-1969.	American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.
Appendix D	"Specification for Octave, Half-Octave and Third-Octave Band Filter Sets," S1.11-1971 (R1976).	Back Numbers Department, Dept. STD, American Institute of Physics, 333 E. 45th St., New York, NY 10017; American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.
Appendix G	"List of Personal Hearing Protectors and Attenuation Data," HEW Pub. No. 76-120, 1975.	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

The referenced publications (or a microfiche of the publications) are available for review at many universities and public libraries throughout the country. These publications may also be examined at the OSHA Technical Data Center, Room N2439, United States Department of Labor, 200 Constitution Avenue N.W., Washington, D.C. 20210, (202) 523-9700 or at any OSHA Regional Office (see telephone directories under United States Government—Labor Department).

Appendix I: Definitions

These definitions apply to the following terms as used in paragraphs (c) through (r) of 29 CFR 1910.95.

Audiogram—A chart, graph, or table resulting from an audiometric test showing an individual's hearing threshold levels as a function of frequency.

Audiologist—A professional, specializing in the study and rehabilitation of hearing, who is certified by the American Speech, Hearing, and Language Association or licensed by a state board of examiners.

Baseline audiogram—The audiogram against which future audiograms are compared.

Crest factor—Absolute value of the ratio of the peak value and the root-mean-square value measured over a specified time interval where both values are measured in reference to the arithmetic mean value of the wave.

Criterion sound level—A sound level of 90 decibels.

Decibel (dB)—Unit of measurement of sound level.

Hertz (Hz)—Unit of measurement of frequency, numerically equal to cycles per second.

Medical pathology—A disorder or disease. For purposes of this regulation, a condition or disease affecting the ear, which should be treated by a physician specialist.

Noise dose—The ratio, expressed as a percentage, of (1) the time integral, over a stated time or event, of the 0.6 power of the measured SLOW exponential time-averaged, squared A-weighted sound pressure and (2) the product of the criterion duration (8 hours) and the 0.6 power of the squared sound pressure corresponding to the criterion sound level (90 dB).

Noise dosimeter—An instrument that integrates a function of sound pressure over a period of time in such a manner that it directly indicates a noise dose.

Otolaryngologist—A physician specializing in diagnosis and treatment of disorders of the ear, nose and throat.

Representative exposure—Measurements of an employee's noise dose or 8-hour time-weighted average sound level that the employers deem to be representative of the exposures of other employees in the workplace.

Sound level—Ten times the common logarithm of the ratio of the square of the measured A-weighted sound pressure to the square of the standard reference pressure of 20 micropascals. Unit: decibels (dB). For use with this regulation, SLOW time response, in accordance with ANSI S1.4-1971 (R1976), is required.

Sound level meter—An instrument for the measurement of sound level.

Time-weighted average sound level—That sound level, which if constant over an 8-hour exposure, would result in the same noise dose as is measured.

VII. Authority

This document was prepared under the direction of Thorne G. Auchter, Assistant Secretary of Labor for Occupational Safety and Health, 200 Constitution Avenue, N.W., Washington, D.C. 20210.

(Secs. 4, 6, 8, 84 Stat. 1592, 1593, 1599, (29 U.S.C. 653, 655, 657); 5 U.S.C. 553; Secretary of Labor's Order No. 8-76 (41 FR 25059))

Signed at Washington, D.C. this 18th day of August, 1981.

Thorne G. Auchter,

Assistant Secretary of Labor.

[FR Doc. 81-24448 Filed 8-19-81; 12:00 pm]

BILLING CODE 4510-26-M

DEPARTMENT OF LABOR

Occupational Safety and Health Administration

29 CFR Part 1910

Occupational Noise Exposure; Hearing Conservation Amendment

AGENCY: Occupational Safety and Health Administration (OSHA), Labor.

ACTION: Request for comments.

SUMMARY: In the Rules section of this issue, the Occupational Safety and Health Administration is publishing a document partially lifting an administrative stay of the hearing conservation amendment. As explained more fully in the Rules section document, certain provisions of the amendment are being reopened for comment and comments are also being requested on whether many of the provisions which have been reopened for comment should be stayed in the interim. Refer to this document for further details.

FOR FURTHER INFORMATION CONTACT: Dr. Alice Suter, Telephone (202) 523-7151.

Signed at Washington, D.C. this 18th day of August, 1981.

Thorne G. Auchter,

Assistant Secretary of Labor.

[FR Doc. 81-24440 Filed 8-19-81; 12:00 pm]

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federal register

Friday
January 16, 1981

Part III

Department of Labor

Occupational Safety and Health Administration

Occupational Noise Exposure; Hearing Conservation Amendment

DEPARTMENT OF LABOR

29 CFR Part 1910

Occupational Noise Exposure; Hearing Conservation Amendment

AGENCY: The Occupational Safety and Health Administration (OSHA) of the United States Department of Labor.

ACTION: Final rule.

SUMMARY: This final rule establishes a hearing conservation program, including exposure monitoring, audiometric testing, and training, for all employees who have occupational noise exposures equal to or exceeding an 8-hour time-weighted average of 85 dBA. This amendment covers all employees except those engaged in construction or agriculture. This rule is the outgrowth of the proposed revision of the occupational noise exposure standard which was proposed in 1974. By its action today, OSHA is deferring final action on two issues raised in the 1974 proposal: the permissible exposure level for occupational noise and the appropriate method of compliance with the permissible exposure level. These two issues will continue to be governed by the existing standard.

OSHA plans to study these two issues further and will in the near future reopen the record for the submission of new evidence on these issues.

EFFECTIVE DATE: This standard will become effective April 15, 1981. Start-up dates: Employee exposure monitoring shall be completed by October 15, 1981. Dosimeters used to measure employee exposures must meet the specifications in the standard by April 15, 1983. Baseline audiograms shall be completed by April 15, 1982.

FOR FURTHER INFORMATION CONTACT: Dr. Alice Suter, Office of Physical Agents Standards, Occupational Safety and Health Administration, Room N-3718, U.S. Department of Labor, 200 Constitution Avenue NW., Washington, D.C. 20210, Telephone (202) 523-7151.

Copies of any portion of the record including the Final Environmental Impact Statement and Regulatory Analysis may be obtained by contacting: Docket Officer, Docket No. OSH-11, Room S-6212, U.S. Department of Labor, 200 Constitution Avenue, N.W., Washington, D.C. 20210, Telephone (202) 523-7894.

I. Introduction

Rationale for Amendment

Noise is one of the most pervasive occupational health problems. It is a by-product of many industrial processes. Exposure to high levels of noise causes temporary or permanent hearing loss and may cause other harmful health effects as well. The extent of damage depends primarily on the intensity of the noise and the duration of the exposure.

There is an abundance of epidemiological and laboratory evidence that protracted noise exposure above 90 decibels (dB) causes hearing loss in a substantial portion of the exposed population, and that more susceptible individuals will incur hearing loss at levels below 90 dB (Ex. 11; Ex. 12; Ex. 17; Ex. 26-2). This is discussed more fully in the Health Effects section below. Noise-induced hearing loss in an irreversible condition that progresses with increased exposure, and is exacerbrated by the normal aging process. Although such a loss may be slight at first, continued exposure may result in a loss that is severe enough to affect seriously an individual's ability to understand speech. In some cases, even slight losses in the audiometric frequencies that are critical for the understanding of speech can adversely affect an individual's ability to earn a living and to function in society in general. It constitutes a serious physical, psychological, and social handicap. Such impairment of a critical functional capacity clearly is the type of material impairment of health, which Congress, in Section 6(b)(5) of the Act, directed the Secretary to prevent.

Noise can also cause other adverse effects, such as degraded job performance, increases in accidents and absenteeism, job dissatisfaction, headaches, fatigue, sleeplessness, stress-related illnesses, and other effects that are more difficult to quantify and identify as noise-related than is hearing loss (Ex. 2C-106, p. 2; Ex. 2C-111, p. 1; Ex. 96, pp. 277-281; Ex. 169-8, p. 2; Ex. 28A, pp. 18-24, 27-28, 41-44, 46-49; Ex. 32, App. B, Gulian, pp. 6-11; Ex. 79, p. 2; Ex. 173, pp. 1-2, 7-8; Ex. 84, attach. 2, pp. 1-2).

OSHA's existing standard for occupational exposure to noise (29 CFR 1910.95) specifies a maximum permissible noise exposure level of 90 dB for a duration of 8 hours, with higher levels allowed for shorter durations. (This level is called a time-weighted average sound level, abbreviated TWA.) Employers must use feasible engineering or administrative controls, or combinations of both, whenever employee exposure to noise in the workplace exceeds the permissible exposure level. Personal protective equipment may be used to supplement the engineering and administrative controls where such controls are not able to reduce the employee exposures to within permissible limits. The standard also requires employers to administer a "continuing, effective hearing conservation program" for overexposed employees, but the standard does not define such a program.

OSHA proposed a revised noise standard in 1974, which maintained the current standard's 90 dB time-weighted average exposure limit, but required exposure monitoring, and articulated the requirements for hearing conservation programs. There was a great deal of controversy in the rulemaking proceedings about alternative permissible exposure limits and their technical and economic feasibility, but few challenged the concept or the appropriateness of a hearing conservation program. (Tr. 551-553; Tr. 210; Ex. 306, Secs. J2C, J1C, J4C; Ex. 305; Ex. 2C-16A; Ex. 2C-16B)

Analysis of the hearing record reveals information gaps in the area of extra-auditory physiological effects of noise (adverse health effects other than loss of hearing, such as high blood pressure), and also in the areas of economic and technological feasibility of noise control. The Agency needs to obtain additional material and to perform additional impact analyses before issuing a comprehensive new regulation. Therefore, for the present, OSHA will leave the permissible exposure level and compliance mechanisms of the current noise standard unchanged and continue its enforcement. The Agency will defer the final decision on methods of compliance and the permissible exposure level until it has obtained and evaluated the necessary information. The decision to implement a hearing conservation program is separate and severable from the remaining issues.

While such information is being obtained, employees must be afforded additional protection against the effects of noise. Information in the record indicates that many employees are not receiving the benefits of engineering controls to reduce their exposures to within the permissible exposure limits. In fact, there are some 2.9 million workers in American production industries with TWAs in excess of 90 dB, and an additional 2.3 million whose exposure levels exceed 85 dB. These workers, who face a significant risk or material impairment of health or functional capacity, will receive greatly increased protection from the promulgation and enforcement of these hearing conservation requirements, which amend certain provisions of the present noise standard. The provision of this protection in the form of a well-defined hearing conservation program does not depend upon a determination of an appropriate exposure level or compliance strategy. These issues were treated separately in the proposal and the decision to implement a hearing conservation program first is consistent with the mandate of the Act that, insofar as possible, workers be protected from any material impairment of health or functional capacity.

Hearing conservation programs constitute commonly accepted industrial hygiene practice. Many companies already have instituted programs for their noise-exposed workforce (Ex. 300; Ex. 147A; Ex. 147C). This amendment clarifies what a hearing conservation program must be, and gives direction to the implementation of such a program.

Hearing conservation includes noise exposure monitoring, audiometric testing, the use of hearing protective devices where necessary, and employee education. All of these elements are reasonably necessary and appropriate for a continuing effective hearing conservation program. These procedures will result in considerable benefits for more than 5.2 million employees. Hearing protective devices will reduce the incidence of noise-induced hearing loss and also the various extra-auditory effects described below. Audiometric tests will enable employers and employees to take proper precautions to prevent further deterioration of hearing. Monitoring and educational programs will increase general awareness of noise problems, and promote the effective use of ear protectors. Another benefit, which was suggested by a National Institute for Occupational Safety and Health study, is a reduction in workplace accidents and absenteeism (Ex. 20–11, pp. ii, 5–2).

At this time the Agency does not believe that a hearing conservation program alone is the solution to the problem of workplace noise. The Agency continues to support the policy, reflected in the existing standard and not affected by this amendment, that engineering control of noise is preferable to the use of personal protective devices. The record contains considerable evidence that hearing protectors do not always provide as much attenuation in practice as the manufacturer indicates (Ex. 319, B–12, p. 4; Ex. 300A, p. 91; Ex. 301, p. 33), that many workers dislike using hearing protectors (Ex. 79, pp. 7–8; Ex. 94, pp. 9–10; Ex. 78, p. 14), and that protectors can be very uncomfortable (Ex. 73, Attach. 4, p. 1; Ex. 79, p. 7; Ex. 321–45A, pp. 1–11; Ex. 94, p. 10; Ex. 78, p. 14). In fact the degree of protection provided by such devices is questionable since they may become unseated through talking or chewing during the course of the workday.

When hearing protectors are relied upon, the adequacy of protection will depend upon the quality of the hearing protector, the tightness of the fit, and its use by employees. Permanent hearing loss can occur before it is identified by audiometric testing and, of course, extra-auditory effects cannot be detected by audiometry. Thus, none of these measures are as effective as controlling the hazard at the source.

Physical Properties of Sound

Sound consists of pressure changes in a medium (usually air), caused by vibration or turbulence. These pressure changes take the form of alternating compression and rarefaction of molecules, producing waves that propagate away from a vibrating or turbulent source. The magnitude and the type of effect on humans depend on three physical parameters of sound: level, frequency, and duration. Sound pressure level is a logarithmic measure of the magnitude of the pressure change, which is perceived as loudness. Sound pressure level is expressed in decibels, abbreviated dB. The magnitude, or intensity, of sound is perceived as loudness. The entire range of audible sound pressure (for individuals with normal hearing a range of more than ten million to one), can be compressed into a practical scale of 0 to 140 dB. Because of the logarithmic scale, a small increase in decibels represents a large increase in sound energy. Technically, each increase of 3 dB represents a doubling of sound energy, an increase of 10 dB represents a tenfold increase, and a 20-dB increase represents a 100-fold increase in sound energy.

The frequency of a sound is the number of times that a complete cycle of compressions and rarefactions occurs in a second. The descriptor, which used to be "cycles per second," is now hertz, abbreviated Hz. Frequency is perceived as pitch. The audible range of frequencies for humans with good hearing is 20 Hz to 20,000 Hz. Most everyday sounds contain a mixture of frequencies generated by a variety of sources. A sound's frequency composition is referred to as the spectrum. Frequency spectrum can be a determinant of the annoyance caused by noise, with high frequency noise being generally more annoying than low frequency noise. Also, narrow frequency bands or pure tones (single frequencies) can be somewhat more harmful to hearing than is broad band noise.

The third important parameter is the way a sound level varies over time. The duration of a sound can be measured in microseconds (the duration of a gunshot) to indefinitely long periods (typical of the hum of an electrical transformer). Industrial noise is usually described as continuous, fluctuating, intermittent, or impulsive. Continuous noise, like the sound of a fan or a motor, remains relatively constant for a long period of time. Fluctuating noise, such as the sound of a vehicle in different gears, rises and falls in intensity over a period of time. Intermittent noise ceases or falls to low levels between "on-times," or periods of much higher levels. Drilling or sawing operations are examples of intermittent noise. Impulse noise is characterized by a sharp rise in sound pressure level to a high peak, followed by a rapid decay. Impulses can occur in quiet conditions, or they can be superimposed on a background of continuous or fluctuating noise, which is typical of the production industries. Sometimes a distinction is made between impulse noise, which is non-reverberant, and impact noise, which is reverberant. Since impulsive noise in industry can be either reverberant or non-reverberant, and since the relevant parameter is pulse duration, only one term, "impulse noise," will be used.

Sound levels are relevant under this standard only as they affect employees. If the employee is not present while high sound levels are being generated, OSHA is not concerned. The Agency is concerned with employee *exposure*, which is the accumulation of noise levels experienced by employees, as these levels are distributed over the workshift. This distinction is important because some comments in the record reflected a misunderstanding of the difference between workplace sound levels and employee levels (Ex. 14–96, p. 1; Ex. 14–79, p. 1). Although the frequency spectrum of a sound may have some effect on hearing loss, it is primarily the combination of level and duration that determines the degree to which noise will cause hearing loss and extra-auditory health effects. The manner in which level and duration are combined, for purposes of predicting adverse effects or calculating noise "dose" or 8-hour time-weighted average sound level, depends upon the "exchange rate." This combination is sometimes referred to as the "doubling rate," or the "time-intensity" tradeoff. A 5-dB exchange rate is used in 29 CFR 1910.95 and in this amendment. Specifically, a 5-dB increase in level is permitted for each halving of duration.

or conversely, a doubling of duration necessitates a 5-dB decrease in level.

Noise exposure can be described either in terms of an 8-hour time-weighted average sound level or a noise dose. For purposes of Section 29 CFR 1910.95 and this amendment the integration is performed according to a 5-dB exchange rate, referenced to a "criterion" level of 90 dB and a criterion duration of 8 hours. A worker's 8-hour time-weighted average sound level (TWA) is obtained from the time integral of the various noise levels experienced over the entire workshift. For example, for purposes of the hearing conservation amendment, the exposure of an individual who works 12 hours in continuous noise of 90 dB would correspond to a TWA of 93 dB.

Noise dose is the same concept expressed in percent. A dose of 50 percent means that one-half of the permitted TWA has been experienced. It could represent 8 hours at 85 dB, 4 hours at 90 dB, 16 hours at 80 dB, or other such combinations.

Hearing and Hearing Loss

The auditory system has three primary components: the outer ear serves to direct sound into the ear, the middle ear mechanically transmits the sound waves from the air to the fluid-filled inner ear, and the inner ear changes the sound waves from mechanical to neural energy. This last process is done in a small organ known as the cochlea, where sensory cells respond to the mechanical vibrations, change them into electrical energy, and transmit the message to the brain via the auditory nerve.

Noise-induced hearing loss can be temporary or permanent. Temporary hearing loss results from short-term exposures to noise, with normal hearing returning after a period of rest. This temporary decrease in hearing ability is called temporary threshold shift (TTS), a person's hearing threshold being the level of sound that he or she can just barely hear. For example, if a person with normal hearing works all day in a noisy environment, measurements at the end of the day would show that he or she could not hear as well as at the beginning of the day. But by the next morning, after a period of quiet, this person's hearing would have returned to normal. Generally, prolonged exposure to noise over a period of several years causes permanent damage to the sensory cells of the cochlea. A person who regularly sustains TTS will eventually suffer permanent hearing loss, which will occur gradually over time. The occurrence of TTS shows that a worker has been affected by noise, and if that individual continues to be exposed to the same levels of noise, it will result in a noise-induced permanent threshold shift (NIPTS).

The ability to hear sounds with clarity is a distinct attribute of normal hearing. Damage to the outer or middle ear can produce a problem with the perception of sound intensity. Damage to the cochlea or the auditory nerve is termed "sensori-neural," and causes impaired perception of intelligibility as well as intensity. Even if sounds are amplified, they still seem indistinct. Sensori-neural hearing loss is irreversible. People with noise-induced hearing loss sometimes can benefit from the use of a hearing aid, but the aid can never "correct" a hearing loss the way eyeglasses usually can correct for impaired vision (Ex. 231, written testimony, p. 5). Hearing aids merely amplify sound, but they do not make it clearer, or less distorted. Also, they amplify the unwanted noise as well as the wanted speech signals.

Noise-induced hearing loss is sensori-neural. It is a permanent condition, and cannot be treated medically. It is characterized by a declining sensitivity to high frequency sounds, usually to frequencies above 2000 Hz. The loss usually appears first and is most severe for the 4000-Hz frequency; the "4000-Hz notch" in the audiogram is typical of noise-induced hearing loss. With continued exposure, the loss spreads to the other audiometric frequencies, 500 through 6000 Hz. This phenomenon results in difficulties in the perception of speech. Most of the sound energy of speech is in the vowel sounds, and yet most of the intelligibility lies in the consonants. People with noise-induced, high-frequency hearing loss typically have difficulty hearing consonant sounds, and therefore have difficulty understanding speech (Ex. 9, p. 18). These problems will be discussed more fully in the Health Effects section below.

The hearing-impaired person is often frustrated by missing information that is vital for social or vocational functioning. Not only will people have to speak louder, but they must speak more clearly in order to be understood. In addition, background noise, such as radio, TV, or other people talking, has a much more disruptive effect on hearing-impaired individuals than on the normal listener because these individuals are less able to differentiate between the wanted signal and the unwanted background noise (Ex. 50, p. 6; Ex. 321-16 B, pp. 9, 10, 14, 49-50). People with noise-induced hearing impairments may be lost when trying to communicate in a group or on a noisy street.

Studies in the record show that some individuals suffer severe hearing losses as a result of noise exposure (Ex. 12, p. 158; Ex. 310, p. 22; Ex. 279, 11-13, p. 443; Ex. 26-2, p. 51). These individuals would rate themselves as hearing very poorly, or even as deaf (Ex. 29, p. 85).

Social relationships become increasingly difficult as the hearing impairment becomes more severe. Audiologist Dr. W. Grady Thomas of the University of North Carolina explains some of the difficulties experienced by the hearing impaired as follows:

> depression, isolation, suspicion and withdrawal from social contacts . . . can be expected in some individuals with moderate hearing loss. . . . Adjustment problems in adults who lose hearing are difficult because habit patterns are firmly established. . . . Also, the evaluation of self, to a great extent is affected by the individual's perceptions of the evaluation of himself by others. Having to continually ask people to repeat misunderstood speech messages can contribute to feelings of inadequacy and insecurity. (Tr. 815-816)

Other Adverse Effects

In addition to hearing loss, noise can cause other harmful effects. Noise can interfere with conversation to the extent that communication is virtually impossible, causing a feeling of isolation among workers. High levels of noise, even though they may be of relatively short duration, can mask warning shouts or signals. Injuries and even fatalities have been reported in conditions where the noise masked danger signals or cries for help (Ex. 26-1, p. 7; Ex. 76, p. 20).

There is increasing evidence that noise can cause adverse effects on general health. Laboratory and field studies implicate noise as a causative factor in stress-related illnesses, such as hypertension, ulcers, and neurological disorders. These effects, as well as more details on noise-induced hearing loss, will be discussed in subsequent sections of this preamble.

Measurement of Noise and Hearing Loss

There are two major types of instruments that are used to measure occupational noise. These are the noise dosimeter and the sound level meter. Noise dosimeters measure noise dose by directly integrating a function of the various sound levels over the entire workshift. For this reason they are quite useful in workplaces where noise levels vary throughout the workshift. The dosimeter gives a reading in terms of percentage of allowable exposure. The person being monitored wears the dosimeter throughout the workshift. Results of the monitoring are obtained after the dosimeter is taken off, either by pressing a button on the dosimeter or by plugging it into a master unit which then gives a "readout." Since employee noise exposure is expressed either as percentage of allowable dose, or as a TWA, OSHA has included a chart in Appendix A, which presents the relationship between these forms of measurement.

A sound level meter registers the level of sound that occurs at a particular time. It is useful for measuring the noise level due to a given process, or for measuring a worker's exposure to sound that fluctuates relatively little. Sound level meters contain a microphone, an amplifier with a calibrated attenuator, a set of frequency response networks, and an indicator meter.

Most sound level meters and dosimeters are small, "general purpose" (Type 2) instruments, equipped with "weighting networks," which adjust the meter response to predetermined frequency portions of the measured sounds. The A-weighting network is most commonly used in the measurement of industrial and environmental noise. The A-weighting network discriminates against low-frequency sound and, to a lesser extent, against high-frequency sound. The rationale behind A-weighting is that low frequency sound, and some fairly high-frequency sound, is not as damaging or as irritating as sound in the mid-frequency range. Thus, A-weighted sound level appears to be a good predictor of human response to noise. A-weighted sound levels will be assumed throughout the amendment and preamble unless otherwise specified. Most general purpose sound level meters also have a C-weighting network, which basically reflects sound as it occurs in the environment, without any adjustment for human response. The C-weighting network is useful in determining the effectiveness of hearing protectors for particular noise conditions, since it does not discount the presence of low-frequency sound.

The frequency range is sometimes divided into octave bands. By measuring the sound level in each octave-band one can determine the spectrum of the noise. Each band is identified by its center frequency, such as 125, 250, 500, 1000, 2000, 4000 and 8000 Hz. Octave band measurements are necessary when selecting a room in which to perform audiometric testing, and in certain audiometer calibrations. They can also be helpful for assessing engineering control strategies. To determine the level of noise in different frequency bands, a sound level meter with an octave-band filter set is needed. This instrument is somewhat larger and more complex than the general purpose sound level meter that is used for measuring A-weighted and C-weighted sound levels.

The instrument that is used to test hearing is the audiometer. Audiometers produce pure tones at specific frequencies (e.g., 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz) and at specific sound levels. OSHA has required that employee hearing be tested at the frequencies 500 through 6000 Hz, since these are the most important frequencies for understanding speech, and since they are useful for determining the cause of the hearing loss.

The record of a given individual's hearing sensitivity is an audiogram. An audiogram shows hearing threshold level measured in decibels as a function of frequency in hertz. It indicates how intense or loud a sound at a given frequency must be before it can be perceived, thereby providing a graphic representation of the status of the individual's hearing. With periodic audiometric testing it is possible to trace and document hearing loss, and by doing so, to prevent further loss from occurring. The audiogram is an important indicator of early hearing loss, since losses can occur so gradually that a person may not realize that he or she is becoming impaired until a substantial amount of hearing is lost.

There are two principal types of audiometers, manual and self-recording. When a manual audiometer is used the technician adjusts the level of the tone to the point where the individual being tested can just hear it, and the technician records the level as hearing threshold. A self-recording audiometer allows the test subject to adjust the level of the tone, and the intensity of the tone is constantly recorded by a stylus, which records the results on a moving card.

Hearing threshold levels, as they are recorded from the audiometer, are given in decibels above audiometric zero. Audiometric zero is not the same as 0 dB sound pressure level, the zero reference level to which sound level meters are set. Audiometric zero deviates somewhat from 0 dB sound pressure level at each test frequency. (For example, the deviation is 10 dB at 1000 Hz, and 8.5 dB at 2000 Hz.) Audiometric zero represents the median hearing threshold level of young people with normal hearing. While some individuals may have unusually good hearing sensitivity (as good as −10 dB), others may have hearing thresholds of 10 or 15 dB and still be considered within the range of normal. Therefore, audiometric zero (as opposed to 0 dB sound pressure level) reflects an adjustment to represent normal baseline hearing.

Audiometric zero has been standardized for the U.S. population in American National Standard Specification for Audiometers S3.6—1969. This zero reference level is assumed throughout the amendment and preamble unless otherwise specified.

II. Health Effects

The effects of occupational noise can be divided into two principal categories: auditory effects and extra-auditory effects. There is a wealth of information on the relationship between noise exposure and hearing loss. Dose-response relationships have been well established. Numerous studies are available which describe the effects of noise on hearing as a function of level and duration. The effects are stated in terms of the audiometric frequencies at which the loss occurs, degree of hearing loss, anatomical changes (in animal experiments), and differential changes in hearing as variables such as age and sex interact with noise exposure.

The extra-auditory effects of noise involve complex physiological and psychosocial reactions, which are much more difficult to document. Although stress-related illnesses have been associated with noise exposure, isolating all of the factors which contribute to stress confounds efforts to provide a direct "cause and effect" relationship between noise and such stress-related conditions as hypertension or ulcers. Although precise dose-response relationships are lacking at this time, information on the extra-auditory effects is included in this discussion because the data are highly suggestive of adverse effects, and therefore provide added incentive for protecting noise exposed workers.

A. *Hearing Loss.*

There is no doubt that noise exposure causes hearing loss, which grows more severe as exposure continues over the years. Many witnesses spoke with first-hand knowledge of the effect of noise exposure on their hearing, and consequently, on their lives. Ruth Knowles, President of Local 1716 of the Textile Workers Union, testified as follows about her noise-induced hearing loss:

> It has been a gradual loss of hearing for me, so gradual that I never really realized it until a few years ago, when a relative asked me if I did not hear well. After then I started noticing that it was getting worse and that I was having to strain more to hear clearly. I became alarmed and consulted a specialist, only to be told that nothing could be done and that the hearing loss had been caused by high noise exposure.
>
> It is truly a sad, helpless feeling that you have been told that you have lost a significant part of your second most

important sensor. As time has passed, I have been embarrassed because I was not able to hear well enough to know what was going on. I have even given an affirmative nod only to find out later that it shoud have been a negative answer. Socially speaking, there have been many, many instances that because of my hearing impairment, I would rather have stayed at home. It is difficult for me to hear and understand most waitresses in restaurants and a few times I have even had to tell them that I did not hear well, after which they speak so loudly that everyone around turns to look. My family has come to realize this problem and usually volunteers their help.

Also, I am never able to hear sales persons in grocery stores or bank tellers. At times it has become so disturbing that I have actually sat down and cried when I would get home. Persons who do not suffer any loss of hearing can't possibly realize the humiliation those of us who have impaired hearing go through. (Tr. 2021-2022).

Material Impairment

Section 6(b)(5) of the Occupational Safety and Health Act indicates that when dealing with a harmful physical agent the Secretary should set a standard which guards against material impairment of health or functional capacity, even if the worker is exposed for a working lifetime. As discussed below, noise is a harmful physical agent. The hearing conservation amendment is reasonably necessary to mitigate the significant risk of noise, which is present in most workplaces. This amendment is necessary to prevent large numbers of workers from suffering material impairment of health and functional capacity resulting from exposure to noise. As shown below, even assuming compliance with the current occupational noise exposure standard, many workers will still be at increased risk of suffering material impairment of functional capacity from noise in the workplace. The hearing conservation program prescribed in this amendment will save at least 189,000 workers from suffering material impairment after the program is fully effective. Accordingly OSHA finds that this amendment is reasonably necessary and appropriate, not only to provide healthful, but to provide safe places of employment.

OSHA defines material impairment of hearing as an average hearing level, with respect to audiometric zero, that exceeds 25 dB for the frequencies 1000, 2000, and 3000 Hz. This hearing level is sometimes called a "fence" in that it provides a demarcation point along the continuum of hearing levels, above which a hearing loss is considered, in the language of the Occupational Safety and Health Act, a "material impairment of health or functional capacity." Most audiologists and acousticians will agree that small amounts of hearing loss can be tolerated. If more than a small amount of loss is suffered, a person cannot function as well as a normally hearing individual. The selection of the point or "fence" beyond which an individual person cannot function as well becomes the definition of material impairment of hearing.

OSHA believes that the capacity to hear and understand speech is the most critical function of human hearing. Therefore the definition of material impairment of hearing is directly related to people's ability to understand speech as it is spoken in everyday social conditions. Assessing this ability can be done by a variety of speech audiometric tests. Since speech audiometry is not well standardized, researchers and administrators have used pure-tone thresholds to estimate hearing for speech. As explained in the introductory section, these thresholds are the lowest levels at which a listener can just barely hear discrete frequency tones.

There is very little debate about the usefulness of pure tones to assess hearing impairment, but there is some disagreement about the hearing level, or fence, at which material impairment begins, and about which audiometric frequencies to use in the assessment. Setting the fence at a high hearing level means that workers are allowed to lose quite a lot of hearing before the loss is considered to be a material impairment to be prevented. Setting the fence at a low hearing level means that relatively little hearing is lost before the loss or impairment is considered material. The lower the fence, the larger will be the number of workers identified as materially impaired. The selection of audiometric frequencies also has an effect on the number of workers that will be identified. Since noise-induced hearing loss affects the high frequencies earlier and more severely than the low frequencies, more workers will be identified as crossing the fence or suffering material impairment when high frequencies are used in the definition. It should be noted that the use of high frequencies in the definition of material impairment more accurately portrays a worker's actual hearing loss, since those frequencies are more severely affected by noise.

The hearing levels and audiometric frequencies that constitute the definition of material impairment of hearing have been identified through studies of the ability to communicate in everyday listening conditions. Some of these studies were submitted to the record, and the issue of material impairment received considerable attention.

Until now, the Agency had not conclusively defined material impairment of hearing. For purposes of the proposal, OSHA had used the definition of hearing handicap developed in 1959 by the American Academy of Ophthalmology and Otolaryngology (AAOO), a subgroup of the American Medical Association (Ex. 3, p. 44; Ex. 6, p. 12337). The AAOO definition, which has been used primarily for workers' compensation purposes, uses a 25-dB fence for average hearing levels at the frequencies 500, 1000, and 2000 Hz. Some comments to the record (Ex. 35, p. 1; Ex. 26-3, p. 5-24; Ex. 26-4, p. 1) favored this definition, because it was thought to describe an individual's ability to communicate under everyday conditions. However, several commenters pointed out that it would not be appropriate to use the same formula for prevention and compensation (Ex. 47, p. 5; Ex. 46, pp. 304-305; Ex. 51, p. 4; Ex. 57, pp. 9-10). Dr. H. E. von Gierke of the U.S. Air Force commented on this subject on behalf of the EPA. He states that: "Formulas developed for assessing hearing handicap for compensation purposes were never intended to be used for purposes of preventive criteria." (Ex. 47, p. 5).

In its criteria document NIOSH recommended that the defintion of material impairment be expanded to include the ability to hear and to understand speech in noisy or difficult listening conditions. NIOSH used an average loss of 1000, 2000, and 3000 Hz in the frequency averaging, still using a 25-dB fence (Ex. 1, pp. VI-11 through VI-14). Various studies and comments supported the 1000, 2000, and 3000 Hz definition as being more realistic than the 500, 1000, and 2000 Hz AAOO defintion, because good hearing in the higher frequencies (2000 and 3000 Hz) is very important for understanding speech especially when there is noise in the background, or when speech is not clear. It was also noted that everyday listening conditions are noisy at least part of the time rather than being completely quiet (Ex. 1, p. VI-13; Ex. 50, p. 16; Ex. 321-16B, pp. 9-10, 61; Ex. 5, p. 43803), which is the assumption in the AAOO formula.

Dr. Aage Moller, Professor of Physiological Acoustics at the Karolinska Institute in Stockholm, commented on the severity of the AAOO definition in his testimony for the AFL-CIO:

The 26 dB hearing loss average value for frequencies 500, 1000 and 2000 Hz is (by AAOO) assumed to correspond to a beginning loss of ability to understand speech in the quiet. Historically this definition originates from the limit where workmen's copensation was to be paid for loss of earning power. Such a hearing loss will no doubt by most people be regarded as a rather severe handicap in normal social life. It will with most people make it impossible or at least very difficult to participate in parties where more than one person speaks at a time. People with that degree of hearing loss will also have difficulties to understand novel words and numbers. It is thus somewhat surprising that this *"limit of a handicap"* at present has been accepted as *"the limit of a tolerable"* impairment of the hearing. It has been suggested to exchange 500 Hz with 3000 Hz to give more realistic estimates of beginning loss of intelligibility of speech. (Ex. 88, pp. 3–4).

William C. Sperry, a private individual whose hearing impairment was very close to the AAOO-identified point of beginning handicap, filed a comment (Ex. 184). He believed that his hearing loss was sufficient to warrant buying a hearing aid. Although the hearing aid sometimes helped, there were other times when hearing was extremely difficult. He stated:

> In a situation where there is a high ambient noise level, such as parties, I might as well leave my hearing aid at home, and very often, I go home after a short while since the multitude of speakers and all of the noise frequently makes it impossible to follow conversations. In any situation, where there is background noise, such as an air-conditioner, I find that communication is difficult, with or without the hearing aid. . . . I submit to you that people with my hearing loss are considerably more than just barely impaired. A standard that allows an average of 25 dB hearing loss at 500, 1000 and 2000 Hz very definitely allows material impairment to occur, and does not prevent people from losing one of their most valuable abilities, namely the ability to communicate effectively with each other. (Ex. 184, pp. 4–5).

Finally it was pointed out that the AAOO formula does not distinguish between a person who has a noise-induced hearing loss and a person who has a conductive hearing loss since it includes 500 Hz and excludes the frequencies above 2000 Hz (Ex. 1, pp. VI–12 and VI–13). Conductive hearing loss (which can be the result of many nonoccupational factors such as ear infections) tends to be of the same magnitude across all frequencies so that the loss has a flat appearance on the audiogram. Noise-induced hearing loss produces a sloping configuration, the loss being much more severe in the high frequencies than in the low frequencies, especially in the early stages. Since 500 Hz is the last and least severely affected of the test frequencies, it is not nearly so important as 3000 Hz in characterizing the audiogram of the individual with noise-induced hearing loss.

In 1979 the American Medical Association (AMA) (Ex. 321–10, p. 2058) changed its formula for hearing handicap, and now advocates a low fence of 25 dB for hearing levels averaged at the frequencies 500, 1000, 2000, and 3000 Hz. The AMA has chosen to include 3000 Hz because it now recognizes the value of high-frequency hearing in more realistic listening situations (Ex. 321–10, p. 2058). However, the primary use of the AMA formula for "medico-legal" (compensation) purposes remains unchanged.

Another method for describing material impairment, developed by the Committee on Hearing, Bioacoustics and Biomechanics of the National Academy of Sciences (CHABA), was discussed by Dr. W. Dixon Ward (Ex. 222C, pp. 12–13) and Dr. Thomas (Ex. 51, pp. 7, 8). The CHABA report specified that a fence of 35 dB should be used if hearing levels at 1000, 2000, and 3000 Hz were averaged (Ex. 222C, pp. 12–13). CHABA's charge was to find a low fence for the frequencies 1000, 2000, and 3000 Hz that would yield the same compensation as a 25-dB fence at 500, 1000, and 2000 Hz (Ex. 51, pp. 7–8). Since this formula was specifically concerned with compensation, rather than with prevention, OSHA does not consider it appropriate for use in a standard to prevent material impairment of hearing. The CHABA committee made no attempt to define material impairment of hearing by examining research results on the ability to understand speech and to function in everyday life.

EPA (Ex. 189–5, p. 11) recommended a 25-dB fence for hearing levels averaged at the frequencies 1000, 2000, and 4000 Hz, and later submitted a study (Ex. 321–16B, pp. 60, 61) to support the same frequencies but using an even lower fence.

Other witnesses also recommended lower fences or higher frequencies than those employed by the AAOO. Dr. Karl Kryter of the Stanford Research Institute, testifying on behalf of EPA (Ex. 50, p. 6; Tr. 776–778) criticized the AAOD formula, and suggested a fence at least as low as 15 dB if the frequencies 500, 1000, and 2000 Hz were used. Joseph Hafkenschiel of the Communications Workers of America, recommended a 15-dB fence for the frequencies 500, 1000, and 2000 Hz (Ex. 82, p. 4), and others also argued that a 25-dB fence allows too much hearing loss (Ex. 189–5, p. 7; Ex. 184, p. 5; Ex. 50, p. 4). A fence of 15 dB at 500, 1000, and 2000 Hz would be equivalent to a hearing level of 25 dB if the frequencies 1000, 2000, and 3000 Hz were used (Ex. 50, p. 19).

A report submitted by the Center for Policy Alternatives at the Massachusetts Institute of Technology (Ex. 138A, pp. 2–2 to 2–3) recommended using a variety of fences to describe different degrees of hearing loss experienced by a noise exposed population.

Dr. William Burns, professor of physiology at the University of London, pointed out (Tr. 651) that the British Standard, Method of Test for Estimating the Risk of Hearing Handicap due to Noise Exposure (in draft form at the time of his testimony), estimated risk data for the frequencies 1000, 2000, and 3000 Hz, although the standard used a fence of 30 dB. This fence and frequency combination were also recommended by the British to the International Organization for Standardization (Proposal from the UK-Member Body of ISO/TC 43/SC 1 for a revision of ISO 1999—Acoustics—Assessment of Occupational Noise Exposure for Hearing Conservation Purposes). These two documents later were submitted to the record by EPA as Exhibits 266E (p. 15) and 279, 11–10 (p. 1).

Following the original recommendation of NIOSH, OSHA will consider as material impairment a 25-dB fence for the frequencies 1000, 2000, and 3000 Hz. The agency agrees with the many comments and studies cited to show that high-frequency hearing is critically important for the understanding of speech (Ex. 46, p. 363; Ex. 26–1, p. 3; Ex. 26–6, p. 830; Ex. 228, p. 6; Ex. 5, p. 43603; Ex. 51, pp. 6–7), and that everyday speech is sometimes distorted and often takes place in noisy conditions. Therefore, the Agency believes that 3000 Hz should be included in the definition of material impairment, and 500 Hz, since it is not so important for understanding speech (Ex. 1, p. VI–16; Ex. 26–6, p. 830; Ex. 26–7, p. 1217; Ex. 321–16B, pp. 42–44) and since it is last and least affected by noise, should be excluded from the definition.

OSHA has considered including the 4000-Hz frequency in the definition of material impairment as recommended by EPA, since hearing at this frequency appears to be particularly valuable at times when listening conditions are noisy and distorted (Ex. 26–6, p. 830; Ex. 26–7, p. 1217; Ex. 321–16B, pp. 34–45). However, OSHA recognizes that listening conditions are favorable at least part of the time, and until data become available to show the typical proportion of favorable to unfavorable listening conditions, or the average amount of distortion that occurs in everyday speech, OSHA will continue to use the 25-dB fence at 1000, 2000, and 3000 Hz as recommended by NIOSH (Ex. 1, p. VI–11) and others (Ex. 88, pp. 3–4, Ex. 26–7, pp. 1217, 1223; Ex. 50, pp. 6, 19). This is not to say that the 4000-Hz frequency has no importance for the understanding of speech and that unlimited loss should be allowed in that frequency, but only that it is not included in the definition of material impairment at this time. In the typical noise-induced hearing loss pattern, severe losses at 4000 Hz are almost always accompanied by losses at 3000 Hz which are nearly as severe (Ex. 12, p. 130, fig. 10.19; Ex. 26-2, pp. 30-47; Ex. 1, fig. 7). Therefore, losses at 4000 Hz would not be unaccounted for.

The Agency has accepted the recommendation of the Center for Policy Alternatives to examine the effects of noise on hearing by means of a variety of fences. In the discussion of the anticipated benefits of hearing conservation programs, the Agency uses fences at 15 dB, 25 dB, and 40 dB for the frequencies 1000, 2000, and 3000 Hz. The 25-dB fence, however, is considered the point at which impairment may be considered material.

Quantifying the Effects of Noise

The two most useful concepts for describing dose-response relationships for noise-induced hearing loss are the "percentage risk" and the "noise-induced permanent threshold shift" (NIPTS) concepts. The first concept involves predicting the percentage of a population that will develop material impairment of hearing as a result of given levels and durations of noise. The second concept is used to predict the amount of hearing loss in decibels that will occur as a result of given levels and durations of noise after subtracting for presbycusis (hearing loss from aging).

In order to better understand the methods of describing the effects of noise, the concept of presbycusis should first be discussed. Presbycusis is a natural phenomenon that affects most individuals if they live to be old enough. Some people will lose some hearing by the age of 40 or 50, while others will have normal hearing well into their 70s. Mature adults will seldom have hearing levels as low as 0 dB for all audiometric frequencies. As people age, their hearing levels become higher, and most individuals accept some hearing loss as a natural occurrence (Ex. 29, p. 84). However, when even a minor noise-induced hearing loss is added to presbycusis, the resulting loss can be sufficient to cross the fence into material impairment. Whether a hearing loss is one-third presbycusis and two-thirds noise-induced, or the other way around, the loss of functional capacity is the same. In most cases, people will not be materially impaired by presbycusis alone unless they live to be very old. When noise exposure is added, usually from an occupational source, many will become materially impaired when they are young or middle-aged, and the impairments will grow more severe as age increases. In addition, occupational noise exposures have the effect of making some people suffer more hearing loss at a younger age than they would if not exposed to occupational noise.

Since presbycusis, when it occurs, is a natural and inevitable condition, it is only reasonable to examine the impact of noise exposure on a population that includes some amount of presbycusis. After a working lifetime most individuals will be at least 60 years old, and will have experienced some amount of presbycusis. It is also useful to know the extent of damage produced by noise alone, so as to judge the magnitude of the effect at each audiometric frequency as a function of exposure level and duration. Therefore the Agency has quantified the effects of noise on hearing using both the percentage risk and the NIPTS methods.

The percentage risk method allows the inclusion of presbycusis in that the procedure estimates numbers of people whose hearing levels (including presbycusis or any other impairment) will exceed a certain fence due to noise exposure. It does not include people who will exceed a certain fence because of a hearing loss *only* from aging, since the calculation subtracts the percentage of a non-noise-exposed population who would cross the fence anyway from "natural" causes. The remainder is the population at risk of developing material impairment of hearing due to noise exposure.

OSHA believes that the data in Table 1 provide reliable and consistent estimates of the percentages of the population at risk of developing material impairment due to exposure to daily average noise levels of 80, 85 and 90 dB for a working lifetime.

Table 1

[Estimated percentages of the population at risk of exceeding a 25-dB fence at 500, 1000, and 2000 Hz as a function of average noise exposure level for 40 years. (EPA, Ex. 5, p. 43805)]

Organization	Noise exposure in dB	Risk (percent)
ISO	90	21
	85	10
	80	0
EPA	90	22
	85	12
	80	5
NIOSH	90	29
	85	15
	80	3

This table, which was submitted by EPA (Ex. 5, p. 43805), shows the percentage of the exposed population expected to exceed a 25-dB fence at the frequencies 500, 1000, and 2000 Hz. The risk figures were developed by the International Organization for Standardization (ISO) (based on the data for Baughn), EPA, and NIOSH. These organizations estimated percentage risk for the 500, 1000, and 2000 Hz combination since the AAOO definition of hearing handicap still was used widely at the time these percentage risk estimates were developed (ISO in 1975, Ex. 20-4; EPA in 1973, Ex. 31; and NIOSH in 1972, Ex. 1). Two of the three organizations have now advocated the inclusion of frequencies above 2000 Hz in the definition of material impairment (Ex. 5, pp. 43803, 43805; Ex. 1, pp. VI-11, VI-14). The ISO-1980 proposal, which still is in draft form at this time, does not prescribe a specific formula for risk assessment but provides an array of formulas that can be used for predictive purposes (Ex. 321-43A, p. 3).

It can be seen that the risk of material impairment at an average exposure level of 90 dB is a substantial 21 to 29 percent. The risk of incurring material impairment after a working lifetime of 85 dB is 10 to 15 percent, and at 80 dB is 0 to 5 percent. The inclusion of 3000 or 4000 Hz in the definition of material impairment would tend to make the percentages at risk somewhat higher, since hearing loss at these frequencies from noise exposure is almost always greater than it is at 500 and 1000 Hz.

Because these risk figures were developed virtually independently [1] by the three organizations, the percentages for each exposure level are slightly different. These differences are to be expected when using the percentage risk concept because the estimates can be influenced by the extent to which a noise-exposed population is screened to exclude people with nonoccupational hearing loss, and also by the extent to which the population includes hearing loss from aging (Ex. 5, p. 43800). For example, NIOSH suggested that its percentage risk estimates might be slightly higher than those derived from the "severely" screened population (Ex. 1, p. VI-31). (An exposed population that includes some amount of nonoccupational hearing loss and some presbycusis would be representative of the U.S. population, and thus the risk figures should not be unrealistic.)

[1] As mentioned above, the ISO risk estimates were derived from data collected by Dr. W. L. Baughn. The EPA also used Baughn's data, and averaged them with data collected by Drs. Burns and Robinson, and Dr. Passchier-Vermeer. All of these studies will be discussed in further detail below. Since EPA's estimates are based in part on the same data that were used by ISO, the relationship between the EPA and ISO risk estimates is not entirely independent.

Although Table 1 shows small differences, the risk estimates for the same exposure level are very similar.

The percentage risk concept, while easy to understand, is in some ways a limited descriptor of noise-induced hearing loss (Ex. 5, p. 43806; Ex. 47, pp. 9–10; Ex. 231, written testimony, p. 1). First, the use of a single fence such as 25 dB does not adequately describe the effects of noise on all of the impaired workers in that it does not quantify the amount of loss (Ex. 5, p. 43805; Ex. 231, p. 7). Everyone whose hearing threshold has exceeded the 25-dB fence is considered to have the same amount of hearing loss. The single fence conveys nothing about the people who start with excellent hearing and lose up to 25 dB from noise exposure, nor does it indicate how many people suffer severe losses, greater than 40 or 50 dB, for example (Ex. 5, p. 43806; Ex. 231, p. 7; Ex. 47, pp. 9–10). In an attempt to overcome these limitations, OSHA uses three fences to discuss the benefits anticipated from hearing conservation programs.

Noise-induced permanent threshold shift (NIPTS) is the actual shift in hearing level due to noise exposure, after corrections have been made for aging. NIPTS values may be designated for combinations of frequencies, but they are usually given for each audiometric frequency separately, and it can be helpful to examine hearing loss at individual frequencies. (The percentage risk method nearly always averages hearing levels at three or more frequencies.) The NIPTS method allows examination of the effects of noise on hearing level at 4000 and 6000 Hz, which, although they are not usually included in the definition of material impairment, are the frequencies where hearing is earliest and most severely affected by noise. NIPTS usually is presented for certain percentages of the exposed population, such as the median, the 90th and the 10th percentiles, the lower percentiles representing the more severely affected members.

The disadvantage in presenting the data only as NIPTS is that the full impact of noise exposure is not as easily comprehended as it is with percentage risk. Since NIPTS values do not include any hearing loss from nonoccupational causes, they do not reflect actual hearing levels. However, for comparing the effects of one exposure level against another they are very useful.

Table 2 shows NIPTS as a function of exposure level and exposure duration in years (see Johnson's Table 3, Ex. 310, pp. 27–28). NIPTS values are given for each audiometric frequency from 500 Hz to 6000 Hz, and are shown for the less sensitive 90th percentile, the median, and the more sensitive 10th percentile. When added to presbycusis values from a "normal" non-noise exposed population, these resulting hearing levels would reflect realistic hearing levels to be expected in noise exposed populations.

Table 2 is taken from a report by Col. Daniel Johnson of the U.S. Air Force, entitled "Derivation of Presbycusis and Noise Induced Permanent Threshold Shift (NIPTS) to be used for the Basis of a Standard on the Effects of Noise on Hearing" (Ex. 310, pp. 27–28). As in a previous report, which Col. Johnson had prepared for the EPA (Ex. 17), he averaged the hearing loss data from some well-known studies. While in the earlier report Col. Johnson used the data of Baughn, Burns and Robinson, and Passchier-Vermeer, in the more recent report he combined only the data of Burns and Robinson with those of Passchier-Vermeer. Details of these studies will be discussed further below.

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TABLE 2

Noise-induced permanent threshold shift in decibels as a function of audiometric frequency, resulting from 8-hour daily average sound levels of 75 dB to 100 dB, for durations of 10 to 40 years. Data are presented for the 90th, 50th and 10th population centiles. From Johnson, Ex. 310, pp. 27-28, using the combined date of Burns/Robinson and Passchier-Vermeer.

Sound Level	Freq.	10 yrs.			20 yrs.			30 yrs.			40 yrs.		
[dB]	[Hz]	.9	.5	.1	.9	.5	.1	.9	.5	.1	.9	.5	.1
75	500	0	0	0	0	0	0	0	0	0	0	0	0
80	500	0	.1	.6	.1	.1	.3	.4	.1	.4	.8	.2	.4
85	500	.1	.2	1.4	.1	.3	1.2	.5	.7	1.5	.9	.4	1.1
90	500	.2	.5	2.3	.2	.7	2.4	.6	.8	2.5	1.1	1.0	2.4
95	500	.3	.9	3.5	.5	1.3	4.0	.6	1.7	4.5	1.0	1.9	4.6
100	500	1.7	3.9	7.6	2.8	5.1	9.2	3.9	6.2	10.6	4.9	7.2	11.4
75	1000	0	0	0	0	0	0	0	0	0	0	0	0
80	1000	.1	.1	.7	.1	.2	.4	.4	.2	.6	.8	.2	.6
85	1000	.1	.3	2.0	.2	.5	1.9	.5	.6	1.9	.9	.7	1.7
90	1000	.3	.7	2.9	.4	1.0	3.3	.8	1.3	3.6	1.3	1.5	3.6
95	1000	.5	2.7	5.9	.8	3.7	7.2	3.3	4.6	8.4	4.3	5.3	8.9
100	1000	3.1	6.1	11.0	4.8	8.1	13.5	6.4	9.9	15.6	8.3	11.3	16.9
75	2000	0	0	0	0	0	0	0	0	0	0	0	0
80	2000	.1	.3	1.6	.1	.4	.9	1.1	.5	1.2	1.8	.6	1.3
85	2000	.3	.9	4.9	.7	1.3	4.8	1.8	1.8	4.6	2.8	2.1	3.9
90	2000	.6	2.4	8.0	1.6	3.9	9.3	3.6	5.4	11.8	5.3	6.6	10.6
95	2000	1.2	5.5	14.2	3.7	8.7	17.4	7.4	12.0	20.1	10.6	14.8	21.9
100	2000	2.3	9.2	21.5	6.5	14.6	26.6	12.0	19.9	35.9	16.7	24.1	33.9
75	3000	0	0	0	0	0	0	0	0	0	0	0	0
80	3000	.2	2.0	4.1	1.9	2.4	3.4	3.5	2.7	2.7	5.1	3.0	2.3
85	3000	1.6	4.4	7.7	3.6	5.3	7.8	5.5	6.2	7.6	7.4	6.7	7.2
90	3000	3.9	9.2	16.9	6.6	11.0	17.9	8.5	12.6	18.4	11.3	13.7	18.4
95	3000	8.1	16.0	26.8	11.6	18.9	29.1	14.9	21.4	30.1	17.8	23.1	30.5
100	3000	15.8	25.4	37.5	20.6	29.5	39.7	24.8	32.7	41.0	28.6	35.0	41.6
75	4000	0	0	0	0	0	0	0	0	0	0	0	0
80	4000	.3	3.1	1.9	.3	3.4	2.1	1.8	3.7	6.3	3.3	3.8	5.3
85	4000	1.6	6.7	12.3	3.4	7.4	12.2	5.0	8.0	11.9	6.7	8.3	11.0
90	4000	6.3	11.9	19.1	8.4	13.3	19.5	10.3	14.4	19.4	12.1	14.9	18.6
95	4000	13.7	20.4	28.2	16.4	22.5	28.7	18.7	23.9	28.5	20.7	24.6	27.6
100	4000	22.3	30.2	37.8	25.6	32.6	37.8	28.4	34.1	37.2	30.6	34.8	36.1
75	6000	0	0	0	0	0	0	0	0	0	0	0	0
80	6000	.3	2.0	4.0	1.8	2.2	3.1	3.2	2.4	2.2	4.6	2.5	2.1
85	6000	1.1	4.8	8.9	2.8	5.3	8.6	4.3	5.8	8.2	5.8	6.1	7.3
90	6000	1.9	8.5	15.6	3.8	9.5	16.0	5.6	10.4	16.0	7.3	10.9	15.3
95	6000	4.3	13.7	23.5	6.7	15.5	24.4	8.9	16.8	24.5	10.8	17.6	23.8
100	6000	9.2	20.3	32.2	13.3	23.7	33.9	17.0	26.5	34.9	20.2	28.4	35.1

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Studies of Noise and Hearing Loss

Numerous studies of the effects of noise on hearing were submitted to the record. For purposes of this discussion, the studies have been divided into the categories of continuous and impulsive noise. The word "continuous" refers here to time-varying exposures as well, since in most of the studies noise levels varied somewhat throughout the day (Ex. 11, p. 2-3; Ex. 12, pp. 93-99; Ex. 26-2, p. 10).

Exposure to intermittent (on and off) noise will not be treated separately since the same methods for predicting hearing loss from continuous noise apply to losses resulting from intermittent noise (Ex. 279, 11-3, p. 447; Ex. 54, pp. 16-17; Ex. 29, p. 217). There was some disagreement as to whether the 5-dB or the 3-dB exchange rate should be used in calculating the time-weighted average exposure level from noncontinuous noise. But since the current noise standard (29 CFR 1910.95) uses the 5-dB exchange rate, and since the permissible exposure level remains unchanged at this time, the debate over the exchange rate will not be treated extensively at this time.

OSHA has examined the many studies and reports in the record that describe the effects of continuous noise on hearing (Ex. 11; Ex. 17; Ex. 310; Ex. 12; Ex. 26-2; Ex. 36; Ex. 206 A; Ex. 304), and the Agency believes that they comprise the best available data on the subject. The results of the various studies are relatively consistent, both in terms of the population at risk, and the extent of NIPTS as a function of noise exposure. The various studies, if considered together, contain data on more than 10,000 subjects.

As stated above, Col. Johnson averaged the data of different researchers in the preparation of a report for EPA. Later, the EPA used Col. Johnson's analysis of those data in the development of criteria for the effects of noise (Ex. 31, p. 5-17) and for the identification of safe levels of noise (Ex. 30, p. C-5). The three studies that were used in the EPA reports were the subject of much discussion during the hearings. Although some criticisms were raised, they were also widely supported (Tr. 734, 738, 779, 785, 834). The three studies were the following:

"Relationship between Daily Noise Exposure and hearing loss based on the evaluation of 6,835 industrial noise exposure cases" by W. L. Baughn (Ex. 11).

"Hearing and Noise in Industry" by W. Burns and D. W. Robinson (Ex. 12).

"Hearing Loss Due to Exposure to Steady-state Broadband Noise" by W. Passchier-Vermeer (as displayed and used in "Prediction of NIPTS due to continuous noise exposure" by D. L. Johnson (Ex. 17).

The study by Dr. William L. Baughn of the General Motors Corporation was performed between 1960 and 1965 (Ex. 11). These data have been used in the development of the Air Force report "Hazardous Noise Exposure" (Ex. 48) and for the current ISO standard 1999, "Assessment of Occupational Noise Exposure for Hearing Conservation Purposes" (Ex. 11, p. iii). The data were published in 1973 as an Air Force technical report (Ex. 11). Dr. Baughn studied the effects of average noise exposures of 78 dB, 86 dB, and 92dB on 6,835 industrial workers employed in midwestern plants producing automobile parts. Approximately 20,000 subjects had been excluded from the study because there was insufficient information about their exposure histories, or because they had "mixed" exposures (including nonoccupational sources). Subjects with anatomical abnormalities (such as ear infections) were not screened from the noise-exposed or control groups. Noise measurements had been taken over a period of 14 years, and through interviews, exposure histories were estimated as far back as 40 years (Ex. 11, p. 2. Dr. Baughn "smoothed" the data and presented families of curves showing the numbers of people exceeding a 15-dB fence at 500, 1000, and 2000 Hz referenced to the ASA 1951 audiometric zero, which is the equivalent of a 25-dB fence referenced to the ANSI 1969 zero level. He also provided data for fences of 5 dB to 40 dB (ASA), which would translate to 15 dB to 50 dB (ANSI). Since the exposure categories were for 78 dB, 86 dB and 92 dB, Dr. Baughn interpolated so as to provide estimates for exposures to 80 dB, 85 dB and 92 dB. He also extrapolated to exposure levels up to 115 dB, but the data above 95 dB were not used in Col. Johnson's report or the comparisons shown earlier.

Figure 1 shows Baughn's estimates of the percentages of the exposed population that will cross a 25-dB fence as a result of exposure to daily average noise levels of 80 dB to 115 dB. Since these estimates use the frequencies 500, 1000, and 2000 Hz, the numbers of people crossing a 25-dB fence at 1000, 2000, and 3000 Hz would be expected to be greater.

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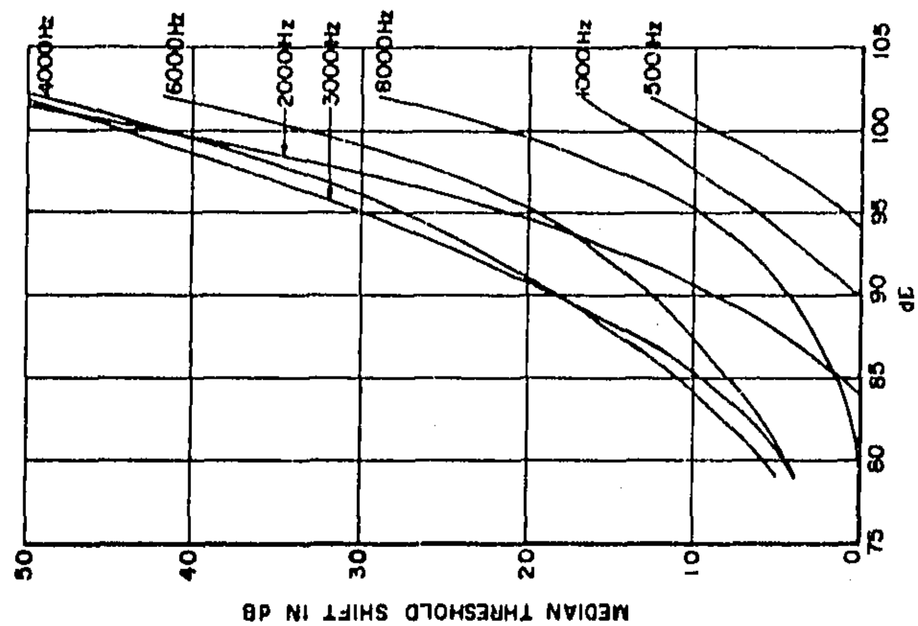

Figure 3. Median noise-induced threshold shift for various audiometric frequencies as a function of average daily noise exposure level for 40 years. Data are from Passchier-Vermeer (in Ex. 5, p. 43803).

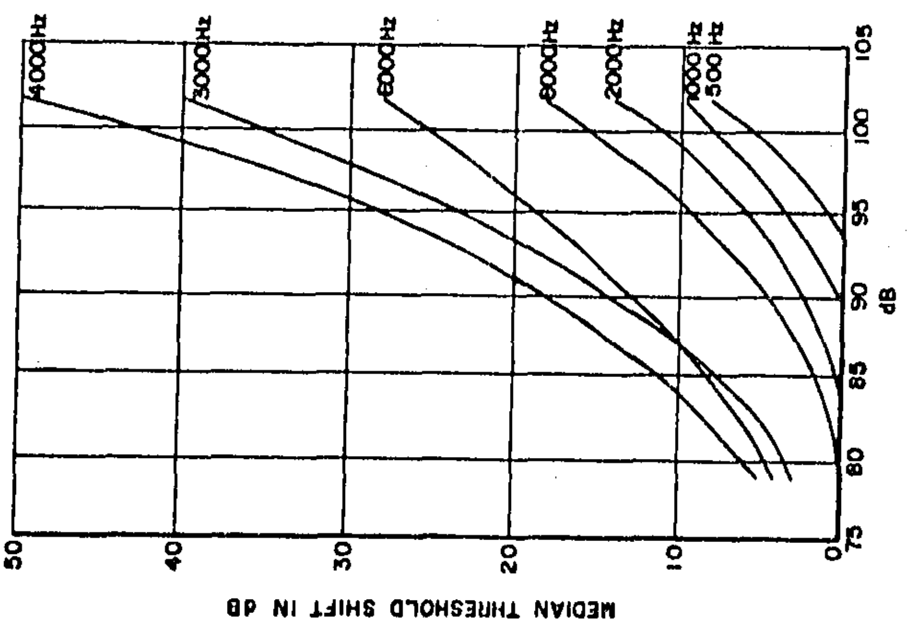

Figure 2. Median noise-induced threshold shift for various audiometric frequencies as a function of average daily noise exposure level for 10 years. Data are from Passchier-Vermeer (in Ex. 5, p. 43803).

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Baughn's study was criticized because in some cases as little as 20 minutes of recovery time was allowed prior to audiometric testing (Ex. 17, p. 2; Ex. 3, p. 39; Ex. 26-3, p. 5-15; Ex. 138A, p. 2-17). As a result the data may have been influenced to some extent by temporary threshold shift, which would have the effect of making the noise-exposed group's hearing threshold levels appear worse than they should. The study was also criticized because the control group may have had average exposures as high as 78 dB so that they may also have had a small amount of occupational hearing loss (Ex. 17, p. 2; Ex. 138A, p. 2-17). If the control group's hearing levels were slightly inflated, this would tend to reduce the difference between the hearing levels of the exposed and control groups. These potential flaws would have the tendency to offset each other when NIPTS is calculated. In addition, Dr. Kryter (Ex. 50, pp. 9-12) pointed out that any residual TTS after 20 minutes would be quite small (only 1 to 2 dB) for those subjects who had already incurred a noise-induced hearing loss. (TTS tends to become smaller after significant permanent loss is incurred.)

One practical limitation of the Baughn study is that the author did not provide hearing loss data at separate frequencies, but only at the combined frequencies of 50, 1000, and 2000 Hz, and then separately for 4000 Hz (Ex. 11, pp. 4, 30; Ex. 5, p. 43804). Thus, it is not possible to estimate hearing loss, for example, at only 2000 Hz, or for the combined frequencies 1000, 2000, and 3000 Hz. While this may result in some procedural problems for researchers and administrators, it does not detract from the validity of the study. The sample size appears to be the largest in any single hearing loss study, and the study has received support from other scientists and organizations. The results are not incompatible with other data in the record. Therefore, OSHA believes that the Baughn study represents a valuable contribution to the public record.

Dr. W. Passchier-Vermeer's data on steady-state noise exposure do not appear in the hearing record except as they are presented by Col. Johnson (Ex. 17 and Ex. 310). Dr. Passchier-Vermeer presented in 1968 an exhaustive review of hearing loss as a function of exposure to average noise levels of about 80 dB to 102 dB, having summed, analyzed, and correlated data from any sources (Ex. 17, pp. 2, 3, 12-14). The data consisted of laboratory and field studies conducted by British, Dutch, Swedish, and U.S. investigators.

Figure 2 shows median NIPTS at various frequencies as a function of noise exposure for a period of 10 years. Figure 3 shows median NIPTS after 40 years of noise exposure. These figures, which were submitted by EPA (Ex. 5, p. 43803), are taken from Dr. Passchier-Vermeer's reports. Of course the noise-induced permanent threshold shift would be expected to be more severe for the more susceptible individuals in the higher centiles of the population, such as the 10th or the 95th centiles.

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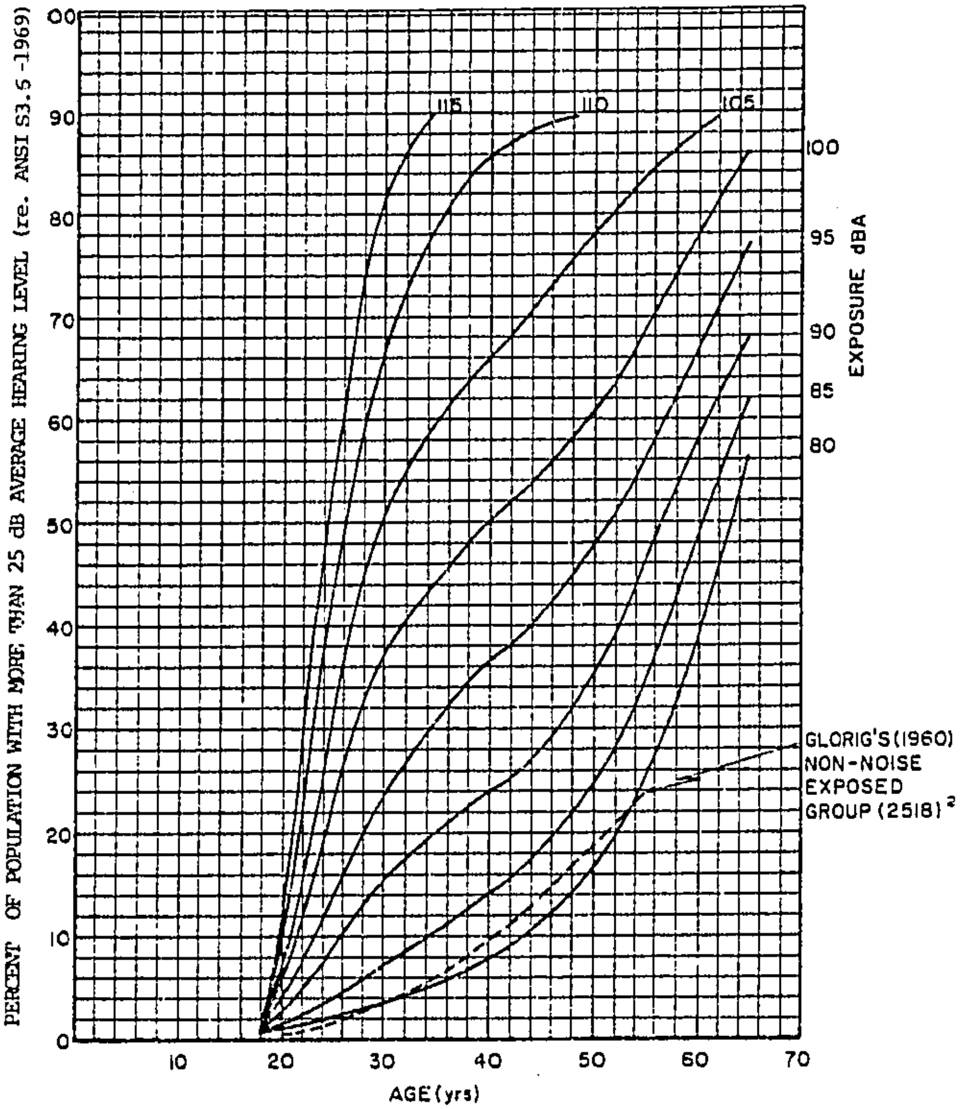

Figure 1. Percent of the population with more than 25 dB average hearing level forthe frequencies 500, 1000, and 2000 Hz as a function of noise exposure level. From Baughn (Ex. 11, p. 41).

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Four of the 10 studies analyzed by Dr. Passchier-Vermeer were discussed briefly in documents prepared by NIOSH (Ex. 1), EPA (Ex. 31), and Drs. Burns and Robinson (Ex. 12). The NIOSH criteria document reported that Drs. Taylor, Pearson, Mair, and Burns studied 251 working and retired jute weavers who were exposed to average overall sound pressure levels of 99 to 102 dB. The investigators found the greatest deterioration of hearing occurred in the first 10 to 15 years of exposure (Ex. 1, p. 5 Table IV). NIOSH also reported on a study by Drs. Burns, Hinchcliffe, and Littler of 174 textile spinners and weavers exposed to average overall (unweighted) sound pressure levels of 100 to 101 dB. Hearing losses were found to be greater for the weavers than the spinners (Ex. 1, p. 6 of Table IV).

EPA's document entitled Public Health and Welfare Criteria for Noise described a study by Gallo and Glorig, which also was used by Dr. Passchier-Vermeer, as well as the study by Taylor et al., mentioned above. According to EPA (Ex. 31, p. 5-5), Drs. Gallo and Glorig measured the hearing levels of 400 men aged 18-65, and 90 women, aged 18-35, exposed to an average overall sound pressure level of 102 dB. The population had been screened to exclude nonoccupational noise exposure and otological abnormalities. The results showed that high-frequency hearing loss rose rapidly during the first 15 years of exposure, but that hearing loss in the mid-frequencies continued to rise in a linear manner up to 40 years of exposure.

Drs. Burns and Robinson (Ex. 12, pp. 220-228) also discussed the studies of Gallo and Glorig, and Taylor et al. In addition, they described a study by Dr. B. Kylin, which also was used by Dr. Passchier-Vermeer, of 89 men exposed for durations of 10 to 15 years, and 29 male controls. Neither population was screened for military noise exposure or for ear disease. (These factors should not have influenced the actual NIPTS since they were distributed evenly among the noise exposed and control populations (Ex. 12, p. 226).) Drs. Burns and Robinson compared the results of their study with those of the three selected studies (Gallo and Glorig, Taylor et al., and Kylin), and with the results predicted by Dr. Passchier-Vermeer on the basis of all of the studies she analyzed. They found, using median hearing loss values, that agreement among all of the results was good for the mid-frequencies (500, 1000, and 2000 Hz), but that their own data and method of prediction showed somewhat lower values (less hearing loss) for the higher frequencies (3000, 4000, and 6000 Hz) (Ex. 12, p. 227). The authors suggested that this finding might be due to differences in noise monitoring and subject selection techniques used by the various investigators (Ex. 12, p. 228).

Because the Passchier-Vermeer data resulted from a synthesis of many studies, some people argued that their quality was difficult to judge (Ex. 50, p. 8). Others noted that the original report only presented data for quartile groups (25th, 50th and 75th centiles) and neglected to address the more variant hearing levels found in the extremes of the population (Ex. 3, p. 39; Ex. 17, p. 2; Ex. 26-3, p. 5-14). Col. Johnson has extrapolated the data to the 10th and 90th centiles so that it would be averaged with those of the other studies (Ex. 17, p. 14 and Ex. 310, p. 7). Col. Johnson reported (Ex. 17, p. 14) that in a paper published in 1971, Dr. Passchier-Vermeer did publish the data for the 10th and 90th centiles, and these data were in agreement with Johnson's extrapolations.

The Passchier-Vermeer data are useful in that hearing levels are given for the discrete audiometric frequencies 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz, resulting from exposure levels of 80 dB, 85 dB, and 90 dB. Also, the Agency believes that averaging the results from a number of studies may be considered an advantage in that it ought to minimize any anomalies that might occur as a result of any one study. The Passchier-Vermeer data also were supported by various witnesses and comments to the record. (Ex. 47, p. 8; Ex. 218 A, p. 5).

Dr. W. Burns (Ex. 54) reported on a study of British factory workers that he and Dr. D. W. Robinson conducted between 1963 and 1968. The complete study was submitted to the record by OSHA as Exhibit 12. The study's population consisted of 759 subjects exposed to average noise levels between 75 dB and 120 dB and 97 non-noise exposed control subjects. The range of exposure durations was one month to 50 years. Exposure levels were taken in octave bands from 63 to 8000 Hz, and A-weighted measurements also were taken. Approximately 4000 audiograms were performed. Subjects were screened thoroughly to exclude exposure histories that were not readily quantifiable (to some extent unknown), exposure to gunfire, ear disease or abnormality, and language difficulties (Ex. 12, p. 12). The investigators found that hearing levels of people exposed to certain noise levels for certain durations were much the same as those of others exposed to higher levels for shorter times (Ex. 12, p. 17). They found that this relationship held for relatively short durations as well as for many years of exposure (Ex. 12, pp. 17-18). Consequently, they developed a mathematical formula to predict hearing levels in the frequencies 500 through 6000 Hz in various percentages of the exposed population due to specific levels and durations of noise (Ex. 12, pp. 100-151). Data from the Burns and Robinson study are shown combined with those of Dr. Passchier-Vermeer in Table 2 above.

The Burns and Robinson study has been criticized on the gounds that eliminating all workers with any form of nonoccupational hearing loss by extensive screening (which appeared to be more rigorous than in the other studies) would cause the resulting hearing levels to be an underestimate of the total "real-life" hearing loss picture (Ex. 40, p. 7; Ex. 50, p. 17). This problem has been eliminated in the analyses performed by Col. Johnson (Ex. 17 and 310) and by OSHA in the Benefits section, by using only the NIPTS data from Burns and Robinson and adding values for presbycusis from a normal, unscreened population (such as the U.S. Public Health Survey data).

The Burns and Robinson study was also criticized by Terrence Dear of the DuPont Company for including subjects exposed to impulse noise (Tr: 864-866), although the authors maintained that they tried to minimize such exposures, and that impulse noise exposures only would have occurred in a relatively small number of cases where subjects were exposed to high levels of continuous noise (Tr: 864-866; Ex. 12, p. 97).

On the whole, OSHA believes that the study by Burns and Robinson represents a very thorough, well-controlled study, with results that are extremely useful in predicting the effect of noise exposure on hearing.

NIOSH submitted to the record a report entitled "Occupational Noise and Hearing", 1968-1972 (Ex. 26-2). The dose-response relationships described in this report had been used by NIOSH in making the recommendations in its criteria document (Ex. 1). The report (Ex. 26-2, p. vi) presented background information about the study, and statistical analyses that were meant to complement the analyses that had already been published in the criteria document. NIOSH studied a population of 792 industrial workers exposed to average noise levels of 85 dB, 90 dB, and 95 dB, and a control population of 380 subjects who were exposed to average levels below 80 dB. (Since the control population was exposed to levels as high as 80 dB, a few members of the group may have incurred some amount of occupational hearing loss, and therefore the study would be subject to the same criticism as the study of Dr. Baughn.) Although the exposures were primarily to steady-state noise, exposure levels fluctuated slightly within each category. The total population was screened to exclude subjects who had been exposed to noise from gunfire, and who showed some sign of ear disease or audiometric irregularity (Ex. 26-2, pp. 6-7). Subjects ranged in age from 17 to 65 years. Data were presented for hearing levels of the 10th, 25th, 50th, 75th, and 90th centiles for various age groups and exposure durations, resulting from average exposures to 85 dB, 90 dB, and 95 dB. The authors concluded that the data substantiated the results of other similar investigations, but that they pertained only to simple or "ordinary" noise environments, as opposed to complex environments such as lengthened exposures, seasonal exposures, impact or impulsive noise, and high frequency noise (Ex. 26-2, p. 15).

Data from the NIOSH study have not been used in the prediction of benefits from the hearing conservation amendment. Col. Johnson stated in his report (Ex. 17, p. 10) that he did not use the NIOSH data in the analysis performed for EPA because the data had not yet been "smoothed," which would make it difficult to make predictions. Also, the NIOSH data were limited to exposures of 85, 90 and 95 dB, thus preventing hearing loss estimates for exposures to 80 dB and 100 dB. Nevertheless, the data are generally consistent with the results of the other studies discussed above.

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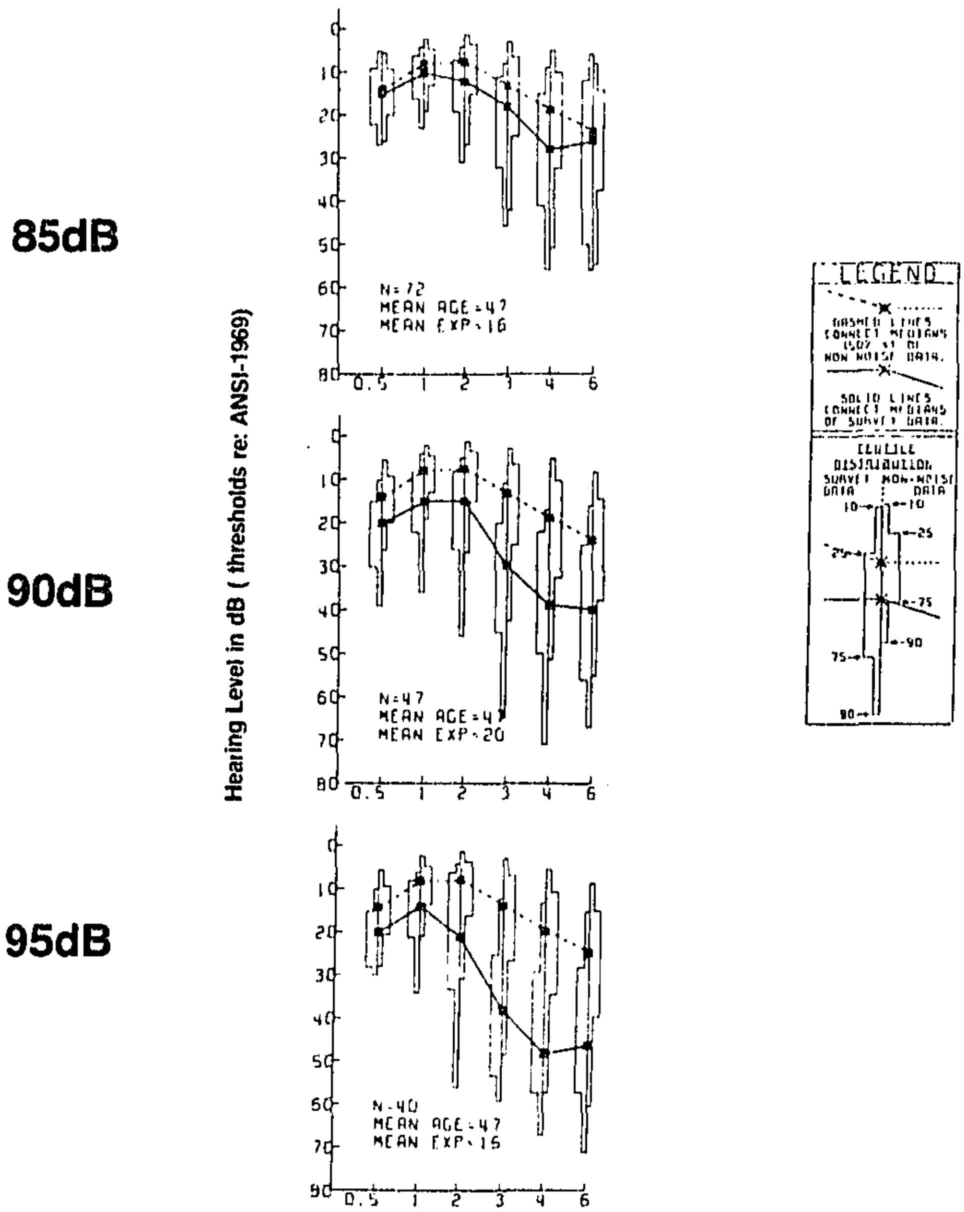

Figure 4. Hearing level distribution for workers aged 43 to 51 years exposed to daily average noise levels of 85dB, 90dB, and 95dB, and for non-noise-exposed workers.

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Results of the NIOSH study are shown in Figure 4 (Ex. 26-2, p. 41). This figure shows hearing level by audiometric frequency as a function of noise exposure to levels of 85, 90, and 95 dB. Population distributions are shown for the least sensitive (labeled in this case the 10th centile) to the most sensitive (the 90th centile) groups, and are compared to the non-noise-exposed control group. This study shows that differences between median hearing levels increase with exposure level, duration, and age. Also, more importantly, the distribution of hearing levels becomes considerably greater as exposure level, duration, and age increase.

In another study, Dr. R. H. Martin, Dr. E. S. Gibson, and J. N. Lockington (Ex. 36) related the degree of employee hearing loss to average noise levels of 85 and 90 dB in industrial plants. The population consisted of 228 Canadian industrial workers ranging from 18 to 65 years of age who were screened to exclude non-occupational hearing loss. The control group consisted of 143 subjects with minimal occupational noise exposure. The study concluded that the risk of hearing loss at 500, 1000, and 2000 Hz increases significantly between 85 and 90 dB, leaving a portion of the population at risk (up to 22 percent) by a noise exposure standard of 90 dB.

Elliott Berger, with Drs. Royster and Thomas (Ex. 266A) examined a North Carolina industrial population that had been exposed for 10 to 12 years to daily average noise levels of 88 to 89 dB. The population consisted of 42 men working in one location of the plant and 56 women working in another location. Control subjects were drawn from the same geographical area, and were screened to exclude any occupational noise exposure. Because of the relatively short exposure duration and the moderate exposure levels, the investigators analyzed only the losses at 4000 Hz, where they found hearing levels somewhat worse for men than for women (Ex. 266A, pp. 82-83). They concluded that the observed hearing losses were compatible with the data of Baughn, Passchier-Vermeer, Burns and Robinson, and NIOSH, with compatibility being greater for the male than for the female subjects (Ex. 266A, pp. 81-85).

In the Inter-Industry Noise Study (IINS) (Ex. 304) the authors measured noise exposure and hearing levels of 348 industrial subjects. Daily average noise exposure levels were between 82 and 92 dB for durations ranging from 3 years to greater than 30 years. There were 228 matched control subjects whose noise exposures were less than 75 dB. After analyzing the data the authors concluded that differences in hearing levels between the control and experimental populations were not statistically significant at the frequencies 500, 1000, and 2000 Hz. Differences at 3000, 4000, and 6000 Hz were statistically significant for male subjects, but not for females (Ex. 304, p. 8). In an editorial immediately following the IINS Research Report in the Journal of Occupational Medicine (JOM), Dr. Robert O'Connor stated:

> From this study it appears that 90 dB is as protective as 85, as far as women's hearing is concerned. In the case of men, if a small amount of hearing loss in frequencies that are well beyond the speech range is considered unacceptable, then this study supports a standard of 85. (Ex. 304, p. 8) (in JOM, 17: 760-770, 1975, p. 770).

The Environmental Protection Agency (Ex. 321-16A, p. 2) stated that there were major technical problems in the design, administration, and analysis of the Inter-Industry Noise Study which "raise serious questions concerning the technical appropriateness and usefulness of a number of the conclusions which were presented in the 1978 JOM publication."

A NIOSH report prepared by Barry Lempert also criticized the study by stating that the results included only mean or average hearing level comparisons while much more highly significant effects are found when the full distribution of hearing levels is presented (Ex. 321-36A, p. 1). After reviewing and reanalyzing the IINS raw data, and using evaluation techniques developed for the 1972 criteria document, NIOSH reaffirmed that "exposure to 85 dBA should allow no more than an increase of 10 to 15 percentage points in the incidence of hearing impairment" relative to a non-noise exposed population (Ex. 321-36A, p. 4).

Col. Johnson and Dr. Thomas Schori also analyzed the raw data from the IINS, and submitted a review of the data (Ex. 321-21A). The authors concluded that the hearing levels found in the IINS were essentially the same as those found in other noise and hearing loss studies (Ex. 321-22A, p. 16).

Having reviewed the study, the critiques (Ex. 321-16A; Ex. 321-36A; Ex. 321-21A), and a critique of a critique (Motor Vehicle Manufacturers Assoc., Ex. 321-8A), OSHA has determined that the findings of the IINS do not contradict those of the studies described earlier. The Agency disagrees with the conclusions of Dr. O'Connor that 90 dB is as protective as 85 dB. Although the IINS did not find the differences between mean hearing levels of the female experimental and control groups statistically significant, there *were* differences at every frequency, showing greater hearing loss for noise-exposed than for control subjects (Ex. 304, p. 4). As Lempert pointed out, these differences would have been much larger if the full distribution of hearing levels had been presented, showing the more susceptible elements of the population. The same argument would apply to the differences between mean hearing levels of the male experimental and control groups, where systematic differences are shown. The fact that the standard deviations were greater for noise-exposed than for non-noise-exposed groups at nearly every frequency (Ex. 304, p. 4) supports this argument. In addition, OSHA disagrees with Dr. O'Connor that the frequencies above 2000 Hz "are well beyond the speech range," on the basis of the many studies and comments cited earlier, showing the importance of high-frequency hearing for understanding speech in everyday conditions (Ex. 46, p. 383; Ex. 26-1; p. 3; Ex. 26-6, p. 830; Ex. 226, p. 8; Ex. 5, p. 43803; Ex. 51, pp. 6-7).

Dr. Royster submitted a series of reports to the record (Ex. 321-22 A through H). Some of these reports discussed recent findings by Dr. Royster and his colleagues that differences in sex and race are evident in the growth of NIPTS (Ex. 321-22A, pp. 18-19), as well as in the growth of presbycusis (Ex. 321-22B, p. 510; Ex. 321-22C, pp. 116-118; Ex. 321-22D, pp. 1-2). After examining the audiograms of a large North Carolina industrial population (Ex. 321-22A), Drs. Royster and Thomas concluded that hearing threshold levels differ significantly according to race and sex and that these differences are greater for the higher audiometric frequencies and increase with age. In their subject population, black women had the best hearing, followed by white women, black men, and finally, white men after noise exposure (Ex. 321-22A, pp. 15, 18-19).

Sex differences in hearing levels have been noted in numerous studies of non-noise-exposed populations (Ex. 31, p. 4-4, Ex. 321-22, p. 7, Ex. 279, pp. 11-8, pp. 41-44). OSHA has incorporated the NIOSH presbycusis data (Ex. 1, pp. I-16 to I-17) for men and women separately in Appendix F of the amendment. Also, the Agency has calculated the benefits anticipated from hearing conservation programs using separate presbycusis data for men and for women. Actual NIPTS values have not been differentiated according to sex because data for men and women shown separately were not available for the major studies mentioned above (Burns and Robinson, Passchier-Vermeer, Baughn, and NIOSH).

Drs. Burns and Robinson (Ex. 12, pp. 145–147) found small but persistent sex differences in noise-induced hearing loss, suggesting that NIPTS developed slightly more rapidly in men than in women. However, they did not present separate data for men and women. The IINS also showed slightly larger NIPTS values for men than for women both in the control and in the experimental populations (Ex. 304, pp. 4–8). Col. Johnson (Ex. 17 and Ex. 310) did not display NIPTS values separately for men and women, but he did show different data for certain non-noise-exposed populations, and therefore for certain estimates of the percentage at risk (Ex. 310). The studies by Baughn (Ex. 11), NIOSH (Ex. 26–2), Passchier-Vermeer (as reported by Johnson in Ex. 17), and Martin et al. (Ex. 36) did not present different NIPTS data for male and female subjects. OSHA believes that there is relatively little evidence available at this time to show that the hearing of men and women is differently affected by noise exposure, but that there is considerable evidence that differences exist in non-noise-exposed populations. Therefore, for estimating the benefits of hearing conservation programs, the Agency has used Col. Johnson's analysis of the Burns and Robinson and Passchier-Vermeer data, which shows sex differences for presbycusis but not for NIPTS. For any additional breakdown by sex or race the Agency will await further experimental evidence.

OSHA believes that the above studies are meritorious and are sufficient to make good estimates of the benefits to be derived from hearing conservation programs, despite any criticisms raised. Dr. von Gierke stated that "in spite of some uncertainties and everybody's desire for the 'perfect' study, there is adequate information available to predict with reasonable confidence the hearing impairment produced in the general population by a lifetime's exposure to continuous noise" (Tr. 705–706).

Discussion

Having established a definition of material impairment of hearing and discussed the various studies, some attention must be given to the various interpretations of the noise exposure and hearing loss data. Not all of the commenters interpreted the data in a similar manner.

Generally the argument for protecting workers above 85 dB is made on two grounds: analysis of NIPTS and of the percentage at risk showed that not only is the amount of hearing loss significantly greater at an average daily exposure level of 90 dB than at 85 dB, but also considerably more people are at risk of incurring material impairment (Ex. 40, p. 3; Ex. 47, p. 19; Ex. 57, p. 8; Ex. 82, pp. 1–4; Ex. 6, p. 12337; Ex. 26–1, p. 2).

Using the data of Baughn, Passchier-Vermeer, and Burns and Robinson, the Environmental Protection Agency found that half as many people are at risk of impairment at a daily average noise level of 85 dB as at 90 dB (Ex. 136A, pp. 1–4; Ex. 5, p. 43805; Ex. 189–5, p. 6). In addition, the amount of NIPTS doubles between 85 dB and 90 dB, especially for the frequencies 1000, 2000, and 3000 Hz (Ex. 5, p. 43804). In order to prevent *any* measurable hearing loss over a 40-year period the EPA identified a maximum 8-hour average daily noise exposure level of 75 dB (Ex. 5, p. 43803; Ex. 30, p. 4).

NIOSH also found that the population at risk due to lifetime exposures to average daily levels of 90 dB would be twice the size of the population at risk from 85 dB. The estimates were 29 percent and 15 percent, respectively (Ex. 1, Tables XV and XVII). Dr. Moller also noted that the number of impaired people doubles when average levels are increased from 85 to 90 dB (Ex. 88, p. 33).

There were numerous comments in the record concerning the amount of protection afforded by an average daily exposure level of 90 dB. Estimates of the percentage of unprotected workers ranged from 1 percent to 30 percent. Many commenters supported the 90-dB level based on OSHA's estimate that 98 percent of the population would be protected (Ex. 14–11, p. 1; Ex. 14–45, p. 1; Ex. 14–81, p. 1; Ex. 14–157, p. 2; Ex. 14–189, p. 1).

In OSHA's draft Environmental Impact Statement (Ex. 3, App. D, p. 12337) the Agency incorrectly stated that an exposure level of 90 dB would protect 98 percent of the exposed population. This estimate was based on the data and method of Burns and Robinson, using a 25-dB fence for the frequencies 500, 1000, and 2000 Hz, and a 30-year exposure duration. Later, an EPA representative (Ex. 40) pointed out that OSHA had neglected to perform one of the steps in the Burns and Robinson method, (step 7 on p. 132 of Ex. 12). Using the same data and method, the risk would actually be much greater than 2 percent (Ex. 40, pp. 5–6). Dr. Burns clarified the matter by explaining the distinction between hearing *level*, which includes presbycusis, and hearing *loss*, which does not (Ex. 54–2, pp. 1, 2).

Dr. Ward (Ex. 222C, p. 7) based his recommendation exclusively on Passchier-Vermeer's data, which, he claimed, showed that no workers would exceed a 25-dB hearing loss at the frequencies 500, 1000, or 2000 Hz due to exposure between 85 and 90 dB. For this reason Dr. Ward concluded that 90 dB protects workers from a "noticeable" hearing loss (Ex. 64, p. 3). This interpretation of Passchier-Vermeer's data is at variance with the interpretation of EPA and Col. Johnson. EPA submitted a graph of Passchier-Vermeer's data showing hearing loss as a function of noise exposure (Ex. 5, p. 43803). Although the median NIPTS from a 40-year exposure to 90 dB is essentially zero at 500 and 1000 Hz, it is nearly 10 dB at 2000 Hz. While the resulting average hearing levels would be quite small when added to the hearing loss from aging, they would be sufficient to ensure that some members of the exposed population would cross a 25-dB fence. Considering that nearly 3 million workers are exposed to daily averge noise levels of 90 dB and above, 50 percent of the population, or 1.5 million workers, would be expected to have at least this much NIPTS. Also, the NIPTS values would be expected to be larger for more sensitive individuals. Median NIPTS data say very little about actual hearing levels in the more susceptible members of the exposed population. As described above, when Johnson and EPA combined the data of Passchier-Vermeer with those of Baughn, and Burns and Robinson, the risk of crossing a 25-dB fence at 500, 1000, and 2000 Hz was 12 percent from exposure to 85 dB, and 22 percent from exposure to 90 dB (Ex. 5, p. 43805). Finally, as mentioned earlier, both the NIPTS and the risk are greater when 3000 Hz is included in the averaging and 500 Hz is eliminated.

OSHA has considered the definition of material impairment as it relates to hearing loss in light of a large body of data on the effects of noise on hearing. The Agency has determined that many workers will be at risk of material impairment of hearing, and possibly incur other kinds of physiological damage, when they are exposed to daily average sound levels above 90 dB over a working lifetime. Some workers will be expected to develop a material impairment of hearing if they are exposed to daily average sound levels between 85 and 90 dB, and a few will even develop a material impairment from average levels between 80 and 85 dB. Since it is possible to incur noise-induced hearing loss as a result of exposure to daily average levels less than 90 dB, OSHA has determined that it is necessary to initiate audiometric testing and other aspects of the hearing conservation program at a time-weighted average sound level of 85 dB. The practice of requring an "action level," a point well below the permissible exposure level at which protective action is taken, is consistent with OSHA's policy of protecting workers before they are overexposed. Moreover, the final standard will identify those in the exposed population that might be more sensitive to noise, and protect them before they suffer further adverse effects. In keeping with this policy, employers may wish to provide audiometric testing for employees whose TWAs are between 80 and 85 dB, so that the few most susceptible workers might be identified and protected.

B. *Effects of Impulse Noise on Hearing*

The fact that impulse noise can be extremely damaging to hearing is widely supported in studies submitted to the record (Ex. 29, pp. 211–216, pp. 219–228, pp. 229–234; Ex. 30, App. G; Ex. 37 or Ex. 26–12(B); Ex. 279, 11–3 and 11–5). Although these studies suggest that there is no uniformly accepted definition of impulse noise, everyone agrees on certain of its characteristics. Impulse noise is characterized by a rapid rise time, high peak value of short duration, and a rapid decay. These sounds may be divided into two general categories: "A-duration" impulses are of very short duration (usually measured in microseconds) and are non-reverberant, in that they usually occur outside or in a sound-deadening environment. An example would be gunfire outdoors or in a sound-treated firing range. "B-duration" impulses are of longer duration (usually measured in milliseconds), and are reverberant mainly because they occur inside where the sound is augmented by reflective surfaces. B-duration impulses are more typical of industrial conditions where the sounds of metal impacting on metal, or short, high-level bursts of compressed air, are quite common. B-duration impulses are considerably more damaging to hearing than A-duration impulses of the same level because of the increased duration (Ex. 30, App. G, p. G–4).

There were a number of comments and exhibits in the record concerning impulse noise. Some were reports of studies, others were reviews of research on impulse noise, and others were discussions and recommendations for the standard.

In contrast to the studies of continuous noise mentioned above, dose-response relationships for impulse noise are not so easily defined. This may be due in part to the fact that the different studies of impulse noise varied considerably in such parameters as the subject (human or animal), the effect (TTS or NIPTS) and the stimulus (level, rise time, A-duration, B-duration, etc.). Also, there appears to be more individual variability associated with response to impulse noise than there is with response to continuous noise (Ex. 29, p. 227).

Many of the investigators and witnesses concluded that the best way to describe the effects of impulse noise was an approach called the "equal energy" method or rule (Ex. 54, pp. 16, 17; Ex. 279, 11–3, pp. 444, 449; Ex. 29, pp. 213–214; Ex. 321–21E, pp. 1–9; Ex. 80, App. B, p. 3, Ex. 81A, p. 3). According to this approach, equal amounts of sound energy produce equal effects on hearing, even though they are distributed differently in time. As explained in the introduction, sound energy is represented logarithmically by the decibel scale, an increase or decrease of 3 dB representing a doubling or halving of sound energy, and an increase or decrease of 10 dB representing a tenfold change in sound energy. Therefore, this approach is also called the 3-dB rule or the 3-dB exchange rate. It is somewhat more conservative than the 5-dB exchange rate presently used in OSHA's noise standard, 29 CFR 1910.95, and in this amendment.

Studies

In an article that OSHA had used to support the impulse requirements in the proposal, Dr. D. H. McRobert and Dr. Ward (Ex. 13) discussed their laboratory study of TTS due to short-duration impulses. The purpose of the study was to determine the appropriate trading relationship between sound level and number of impulses. Drs. McRobert and Ward used impulses with peak sound pressure levels of about 146 to 155 dB and about 2 milliseconds in duration. After establishing an individual's "critical level" (the level that produced a 20-dB TTS), the investigators lowered the level and increased the numbers of impulses. They found that subjects could tolerate greater numbers of lower-level impulses than would have been predicted by the equal energy rule (Ex. 13, p. 1299). On the basis of their experiment, Drs. McRobert and Ward recommended a 5-dB decrase in peak level for every tenfold increase permitted in number of impulses. However, they cautioned that this relationship would only be correct for non-reverberant impulses, not for reverberant impulses. In fact, they stated that it is probably erroneous to have a single dose-response curve for both reverberant and non-reverberant impulses (Ex. 13, p. 1300).

In a document submitted by EPA (Ex. 29, pp. 219–228), Drs. T. Ceypek, J. Kuzniarz, and A. Lipowczan reported on their field study of 213 drop-forge workers. The noise environment consisted of impulses with peak sound pressure levels of 127 to 134 dB and durations of 100 to 200 milliseconds repeated 3,000 to 10,000 times per day, superimposed on a background noise of about 110 dB. Subjects had been exposed to these conditions for one to 30 years. The results showed large hearing losses even after fairly short durations, such as two years (Ex. 29, pp. 221, 227). The authors concluded that impulses combined with continuous noise produced a more rapid development of permanent hearing loss than would continuous noise alone and that the loss observed after five years was the same as that which would be expected after 10 years of exposure to continuous noise (Ex. 29, pp. 221, 227). They also concluded that the criteria developed for gunfire (non-reverberant impulses) were inappropriate for such industrial conditions as dropforging (Ex. 29, pp. 221, 227).

In another chapter of the document submitted by EPA (Ex. 29, pp. 229–234), Dr. H. G. Dieroff described a laboratory study that he had conducted of the effects of impulse noise on guinea pigs. In an attempt to discover a mechanism causing the hearing loss that is different from the one involved in continuous noise-induced hearing loss, he studied the effects of impulse noise on the cochlear microphonic potential (MP), and on the secretion of succinodehydrogenase (SDH) activity in the cochlear. In so doing he compared a mechanical and a histochemical response to sound stimuli. He found that when guinea pigs were exposed to peak sound pressure levels of 162 dB for durations of 200 to 400 milliseconds the MP was very rapidly adversely affected, whereas any adverse SDH changes were not detected until much longer after they would have been predicted to appear with exposure to equivalent levels of continuous noise (Ex. 29, pp. 232–233). These seemingly conflicting results were not easily explained.

NIOSH submitted to the hearing record three studies on the effects of impulse noise (Ex. 26–12 (A) (B) and (C)), which had been performed at the Upstate Medical Center of the State University of New York by Drs. Roger Hamernik and Donald Henderson and their colleagues. In the experiments chinchillas were used, a practice that is not unusual for laboratory studies of permanent hearing loss. In the first of these studies (Ex. 26-12(A), pp. 1-20), Dr. C. R. Perkins, with Drs. Hamernik and Henderson, explored the effects of the time interval between impulses on the magnitude of hearing loss. They exposed five chinchillas to 50 A-duration impulses with a peak sound pressure level of 155 dB and an interval between sound stimuli of one minute. Five more chinchillas were exposed to impulses of the same number and level, but with an interval between stimuli of only 10 seconds. The results showed that the group with the shorter interval between stimuli (and hence less recovery time) had much more temporary and permanent hearing loss than the group with the longer recovery interval (Ex. 26-12(A), pp. 6-7).

In the second study, Drs. Hamernik, Henderson, J. Crossley, and R. Salvi (Ex. 26-12(B), and Ex. 37) reported on a laboratory experiment on the interaction of continuous and impulsive noise. As justification for the experiment, the authors cited the high incidence of serious hearing losses among army personnel in the armored branch, where exposure to a combination of continuous and impulsive noise is common (Ex. 26-12(B), p. 117). Groups of chinchillas were exposed to 50 impulses having a 40-millisecond A-duration with peak sound pressure levels of 158 dB and 175 dB, a 2000 to 4000 Hz band of continuous noise of 95 dB, and two combination exposures of impulsive noise at 158 dB with continuous noise at 95 dB. Results showed that the combination of impulsive and continuous noise produced sizeable permanent hearing losses, whereas the TTS from the exposures to continuous noise alone and impulsive noise alone recovered fully with time (Ex. 26-12(B), pp. 118-119). The exposure to impulsive noise of 175 dB proved to be less damaging than the combined exposure (of 90 dB plus 175 dB), even though the impulse was 17 dB higher in level (Ex. 26-12(B), p. 119). When the combined exposure was interrupted with quiet periods of approximately 2 seconds, the damage was less severe even though the total sound energy was the same (Ex. 26-12(B), p. 120). Dr. Hamernik and his co-workers concluded that since the addition of the background noise to the impulses added very little to the total sound energy, the large increase in damage must be due to something else, such as "metabolic insufficiency" in the cochlea (Ex. 26-12(B), p. 120). The authors suggested that the interactive effect of impulsive and continuous noise might be similar to the drug-noise interaction, where damage due to the interaction can be two to four times greater than the damage expected from each stimulus alone (Ex. 26-12(B), p. 120).

In the third study (Ex. 26-12(C)) Drs. Hamernik and Henderson and Charles M. Woodford attempted to determine a safe level of B-duration impulses and to explore the trading relation between impulse intensity and duration. They exposed a total of 23 chinchillas to 50 impulses with the same duration (200 milliseconds) and interval between stimuli (one per minute), but with differing peak sound pressure levels. The investigators found that 50 impulses at the 140-dB level produced no permanent hearing loss or cochlear destruction, and was presumed safe for chinchillas, whereas the 155-dB level produced profound changes in hearing and cochlear structure, and was presumed hazardous (Ex. 26-12(C), pp. 2-3). In the group exposed to 150 dB some animals were severely affected, and others appeared to be nearly normal. The authors concluded that 150 dB may be close to a critical level at least for the number and temporal pattern of impulses that were used in the experiment (Ex. 26-12(C), p. 4).

Reviews

In a publication submitted by the Environmental Protection Agency, Drs. R. Coles, C. Rice, and A. Martin reviewed research on the effects of impulse noise performed before 1973 (Ex. 29, pp. 211-217). According to the authors (Ex. 29, p. 212), the first comprehensive set of recommendations for impulse noise was published in 1966 by Coles, Garinther, Hodge, and Rice. These recommendations were based on gunfire-induced TTS (Ex. 29, p. 212), and assumed that a similar amount of permanent hearing loss would occur after years of habitual exposure (Ex. 29, p. 214). They were applicable to military situations where about 10 to 20 exposures per year would occur (Ex. 29, p. 214). These criteria allowed A-duration impulses with peak levels up to about 175 dB, so long as the duration was extremely short (only a few microseconds). Peak levels must be reduced as duration increases. The authors also described (Ex. 29, p. 213) the attempt in 1970 of Coles and Rice to extend the criteria (previously based on gunfire-type impulses) to longer duration impulses, which would be typical of industrial conditions. Coles and Rice added data points to the criteria, indicating that the peak level should be considerably lower for B-duration than for A-duration impulses in order to produce the same amount of hearing loss. According to Coles et al. (Ex. 29, p. 213), this extension was based on TTS studies by Cohen, Kylin, and LaBenz in 1966, and Walker in 1969.

Another document (Ex. 279, 11-3), a report by Dr. Alan Martin entitled "The Equal Energy Concept Applied to Impulse Noise," presented an extensive review of research conducted before 1976 on the effects of impulse noise. In addition to some of the studies mentioned above, he discussed his own field study (Ex. 279, 11-3, p. 432) of 77 dropforge workers exposed to peak sound pressure levels of 65 to 448 Pascals (130 to 147 dB) with a repetition rate of 0.2 to 0.7 per second. Dr. Martin combined noise levels and duration according to the method advocated by Robinson (Ex. 12, App. 10, and Ex. 17, p. 14). His experiment supported the use of the equal energy (or 3 dB) rule for predicting the amount of permanent hearing loss resulting from all kinds and combinations of noise (Ex. 279, 11-3, pp. 437, 449). Instead of starting with critical peak levels and progressing to lower levels with increases of duration (like Coles et al. in Ex. 29, p. 212), Dr. Martin advocated building on the existing criteria for continuous noise, decreasing the duration as the level became higher (Ex. 279, 11-3, pp. 444-449).

Using the data from other impulse noise investigations, Dr. Martin combined level and duration of exposure according to the equal energy rule, and compared the results to studies of continuous noise. A study of 70 dropforgers by Cuberan, Fernandez, Cardinet, and Terrier was supported by Dr. Burns (Ex. 54, pp. 9,11) as well as by Dr. Martin (Ex. 279, 11-3, p. 439) as supporting the equal energy rule for predicting hearing levels resulting from impulse noise. Dr. Martin also used Ceypek's data (Ex. 279, 11-3, p. 440) on dropforgers and achieved the same results. In addition he cited a study by Atherly (Ex. 279, 11-3, p. 443) of 50 trimmers who used pneumatic chisels on manganese bronze castings. Once again the observed hearing levels agreed very closely with predicted levels according to the equal energy rule, even in the extremes of the population distribution (at the first and 99th percentiles) (Ex. 279, 11-3, pp. 443-444). Dr. Martin concluded that these studies provided ample proof that the equal energy concept may be extended to include exposures to industrial impulse noises (Ex. 279, 11-3, p. 444).

Dr. Martin believed that the preponderance of the evidence indicated that the equal energy concept should be extended from steady-state noise exposure to include industrial impulse noise. He concluded by stating:

It is somewhat surprising that, in the past and in the context of injury to hearing, impulse noise has been treated as a special type of noise having different properties than steady-state noise. It is now apparent from research, as perhaps has been from a logical viewpoint for some time, that it merely forms part of a "temporal" continuum of noise, and therefore should be treated in a similar manner to the rest of that continuum. (Ex. 279, 11-3, p. 449).

Criteria and Standards

The current noise standard, 29 CFR 1910.95, limits impulse noise to a peak sound pressure level of 140 dB.

OSHA's proposal maintained the maximum allowable level for impulses at a peak sound pressure level of 140 dB but specified a maximum of 100 impulses at that level with a 10-dB decrease in level for each tenfold increase in number (39 FR 37775, October 24, 1974), (an equal energy approach). According to the proposal's preamble, this requirement was based on the study by Drs. McRobert and Ward (Ex. 13), discussed above. In addition the proposal defined "impulse or impact noise" as "a sound with a rise time of not more than 35 milliseconds to peak intensity and a duration of not more than 500 milliseconds to the time when the level is 20 dB below the peak." If impulses occurred more often than once every half second they were to be considered as continuous noise.

Certain other standards and criteria for impulse noise were submitted to the record. In a report entitled "Proposed Damage-Risk Criterion for Impulse Noise (Gunfire)" (Ex. 16), the Committee on Hearing, Bioacoustics, and Biomechanics (CHABA) modified the criteria of Coles et al. (Ex. 29, pp. 212-214; Ex. 279, 11-3, p. 421), making it about 10 dB more stringent (Ex. 16, p. 5) in order to protect a higher percentage (95 percent) of the exposed population (Ex. 16, p. 2). Even so, the criteria were designed to permit NIPTS of 10 dB at 1000 Hz, 15 dB at 2000 Hz, and 20 dB at 3000 Hz and above in a small percentage of the population (Ex. 16, p. 1). The criteria specified a maximum peak sound pressure level of 164 dB for the short pulses (25 microsecond or less), with a 2-dB decrease for each doubling of duration, dropping to a plateau of 152 dB for A-duration impulses or 138 dB for B-duration impulses (200 to 1000 milliseconds) (Ex. 16, pp. 2, 4-5).

The authors of the CHABA report cautioned that it was only a first attempt at reasonable damage risk criteria for impulses, and it rested heavily on the assumption of a constant relation between TTS and NIPTS, and that this assumption might be incorrect (Ex. 16, p. 6). However, they believed that the report designated "reasonable limits for the type of impulse noise to which most service personnel will be exposed: rifle and pistol reports from his own and his fellows' weapons, and single rounds fired by higher caliber armament in both reverberant and non-reverberant conditions." (Ex. 16, p. 6).

The NIOSH criteria document (Ex. 1) made very little mention of impulse noise, except to say that the provisions in the recommended standard were "intended to apply for all noise even though additional controls may be necessary for certain specific types of noise, such as some impact and impulsive noise." (Ex. 1, p. I-1). However, no specific recommendations were given for the measurement of impulse noise, or for calculating its contribution to the daily dose. In the supporting text NIOSH stated that industrial noise and hearing surveys dealing with this kind of exposure were just beginning at that time (1972) (Ex. 1, p. IV-9).

EPA submitted to the record a document entitled "Information on Levels of Environmental Noise Requisite To Protect the Public Health and Welfare With an Adequate Margin of Safety" (Ex. 30). This document contained a section on impulse noise (Appendix G), which modified the CHABA criteria so that the allowable levels would prevent 90 percent of the exposed population from incurring more than a 5-dB hearing loss at 4000 Hz (Ex. 30, App. G, pp. G-4, p. G-10). The allowable levels became accordingly more stringent. A peak sound pressure level of 152 dB was the maximum allowable level for impulses of 25 microseconds or less, with plateaus of 140 dB for A-duration impulses and 126 dB for B-duration impulses (Ex. 30, Appendix G, p. G-6). Unlike the CHABA criteria EPA recommended changes in peak level of 10 dB for every tenfold change in number of impulses based on a limit of 100 impulses (Ex. 30, App. G, p. G-4). The EPA "Levels" document indicated growing support for the extension of the equal energy rule to include impulsive as well as continuous noise exposure (Ex. 30, App. G, p. G-9). However, the authors recommended evaluating impulsive and continuous noise separately, "each according to its own criterion," until combining them according to the equal energy rule had been further justified by more research (Ex. 30, Appendix G, pp. G-8, G-9).

Recently Col. Johnson submitted to the hearing record a preliminary draft ANSI standard entitled "The Evaluation of the Effect on Human Hearing of Sounds with a Peak A-Weighted Sound Pressure Level Above 120 Decibels and a Peak C-Weighted Sound Pressure Level Below 140 Decibels" (Ex. 321-21E). Although the draft ANSI standard is intended to cover impulse noise, the committee decided against unequivocally defining impulse noise, impact noise, or types of non-impulsive noise (Ex. 321-21E, p. 1), and instead refers to "intense" sound (Ex. 321-21E, p. 3). The basic measurement used to assess the effect of intense sound on hearing is the A-weighted equivalent continuous level (calculated by the equal energy rule), and all sound between the levels specified in the title is to be included in the assessment (Ex. 321-21E, p. 1). The measuring system must be able to integrate properly the energy of very short impulses, and the sound environment must be sampled at least every 25 microseconds (Ex. 321-21E, p. 6).

Although the ANSI standard still is in the preliminary draft stages, the intent of integrating impulsive with continuous noise according to the equal energy rule appears to be quite clear.

Discussion

The topic of the maximum permissible peak sound pressure level of 140 dB will not be addressed in this discussion since the requirement is present in the existing standard, 29 CFR 1910.95, and remains unchanged at this time. However, the method with which impulses are to be included in employee dose is germane to the calculation of dose or TWA for purposes of the hearing conservation amendment.

Walter Nowikas, late president of Donley, Miller and Nowikas, Inc. (Ex. 161, 9 B; Tr. 3222), pointed out that OSHA's criteria were derived from studies of short duration impulses, and therefore were not appropriate for longer duration industrial impulses. He believed that the proposed limit of 100 impulses at 140 dB was excessive since it could exceed the allowable exposure for continuous noise when the sound energy was summed. To prevent this discrepancy, he suggested reducing the number of impulses by a factor of 10 (Ex. 14-42, p. 6). Mr. Nowikas recommended changing the criteria "to conform at least with the RMS equivalent" (the equivalent for continuous noise) (Ex. 161, p. 31).

Some comments favored integrating impulses in the manner suggested above by Dr. Martin (Ex. 279, 11-3) and later by Col. Johnson (Ex. 321-21E). Dr. Loren Kerr, Medical Director of the United Mine Workers (Ex. 80, App. B, p. 3), suggested that the standard should read, "Impulse noise, when integrated by the equal energy rule, shall not produce equivalent levels in excess of Table G—16(a)." Dr. Burns (Ex. 54, p. 16) testified that he was "satisfied that impulse noise, suitably handled, is also amenable to a simple energy method of exposure."

In order to be sufficiently protective, Drs. Richard Bolt and Edgar Shaw, speaking for the Acoustical Society of America, recommended the equal energy rule until such time as more definitive criteria could be developed. They stated:

> It is regrettable that no simple but valid damage risk criterion covering all kinds of impulse and impact noise exposure has yet been found or appears within sight. In these circumstances, it may be wise to consider limits based strictly on the A-weighted daily total acoustic energy, i.e. the eight hour energy equivalent level Leq. Such a measure might prove overprotective by as much as 10 decibels in some circumstances, but would have the merit of simplicity with respect to interpretation and instrumentation. (Ex. 14-303, p. 2).

Other commenters pointed out that OSHA had proposed a standard that seemed to allow two separate doses—one for continuous noise, and one for impulse noise (Ex. 79, p. 7; Ex. 80, App. B, p. 3). On this subject Wookcock stated (Ex. 79, p. 7):

> * * * I would like to point out that OSHA has proposed a noise standard which, in effect, sets two separate levels—one for continuous noise and one for impulse and impact noise. Conceivably, the standard allows for a double exposure. This should be corrected so that both hazards are not permitted to exist at the same time.

Dr. Ward must have recognized this problem when he recommended using a combination of the 5-dB and 3-dB trading relations. He suggested using the 5-dB trading relation when calculating noise dose for exposures from 85 dB to 105 dB and the 3-dB trading relation for high level exposures above 105 dB (Tr. 1042–1043). He felt that this combination would bridge the gap between steady and impulsive noise (Ex. 64, Statement by W. Dixon Ward on behalf of AISI—July 1, 1975, pp. 10–11).

Conclusions

It is clear from examining the studies, reviews, standards and comments discussed above that the early criteria for impulse noise were developed using assumptions that are not generally applicable to industrial conditions. The studies on which they were based used A-duration (gunfire) impulses, even though they have been extrapolated to cover B-duration impulses (Ex. 29, pp. 212–213; Ex. 16, p. 6; Ex. 30, App. C, p. C–6). In addition, the early studies of gunfire noise did not include moderate or high levels of continuous noise in the background, which is typical of the industrial situation (Ex. 294, p. 1; Ex. 26-12(B), p. 117). Since the early criteria were meant to apply to the military situation they assumed only 10 to 20 exposures per year (Ex. 29, p. 214), whereas workers in industry often are exposed to impulsive noise on a daily basis.

When impulsive noise was combined with continuous noise, the studies and reports submitted to the hearing record showed fairly clearly that the hazard increased (Ex. 26-12 (B), p. 119; Ex. 29, pp. 221, 227). The study by Hamernik et al. (Ex. 26-12(B), p. 119) showed an effect that was not just additive but synergistic. Field studies where impulses were superimposed on background noise indicated that hearing loss was exacerbated. Ceypek et al. (Ex. 29, p. 221) found considerably more damage than would be expected from continuous noise. Dr. Martin (Ex. 279, pp. 449, 432–444), through the results of his own investigation and by evaluating the data from studies by Guberan et al., Ceypek et al., and Atherly, found that the best way to predict hearing loss was to extend the equal energy rule from continuous through impulsive noise. The draft ANSI standard submitted by Col. Johnson (Ex. 321-21 E, p. 1) supports this method for use in the U.S.

Therefore, OSHA has determined that, for purposes of the hearing conservation program, impulse noise should be combined with continuous noise for purposes of calculating employee noise exposure. Since industrial impulses are almost always superimposed on a background of moderate-to-high levels of continuous noise (Ex. 6, p. 12338; Ex. 26-12(B), p. 117; Ex. 29, p. 229; Ex. 29, p. 227; Ex. 30, p. C–8), and since both may be harmful, it is only reasonable to consider their effect together, rather than to treat each separately. There is ample justification for this approach in the studies and comments submitted to the hearing record (Ex. 26-12(B), pp. 117, 121; Ex. 279, 11-3, p. 449; Ex. 29, p. 213; Ex. 80, App. B, p. 3; Ex. 81A, p. 3; Ex. 54, p. 16). However, since there are still some uncertainties as to the ameliorative effects of certain temporal patterns (Ex. 26-12(A), pp. 6–7, 10; Tr. 1051; Ex. 26-12(B), p. 120), and since there usually are some quiet periods (or less noisy periods) during the work day (Ex. 64-5, p. 2; Ex. 64-6, p. 6; Ex. 6, p. 12338, Ex. 114, p. 7), the Agency cannot determine the precise effects of industrial impulses at this time, and therefore OSHA has chosen to retain the 5-dB exchange rate for purposes of the hearing conservation amendment. Until such time as another method, such as the equal energy rule (the 3-dB exchange rate), or a combination of the 3-dB and 5-dB exchange rate (as suggested by Dr. Ward, Tr. 1042–1043), is borne out by laboratory and field research, OSHA will continue to require the integration of all sound, including impulse noise, according to the 5-dB exchange rate in the computation of dose or TWA.

While the hearing conservation amendment does nothing to change the PEL or methods of compliance required by 29 CFR 1910.95(a) and (b)(1), it does require that all noise exposures above 80 dB, whether impulsive or steady state, be considered in determining whether an employee is included in the hearing conservation program. The decision to measure all noise exposures for purposes of the hearing conservation program is a pragmatic approach to the whole problem of impulse noise. For, while there is some dispute as to the precise definition and effect of impulse noise, there is general agreement that impulse noise is damaging. The hearing conservation program is designed to identify and protect those who show an increased susceptibility to the effects of noise. Accordingly, in computing an employee's noise dose or TWA for purposes of inclusion in the hearing conservation program, the impulsive component of the noise exposure is included. Moreover, there have been many technological advances in the capabilities of measuring instruments, and equipment now exists that can integrate impulse noise into the dose. Therefore, OSHA has determined that it is appropriate to include impulse noise in the dose computation for hearing conservation in order to provide employees exposed to significant amounts of this type of noise the protection of the amendment.

C. *Extra-Auditory Effects of Noise*

The most obvious physiological effect of noise is damage to the auditory system. However, depending upon the level, type, and duration of the noise, a variety of extra-auditory effects have been observed, which will be discussed in the following paragraphs. In addition, it should be noted that people who are exposed to noise at work may also be exposed to noise during their non-working hours. For example, many workers live in areas where there is highway and aircraft noise as well as noise from industrial plants. Industrial workers who live in the urban settings are sometimes stressed by noise 24 hours a day without respite, and without adequate opportunity to recover, either physiologically or psychologically. Thus, effects that might otherwise have been temporary would tend to become chronic.

Although there is a substantial body of data suggesting a wide variety of noise-induced physiological responses, specific responses to specific noise doses have not yet been identified. The evidence of noise-induced health effects is not conclusive for 8-hour exposures of 85 dB, or 90 dB, or even higher levels experienced over a working lifetime. However, to ignore this large body of data is to undervalue the significance of the adverse effects (Ex. 5, p. 43806; Ex. 138A, p. 2-31). Both testimony and written exhibits, including subjective and experimental evidence, indicate that noise can be harmful to human health (Ex. 2C-108, p. 2; Ex. 2C-111, p. 1; Ex. 2C-4, p. 1; Ex. 96, pp. 277-281; Ex. 189-8, p. 2; Ex. 28A, pp. 18-24, 27-28, 41-44, 46-49; Ex. 32, App. B, pp. 6-11; Ex. 79, p. 2; Ex. 173, pp. 1-2, 7-8; Ex. 84, Attach. 2, pp. 1-2).

During the 1975 and 1976 public hearings most of the evidence that was submitted was anecdotal, although some studies were submitted by individuals (Ex. 28A), unions (Ex. 88, Ex. 95, Ex. 96, Ex. 97, Ex. 98), and government agencies (Ex. 26-9; Ex. 26-10; Ex. 26-3; Ex. 26-11; Ex. 32; Ex. 40). Leonard Woodcock, then president of the United Auto Workers, stated:

> I am sure that there are many limitations to these studies, as there always seems to be in this sort of work. But we think there is truth to these studies since it matches our subjective experience. We expect that future research into this important area will offer more definitive data. (Ex. 79, p. 5)

According to Ruth Knowles, then president of Local 1716 of the Textile Workers Union (Tr. 2024), "Some workers have been forced to retire long before retirement age because of hypertension." She goes on to state that in her opinion the high noise exposure in the weave department could have been a factor in those instances.

The major concern over extra-auditory health effects from noise arises from the fact that noise has the ability to act as a general, non-specific, biological stressor (Ex. 138A, p. 2-31). Evidence suggests that the stress reaction produced by noise is not unlike that produced by other stressors; that is, a generalized reaction governed by sympathetic activation of the autonomic nervous system.

The concept of biological stress, first introduced by Dr. Hans Selye, has been described as "the nonspecific response of the body to any demand made upon it; a stereotyped, phylogenetically old adaptation pattern primarily preparing the organism for physical activity, e.g., fight or flight." (Ex. 138A, p. 2-32).

This stress reaction produces a widespread change in bodily activity. There is a rise in blood pressure, a rise in pressure inside the head and an increase in sweating. The heart rate increases, there are changes in breathing and there may be a sharp constriction of the muscles over the whole body (Ex. 26-9, p. 10-8). These change are likely to be mediated by increased adrenal secretion of the catecholamine hormones, epinephrine and norepinephrine (Ex. 138A, p. 2-32).

In the hearing record two theories were proposed to explain mechanisms by which these stress-related physiological changes can have an impact on human health. Two conceivable damage pathways were developed:

1. Abnormalities in blood pressure regulation that lead to hypertension.
2. Increased blood platelet adhesiveness that accelerates the development of atherosclerotic plaques in the walls of the arteries.

Each of these stress-related damage pathways is discussed in turn.

1. The theory that noise stress can result in hypertension is supported by Dr. Bruce Welch (Ex. 321-16E, pp. 1-11) and Dr. Ernest Peterson (Ex. 321-16D, pp. 1, 4, 10) as well as by numerous other researchers, referred to in these and other exhibits (Ex. 88, p. 6; Ex. 96, p. 279). Intense industrial sound impairs the regulation of blood pressure, the most distinct manifestation of which is an increased prevalence of hypertension (Ex. 321-16E, p. 2).

According to Dr. Welch, hypotension, or reduced blood pressure levels, also can result from noise stress (Ex. 321-16E, pp. 3-4). Both hyper- and Hypotension fundamentally are disorders of circulatory regulation. They are characterized by exaggerated and inappropriate cardiac and vasomotor response to changes in body position or physical and psychological stimuli (Ex. 321-16E, p. 8). This increase in vascular lability (or changeability) under noise stress affects the circulatory adjustments that must normally be made during the course of a working day (Ex. 321-16E, p. 9). For those who already have impaired circulation, excessive vascular lability can lead to congestive heart failure, cardiac ischemia, or cardiovascular stroke. In fact it has been established that hypertension, even at moderate elevations, is associated with increased risk of coronary and *cerebrovascular* disease (Ex. 321-16E, p. 3).

2. In a report submitted by EPA (Ex. 138A, p. 2-40) Hattis et al. proposed another pathway theory, which involves an increase in the adhesiveness of blood platelets. Increased platelet adhesiveness has clear potential for negative side effects, due to an increased tendency for the formation of thrombi, small aggregates of platelets and other blood components involved in the clotting process. These thrombi contribute to the buildup of atherosclerotic plaques, which gradually narrow the arteries and reduce the oxygen supply to vital tissues. A heart attack can occur when there is complete blockage of an artery to the heart muscle, or when the demand for blood oxygen is greater than that which can be supplied through a narrowed coronary artery. These effects can be cumulative, for the same thrombi that contributed to a gradual narrowing of the arteries can complete the sequence by forming the final occlusion leading to tissue death in the heart.

Two epidemiological studies that were submitted to the record are of particular importance. In a classic study of German iron and steel workers (Ex. 98, p. 219), Dr. Gerd Jansen found that 62 percent of the workers chronically exposed to noise levels above 90 dB had "peripheral circulatory symptoms", compared to 48 percent of those exposed to lower levels. Physiological and psychological examinations were performed to determine the extent to which the difference could be caused by non-occupational factors. Dr. Jansen concluded that noise interferes with involuntary bodily functions, and as such could be a serious health risk.

A NIOSH-sponsored study (Ex. 29, pp. 441-452) performed by the Raytheon Service Company lends further support to these findings. The medical records of factory workers routinely exposed to high noise levels (at or above 95 dB) were compared to those of a population exposed to lower noise levels (at or below 80 dB). Statistically significant differences in the number of cardiovascular and circulatory disorders as well as other health problems and complaints were found between the two groups. In a follow-up study the Raytheon Service Company compared medical records of workers exposed to high noise levels (prior to the implementation of a hearing conservation program) with records of the same workers after a hearing conservation program has been put into effect. The overall results indicated fewer accidents, diagnosed medical disorders, and absences during the period when workers were involved in a hearing protection program. The Raytheon report summarizes: "In general, the results were interpreted as adding strong support to the hypothesis that prolonged exposure to high intensity noise increases the incidence of various medical, accident and attendance problems." (Ex. 29-11, pp. 5-1 and 5-2).

In an experimental study (Ex. 28A, pp. 42, 46-50) on the effects of prolonged exposure to tonal pulses, Dr. Robert Cantrell found statistically significant increases in plasma cortisol and blood cholesterol levels when compared with the pre-exposure levels of his experimental subjects. Significant increases were noted at noise levels of 80 and 85 dB, and were pronounced at 90 dB.

However, there was skepticism during the hearings about the importance of extra-auditory effects. The Edison Electric Institute maintained that:

> since there is no clear evidence on non-auditory noise impact, an occupational noise standard should not consider this area. We recommend that the federal government undertake additional long-term research as provided for in the OSH Act before promulgating standards for non-auditory noise effects (Ex. 73, p. 2).

According to Dr. Bruce Karrh of DuPont:

> I know of no significant report of extra-auditory physiological effects for persons with noise exposure levels below 115 dBA. We have not conducted a controlled scientific study on non-auditory effects of noise at our plants because of our experience with our hearing conservation program has not indicated a need for such a study (Ex. 114, p. 14).

In May of 1973 three Swedish researchers (Carlestam, Karlsson, and Levi in Ex. 29, p. 485) pointed out that "the evidence in favor of noise as a major pathogenetic environmental agent is rather shaky."

Between the 1975 hearings and the recent reopening of the record (April 1980), considerable research activity has occurred, and new and more persuasive evidence has been submitted to the record.

The EPA submitted an analysis by Dr. Welch (Ex. 321-16E) of over forty studies from European and Soviet bloc nations of the effects of noise exposure on the cardiovascular system. Dr. Welch found evidence of noise-induced structural changes in the heart, increased cardiac morbidity, cerebrovascular and peripheral vascular disorders, and hypertension (Ex. 321-16E, pp. 2-21). Dr. Welch admits that many of these studies suffered from methodological problems, although approximately half of them presented data in a statistically verifiable manner. Viewed as a whole, these studies represent a consistent body of data containing significant evidence that noise levels greater than 90 to 95 dB may increase the risk of cardiovascular disease in exposed workers. He concludes:

> In a practical sense, the available evidence now demands that prolonged exposure to high intensity sound be viewed in a much broader sense than heretofore as a serious threat to general human health. The evidence for associating long-term sound exposure with cardiovascular disease, in particular, is comparable to that for associating it with loss of hearing (Ex. 321-16E, p. 37).

In another report submitted by EPA (Ex. 321-16D, pp. 1-2), Dr. Peterson also discusses recent developments in research on the extra-auditory effects of noise. He finds that by far the largest body of evidence centers about the relationship between prolonged exposure to intense noise and cardiovascular performance. The most common occurrence is one of impaired regulation of blood pressure, which may be manifested either as hypotension or hypertension. Other signs and symptoms that occur more frequently in noise-exposed workers are abnormalities in cardiac pacing, reducing stroke volume, various ECG abnormalities, and narrowing of retinal arteries. Dr. Peterson also reported on his own work (Ex. 321-16D, pp. 6-10), a laboratory study of the effects of protracted noise exposure on rhesus monkeys. Monkeys were chosen as an animal model so as to closely approximate human response. As a result of life-like exposure scenarios (averaging 85 dB) for 9 months, the monkeys showed significant alterations in blood pressure that were sustained even after cessation of the stimulus.

A third submission by EPA (Ex. 321-16F) is a study of German brewery workers by Dr. H. Ising et al., who attempted to quantify the risk to the cardiovascular system associated with exposure to noise levels averaging 95 dB. Dr. Ising used each individual as his own control by comparing various cardiovascular indicators with and without the use of hearing protectors. In so doing he overcame some of the methodological problems discussed by Dr. Peterson (Ex. 321-16D, pp. 2-4) and Dr. Welch (Ex. 321-16E, pp. 35-37). Dr. Ising found that on days when people worked without hearing protection, there was a significant elevation in systolic blood pressure, changes in arterial wall elasticity, and increased levels of catecholamine hormones excreted in the urine. (The catecholamines are characteristically secreted in response to stress, and have been associated with increased blood platelet adhesiveness and with increases in blood pressure (Ex. 138A, pp. 2-32 and 2-33)).

Despite the quantity of evidence in the studies discussed above, clear dose-response relationships do not yet exist for the cardiovascular effects of noise. However, if, as the evidence suggests, there is a cause-effect relationship between noise and hypertension, the health implications would be widespread and serious (Ex. 79, p. 5; Ex. 266B, pp. 2, 13, 14-15; Ex. 138A, p. 2-31; Ex. 321-16E, p. 37; Ex. 29, p. 485). Therefore the Agency urges caution on the part of employers. OSHA has included the above evidence as a qualitative, if not a quantitative, argument for requiring hearing conservation programs.

Other extra-auditory effects are also discussed in the record. The report of the initial Raytheon study, mentioned above, described other possible effects of noise (Ex. 29, pp. 449, 451). In addition to cardiovascular effects, the investigators found evidence of digestive, respiratory, allergenic, and musculo-skeletal disorders. Over a period of 5 years the number of diagnosed disorders in every category was significantly higher for workers exposed to high noise levels that it was for those exposed to lower noise levels.

In his report (Ex. 321-16E, p. 31), Dr. Welch discusses neurological changes associated with long-term exposure to occupational noise. After reviewing the scientific literature, he finds that the sense of balance can be altered, that reaction time is impaired, and that there is decreased tactile sensitivity in the hands and feet. Dr. Cohen and Dr. Joseph Anticaglia (Ex. 96, pp. 277) suggest that noise-induced neurological changes may occur as a result of overstimulation of the brain's reticular formation, leading to a state of reflex hyperactivity and abnormal EEG response. The authors noticed that laboratory subjects complained about feelings of disorientation after exposure to high levels of noise (Ex. 96, p. 278). Studies cited by Dr. Edith Culian (Ex. 97, pp. 38-39) support this observation with factory workers as well. It has also been suggested that high levels of noise reduce the eye's ability to focus clearly, and narrow the visual field (Ex. 97, p. 35; Ex. 98, p. 278). These effects can be significant from the standpoint of potential accidents and injuries (Ex. 96, p. 279).

There was information on the effects of noise on worker performance submitted to the hearing record. According to EPA's Public Health and

Welfare Criteria for Noise (Ex. 31, p. 8-2), a variety of effects have been observed in the literature. EPA cites research by Dr. D. O. Hebb to explain these effects. To paraphrase: Changes in stimulation (such as intense noise) produce arousal activity which originates in the reticular formation. An individual's level of arousal affects the performance of a task. Too little arousal produces inadequate performance whereas too much arousal interferes with performance. The optimum is somewhere at the top of an inverted U-shaped curve. Thus, noise can enhance, interfere with, or fail to affect the performance of certain tasks. The EPA concludes that:

> Continuous noise levels above 90 dBA appear to have potentially detrimental effects on human performance, especially on what have been described as noise-sensitive tasks such as vigilance tasks, information gathering and analytical processes. Effects of noise on more routine tasks appear to be much less important, although cumulative degrading effects have been demonstrated by researchers. Noise levels of less than 90 dBA can be disruptive, especially if they have predominantly high frequency components, are intermittent, unexpected, or uncontrollable. The amount of disruption is highly dependent on the type of task, the state of the human organism, and the state of morale and motivation (Ex. 31, pp. 8-6 and 8-7).

Noise can degrade job safety in some of the same ways that it degrades performance. It is logical to conclude that the same parameters that disrupt job performance (high noise levels, or noise that is high in frequency, intermittent, unexpected, or uncontrollable) can jeopardize job safety. In addition, there are other reasons why noise can be a safety hazard. Noise can effectively mask alarm signals and warning shouts. This includes signals from malfunctioning machines and the sound of approaching vehicles.

I.W. Abel, former president of the Steelworkers Union, reported the following:

> A recent study of the causes of 25 fatalities in railroad accidents by the Federal Railroad Administration showed the common factor was the workers' unawareness of the approach of the railroad cars or equiment that struck them. Many of these workers, the study pointed out, were working under exposure to a high level of noise (Ex. 78, p. 20).

Howard Pemberton, safety committeeman from Local 588 of the UAW, describes the workers' condition: "They cannot escape the noise. They also tell us—and we know from our own experience—that they cannot hear instructions from the foremen, and that they must scream to carry on necessary communication" (Ex. 2C-74, p. 2).

Another way in which noise can lead to accidents (although the cause and effect relationship is less direct), is through workers' aversion to the noise. Dr. John Finklea, then Director of NIOSH, related the following incident:

> Several weeks ago, a worker fatality was reported in a power plant in the Cincinnati area. An investigation revealed that the accident victim and his fellow workers, irritated by the screeching sounds from a pulley drive in a conveyor system, had resorted to repeated "soaping" of the pulley unit to quiet the sound. Gaining access to the pulley for this purpose involved certain risks that were contrary to company work policy. Despite this, a worker in the course of soaping the pulley evidently became caught, was pulled into the moving conveyor and was killed. It is doubtful that even an 85 dBA noise limit would have prevented this accidental death. Yet the case deserves mention if only to show that non-auditory problems of noise cannot be ignored. Indeed, it should motivate more conservative approaches in specifying noise limits meeting both health *and* safety needs (Ex. 26-1, p. 7).

Finally, the general effect of worker absenteeism should be mentioned. Whether from psychological aversion to noise or the physiological consequences of noise stress, absenteeism appears to be higher among workers in noisy industries. According to anecdotal evidence from union witnesses, both fatigue and absenteeism are higher (Ex. 2C-74, p. 2; Ex. 79, p. 2). Studies in the record supported this contention. The Raytheon study mentioned earlier (Ex. 26-11, p. 3-172), found significant differences in absenteeism between groups of workers exposed to average noise levels above 95 dB and below 80 dB. Absenteeism in the high noise group was significantly decreased after the institution of a hearing conservation program.

A study by Schmidt, Royster, and Pearson (Ex. 321-22F, p. 28) found significant differences in absenteeism as well in accident records. The report by Dr. Gulian cites a study by Odescalchi of 50 noisy Italian companies (such as textile, steel and metal fabrication), where the annual number of absences is about 15 percent higher than in quieter ones (Ex. 97, p. 60). Other studies cited by Dr. Gulian are inconclusive on this issue, but enough data exist to be strongly indicative of increased absenteeism, which can be very costly to industry.

III. History of the Regulation

The occupational noise exposure standard, which is found at 29 CFR 1910.95, was originally promulgated as a standard under the Walsh-Healey Public Contracts Act, 41 U.S.C. 35 *et seq.* (See 34 FR 7940, May 20, 1965; 35 FR 1015, January 24, 1970). The Walsh-Healey occupational noise standard (41 CFR 50-204.10) was adopted under § 6(a) of the Occupational Safety and Health Act, 84 Stat. 1590, 29 U.S.C. 651 *et seq.* which, within two years of the effective date of the Act, allowed the Secretary to promulgate without regard to rulemaking any established Federal standard. (See also § 4(b)(2) of the Act).

The present noise standard limits an employee's noise exposure to 90 dB as an 8-hour time-weighted average (TWA). Employee exposure to noise above the permissible exposure level (PEL) must be reduced to within permissible limits by feasible engineering controls or administrative controls. Where such controls cannot reduce employee exposure to within permissible limits, they are to be supplemented with personal protective equipment. The OSHA noise standard also requires that the employer must administer a continuing effective hearing conservation program if exposures exceed the PEL. OSHA has interpreted this to require employers to provide audiometric testing for those employees exposed above the PEL without regard to the use of personal protective equipment. (See Industrial Hygiene Field Operations Manual, Chapter IV, pp. 9-16, OSHA Instruction CPL 2-2.20, April 2, 1979).

On August 14, 1972, the National Institute for Occupational Safety and Health (NIOSH) transmitted to the Department of Labor a criteria document, "Occupational Exposure to Noise" (HSM 73-11001) (Ex. 1), in accordance with section 20(a) and 22(d) of the Occupational Safety and Health Act, (29 U.S.C. 669(a), 671(d)), which authorizes the Secretary of Health, Education and Welfare to conduct research to develop criteria for dealing with harmful physical agents and to make recommendations to the Secretary of Labor concerning new or improved occupational safety and health standards. The criteria document recommended that employee noise exposures be limited to an 8-hour TWA of 85 dB in new installations and that the Secretary should study the feasibility of reducing the PEL in all facilities to an 8-hour TWA of 85 dB. In addition, the criteria document recommended audiometric testing not only for employees whose exposures exceeded the PEL but also for those employees whose exposures were reduced to within the PEL by the use of personal protective equipment.

On January 26, 1973 the Assistant Secretary of Labor for Occupational Safety and Health appointed an Advisory Committee on Noise pursuant to section 7(b) of the Act (29 U.S.C. 656). The Committee consisted of 15 members, representing a broad cross-section of individuals knowledgeable about noise hazards in the industrial environment. The Committee included representatives of employers and employees, as well as representatives of the public and the occupational safety and health professions. The purpose of this committee was to obtain and evaluate additional recommendations from labor, management, government, and independent experts. In its deliberations the Committee considered approximately 135 comments submitted to it by various interested parties (see Ex. 2(c)), as well as numerous oral presentations (see Ex. 2(a)). The Committee held meetings periodically during an eight-month period and on December 20, 1973 it transmitted its recommendations for a revised occupational noise exposure standard (see Ex. 2(b)) to the Occupational Safety and Health Administration (39 FR 6047, February 21, 1974).

Briefly, the Advisory Committee recommended that the permissible exposure level for occupational noise be an 8-hour time-weighted average of 90 dB, with exposures down to 85 dB integrated into the computation. Exposures to steady-state noise were not to exceed 115 dB at any time. In addition, the Advisory Committee recommended audiometric testing be done annually for all employees whose exposures equalled or exceeded 85 dB or would equal or exceed 85 dB but for the use of personal protective equipment.

OSHA considered the information and recommendations contained in the NIOSH Criteria document (Ex. 1), the Advisory Committee's recommendations (Ex. 2(b)), and other available information. On October 24, 1974, OSHA proposed a revision to its occupational noise exposure standard and solicited comments and objections to it from interested persons (39 FR 37773-37778). OSHA proposed to retain an 8-hour TWA of 90 dB as the PEL, with exposures down to 85 integrated into the time-weighted average. In addition, the suggested ceiling of 140 dB for impact noise exposure contained in the old standard (see 29 CFR 1910.95, Table G-16, note) was proposed to be modified to a mandatory ceiling of no more than 100 impulses of 140 dB per day, with a tenfold increase in the permissible number of impulses to which employees could be exposed for each 10 dB decrease in the peak pressure of the impulse. The proposal also required the employer to determine if any employees were exposed to an 8-hour time-weighted average of 85 dB or above and to measure the exposure of any employees so identified. Additional exposure monitoring was required within 30 days of any change of equipment or process which would affect the noise level. Employee exposures to impact or impulse noise were also required to be monitored.

Under the proposal, audiometric testing was to be required for all employees who had noise exposures equal to or exceeding 85 dB as an 8-hour TWA and for all employees who were using personal protective equipment to reduce their exposures to an 8-hour TWA of 90 dB. If the employee's audiogram showed a significant threshold shift (STS) when compared to the employee's first or baseline audiogram, the employee had to be retested within one month. If the diminution of hearing was confirmed on retest, then the employee had to be informed of the change in the hearing level, and had to be provided and fitted with, and instructed in, the use of hearing protectors. Employees whose audiograms showed that they had a significant threshold shift were required to wear hearing protectors under the proposal even if they were not exposed over the PEL.

The preference for engineering controls over personal protective equipment as a method of compliance was retained and clarified and a limited exception was proposed that would have allowed personal protective equipment to be used even where engineering or administrative controls were feasible if the employee overexposure occurred on no more than one day a week. Various other provisions in the proposal required the employer to keep records of employee exposure monitoring, audiometric tests, calibration of audiometers, and notifications of employee overexposures.

On December 18, 1974, the Administrator of the U.S. Environmental Protection Agency (EPA), acting under the authority of section 4(c)(2) of the Noise Control Act of 1972 (86 Stat. 1236, 42 U.S.C. 4903), published a notice in the Federal Register requesting that the Secretary of Labor review the proposed occupational noise exposure regulation and report to the Administrator within 90 days on the advisability of revising the proposed regulation (39 FR 43802). Briefly, EPA contended that the proposal "does not protect the public health and welfare to the extent required and feasible." EPA objected to the proposal's permissible exposure limit, including the use of a 5 dB time-intensity trade-off (doubling rate) in computing the PEL, and to the definition of significant threshold shift which was used in the proposal. On March 18, 1975, OSHA published in the Federal Register the Review and Report Requested by EPA (40 FR 12336). In its response, OSHA reviewed and explained the reasoning underlying its proposed regulation. OSHA noted that the document to which EPA objected was merely a proposal upon which the public had been invited to comment. The Assistant Secretary concluded that "no changes should be made in the proposal at this stage," since the proposal by its very nature did not represent a final agency position and EPA's objections would be aired along with objections raised by concerned persons at an informal public hearing. In addition, OSHA promised to consider EPA's request and the evidence contained therein along with the rest of the evidence in developing its final standard. To the extent that the final hearing conservation rule promulgated today deals with issues raised in the Request for Review and Report, they are discussed below under the appropriate topic headings.

In the notice of proposed rulemaking, interested persons were given approximately 45 days to submit written data, views and arguments on the proposal and to file objections and request a hearing thereon. The comment period was subsequently extended two more times (until March 21, 1975) because of the complexity of the issues raised in the proposal and in response to a number of requests for additional time in which to prepare responses. (See 39 FR 42929, 12/9/74; 40 FR 2822, 1/16/75). Thus, the public was given almost five months in which to file comments and objections on the proposal. OSHA received approximately 1000 written comments on the proposal (Ex. 14).

Section 6(b)(3) of the Act provides for informal public hearings on objections to a proposal. Many persons requested that hearings be held on the proposed occupational noise exposure standard and an informal public hearing was scheduled (40 FR 16336, 4/11/75). The rulemaking hearing was convened by Administrative Law Judge Milton Kramer on June 23, 1975. The hearing lasted through July 30, 1975. Over 90 parties, many of them represented by multi-witness panels, participated in the hearing. In addition, during the course of the hearing approximately 188 exhibits, many containing numerous documents, were submitted to the record. Testimony at the hearing addressed every issue raised by the proposal, as well as environmental issues and economic issues. At the close of the hearing, a 45-day period for the receipt of post-hearing comments was authorized by Judge Kramer. The hearing record also remained open for receipt of an economic impact analysis.

On June 18, 1976, OSHA published a notice of availability of an economic impact analysis which had been prepared for the agency by Bolt, Beranek and Newman, Inc. (BBN) of Cambridge, Massachusetts (41 FR 24718). The economic impact analysis considered the possible inflationary impact and economic feasibility not only of the proposed noise exposure regulation, but of several alternatives such as a standard with a PEL of 85, and various compliance periods. Benefits to be derived from the alternatives were also considered. Basically the economic impact analysis was modeled after the guidelines for implementing Executive Order 11821 (see 39 FR 41501) although the proposal predated the Executive Order (see Ex. 192, p. iii). According to the BBN study noise exposure monitoring was estimated to cost approximately $12 per production worker, while audiometric testing for all workers exposed to an 8-hour TWA of 85 dB or above was estimated to cost about $20 per worker (Ex. 192, p. iv). The cost of keeping the PEL at 90 dB and instituting a hearing conservation program including audiometric testing was estimated to be approximately $241 million per year (Ex. 192, p. iv). BBN also estimated the relative probability of workers experiencing material impairment after 20 and 40 years of exposure at 85 dB as opposed to 90 dB (Ex. 192, pp. 2-26—2-36) and estimated the benefits of including hearing conservation requirements at or below the PEL (Ex. 192, pp. 2-34—2-36).

Interested persons were given an opportunity to comment on the BBN study and a second informal public hearing was scheduled to begin on August 24, 1976 (41 FR 24718). The notice also invited the submission of any new information that might be available on the issue of economic feasibility of the proposed standard and on any of the other issues discussed in the economic impact analysis itself. OSHA subsequently extended the period in which to file comments and rescheduled the public hearing in response to a number of requests for extensions of time (41 FR 32912, 8/6/76). OSHA received approximately 108 comments on the economic impact analysis (Ex. 193).

The economic impact hearing was convened on September 21, 1976 with Administrative Law Judge Jean F. Greene presiding. Approximately 70 parties were scheduled to appear at the hearing (Ex. 196), and approximately 69 exhibits were submitted to the record during the hearing. The hearing lasted through October 8, 1976. Those participating at the hearing were given 60 days from the close of the hearing in which to submit post-hearing comments.

During the hearing OSHA received many requests for information that was not contained in the economic impact analysis itself, but which was related to its preparation. OSHA, through arrangements with BBN, made available that portion of the requested information which had not been obtained under a pledge of confidentiality. BBN prepared a document (Ex. 278) which included some of the data requested at the hearing. In addition, BBN discussed and clarified many of the issues raised at the hearing. On January 28, 1977, OSHA published in the Federal Register a notice of the availability of the BBN post-hearing comment and additional information on the economic impact analysis (42 FR 5374). Those who participated at the hearing were given additional time in which to comment on the BBN submission. OSHA received approximately 18 comments on the BBN submission (Ex. 279).

Although the proposal was published before any of the Executive Orders requiring the preparation of Inflationary or Economic Impact Statements or Regulatory Analyses (Executive Orders 11821, 11949 and 12044), OSHA has prepared a Final Regulatory Analysis for this hearing conservation amendment which is generally consistent with the requirements of the most recent Executive Order on the subject. This analysis was based on information and methodologies contained in the noise record and uses standard techniques of economic and scientific analysis. In addition publicly available population and employment data, such as that published by the Bureau of Labor Statistics *(Employment and Earnings)* was used. Similarly, the estimates of the costs of compliance as well as benefits of the amendment were made using information from the record and publicly available data. The expected economic impact was developed using costs estimated by OSHA, on the basis of record information, publicly available data and standard techniques of economic analysis. OSHA has used the latest available data. Interested persons may request copies of the Final Regulatory Analysis through the Docket Office.

On April 18, 1980, OSHA again opened the record to introduce additional comments, letters and reports that had been sent to the agency since the last time the record had been open (45 FR 26360). Some corrected transcripts from the second hearing were submitted to the record as an exhibit and some updated cost data on hearing conservation programs were also submitted. Interested persons were given over 45 days in which to submit comments. The Agency subsequently extended the comment period until July 3, 1980 in response to requests for additional time (45 FR 40166, 6/13/80). Thus the public was given 11 weeks in which to submit comments on this information.

OSHA received a number of objections to its April 18, 1980, Federal Register notice. Some of these objections, as noted, requested additional time in which to comment, and some raised certain procedural objections (see Ex. 321-15A, 321-11, 321-14). Several comments expressed the belief that OSHA had selectively introduced exhibits into the record (Ex. 321-15A, p. 2, 321-11, p. 2). However, OSHA made no attempt to "select" correspondence to be submitted to the record or correspondence to be withheld. Rather, all the substantive comments on noise which the Agency had on file were submitted to the record. Any comments which may have been inadvertently omitted could have been resubmitted in response to the Federal Register notice.

The Federal Register notice invited comments "on the above materials only," and went on to explain that because of the length and repetition of the existing record the public was asked to refrain from resubmitting material already submitted. The record in this proceeding could be characterized as voluminous, verbose, redundant, and since it contains approximately 38,000 pages, unwieldy. The Agency has tried in every manner consistent with the statutory mandate to accommodate the reasonable demands and concerns of interested persons. However, some few persons apparently interpreted the Federal Register notice to mean that relevant new data would not be allowed into the record. (See Ex. 321-15A, 321-11, p. 2). The vast majority of commenters, however, construed the sentence correctly and did not resubmit evidence but instead confined their comments to the general subject matter of the additional submissions. A number of the comments received in response to the Federal Register notice (see, for example, Ex. 323) did in fact constitute new evidence or studies on the subject matter of the new submissions. (See, for example, Ex. 321-44, 321-53D, 321-17, 321-19, 321-20A, 321-21, 321-22, 321-14D, 321-35, 321-13, 321-16).

In misconstruing the notice, several persons mentioned that they should be given a change to submit new evidence showing the effectiveness of hearing conservation programs and new updated cost estimates on engineering controls (Ex. 321-15A, 321-12A, p. 4; 321-11, p. 2-4; 321-53A, p. 2). As discussed above, the final rule here merely articulates hearing conservation requirements. Several issues, including the appropriate permissible exposure level and priorities among compliance strategies, have not been decided at this time. Both issues have been deferred for further study.

The Agency contemplates further economic studies and another hearing on these and other remaining issues. The record will be reopened to receive any new evidence on the relevant issues, including overall effectiveness of personal protective equipment as opposed to engineering controls in preventing material impairment, the permissible exposure level and the correct doubling rate, economic costs and consequences of various alternative strategies, benefits of the various strategies, and technological advances in engineering controls. Anyone wishing to do so may submit new evidence when the record is reopened.

Certain other participants requested that OSHA repropose the standard in view of advances in technology (Ex. 321-12A, p. 2; 321-11, p. 2). At the present time it is not contemplated that re-proposal will be necessary. The original proposal as well as the EPA Request for Review and Report and the OSHA response, all of which were printed in the Federal Register and actively debated at the hearing, gives the public ample notice of the wide range of regulatory alternatives that are being considered within the general parameters of the permissible exposure level and the method-of-compliance issues. Such alternatives include industry-by-industry standards, different compliance schedules, and a performance standard allowing the employer to choose the best method of compliance.

Another commenter (see Ex. 321-12A, p. 3) objected to a meeting with several audiologists which was held in August 1979. The meeting which was the subject of this objection had been held primarily to discuss various problems with the instructions contained in the Industrial Hygiene Field Operations Manual on audiometric testing as part of an effective hearing conservation program. Since some of the issues discussed at the meeting could have possible relevance to the hearing conservation amendment, OSHA included a detailed summary of the meeting in a group of noise-related materials submitted to the record of April 18, 1980 (see Ex. 317). Interested persons were given an ample amount of time in which to comment upon this material. Clearly, then, the business community as well as other interested persons were permitted "a further opportunity for input" (see Ex. 321-12A, p. 4) on the subject of the meeting.

A few other commenters objected that a new hearing was not being scheduled to discuss the new record submissions. (See Ex. 321-15, 321-15A, p. 2). Section 6(b)(3) of the Act does not indicate a "right" to a hearing every time something new is submitted to the record. Such an interpretation of section 6(b)(3) might even, for example, require a hearing in response to post-hearing comments, a procedure which could easily result in needlessly drawnout rulemakings.

As stated above, the Agency has tried at every point in the proceeding to accommodate all reasonable demands and concerns of the public. This has been done by according more time to respond at numerous junctures in the proceeding, clarifying ambiguities and considering numerous alternative approaches suggested by the public as well as by other government agencies. The public dialogue on the various issues raised during the course of this proceeding has been extensive and helpful. The record has been carefully reviewed and all opinions, comments and evidence therein have been considered in reaching the final decisions reflected in the hearing conservation amendment. The Agency believes this provides workers with adequate protection without undue burden on employers.

IV. Benefits

Summary and Conclusions

The primary purpose of this hearing conservation amendment is to prevent occupationally related cases of hearing impairment. Hearing impairment is a serious obstacle to a person's effectiveness as an employee and in the other aspects of life as discussed elsewhere in this preamble. Occupationally related hearing loss cannot be cured by hearing aids.

The noise record includes extensive evidence indicating that hearing conservation programs can reduce the number of cases of hearing impairment. Based on that record OSHA has made estimates of the number of hearing impairments prevented by the hearing conservation program prescribed herein. Evidence in the record amply demonstrates that many workplaces are not safe from hazards posed by noise. Present noise exposures pose a significant risk of harm to workers and can be lessened or reduced by instituting hearing conservation programs for workers exposed at or above a TWA of 85 dB.

OSHA estimates that hearing conservation programs for all employees exposed above 85 dB will eliminate 212,000 cases of material impairment of hearing after 10 years, 896,000 after 30 years and 898,000 cases at equilibrium. Even assuming full compliance with the present standard which requires hearing conservation programs for all employees exposed over 90 dB, this amendment would prevent 38,000 additional impairments within 10 years, 143,000 within 30 years, and 169,000 at equilibrium. Therefore the standard will significantly reduce the risk of hearing impairment present in many workplaces. Unfortunately this standard will not completely succeed in eliminating occupationally related hearing impairment. Approximately 162,000 cases of impairment will remain at equilibrium after the implementation of this standard.

OSHA anticipates that employers and employees will carefully and conscientiously carry out the provisions of this standard. However, even if only 50% of employees receive protection, there will be a reduction of 381,000 cases of impairment at equilibrium. This is still a very substantial benefit.

The OSHA estimates are based on the methodology of CPA, the exposure estimates of BBN and the scientific data contained in the record. OSHA has utilized its judgment based on the record to choose what it believes are the better methodologies, assumptions and data and has updated the estimates to take into account more recent, publicly available population data. Therefore, as discussed below, OSHA believes that its estimates improve upon the earlier estimates.

The Supreme Court in *Industrial Union Department, AFL-CIO* v. *American Petroleum Institute*, 65 L. Ed. 2d 1010, 100 S. Ct. 2844 (July 2, 1980) indicated that in promulgating a standard dealing with toxic materials or harmful physical agents, the Act "requires the Secretary to find, as a threshold matter, that the toxic substance or harmful physical agent in question poses a significant health risk in the workplace and that a new lower standard is therefore reasonably necessary or appropriate to provide safe or healthful employment." (slip op., p. 5.).

The record in this proceeding clearly demonstrates and OSHA therefore concludes that all these tests have been met. OSHA finds that employee exposure to noise at existing workplace levels poses a significant health risk in the workplace. Even assuming full compliance with the current occupational noise exposure standard, some employees face a significant risk of material impairment of hearing. Accordingly a new and more protective standard is reasonably necessary and appropriate to provide healthful employment. Indeed OSHA would reach this same conclusion even if the risk of hearing impairment had been substantially less than is the case.

These conclusions have been reached without reliance on the further benefits of reduced absenteeism, improved workplace safety, and reduced extra-auditory health effects also resulting from the standard. But, of course, those benefits provide additional justification for the standard.

Finally, workplace noise, and the resulting occupationally related hearing loss, is perhaps the most widespread hazard faced by workers. As Leonard Woodcock, then President of the United Auto Workers stated, "noise is probably the most pervasive of the many job hazards which our members face today. We have had no health and safety problem about which our members complain more" (Tr. p. 1308).

The hearing conservation standard will go a substantial way towards alleviating the worst aspect of the hazard, hearing loss, though it will not achieve the ideal solution, eliminating the hazard at its source. The Agency finds that eliminating noise exposure utilizing engineering controls would create substantial additional benefits of reduced discomfort and more effective hearing conservation.

The existing level of risk in absolute numbers and the amount of risk reduced by this standard is great. Clearly, even if the level of risk were lower and the reduction of risk were not as great, OSHA would still be able to make a valid threshold finding of significant risk. While in this instance detailed data were available to estimate the hearing impairment benefits of this noise regulation, it should be recognized that in many circumstances much less evidence will be available, especially for relatively new substances which may create life threatening risks. As the Supreme Court noted, OSHA may make a finding of significant risk even when much less evidence is available upon which to base such judgments. "OSHA is not required to support its findings that significant risk exists with anything approaching scientific certainty . . . this provision requires a reviewing court to give OSHA some leeway where its findings must be made on the frontiers of scientific knowledge . . ." (slip op., p. 45).

The rest of this section sets forth, in depth, the basis for OSHA's estimates of hearing impairment and analyzes the relevant portions of the record. To make its estimates as current and exact as possible, OSHA made use of some publicly available census and labor statistics data, such as employment by SIC code, which is not physically in the noise record. The limited amount of data in this category that has been utilized is not controversial and is publicly available.

It is relatively complicated to present data on the number of noise-related cases of hearing impairment because it occurs at varying ages and lasts a varying number of years before death. The approach selected here is the "snapshot" approach. This estimates in a given year, the absolute number of cases of impairments existing if there were no regulation, the number eliminated by the standard or an alternative, and the number of impairments remaining. It is not appropriate to add the number of impairments in the 10th year to those in the 20th year, for example, since that would double-count the persons who were impaired in both years. On the other hand, the actual number of impaired individuals over periods of time greater than a year are greater than the number present in a given year. Over time persons die and then are subtracted from the totals while others enter into the totals for the first time.

For example, OSHA estimated that hearing conservation programs for all employees exposed above 85 dB would prevent 696,000 material hearing impairments in the 30th year and 799,000 in the 40th year. The total number of individuals saved from impairment by these programs during the decade is less than the sum of 696,000 + 799,000, because some individuals lived through that period and would have been counted as saved from impairment at each of those timepoints. On the other hand, the number of individuals saved from impairment prior to the 40th year is much greater than 799,000 since many who will be saved from impairment by these programs will die before the 40th year and were therefore not counted in the 40th year totals. OSHA has also presented data on the number of person-years of hearing impairment prevented. This data does not present the same problems, but does not indicate how many individuals will suffer impairment.

Much of the data presented is for the equilibrium year. Hearing impairment develops gradually over time from the accumulation of noise the employee is subject to in each year of employment. In addition, hearing impairment once developed lasts beyond age 65 and through the entire time of retirement until death. Clearly hearing impairment is a substantial loss to retired persons as well. Many people live well into their 80's. (For example, the average life expectancy of males at age 65 is 14 years and females 19 years. Of course a substantial portion of the population lives longer than these averages.) Therefore, the full effects of hearing conservation programs will not be achieved until the entire population has been replaced by a population who have spent their entire working lives covered by these programs. This does not occur for at least 70 years, the time from age 18 until when most retirees have died by age 88. However, benefits are also presented at the 10th, 20th, 30th and 40th years after the implementation of hearing conservation programs. It can be seen that by the 30th year, about ¾ of the number of employees who will ultimately be protected will receive the full benefits of hearing conservation programs.

Introduction

Workers will derive substantial benefits from the hearing conservation amendment. The primary benefit of the amendment will be a sizable reduction in the incidence of occupational hearing impairment for U.S. workers. This reduction will substantially improve the health and quality of life of these workers. In addition, there will be possible declines in the number of workplace accidents and in the incidence of cardiovascular disease following the implementation of the amendment. The hearing conservation amendment will also create financial benefits stemming from reductions in worker absenteeism and medical costs, which will partially offset the costs of the amendment. Employers will profit by the decline in workers' absences, while workers will benefit from the reduction in medical costs. Consumers and taxpayers as a whole will gain from a reduction in the societal subsidy to medical costs. These financial benefits furnish additional support for the amendment.

Occupational hearing loss damages the social relationships of impaired workers by hindering their ability to communicate with other workers, their families, and their friends. OSHA's hearing conservation amendment, by substantially reducing the incidence of occupational hearing loss, will improve the quality of life for these individuals since they will no longer need to endure the difficulties and hardships experienced by those who associate with impaired workers. These improvements are also benefits of this amendment.

In addition, other indirect benefits will occur. For example, audiometric testing will indicate that there are workers with non-occupationally caused hearing difficulties, thereby enabling their referral to otologists for treatment. (For an example, see Ex. 321-1, p. 2.) Monitoring will provide information on workplace noise levels that may be used by workers and their union representatives in collective bargaining negotiations concerning work conditions. However, these informational benefits are not easily quantified, and the following discussion will focus on the benefits resulting from the increased use of personal hearing protectors as required by the amendment.

The hearing conservation amendment will also lead to a more equitable distribution of the costs and benefits of industrial production. Currently, one undesirable side effect of industrial production is the loss of hearing ability among a substantial number of workers. Although workers bear this cost of industrial production, the benefits of this production are shared by firms, stockholders, and consumers, as well as by workers. One traditional principle of distributional equity is that those who benefit from an activity should share in its costs. In order to prevent occupational hearing loss, implementation of the hearing conservation amendment will impose compliance costs on firms. Depending on the particular economic circumstances of these firms, these costs may be passed on to consumers or borne by stockholders. In both cases, most workers will no longer bear the cost of occupational hearing loss, while those who share the benefits of industrial production will share the costs of preventing that loss.

Moreover, the benefits of the reduced incidence of occupational hearing loss will be experienced to a greater extent by poorer and lesser educated workers who often have little choice except to work in the noisiest and least healthful jobs. Evidence derived from a U.S. Public Health Service Survey shows that for every age group, those of lower educational attainment have a higher risk of hearing impairment than those with higher levels of education (Center for Policy Alternatives, "Some Considerations," Ex. 138A, 3-2 to 3-3). Thus, the reduced incidence of occupational hearing impairment will more than proportionately benefit those with fewer material resources.

In this section, the various benefits of the hearing conservation amendment are discussed. The primary benefit of the amendment—the prevention of occupational hearing impairment—is treated extensively by including first, an examination of the major studies in the record, second, a description of OSHA's methodology for updating the estimates of the benefits and third, a presentation of the results of OSHA's calculations. Several other effects of the amendment, including improved workplace safety, and possible reductions in cardiovascular illness, absenteeism, medical costs, and workers' compensation payments, are also discussed. Finally, although the current record lacks the information needed for a final evaluation, two possible benefits are analyzed: reduced annoyance and improved productivity.

Material Impairment of Hearing Prevented

Previous Estimates

Four major studies present in the record estimate the number of hearing impairments that would be prevented by an OSHA standard regulating occupational noise exposure. Although each has certain inadequacies, taken together they reveal that occupational noise >85 dB impairs a substantial number of workers. Based on these studies and OSHA's own calculations and analysis, presented below, the Agency has concluded that regulatory action is necessary.

Bolt, Beranek, and Newman, Inc. (BBN), a consulting firm under contract to OSHA, prepared a report entitled "Impact of Noise Control at the Workplace" (Ex. 7), which was dated January 1, 1974. They estimated, based on "informal discussions with industry spokesmen", their extensive experience conducting noise surveys, and 1973 employment data, that 8,524,000 workers (59.3 percent of the 14,362,000 production workers in 19 two-digit industries) were exposed to noise levels > 85 dB, while 3,755,000 workers (26.1 percent) were exposed to levels > 90 dB (BBN, Ex. 7, p. C-2). For demonstration purposes they assumed that 30 percent of production workers were exposed to levels > 90 dB and an additional 40 percent were exposed between 85 and 90 dB. (Ex. 7, p. D-3). Then using the risk data of Baughn, they calculated that maximum compliance with a 90 dB Permissible Exposure Limit (PEL), which they referred to as "the present standard," would reduce the number handicapped at retirement by 700,000 (25 dB fence at 500, 1000, and 2000 Hz); and that compliance with an 85 dB PEL would reduce this number by an additional 770,000.

This study formed the basis for BBN's testimony at the 1975 hearings. After those hearings, OSHA contracted with BBN for a more extensive study of workplace noise and the impact of 85 and 90 dB PEL's. The resulting study, entitled "Economic Impact Analysis of Proposed Noise Control Regulation" (Ex. 192), was released by OSHA in 1976. In it, BBN estimated that 4,408,400 workers (34.5 percent of the 12,939,300 production workers in the 19 industries studied) were exposed to noise levels > 85 dB, while 2,393,200 workers (19.3 percent) were exposed to levels > 90 dB (BBN, Ex. 192, p. 2-7).

Using dose-response relationships for noise exposure and hearing impairment developed by Baughn and the team of Burns and Robinson, BBN estimated the number of hearing impairments that would occur under a number of alternative regulations, definitions of material impairment, and assumptions concerning job mobility. They estimated that after implementation of a 90 dB PEL, between 86,400 and 875,100 workers would still be impaired (25 dB fence at 500, 1000, and 2000 Hz) while an 85 dB PEL would reduce this to between 44,400 and 631,200. Therefore, the additional impairments prevented by an 85 dB PEL would be between 42,000 and 243,900 (BBN, Ex. 192, p. 2-35). (The range of estimates was due to the use of two measures of the risk of impairment: the Burns and Robinson data for the lower bound and the Baughn data for the upper bound.)

In addition, BBN made estimates of the benefits of requiring hearing protector use in combination with the 90 and 85 dB PEL's. They did this using three different assumptions concerning hearing protector use. First, that all workers required would wear hearing protectors and three-fourths of them would wear them correctly. Second, that three-fourths of the workers required to do so would wear hearing protectors and three-fourths of them would wear their hearing protectors correctly. Third, that one-half of the workers required to do so would wear hearing protectors and one-half of them would wear them correctly. In all cases, correct use of hearing protectors was assumed to yield a 30 dB attenuation.

Using these assumptions, BBN calculated that a 90 dB PEL for engineering controls, with hearing protector use for those exposed above 85 dB, would leave between 10,800 and 324,200 impairments after 20 years of exposure if everyone who required hearing protectors wore them. The number of impairments remaining in the workforce was larger under the second and third assumptions. For these two assumptions, the estimates of impairments remaining in the population were between 30,000 and 488,400 impairments (second assumption), and 32,900 and 634,900 impairments (third assumption) (BBN, Ex. 192, p. 2–35). Compared to the effects of a 90 dB PEL, the use of hearing protectors by those exposed above 85 dB was therefore estimated to prevent at least an additional 53,500 to 75,600 impairments (lower bound estimate based on the Burns and Robinson data) or an additional 240,200 to 550,900 impairments (upper bound estimate based on the Baughn data).

The estimates provided by BBN require updating for several reasons. First, the production work force of 12,939,300 for the 19 industries studied by BBN was based on employment data for 1975. Second, BBN calculated the benefits of noise control assuming a workforce composed entirely of 20-year-olds who would be exposed to noise for 20 years. This inaccurately depicts the effects of noise on a real work force that also contains older workers and retirees who have been exposed for more than 20 years. Third, in most cases, the number of hearing impairments was calculated for hearing thresholds greater than or equal to a 25 dB average of 500, 1000, and 2000 Hz. For reasons discussed in the Health Effects section, OSHA believes that this combination of frequencies is not the most appropriate measure of material hearing impairment and that a 25 dB average of hearing threshold levels at the frequencies of 1000, 2000, and 3000 Hz is preferable.

A third benefits estimate was performed by the Center for Policy Alternatives (CPA) under contract to the Environmental Protection Agency (EPA). Entitled "Some Considerations in Choosing an Occupational Noise Exposure Regulation," it was presented at the first hearings. Using the risk data of Baughn throughout their report, CPA estimated that present noise exposures (based on the estimates in BBN's first report and assuming no job mobility) would lead to 1,649,000 impairments (25 dB at 500, 1000, and 2000 Hz) after 40 years of exposure. They calculated that if noise exposures for all workers above 90 dB were brought down to 90 dB, the number of impairments could be reduced to 1,106,000, while if all exposures above 85 dB were brought down to 85 dB, the number of impairments could be reduced to 710,000 (CPA, Ex. 138A, p. 2–26). Thus a 90 dB PEL could prevent 543,000 hearing impairments while an 85 dB PEL could prevent an additional 396,000 impairments.

A fourth estimate of the impairments prevented by the proposed noise regulation that was submitted to the record and subjected to examination at the 1976 hearings was also performed by CPA under contract to EPA. ("Economic/Social Impact of Occupational Noise Exposure Regulations," Ex. 232). This report continued the earlier research CPA had performed for EPA (Ex. 138A). The noise exposure profile used in the second CPA report was based on the same raw exposure data that BBN had collected for their second report (Ex. 192), although the data were modified by CPA. CPA estimated that after the establishment of equilibrium, compliance with a 90 dB PEL would prevent 770,000 workers from impairment (25 dB fence at 500, 1000, and 2000 Hz) while an 85 dB PEL would prevent 1,350,000 impairments (CPA, Ex. 232, p. 5p7). Thus the additional impairments prevented by the 85 dB PEL would total 580,000.

For various reasons the CPA estimates also require updating. First, the estimates were based on 1974 employment levels rather than on the latest available data. Second, although CPA used an age distribution of the exposed population, they excluded retirees and did not distinguish between men and women. OSHA has determined that these calculations should include future retirees because they will also benefit from hearing conservation programs. In addition the calculations must distinguish between men and women because of the presbycusis differences between the sexes. Third, CPA used the frequencies 500, 1000, and 2000 Hz instead of the more appropriate 1000, 2000, and 3000 Hz. Fourth, the CPA study discussed the benefits of engineering control strategies to reduce noise levels to 90 and 85 dB, but not the benefits of hearing conservation programs that require the issuance and use of hearing protectors.

OSHA's Methodology

In order to improve upon the estimates of BBN and CPA, OSHA has decided to revise and update the calculation of the benefits of the hearing conservation amendment. The principal benefit of the hearing conservation amendment will be to prevent occupational hearing impairments through the inter-related aspects of effective hearing conservation programs. For example, monitoring provides information on the need for hearing protection and the type of protectors required. The use of these hearing protectors will reduce worker exposures. Training sessions will instruct workers in properly fitting, maintaining, and using hearing protectors. Audiometric testing detects temporary and permanent shifts in hearing ability, thereby detecting workers who are susceptible to hearing loss, identifying workers who may be wearing their hearing protectors improperly, and motivating those who would not otherwise wear them.

OSHA's estimates of the benefits of hearing conservation programs were calculated by comparing the number of hearing impairments that would occur if no hearing conservation programs exist with the number that will occur after they are established. The methodology used to estimate the benefits is derived from the studies summarized above as well as from other evidence contained in the record. Specifically, OSHA has determined that the methodology of the CPA report is more appropriate than the simpler methodology followed by BBN. BBN's methodology was based on a hypothetical work force composed of 20-year-olds, while CPA's methodology used the actual age distribution of the noise-exposed population. OSHA's calculations do, however, use the noise exposure distribution developed by BBN since it is the best available evidence on occupational noise exposures.

The benefits of preventing hearing impairment are described here by presenting (1) the number of persons prevented by hearing conservation programs from incurring material impairment of hearing after the full effects of these programs are realized, (2) the number of persons prevented from incurring material impairment of hearing at years selected from the interim time period before the full effects are realized, and (3) the accumulated person-years of impairment prevented over that time period.

People in the *current* workforce will only gain a limited benefit from the hearing conservation programs established by this hearing conservation amendment since many of these workers have already suffered noise-induced hearing loss. The full benefits of the amendment will be realized only by workers who spend their entire working lives covered by its provisions. It will take a number of years for the current worker population to be completely replaced by people who have been covered by hearing conservation programs for all of their working lives. Over time, the number of people prevented from incurring a material impairment will rise until an equilibrium is reached after the entire pre-hearing conservation work force has been replaced. With the continued provision of hearing protectors and hearing conservation programs, this equilibrium level of impairments prevented should continue for the years following the establishment of equilibrium.

Although the benefits of preventing occupational hearing impairment are not fully realized until equilibrium is reached, benefits will accrue during the period prior to equilibrium. As the years advance, the number of workers prevented, at any one time, from having a material impairment of hearing will increase. In order to describe this progression, the number of material impairments prevented during the 10th, 20th, 30th, and 40th years following implementation were calculated and are referred to as the interim benefits of the hearing conservation programs.

These first two descriptions, the number of impairments prevented at equilibrium and the number prevented at 4 interim years, provide only views of the benefits at particular time points. These "snapshot" views fail to capture the differences in the number of impairment-free years each person has enjoyed. For example, the number of impairments prevented at the 40th interim year will include some people who have been free from impairment for 40 years, as well as some people free from impairment for as short as 1 year. In fact, as time passes after implementation, the average number of impairment-free years per impairment prevented increases.

In order to describe this pattern, OSHA has calculated the accumulated number of person-years of impairment prevented over the interim time period. The number of person-years of impairment prevented is derived by multiplying the number of impairments prevented by the number of years each individual was kept free from impairment. For example, 2 people prevented from incurring a material impairment of hearing for 10 years apiece equals 20 person-years of impairment prevented. This would also be equal to 1 person for 20 years or 4 people for 5 years.

The accumulated person-years of impairment prevented were estimated from the interim benefits using the procedures suggested and used by CPA (Ex. 232, p. B-21), and described in Appendix A of OSHA's Final Regulatory Analysis. Estimates of the accumulated number of person-years of impairment prevented were calculated for 10, 20, 30, 40, and 70 years after the implementation of hearing conservation programs. Seventy years was chosen to approximate the length of time required for equilibrium to be reached. Since these calculations were based on a population that included retirees, and since many retirees live well into their 80's, it will take at least 70 years for people in the existing workforce, who have spent some of their working lives without the benefits of hearing conservation programs, to be replaced by people who have had those benefits.

Noise Exposure Distribution. These updated hearing impairment calculations are based on the same set of 19 industries and the same noise exposure data used by BBN for their second study of the proposed regulation. (CPA used the same set of industries, but modified the exposure data.) BBN, in their economic impact analysis, presented a noise exposure distribution based on surveys of 68 different establishments in 19 two-digit standard industrial classification (SIC) industries. The industries selected by BBN were the ones believed to contain most of the noisy workplaces in the U.S. (BBN, Ex. 192, p. 2-1). These industries and the number of production workers in them during 1979 are listed in Table 3.

Note.—That the total number of workers in these industries today is about 2 million greater than BBN's 1976 estimate.

The selection of industries and establishments was based on BBN's extensive experience with industrial noise and its control. During the survey, BBN estimated the number of workers exposed to various noise levels within 5 dB ranges. Because of uncertainty in the classification of workers by exposure level, BBN adjusted the raw data by distributing one-fourth of the workers in each 5 dB range to the next highest 5 dB range and one-fourth to the next lowest 5 dB range. Although CPA judged this adjustment to be inappropriate (See Ex. 232, p. B-4), OSHA has retained it because BBN was more familiar with the raw data and its peculiarities.

Table 3.—*Industries Studied*

SIC code [1]	Industry title [1]	Production workers [2] (thousands)
20	Food	1,176.2
21	Tobacco	52.5
22	Textiles	777.0
23	Apparel	1,122.2
24	Lumber and wood	648.3
25	Furniture and fixtures	398.0
26	Paper	641.5
27	Printing and publishing	702.2
28	Chemicals	638.9
29	Petroleum and coal	139.7
30	Rubber and plastics	601.1
31	Leather	207.4
32	Stone, clay, and glass	560.5
33	Primary metals	978.3
34	Fabricated metals	1,305.9
35	Machinery, except electrical	1,618.2
36	Electrical machinery	1,378.6
37	Transportation equipment	1,404.2
49	Utilities	659.3
Total		14,904.0

[1] Executive Office of the President, Office of Management and Budget, *Standard Industrial Classification* Manual, 1972.
[2] Average number of production workers in 1979.

Source: U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings,* 27, (March 1980): 58-66, Table B-2.

These exposure estimates, which were published in the 1976 BBN report (BBN, Ex. 192, *pp. 2-4 and 2-7) and discussed* at the hearings, have been recalculated to correct minor errors in the original profile. Thus, the noise exposure profile used here differs slightly from the profile *published by BBN as Table 2.1 of their* report. These differences are small—no more than one-half of one percentage point for any 5 dB exposure range. This recalculation has also corrected the inconsistency of Tables 2.1 and 2.2 of the 1976 BBN report (BBN, Ex. 192, pp. 2-4 and 2-7). Except for the total percentage exposed above 85 dB, the exposure profile used here is consistent with BBN's Table 2.2. The total percentage above 85 dB differs by only one-tenth of one percentage point. (See also Table 11 in the Cost of Compliance section below.) Table 4 presents the corrected noise exposure distribution for the 19 industries.

Table 4.—*Noise Exposure Distribution*

Exposure Level (db)	Percent
Less than 80	46.88
80-85	18.74
85-90	15.06
90-95	10.98
95-100	5.47
100 +	2.87
Total	100.00

Source: Bolt, Beranek, and Newman. This is a corrected version of Table 2.1 from "Economic Impact of Proposed Noise Control Regulation," Ex. 192, p. 2-4.

OSHA has chosen to use the BBN exposure estimates because they remain the most comprehensive and detailed estimates of occupational noise exposures in U.S. industry. Although these estimates were briefly criticized at the hearings (see Hearing Transcript, Sept. 21, 1976, pp. 139–43; Sept. 22, 1976, pp. 237–42, 360–1) as well as in the post-hearing comments (Ex. 279–8, pp. 37–8, 69–72), no one came forward with another set of exposure estimates that includes both the full range of industries and the detailed exposure levels of the BBN estimates. The American Road Builders Association (Ex. 186B) and the Motor Vehicle Manufacturing Association (Ex. 242D) presented estimates limited to the specific industries in which their member companies operate. Evidence, based on samples drawn from a wider range of industries, is included in surveys by Hearing Conservation Noise Control (Ex. 240B) and NIOSH (Ex. 321–14B and Ex. 321–14D). These surveys present the number of workers exposed above either 90 or 85 dB but do not provide a detailed classification of employees by 5 dB exposure level ranges as do the BBN estimates. This classification is necessary for the matching of the exposure distribution with the risk matrices to estimate the number of hearing impairments prevented by hearing conservation programs.

OSHA has concluded that three simplifying assumptions were necessary in order to use the BBN noise exposure distribution to estimate the number of hearing impairments prevented. First, that BBN's noise exposure distribution adequately describes the occupational noise environment in the 19 industries studied, and that the 19 industries encompass all substantial occupational noise exposure. Second, that the noise exposure distribution and the size of the work force in the 19 industries will remain unchanged for the 70-year period used to calculate benefits. If there are changes in the noise distribution and the size of the work force which increase the number of persons exposed to harmful noise levels, this assumption will lead to an understatement of the number of hearing impairments prevented. On the other hand, if these changes decrease the number of persons exposed, then there will be an overstatement of the number of impairments prevented. Third, in industries with fluctuating noise levels, it was assumed that a 5 dB exchange rate adequately represents time-weighted exposure levels. The BBN data are based on a 5 dB exchange rate. The CPA report argued that these data should be adjusted to take into account a 3 dB exchange rate (CPA, Ex. 232, p. B–5).

The exchange rate or the "doubling rate" is a way of either averaging or comparing exposure levels and durations. Under a 5 dB exchange rate, for a 5 dB increase in the exposure level the exposure duration must be halved to obtain an equivalent time-weighted exposure. Thus, 8 hours of exposure to a level of 90 dB is equal to 4 hours at 95 dB. Similarly, under a 3 dB rate, an increase of 3 dB necessitates halving the duration—e.g., 8 hours at 90 dB equals 4 hours at 93 dB. Since OSHA is currently retaining the 5dB exchange rate used in 29 CFR 1910.95, and since the procedure used by CPA to adjust the BBN data does not appear to be based on actual exposure data, the Agency did not adjust the noise exposure distribution to account for a 3 dB exchange rate. This adjustment would have increased the effective exposure level of the work force and would have increased the estimated number of hearing impairments. By not performing this adjustment, OSHA may be understating the number of hearing impairments prevented by the final amendment.

Fences. The methodology used to estimate the number of people suffering impairments of hearing continues the standard practice of drawing fences to demarcate "normal" from "materially impaired" and then calculating the number of persons with hearing abilities worse than the level of that fence. An important issue is the choice of appropriate fences, both in terms of the levels used as well as the frequencies to be examined or averaged. BBN did most of their calculations using a 25 dB average of hearing threshold levels at the frequencies of 500, 1000, and 2000 Hz. However, BBN also examined the effects of choosing other levels, 15 and 35 dB, as well as an average of the frequencies of 1000, 2000, and 3000 Hz (BBN, Ex. 192, pp. 2–27, 2–28). CPA correctly pointed out that the effect of noise on a population of workers is to cause a change from one population distribution to another. They state:

> Essentially the entire population of workers has worse hearing because of the influence of noise. Those which, without noise, might have had excellent hearing are shifted so that they have less than excellent hearing. Those which without noise, would have had only fair or poor hearing have their hearing handicaps increased. (CPA, Ex. 232, p. 5–2)

Thus, the usual practice of drawing a single fence does not adequately describe the shift of the entire distribution of workers. Therefore, CPA suggested that a series of fences be employed (CPA, Ex. 232, p. 5–3). There were many other comments submitted to the record concerning the choice of appropriate fences, both for the determination of the number of workers suffering material impairment as well as for workers' compensation purposes. (For a discussion of these comments, see the Health Effects Section.) After a thorough review of these comments, OSHA has concluded that the number of hearing impairments prevented by the final amendment should be measured using the fences of 15, 25, and 40 dB. These fences are defined as the average of a person's hearing threshold levels for the frequencies 1000, 2000, and 3000 Hz. As described in the discussion on health effects, these frequencies were chosen as those most appropriate to describe the ability of persons to understand human speech under everyday conditions. The levels were chosen to describe the number of persons with various degrees of hearing loss: mild hearing loss, material impairment, and moderate to severe impairment.

Dose-Response Relationship. A person's hearing ability can be estimated by analyzing two components: the loss in hearing ability due to noise and the loss in hearing ability due to the effects of aging (presbycusis). The following discussion will focus on these two components, presenting OSHA's arguments concerning the best available and most appropriate evidence for each.

The change in hearing ability due to noise exposure is measured in terms of the permanent decibel shift in hearing thresholds caused by noise. This change, the amount of lost hearing ability, is more commonly called the Noise-Induced Permanent Threshold Shift or NIPTS. An examination of the hearing loss studies cited in the Health Effects section reveals a fair degree of consistency in their basic findings concerning the amount of NIPTS caused by various combinations of exposure levels and durations. One way to incorporate all of the information in these studies is to average the results. Col. Daniel Johnson has recommended such an approach (Ex. 17, p. 2) and EPA has applied it to the data of Baughn, Burns and Robinson, and Passchier-Vermeer both for establishing criteria for noise regulation (Ex. 26–3) and for identifying safe levels of noise exposure (Ex. 30, p. C–5). Recently Col. Johnson published a variety of calculations based on averaging the data of Burns and Robinson (referred to only as "Robinson" by Johnson) and Passchier-Vermeer (Ex. 310).

OSHA has chosen to use the studies of Burns and Robinson and Passchier-Vermeer because of the completeness of their data for describing the NIPTS at frequencies from 500 to 6000 Hz for various population percentiles, noise levels, and exposure durations. Baughn's data (Ex. 11) were not available for individual frequencies, thus preventing the averaging of hearing threshold levels at 1000, 2000, and 3000 Hz. The NIOSH data (Ex. 26-2) were limited to exposures of 85, 90, and 95 dB, thus preventing the estimation of hearing loss for exposures to 80 and 100 dB.

OSHA has determined that the results of the Burns and Robinson and Passchier-Vermeer studies can be strengthened by averaging the NIPTS values from each. Because Johnson's recent publication, *Derivation of Presbycusis and Noise Induced Permanent Threshold Shift* (Ex. 310), provides a convenient presentation of this data, OSHA has used it as the basis for the calculation of the number of occupational hearing impairments. Table A.7 in Appendix A of OSHA's Final Regulatory Analysis presents the NIPTS values, derived from the Johnson publication, which were used by OSHA.

The second component that determines a person's hearing ability is calculated by observing the hearing ability of a "normal" population, and making adjustments to account for the effects of aging (presbycusis) on hearing ability. For this study, OSHA has used a presbycusis base developed by Johnson from the data of the U.S. Public Health Survey conducted in 1960-62. In this survey, 6,672 persons aged 18-79, drawn from the civilian, non-institutional population of the U.S., were given audiometric examinations. Thus, the survey gives a detailed picture of the actual hearing ability of the U.S. population. Other researchers, most notably Burns and Robinson, have screened their populations quite severely in order to eliminate all individuals who have been exposed to gunfire, or had ear disease, or other ear abnormalities. These screening techniques were designed to create a population that is otologically "normal."

But the actual work force is not otologically "normal." Some workers have been exposed to gunfire, both from sport shooting and from service in the armed forces. Other workers have or have had ear disease or other ear abnormalities. OSHA has therefore decided that the presbycusis base to use in calculating the number of hearing impairments in the work force should reflect, as closely as possible, the real world hearing ability of the U.S. population. The Public Health Survey represents the best available description of this hearing ability. An examination of the aging curves in Baughn (Ex. 12, p. 26) and Berger, Royster, and Thomas (Ex. 260A, pp. 42, 43, and 57) reveals that the data of the Public Health Survey are consistent with other major presbycusis bases.

The two components, the NIPTS and the presbycusis, may then be added together to find the total hearing loss for populations of given ages and sexes exposed to specified levels and durations (See Johnson's discussion, Ex. 310, p. 16). Johnson has provided a convenient computer program (Ex. 310, pp. 43-47) which was used to generate dose-response relationships. A simple linear interpolation was used to match the exposure distribution with these dose-response relationships to create the risk matrices (Tables A.9, A.10, A.11 in Appendix A of OSHA's Final Regulatory Analysis) used in the calculation of the number of hearing impairments.

Hearing Protector Use and Attenuation. Under the current noise standard, hearing protector use is mandatory for workers exposed above the PEL (90 dB TWA) where there are no feasible engineering or administrative controls. Under the amendment hearing protectors must also be provided to all workers exposed to noise levels between 85 and 90 dB, but of these workers only those who have experienced a significant threshold shift are required to wear hearing protectors. It is impossible to project accurately the number of workers exposed to noise between 85 and 90 dB who would voluntarily choose or be required to wear hearing protectors, but it is probable that the annual audiometric test will identify, by showing significant threshold shifts, the employees most vulnerable to occupational hearing loss. These employees will then be required to use hearing protectors, which should prevent most of them from incurring a material impairment of hearing. Thus, the following calculations are based on the assumption that following the implementation of this amendment, all workers who are vulnerable to occupational hearing loss will wear hearing protectors when exposed to noise >85 dB.

The CPA report did not present any assumptions concerning hearing protector use or attenuation. BBN assumed for correct usage, an attenuation value of 30 dB (BBN, Ex. 192, p. 2-34). As the following studies indicate, this is an attenuation that is generally achieved only in laboratory settings.

In a NIOSH-sponsored study (*A Field Investigation of Noise Reduction Afforded by Insert-Type Hearing Protectors*, Ex. 308), a team of researchers investigated the attenuation received by workers using various types of hearing protectors in actual industrial settings. The three earplugs tested had median attenuation values of 7.5, 10.0, and 12.8 dB (Ex. 308, p. 26). Padilla's study revealed an overall mean attenuation of 12 dB at 500 Hz for the earplugs he tested. He estimated that this was equal to approximately 7 dB over the frequencies 125-8000 Hz. ("Ear Plug Performance in Industrial Field Conditions," Ex. 301, p. 34). Regan found mean attenuation values of 25.11 and 19.74 dB for two types of earplugs and 33.04 dB for one type of earmuff (*Real Ear Attenuation of Ear Protective Devices Worn in Industry*, Ex. 300A, pp. 67-71). In addition, Berger presents information from the National Acoustic Laboratories (Australia) for four different earplugs. For these earplugs, the Noise Reduction Rating with a correction of two standard deviations ranged from 0-14 dB, while with a correction of one standard deviation the range was 9-19 dB ("Laboratory Estimates of the Real World Performance of Hearing Protectors," Ex. 321-35E).

The results of these studies reveal, for the earplugs tested, a mean attenuation of approximately 10-15 dB in industrial settings. It is reasonable to assume that the training and audiometric testing provisions of the hearing conservation amendment will improve industrial hearing conservation programs to at least maintain the upper bound of this average attenuation range. Moreover, those exposed to very loud workplace noise can use earmuffs or a combination of earmuffs and earplugs. These two options appear to have a higher attenuation rating than the earplugs tested in the studies mentioned. Accordingly, for the purposes of these calculations, OSHA has concluded that a reasonable assumption is that workers using personal hearing protection will receive an attenuation of 15 dB.

Mobility. The OSHA calculations were based on the assumption that workers do not move between jobs with harmful noise exposures and jobs without such exposures. Both BBN and CPA generally assumed such mobility to calculate the number of material hearing impairments. However, they used different procedures and assumptions concerning the effect of mobility on the number of material impairments in the population and the number that would benefit from reduced occupational noise exposure. BBN's calculations suggest that assuming mobility reduces the number of additional workers protected by controlling noise levels to 85 dB. (BBN, Ex. 192, Table 2.11, p. 2-30). CPA, on the other hand, argued that an assumption of mobility dramatically increases both the estimated number of material impairments in the pre-regulation population and the number of impairments that would be prevented by regulatory action (Ex. 232, p. 5-8. See also discussion at the hearings by CPA: Hearing Transcript, Oct. 8, 1976, pp. 2286-92, 2343-9, 2354-8 and BBN's reply in their Post-Hearing Comments, Ex. 278, pp. 60-65).

Occupational mobility has two separate, contradictory effects. First, mobility from jobs with harmful noise exposures to jobs without such exposures means that each individual worker will be exposed to harmful levels of noise for a shorter length of time because he or she will not have spent an entire lifetime exposed to harmful levels of occupational noise. This shortened duration of exposure lowers a worker's chance of suffering an occupational hearing impairment as well as the amount of lost hearing ability, and thus would tend to reduce the number of impairments in the entire population. The second effect of mobility, however, is to increase the population exposed to harmful noise levels, even though for shorter periods of time. This increase in the population at risk will tend to increase the number of occupational hearing impairments.

CPA has calculated that, on the average, workers hold three different jobs during their lifetimes. If one assumes that during one of these jobs they will be exposed to harmful occupational noise levels and that the other two jobs have no such noise exposure, then the total population at risk will be increased threefold. (The noise exposure distribution indicates that approximately one-third of the jobs in the 19 industries have noise exposures >85 dB; while two-thirds have exposures less than this. See Table 4.) In order for there to be no difference in the estimated number of hearing impairments when comparing the assumptions of mobility and no mobility, this threefold increase in the number of workers must be matched by a two-thirds decrease for each worker in the percentage risk of crossing a fence. If the decrease is less than two-thirds, then mobility will increase the number of impairments. If it is more than two-thirds, then mobility will decrease the number of impairments.

CPA calculated, using the equal energy rule (the 3 dB exchange rate), equivalent lifetime exposure levels for workers holding one job with harmful noise exposures and two jobs without such exposures during a working lifetime. This calculation reveals that the maximum reduction in a worker's lifetime exposure level with an assumption of three jobs per worker is about 5 dB for exposures >90 dB, 4 dB for exposures of 85-90 dB, and 3 dB for exposures of 80-85 dB (CPA, Ex. 232, Table B-6, p. B-14). An examination of the risk matrices (Tables A.9, A.10, A.11 in Appendix A of OSHA's Final Regulatory Analysis) shows that these reductions in lifetime exposure levels lead to a decrease of less than two-thirds in the percentage risk. Therefore, the decrease in the percentage risk is more than matched by the increase in the population at risk due to mobility. Thus, even though an individual's risk of impairment declines from the shortened exposure duration, the increase in the number of persons at risk leads to an increase in the total number of impairments in the population.

Accordingly, the Agency concurs with the judgment of CPA that an assumption of mobility will increase the estimated number of material impairments in the noise-exposed population and therefore will increase the estimated number of impairments prevented by the regulation. As CPA also argued, this effect occurs whenever workers move between jobs with and jobs without harmful noise levels and is intensified by increasing the assumed number of jobs per worker (CPA, Ex. 232, p. 5-8). This effect follows from the shape of the dose-response curve for noise, which is such that the first exposure to noise is more damaging than successive increments of exposure (Hearing Transcript, Oct. 8, 1976, p. 2357).

However, the current record does not contain sufficient information on the current pattern of occupational mobility for the industries under study to enable OSHA to update the hearing impairment calculations using a specific mobility rate. Therefore, OSHA has assumed that no mobility occurs. Since such mobility does take place, this assumption will lead to an understatement of the estimated number of material impairments in the population as well as to an understatement of the number of hearing impairments prevented by the final hearing conservation amendment.

Results of OSHA's Calculations

Occupational hearing impairment is a function of age, sex, exposure level, and exposure duration. OSHA's methodology for calculating the number of material impairments incorporates these functional relationships.

The six basic steps used to calculate the number of material impairments prevented by the hearing conservation amendment were:

1. Develop an age distribution.
2. Develop an age by exposure level distribution.
3. Adjust exposure levels for the use of hearing protectors.
4. Develop a sex distribution and combine with the age by exposure level distribution.
5. Calculate the number of hearing impairments from all causes.
6. Determine the number of occupational hearing impairments.

These six steps, as well as the procedure used to estimate the interim benefits of the regulation, are described in detail in Appendix A of OSHA's Final Regulatory Analysis. It should be noted that OSHA's procedure uses an age distribution that includes retired workers, as well as incorporating a distribution of the work force by sex, thus improving upon two deficiencies of previous studies.

The benefits of the hearing conservation amendment will accrue primarily to future populations of workers, slowly reducing the number of material impairments in these populations until an equilibrium is reached. The results of these calculations show that 1,060,000 individuals currently have crossed a 25 dB fence (1000, 2000, and 3000 Hz) due to occupational noise. Hearing conservation programs are expected to reduce this number to 848,000 persons 10 years after implementation; 583,000 in 20 years; 364,000 in 30 years; 261,000 in 40 years; and 162,000 at equilibrium (See Appendix A of OSHA's Final Regulatory Analysis, Table A.15). In each of these years, the number of hearing impairments which would have existed in the absence of hearing conservation programs remains constant at 1,060,000.[1] Consequently, the number of hearing impairments prevented by hearing conservation programs can be calculated by subtracting the number that will exist in any of the years from the 1,060,000 impairments that would have existed. Hearing conservation programs, therefore, are expected to reduce the number of hearing impairments (25 dB fence) by at least 212,000 in the 10th year after implementation; 477,000 in the 20th year; 696,000 in the 30th year; 799,000 for the 40th year; and 898,000 at equilibrium (See Table 5). The reduction of 898,000 impairments at any one time after the establishment of equilibrium represents 84.7 percent of the occupational impairments that would have occurred without hearing conservation programs.

In addition, OSHA has calculated the number of individuals with hearing impairments at any one time after the

[1] This is based on the assumption of a constant size for the work force exposed to noise, as discussed above.

establishment of equilibrium for two other fences—15 dB and 40 dB at 1000, 2000, and 3000 Hz. These calculations reveal that without hearing conservation programs, 1,624,000 people will be across a 15 dB fence, and 473,000 will be across the 40 dB fence due to occupational noise exposure. Hearing conservation programs for those exposed to levels >85 dB are expected to reduce this to 321,000 across the 15 dB fence, and 59,000 across the 40 dB fence (Table A.13 of OSHA's Final Regulatory Analysis). Thus after the establishment of equilibrium, these programs can be expected to reduce the number of persons across the fences by 1,303,000 for the 15 dB fence, and 412,000 for the 40 dB fence (See Table 5), reductions of 80.2 percent, and 87.1 percent, respectively.

Table 5.—*Hearing Impairments Prevented by the Hearing Conservation Amendment*

	Years after implementation				Equilibrium
	10	20	30	40	
Number of impairments prevented					
15 dB Fence					1,303,000
25 dB Fence	212,000	477,000	606,000	799,000	898,000
40 dB Fence					412,000
Accumulated person-years of impairment prevented:					
25 dB Fence	1,060,000	4,505,000	10,370,000	17,848,000	43,300,000

Source: OSHA, Office of Regulatory Analysis

Finally, the number of person-years of impairment prevented can be calculated. (The procedure used follows that of CPA, Ex. 232, and is described in Appendix A of OSHA's Final Regulatory Analysis.) In the 70 years following implementation of the amendment, the total accumulated person-years of prevented impairment is 43.3 million. The pattern of this accumulation is presented in Table 5.

Two conclusions follow from these data: First, without hearing conservation programs, a large number of workers will suffer hearing impairment and reduced hearing ability. Therefore, OSHA has determined that workers who are exposed to occupational noise >85 dB (TWA) face a significant risk of material impairment. Second, hearing conservation programs for all workers exposed to >85 dB (TWA) will substantially reduce that risk.

Full Compliance Assumptions

In keeping with past practice concerning the preparation of economic analyses of OSHA regulations, full compliance with the hearing conservation amendment, including 100 percent usage of hearing protectors, has been assumed. For a variety of reasons, this may not occur. Many workers cannot or will not wear hearing protectors. Workers with irregularly shaped or infected ear canals cannot wear ear inserts. Similarly, persons needing to wear either prescription or safety glasses often cannot wear ear muffs because the frames of the glasses will break the seal the muff makes around the ear. More often, hearing protectors will not be worn because they are uncomfortable. Workers have complained about headaches, claustrophobia, and general discomfort from the use of ear protectors. In addition, the use of earplugs may lead to ear infections, especially in dirty workplaces.

Full compliance with this amendment will have substantial benefits. Partial compliance will also provide benefits, although not to the same extent. Moreover, the estimated attenuation of 15 dB after regulation may also be an overestimate of the benefit achieved from the use of hearing protectors. In order to provide this attenuation, hearing protectors must be fitted carefully, worn properly, maintained conscientiously, and replaced in a timely fashion. As illustrated in Table 6, if all workers who are required to do so wear hearing protectors, if they receive a 15 dB attenuation, and if they wear their hearing protection every day that they are exposed to noise, then the total pool of material hearing impairment from occupational causes (at equilibrium) will be reduced by 898,000 persons. If only 10 dB of attenuation is achieved, the number of material impairments prevented falls to 759,000. However, if only 50 percent of workers exposed above 85 dB receive 10 dB attenuation and the remaining 50 percent do not wear ear protection, then the reduction in the number of impairments declines to 381,000. The effectiveness of hearing conservation programs is therefore very dependent on the attenuation that hearing protectors provide and their daily use by all workers.

Table 6.—*Sensitivity Analysis for Assumptions on Hearing Protector Use and Attenuation*

Assumption	Number of occupational impairments prevented[1]
100% of workers required[2] wear hearing protectors and receive 15 dB attenuation	898,000
100% of workers required[2] wear hearing protectors and receive 10 dB attenuation	759,000
50% of workers required[2] wear hearing protectors and receive 10 dB attenuation	381,000
No hearing protector use	0

[1] Hearing threshold levels >25 dB average of 1000, 2000, and 3000 Hz. Data are for equilibrium.

[2] All workers exposed to levels >90 dB after feasible engineering and administrative controls have been implemented and all workers exposed >85 dB who have shown a permanent significant threshold shift.

Source: OSHA, Office of Regulatory Analysis.

These calculations of the number of impairments prevented are also based on the assumption that workers exposed above 85 dB do not currently use hearing protectors. However, the current OSHA standard for noise does require the use of hearing protectors by workers exposed to levels above the PEL of 90 dB (TWA) and the establishment by each employer of a "continuing, effective hearing conservation program" for these employees (29 CFR 1910.95(b)(3)). Moreover, there is evidence in the record to suggest that some employees currently do wear hearing protection and that some companies have established hearing conservation programs. (The BBN exposure estimates were based solely on the use of non-use of engineering controls. The use or personal hearing protectors was not factored into their estimates.)

But the effectiveness of these programs and the length of time they have been in operation is less clear. Submissions by Newport News Shipbuilding (Ex. 131), Dupont (Ex. 273A), and Burlington Industries (Ex. 175) describe hearing conservation programs for three large companies that appear to be effective. But one cannot reasonably conclude that all companies with workers exposed to levels greater than 90 dB are maintaining such programs. A NIOSH study revealed that only 29 percent of the manufacturing respondents had such programs, while another 20 percent were planning such programs. Most of those without programs or plans claimed no noise problems (Ex. 321-14B, p. B-3). This study also included the testing of equipment used by 65 companies with hearing conservation programs. These tests revealed that 80 percent of these companies were not in compliance with at least one of the then existing ANSI specifications for audiometers and audiometric test booths (Ex. 321-14B, p. 55).

Based on data from NIOSH's National Occupational Hazard Survey (Ex. 321-14D), it is reasonable to conclude that up to 20 percent of those exposed to greater than 90 dB currently wear hearing protectors. The lack of adequate audiometric testing, monitoring, and training activities, however, make it less likely that a 15 dB attenuation would be achieved. A more reasonable estimate of the current attenuation would be 10 dB, which is the lower bound of the average attenuation range revealed in several studies on the real world attenuation of hearing protectors. (See discussion above.) OSHA has calculated, using the procedures and assumptions detailed in this section and in Appendix A of OSHA's Final Regulatory Analysis, that the effect of this current hearing protector use would ultimately be a reduction of 120,000 material impairments (25 dB fence) from the 1,060,000 that would continue to exist at any one time in the absence of hearing protector use.

OSHA anticipates that fully effective hearing conservation programs for all workers exposed to levels greater than 85 dB would prevent 898,000 impairments after the entire population has worked with hearing conservation programs in effect. Thus, the incremental or additional benefits due to the hearing conservation amendment will be the difference between these benefits and the 120,000 impairments expected to be prevented by existing programs. The final hearing conservation amendment, therefore, is estimated to prevent 778,000 material impairments over and above the number expected to be prevented by current hearing conservation programs. (These 778,000 impairments prevented consist both of workers exposed to levels >90 dB who are not currently receiving hearing protection as well as those exposed between 85 and 90 dB who will benefit from hearing conservation programs for the first time.)

This discussion on the benefits of preventing hearing impairment has shown that there are substantial benefits to be gained from reducing workplace noise exposure by 15 dB for those exposed above 85 dB. It was assumed in this discussion that the reduction of noise exposures would be achieved through the use of personal hearing protectors. However, that reduction could also be achieved by engineering controls, including the redesign of machinery and the construction of baffles to impede the transmission of sound energy. Engineering controls provide more consistent and dependable protection to worker hearing than personal hearing protectors and are still preferred by OSHA.

Improved Workplace Safety

A second benefit of the hearing conservation amendment is improved workplace safety. The presence of untreated workplace noise can increase the number of accidents because (1) noise can mask warning signals or shouts, and (2) noise exposure might lead to inattentiveness and fatigue, both of which may precipitate accidents. Edith Gulian's summary of studies in the European literature revealed no clear consensus on the relationship between noise and accidents. One study found no relationship, while two others concluded that noise may have contributed to accidents (Gulian, Ex. 97, p. 60). Two other studies in the record, by examining the job safety records of workers before and after the institution of hearing conservation programs, showed a statistically significant reduction in the number of accidents and injuries occurring after the initiation of hearing conservation programs.

Schmidt, Royster, and Pearson (Ex. 321-22F) studied a cotton yarn plant where a hearing conservation program requiring the use of hearing protectors was instituted in 1972. Using a statistical technique by which each worker serves as his or her own control, the researchers compared the mean number of injuries in the 4-year period prior to the hearing conservation program to the 4-year period following institution of the hearing conservation program for two groups of employees exposed to noise levels of 92-96 dB. The results showed a statistically significant reduction in reported injuries.[3] For one group, the reduction in the mean injury rate was from 0.4 to 0.2 injuries per year, or by about 50 percent; for the other group, the reduction was from 0.5 to 0.3 injuries per year, or by about 40 percent (Schmidt, et al., Ex. 321-22F, p. 22).

A second study was performed by the Raytheon Service Company under contract to NIOSH (Ex. 26-11). The researchers studied the records of a boiler fabrication plant for the 2-year period before the initiation of a hearing conservation program and the 2-year period after program initiation. The results of this study showed a statistically significant [4] reduction in the number of accidents among workers exposed to noise levels >95 dB after the initiation of the hearing conservation program. The median frequency of accidents was reduced from 3.8 to 2.3 accidents per worker per year, or by 39.5 percent (Raytheon, Ex. 26-11, pp. 3-5 to 3-6).

Information from the Bureau of Labor Statistics shows that annually there are about 2,474,000 reported occupational injuries in the 19 industries in this noise study, of which about 1,052,900 are lost workday cases (Bureau of Labor Statistics, *Occupational Injuries and Illnesses in 1978: Summary*, March 1980, Report 586, Table 3, pp. 12-13). If these accidents are distributed evenly among all workers in these industries without regard to noise exposure, then approximately 851,000 total cases and 362,000 lost workday cases could occur each year for those exposed above 85 dB (TWA) [2,474,000 injuries × 34.4 percent (workers exposed>85 dB)=851,056; 1,052,900 lost workday cases × 34.4 percent=362,198]. Similarly, there are 477,000 total cases and 203,000 lost workday cases among those exposed above 90 dB (TWA) [2,474,000 injuries × 19.3 percent=477,482; 1,052,900 lost workday cases x 19.3 percent=203,210]. The Schmidt, Royster, and Pearson study, and the Raytheon study together reveal that the initiation of hearing conservation programs may reduce this yearly toll of accidents.

The reduction in the number of accidents, beside improving the quality of worker lives, may also provide financial benefits to employers by reducing the costs of accidents. These costs include administrative and legal fees, safety administration, damage to equipment, loss of productivity, supplements to workers' compensation payments, and lost income due to inefficiency of replacement personnel. Robert Sharkey, Safety Administrator for Alcoa, estimates that these costs total $14,000 per lost-workday case. (See Peter J. Sheridan, "What Are Accidents Really Costing You?" *Occupational Hazards*, March 1979, pp. 41-43.)

Extra-Auditory Health Benefits

As described in the Health Effects section, there is a wealth of evidence suggesting a link between noise

[3] Statistical significance refers to the probability or confidence, based on laws of probability and statistics, that the decline in the number of accidents was not due solely to chance. In this case, the confidence level was 99.9 percent.

[4] 99 percent confidence level.

exposure and ill effects, including cardiovascular, respiratory, allergenic, musculo-skeletal, and glandular disorders. However, because precise dose-response relationships have not yet been developed OSHA has not attempted to quantify these benefits. One example does reveal the magnitude of the occurrence of cardiac disease in the U.S. today. The current rate for deaths due to heart disease for those between 45 and 64 years old is 536.7 per 100,000 (Bureau of the Census, *Statistical Abstract of the United States*, 1979, p. 77, Table 111). If this rate applies to the 4,984,000 workers aged 45–64 in the 19 industries, then approximately 27,000 will die of heart disease annually. By reducing noise exposure, the hearing conservation amendment may help to prevent some of these premature deaths.

Reduced Absenteeism

The reduction in noise exposures due to hearing protector use should reduce the number of noise-induced illnesses and could also lead to better worker attitudes towards their jobs, thus improving both attendance records and job performance. In both cases, employers, firms, and consumers would benefit from increased output and reduced costs. The Raytheon study (Raytheon, Ex. 26–11) found that the median number of absences for the group exposed to >95 dB fell by 12.4 days per year after initiation of a hearing conservation program. This was a reduction of about 63 percent from the preconservation program level of absences (Raytheon, Ex. 26–11, p. 3–177).

Several studies of the economic impact of the proposed regulation placed a monetary value on the expected reduction in absenteeism. CPA, in their first study, assumed a reduction in absenteeism of 1 day per year per worker exposed over 85 dB. This was calculated to provide an estimated benefit of $2 billion per year (CPA, "Some Considerations," Ex. 138A, p. 2–55). In their second study, CPA used a more complex methodology based on information from the Raytheon report concerning the reduction in the average number of days absent. CPA calculated the value of lost production based on lower and upper bounds—i.e., average production worker wages and value added per production worker. Based on 1975 dollars, CPA estimated that the value of improved worker attendance for an 85 dB PEL would be between $341.04 million and $1.2484 billion per year (CPA, "Economic/Social Impact," Ex. 232, p. 5–28). A third estimate of the value of absenteeism savings was performed by the Council on Wage and Price Stability (COWPS). Although not based on any empirical studies, COWPS assumed that an 85 dB PEL would reduce absenteeism by 1 day for those previously exposed to 85–90 dB and by 2 days for those exposed above 90 dB. COWPS calculated the savings by multiplying the number of person-days saved by the average daily wages of manufacturing workers, including an estimate of the costs for turnover and new worker training. Finally, COWPS concluded that controlling noise exposures to 85 dB would produce a benefit of $271.7 million per year (COWPS, Ex. 208, p. 19).

After a review of these estimates, OSHA has concluded that the best estimates are provided by the methodology used by CPA in their September 1976 report, which was based on information from the Raytheon study. OSHA has chosen to reestimate the absenteeism benefits by updating the CPA calculations for the increase in the size in the labor force and changes in wage rates since 1976. For this update, OSHA has used only the wage rate to estimate the value of production lost from absenteeism. These calculations, which assume that hearing conservation programs will reduce exposures to below 85 dB for those exposed at 90 dB and above, follow the CPA methodology. First the total number of worker-days of absenteeism prevented were calculated by using the number of workers exposed to noise >90 dB and the number of days of absenteeism saved according to the CPA presentation of the Raytheon data (See CPA, Ex. 232, p. 5–25). The equation used was: 1.243 million workers exposed >95 dB × 3.9 days saved per worker + 1.636 million workers exposed to 90–95 dB × 1.55 days saved per worker = 7.384 million worker-days saved. The value of the production gain from reduced absenteeism was then estimated using the 1979 average wage rate in the 19 industries (See *Employment and Earnings*, 27, 3, March 1980, Table C–2.). Thus, 7.384 million worker-days saved × 8 hours per day × $6.76 per hour = $399.3 million. This gain of about $400 million per year from reduced absenteeism will benefit employers by partially offsetting the costs of hearing conservation programs and feasible engineering and administrative controls.

Reduced Medical Costs

Workers, and also society, indirectly through third party medical payments, will benefit financially through reduced medical costs. Although in most cases noise-induced hearing loss is untreatable and irreversible, there still is a drain on medical resources—principally professional time—used to reach those diagnoses. In addition, there is the purchase of prescribed hearing aids in the minority of cases for which hearing aids can help, as well as the hearing aids purchased by workers vainly hoping for a cure. In all three cases, social resources are consumed. The prevention of occupational hearing impairments will free those resources for other uses.

Ideally, the magnitude of this loss could be quantified. However, the current noise record does not include either estimates of this loss or information from which estimates could be calculated. Because of this lack of information, OSHA has not attempted to quantify these savings, although preventing 898,000 hearing impairments should lead to a substantial reduction in medical costs.

Reduced Workers' Compensation Payments

Two estimates of the anticipated reduction in workers' compensation payments for occupational hearing loss are contained in the record. BBN estimated that the *additional* workers' compensation liability saved by reducing noise exposures to 85 dB would be $16.097 million (BBN, Ex. 192, p. 2–38). This is the additional savings, comparing a 90 dB with an 85 dB PEL, not the total reduction expected from the implementation of hearing conservation programs. CPA made an estimate of the *total* potential workers' compensation payments that a noise regulation might save. They calculated that the present value of the stream of potential savings for an 85 dB PEL over the next 40 years would be $530 million (CPA, Ex. 232, p. 5–34).

But any of these estimates is speculative since hearing impairment is often not compensated. Over 70 percent of manufacturing workers in the U.S. live in states that pay few or no hearing impairment claims (EPA, *Occupational Hearing Loss: Workers' Compensation under State and Federal Programs*, Ex. 321–16C, p. viii). EPA estimates that in 1977, 6,095 claims totalling approximately $13 million were paid for occupational hearing loss. This figure could change considerably in the future because the number of claims filed has been increasing dramatically (EPA, Ex. 321–16C, pp. 14–15).

It has been pointed out that an estimate of reduced workers' compensation payments cannot be directly added to the other benefits described in this section. As COWPS testified:

Although a reduction in workmen's compensation payments is a benefit to employers who no longer have to pay workmen's compensation premiums, it represents an almost equal and offsetting cost to workers who no longer receive such payments. (COWPS, Ex. 208, pp. 7–8)

In other words, workers' compensation payments are transfer payments from employers to impaired workers. The true social cost is the incidence of occupational hearing impairment and the various other ill effects of noise; the true social benefit is the reduction in the number of hearing impairments and ill effects.

Annoyance

Several of the studies in the record quantified the benefit of reduced annoyance from noise exposures. (See CPA, "Some Considerations," Ex. 138A, pp. 2–55 to 2–59; Smith *The Occupational Safety and Health Act,* Ex. 201A, pp. 46–52; COWPS, Ex. 208, pp. 17–18.) Although these calculations provide interesting information, they primarily apply to the benefits of using engineering controls to reduce noise exposures. The use of hearing protectors to achieve noise reductions will not create the full value of these benefits, because hearing protectors also create disutilities, especially worker discomfort, for those who must wear them. Thus, the benefits of less annoyance due to lowered noise levels are likely to be considerably reduced by this disutility although there are no data in the record enabling OSHA to make a more precise determination.

Worker Productivity

The hearing conservation amendment may also improve the productivity of workers exposed to high levels of noise. There are two possible mechanisms for this: (1) through improvements in conscious worker attitudes towards their jobs, and (2) through subconscious reductions in psychological and physiological stress. The hearing conservation amendment will improve the quality of worker lives by preventing occupational hearing loss and by reducing the incidence of other noise-induced illnesses. These improvements in the quality of life may improve worker attitudes towards their jobs, thus leading to increases in the quantity and the quality of goods and services they produce. The reduction of noise exposures through the issuance and use of hearing protectors may also improve worker performance even if it does not improve conscious worker morale. In particular, workers may still hold the same attitudes towards their jobs, but may be more productive because of a reduction in the subconscious psychological and physiological stress experienced by workers exposed to workplace noise.

In both cases, employers, workers, and consumers would benefit financially. The increased production and improved product quality would benefit employers by offsetting, at least partially, the cost of the amendment. To the extent that the increases in output and improvements in quality increase the productivity of labor inputs, workers could be able to gain improvements in wages and fringe benefits. Finally, consumers would benefit from the increase in the quantity and quality of output. This increase would enable them to purchase an increased quantity at existing prices or continue to purchase the existing quantity but at reduced prices.

Thus, one can reasonably believe that reductions in noise exposure with the use of hearing protectors could, through improved worker morale and reduced subconscious stress, improve worker productivity and lead to financial benefits for employers, workers, and consumers. However, the empirical literature summarized in submissions to the noise record does not provide enough data to confirm or reject this.

In their criteria document on occupational exposure to noise, NIOSH reviewed some of the literature on the effect of noise on job performance (NIOSH, *Criteria for a Recommended Standard,* Ex. 1). NIOSH discovered that the effect of noise appears to be quite variable depending on the type of noise, the nature of the job, and the attitudes of the person affected. It also appeared that impulsive noise (recurring bursts of noise of high intensity) and intermittent noise (on and off exposures) create greater performance losses than continuous noise. The nature of the job is also important—jobs which require "unremitting attention" or "which place extreme mental demands on the employee" appear to be the most vulnerable to decrements in employee performance under noise exposures. For simple, repetitive tasks, performance may be enhanced by the presence of low to moderate levels of noise. Finally, it appears that certain attitudes and personality factors influence the effect noise has on task performance. Tense, anxious individuals, as well as those already dissatisfied with their jobs may be less able to perform productively under noisy conditions than other persons (NIOSH, *Criteria for a Recommended Standard,* Ex. 1, pp. IV–13 to IV–16).

EPA and Edith Gulian drew similar conclusions from their reviews of the literature. EPA concluded that continuous noise levels above 90 dB can impair job performance for "noise sensitive tasks," such as vigilance, information gathering, and analytical tasks. Noise levels of less than 90 dB can be disruptive, especially if the noise is composed of high frequencies, or if it is "intermittent, unexpected, or uncontrollable." The amount of this disruption is a function of the nature of the task, and the psychological and physiological state of the individual. The studies surveyed showed that noise does not usually affect the total quantity which a person produces, but may increase the variability of the work rate and reduce the accuracy of the work (EPA, *Public Health and Welfare Criteria for Noise,* Ex. 31, pp. 8–1 to 8–7). Gulian's survey of the European literature found several studies which indicated increased production with reduced noise exposures, but concluded that the literature was inconclusive on the effects when noise levels were lower than 100 dB, although under certain conditions lower levels have shown adverse effects on productivity (Gulian, Ex. 97, pp. 18–20).

Many of these studies involved testing the ability of persons to perform certain experimental tasks under laboratory conditions and not actual jobs under industrial working conditions. Moreover, the studies mentioned above investigated primarily the effects of noise on performance. They did not examine what effect the issuance and use of hearing protectors might have on job performance.

One study that did examine the effect of hearing protectors indicates that the issuance and use of hearing protectors may have an adverse effect on productivity. This study, by L. R. Hartley (cited by CPA, "Some Considerations," Ex. 138A, pp. 2–45 to 2–46), examined the ability of test subjects to perform a laboratory task under four conditions: quiet, quiet while wearing hearing protectors, noisy, and noisy while wearing hearing protectors. Under quiet conditions, subjects were exposed to broad-band noise at a C-weighted sound level of 70 dB; for noisy conditions exposures were at a C-weighted sound level of 95 dB. The researcher used two measures of subject performance—the number of gaps (pauses of 1½ seconds) and errors. The results revealed that without hearing protectors, exposure to noisy conditions increased both the number of gaps and the number of errors compared to the quiet conditions. When the subjects were exposed to conditions of quiet, the use of hearing protectors increased the number of gaps and errors. Finally, under noise conditions, the use of hearing protectors decreased the number of gaps, but increased the number of errors. CPA concluded their discussion of this study by suggesting that these results:

. . . tend to give added support to the preference of OSHA, NIOSH, and EPA for engineering solutions to noise, rather than personal ear protection. The widely-observed resistance of workers to the discomfort and annoyance of at least some ear protectors increases the probability that their imposition may sometimes have negative effects on the quality, if not the quantity of industrially-produced goods (CPA, "Some Considerations," p. 2-46).

A final determination of the effect of noise and hearing protector use on productivity awaits the completion of further research. Therefore, OSHA has not based its justification of the hearing conservation amendment on possible gains in worker productivity.

Conclusion

In this section, the benefits of the hearing conservation amendment were delineated and discussed. The primary benefit will, of course, be a substantial reduction in the incidence of occupational hearing impairment in the population exposed to workplace noise. The additional benefits to be gained include improved workplace safety, reduced absenteeism, reduced medical costs, and a possible reduction in cardiovascular and certain other illness. The range of health, safety, and financial benefits, and the magnitude of their favorable impact on the quality of life for U.S. workers serve to justify this amendment.

V. Cost and Feasibility Considerations

Summary and Conclusions

The following three sections analyze in depth the costs of the final standard, its economic feasibility and its technical feasibility. This subsection briefly summarizes that analysis.

The cost of the hearing conservation amendment will average $53 per year for each of the 5.1 million employees estimated to be covered by the amendment. This comes to $270 million in total annual costs for the 19 sectors of the economy (2-digit SIC codes) which have significant noise exposures. Approximately $15.7 million is already being spent on hearing conservation programs, so the additional costs generated by the standard are $254.3 million. As explained in the cost section, OSHA believes these costs are somewhat overestimated because of the methodology used.

The industry with the largest compliance costs is lumber and wood with annual costs of $30.9 million. Other industries with annual costs between $20 and $25 million are printing and publishing, primary metals, fabricated metals, machinery except electric, and utilities. The food and textile industries have costs of $17 million. No other industry has costs over $13 million per year.

The only other comprehensive cost estimates were submitted by BBN. They estimated a cost of $85 per employee included in hearing conservation programs. Certain changes in the standard, as well as the use of more timely cost data, account for the differences between the BBN and OSHA estimates.

The section on economic impact discusses in detail the impacts of the costs of the standard. These impacts are small. If the total costs of the regulation are passed on to consumers, prices would increase 0.0148%. Even in the segment most impacted, lumber and wood, prices would increase only 0.0776%.

Even in the unlikely event that firms would be forced to absorb the costs of the amendment, these costs represent only 0.1932% of the profits of the 19 industries. It should be noted that even in the industry most affected, lumber and wood, costs represent slightly under 1% of profits. It is inappropriate to present the increased price and decreased profit data as cumulative when analyzing impacts. The two maximum effects will not occur simultaneously. The greater the increase in prices, the smaller the reduction in profits. Similarly, the greater the reduction in profits, the smaller the increase in prices. The price and profit impacts are both likely to be less than the maximums presented here.

Section 6(b)(5) of the Occupational Safety and Health Act requires standards to be feasible and this includes economic as well as technical considerations. The D.C. Circuit explored this requirement in *Industrial Union Dept., AFL-CIO v. Hodgson*, 499 F.2d 467 (1975). It states,

There can be no question that OSHA represents a decision to require safeguards for the health of employees even if such measures substantially increase production costs. This is not, however, the same thing as saying that Congress intended to require immediate implementation of all protective measures technologically achievable without regard for their economic impact. To the contrary, it would comport with common usage to say that a standard that is prohibitively expensive is not "feasible." . . . practical considerations can temper protective requirements. Congress does not appear to have intended to protect employees by putting their employers out of business—either by requiring protective devices unavailable under existing technology or by making financial viability generally impossible.

This qualification is not intended to provide a route by which recalcitrant employers or industries may avoid the reforms contemplated by the Act. Standards may be economically feasible even though, from the standpoint of employers, they are financially burdensome and affect profit margins adversely. Nor does the concept of economic feasibility necessarily guarantee the continued existence of individual employers. It would appear to be consistent with the purposes of the Act to envisage the economic demise of an employer who has lagged behind the rest of the industry in protecting the health and safety of employees and is consequently financially unable to comply with new standards as quickly as other employers. As the effect becomes more widespread within an industry, the problem of economic feasibility becomes more pressing. (pp. 447-8).

As shown in the economic impact section, the cost impacts of the final hearing conservation amendment will not lead to economic dislocation. The costs are tiny relative to sales (averaging 0.0148%) and small relative to profits.

The worst case is 1% of profits while the average is 0.2%. In reality the costs as a percentage of profits will be less because some costs will be passed forward to consumers. These costs are easily affordable and no economic disruption or anything approaching it will be caused in any industry. Even employers who have a high percentage of employees affected by the amendment should be able to afford the $53 per employee cost. Therefore OSHA finds that the standard is without doubt economically feasible.

Technological feasibility is analyzed in the resource availability section. No difficult engineering problems, or indeed any engineering problems, are created by the standard. The hearing protection devices are already available on the market. The measuring and testing equipment needed (dosimeters, audiometers, etc.) is also available for purchase. In those areas where short-term production may not be adequate to meet immediate demand, a 2-year delayed starting date is provided by the standard. There also are adequate numbers of trained personnel, audiologists, physicians, etc., to meet the needs of employers resulting from the standard.

OSHA therefore finds the hearing conservation amendment is clearly technologically feasible.

VI. Costs of Compliance

Introduction

Many industry groups strongly recommended to OSHA that hearing conservation programs are a cost-effective and affordable means of reducing noise induced hearing impairment among workers. Bolt Beranek and Newman, (BBN), in their 1976 report for OSHA, ("Economic Impact Analysis of Proposed Noise Control Regulation," Ex. 192) estimated that the hearing conservation provisions of the proposed standard would cost the manufacturing and utilities sectors of the U.S. economy a total of $289.3 million per year in 1975 prices. This amounted to an annual cost of $65 per worker included in the program. The monitoring, recordkeeping, and associated tasks were estimated at $155.2 million annually, (p. 3-9) and were based on the assumption that a typical plant had 50 production workers and could be surveyed by a noise engineer for $600. The annual cost for audiometric testing was calculated at $20 per production worker for $89.1 million, and hearing protectors were estimated at $10 per worker for a total of $45 million per year (Ex. 192, p. 3-33). None of these cost estimates were adjusted to reflect the existence of hearing conservation programs already established by industry.

The BBN estimates of these provisions were not widely criticized. However, certain differences between the proposed standard and the final rule, as well as the availability of more timely cost data, have convinced OSHA to update these estimates of the expected compliance costs. The current estimation procedures, which are based on a thorough review and analysis of the entire record, are presented below for each major provision of the final regulation (Appendix B of OSHA's Final Regulatory Analysis provides the detailed caculations for a sample SIC industry). Overall these new calculations show that the total annual cost of the regulation will average about $53 for each of the 5.1 million workers estimated to be covered by the hearing conservation amendment. Thus, the total cost of complying with all of the provisions of the amendment are estimated at about $270 million a year. After accounting for some of the compliance activities already taking place, OSHA estimates that the new compliance costs will not exceed about $254.3 million a year and most likely will fall well below this amount (see Table 7).

Table 7.—*Estimated New Annual Compliance Costs of the Hearing Conservation Amendment*

Monitoring	$73,731,000
Audiometric Testing	87,199,000
Hearing Protectors	45,534,000
Training	40,029,000
Warning Signs	1,705,000
Recordkeeping	6,033,000
Total	254,321,000

Source: OSHA, Office of Regulatory Analysis.

Monitoring

The proposed standard directed employers to monitor worker exposure to noise on an annual basis. The final amendment will be less costly because in most cases, it requires monitoring to be performed only every other year. Although the final hearing conservation amendment requires that a new representative exposure be obtained whenever there is a change in noise levels that would render the employee's hearing protection inadequate, in practice, the general availability of hearing protectors rated to reduce high noise levels should make these occurrences infrequent.

A number of consultants have submitted documents to the record listing their fees for noise measurement services. For example, Exhibit 319 B-8 lists $440 plus expenses as the daily change for a noise engineer and $360 plus expenses as the daily fee for a technician. Exhibit 319 B-11 indicates fees from $250 to $350 for an engineer and from $180 to $240 for a technician, while Exhibit 319 B-16 reported between $229 and $405 plus expenses for an engineer and between $175 and $255 plus expenses for a noise technician. The average of these daily fees is about $362 for an engineer and $262 for a technician. Travel expenses will vary according to each firm's location relative to the consultant. However, as the demand for these services grows, economies of scale will operate to reduce costs below current market charges. For example, the expanded market for consultant services within a region will stimulate the supply of monitoring consultants in the area, thereby minimizing travel expenses. Also, noise engineers should find it increasingly profitable to combine resources with audiometric testing firms to provide industrial clients with a complete range of hearing conservation services. A growing number of firms already market these comprehensive consulting programs (Ex. 305; 319 B-12), and this one-stop approach to satisfying monitoring, testing and training requirements should substantially reduce the costs of these services over time.

Based on its survey experience, OSHA has estimated the average time it would take noise experts to take measurements in plants of varying sizes. Table 8 shows OSHA's estimate of the cost of hiring a noise consultant, based on the daily fee of $362 for an engineer, $262 for a technician, and a $50 average travel expense.

Table 8.—*Cost of Monitoring by Consultant*

Number of employees measured	Days in the field: Engineer	Days in the field: Technician	Days in office—Engineer	Cost
1 to 10	1			$412
11 to 20	1		.5	593
21 to 40	1	1	.5	855
41 to 60	1.5	2	.5	1,298
61 to 80	2	2	1	1,660
81 to 100	2.5	3	1.5	2,284
101 to 120	2	4	2	2,546
121 to 140	2	5	2	2,808

Source: OSHA, Office of Regulatory Analysis.

The monitoring provision of the amendment requires the reporting of representative exposures of all workers exposed to a time weighted average (TWA) of noise above 85 dB, rather than an actual measurement of each such employee. Thus, a measure of the exposure of one employee may be used to represent similarly exposed employees. Since the data shown in Table 8 correspond to measured workers (as opposed to others who are represented by the measured workers), an estimate of the number of employees who would be individually measured is necessary to assess the total monitoring cost. However, there is no data base available to identify statistically the determinants of the number of employees who would actually have to be measured according to the final rule. This number will vary due to the nature of the industrial process and the diversity of the work areas and tasks. For instance, in workplaces where noise levels are fairly uniform throughout the shop, fewer employees will need to be monitored than in workplaces where the noise exposure vary extensively among workers. Nevertheless, it can be assumed that, in general, the percent of the work force to be measured would vary inversely with the size of the plant. (See Ex. 309, p. 35, Table 3.1 for an example of how the percentage of workers to be sampled within a group of similarly exposed workers might decline as the group grows larger.) Table 9 gives estimates of the percentage of employees who would have to be measured individually to provide representative exposures of workplace noise for all exposed workers. These estimates were developed by OSHA, based on its broad experience with noise surveys for numerous industrial establishments, and are consistent with the final monitoring requirement as they are predicted on a sampling strategy designed to place employees within 5 dB ranges.

Table 9.—*Percent of Employees Measured To Provide Representative Exposures*

Number of employees	Employees measured (percent)
1 to 19	100
20 to 49	60
50 to 99	50
100 to 249	40
250 and over	30

Source: OSHA, Office of Regulatory Analysis.

To refine the estimate of the cost of using consulting services to conduct industrial noise measurements, it was necessary to construct a statistical distribution of the number of production workers in manufacturing establishments of different sizes. The U.S. Bureau of the Census provides 1977 data on the total number of employees in five establishment size categories (*County Business Patterns*, CBP-77-1). The conversion of this size distribution from total employees to one limited to production workers was accomplished by combining these data with information from the U.S. Bureau of Labor Statistics (BLS) (*Employment and Earnings*, 1909-1978) to obtain a 15-year average ratio of the number of production workers to the total number of employees. When multiplied by the 1977 Census estimates of total employment by industry and establishment size, this procedure yields estimates of 1977 production worker employment by industry and establishment size. These data are shown in Table 10.

OSHA believes that the best estimates of the total number of workers affected by this hearing conservation program are obtained from the BBN data on the percentage of workers exposed to various levels of noise in those industrial sectors which include most manufacturing and public utility firms (Ex. 192, p. 2-7). BBN's industry-wide estimates, as presented in Table 11, were developed from surveys of 68 firms representing 19 two-digit SIC categories, were based on years of extensive experience and expertise in noise control surveys, and were the most comprehensive and detailed noise exposure estimates submitted to the record. Thus, they remain the best source of data on TWA exposures in typical noisy industrial surroundings.

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Table 10

Number of Production Workers and Establishments by Industry and Establishment Size

	1-19 Employees		20-49 Employees		50-99 Employees		100-249 Employees		Over 250 Employees	
SIC	Production Workers	Establish-ments	Production Workers	Establish-ments	Production Workers	Establish-ments	Production Workers	Establish-ments	Production Workers	Establish-ments
20	75,583	13,118	122,613	4,783	150,034	2,813	292,110	2,332	527,859	1,248
21	431	102	817	30	1,402	22	5,487	37	44,363	42
22	17,182	2,647	36,791	1,238	53,829	825	143,386	1,007	525,812	985
23	73,714	12,301	150,593	4,490	180,224	2,810	314,631	2,257	403,037	1,020
24	131,794	25,577	108,400	3,550	117,628	1,697	159,585	1,103	128,894	319
25	33,894	5,762	45,134	1,527	52,706	819	91,521	647	174,745	373
26	15,173	2,204	38,254	1,360	61,079	983	149,706	1,146	277,289	538
27	126,470	35,518	101,748	5,199	89,263	2,042	117,751	1,251	266,969	641
28	33,186	6,812	48,072	2,091	54,695	1,082	94,994	841	405,853	687
29	8,380	1,379	9,271	286	9,988	137	23,797	142	88,264	123
30	33,391	5,590	62,459	2,230	82,901	1,353	134,120	989	288,230	498
31	8,275	1,410	13,415	467	20,528	332	48,213	341	116,969	325
32	74,668	11,639	80,305	2,810	65,780	998	107,929	750	231,819	422
33	20,304	3,003	41,908	1,475	54,945	893	130,046	945	731,098	795
34	117,675	19,020	169,809	6,154	170,975	2,815	274,821	2,041	572,619	1,088
35	163,075	32,304	155,393	6,406	135,719	2,502	219,331	1,703	942,683	1,468
36	38,208	7,192	59,430	2,212	80,109	1,322	179,628	1,383	1,021,145	1,394
37	27,347	5,379	34,035	1,318	44,954	801	93,414	751	1,204,430	898
49	67,188	10,593	66,942	2,179	79,232	1,156	110,509	744	335,430	421
Total	1,065,937	201,550	1,349,308	50,310	1,514,071	25,459	2,690,979	20,490	8,287,626	13,285

Source: Estimated as described in text from the U.S. Bureau of the Census, County Business Patterns, CBP-77-1; and the U.S. Bureau of Labor Statistics, Employment and Earnings, 1909-1978.

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Table 11.—Percentage of Production Workers Exposed to Noise

SIC	90 dB	85 dB	80 dB	75 dB
20	16	28	47	
21	6.6	9.7	26	
22	52	75	87	
23	0	1	20	
24	72	94	07	
25	12	30	53	
26	21	40	59	
27	19	45	66	
28	20	37	55	
29	52	76	82	
30	8.9	20	40	
31	0	1	20	
32	4.8	18	42	
33	38	63	81	
34	19	34	56	
35	13	26	48	
36	2.5	7	27	
37	13	23	42	
49	30	74	89	
Total	19.3	34.4	53.1	71.5

Source: Bolt, Beranek, and Newman. "Economic Impact Analysis of Proposed Noise Control Regulation." (Ex 192, p. 2-7; and BBN worksheets).

Technically, representative exposures are only required for workers with a TWA exposure to noise of 85 dB or above. However, it seems probable that many employees exposed to noise below a TWA of 85 dB would be surveyed also. This is because, at least initially, employers would not know which workers were exposed to 85 dB without monitoring representatives of most of the workers stationed in fairly noisy work areas. Consequently, all workers exposed above a TWA of 80 dB were assumed to be surveyed for cost estimation purposes despite the fact that, as employers become more knowledgeable about the exposures, this adjustment will overestimate monitoring costs.

Therefore, the number of measurements for each establishment size category in each SIC industry studied can be estimated by the following equation:

(1) M=(PM/100)(PW/E)(N)

where:

M=the number of measurements

PM=the percent of workers actually measured (Table 9)

PW=the number of production workers (Table 10)

E=the number of establishments (Table 10)

N=the percentage of workers exposed to >80 dB (Table 11)

This formula simply multiplies: (the percent of workers that the sampling strategy would require to be actually measured) × (the average number of production workers per establishment) × (the percentage of workers exposed to >80 dB). When the number of measurements for each establishment size are matched to estimates of the corresponding consultant charge (Table 8) this provides estimates of the average cost for a firm using a noise consultant. Since monitoring will usually be required biennially, the annual consultant cost is one-half of the values listed in Table 8.

However, employers may elect to monitor with in-houe personnel. An acceptable dosimeter, readout and calibrator, such as described in Exhibit 319 A-7, costs $1,230. The standard capital recovery formula with a 10 percent interest rate and a 10-year equipment lifetime gives an annualized capital cost of about $200. Periodic calibration costs could add another $60 a year. In addition, it might take an employer about an hour per measured employee to select representative workers, make daily calibrations of the dosimeter, and place and remove the dosimeters from the individual workers. Since this task may be performed by the employer or by supervisory employees earning more than the average industry production worker wage, an average cost of $10 per hour was used to account for the time required to complete this task. Thus, the average annual cost for each establishment can be calculated as $260 +($10 × the number of measured workers/2 years). The resulting values imply that monitoring would usually be done by in-house staff only in the largest plants where the average cost of $755 [5] is substantially below the $1,142 [6] average consultant cost. However, for the smallest establishments, the annual consultant fee of $206 is significantly less than the cost of developing an in-house program by purchasing the required equipment.

Alternatively, sound level meters and calibrators may be purchased for $610 (Ex. 319 A-7). Since these meters are expected to last at least 10 years (Ex. 319 A-7; Ex. 319 A-72), a 10 percent interest rate yields an annualized equipment cost of $99.27. Biennial calibration would add an additional $30 per year (Ex. 319 A-7). However, the time employers would need to make TWA exposure measurements with a sound level meter would often exceed the time required using a dosimeter because sound level meter measurements often require following employees through various phases of the work process. For this reason, the following calculations assume the use of dosimeters for in-house monitoring.

It was assumed that employers would select the least expensive mode of complying with the provision. Therefore, for each SIC sector, multiplying the number of establishments in each size class by the average consultant cost where consultant services would be more efficient (generally the first three or four establishment size categories), and the average in-house cost using dosimeters for the larger size categories where in-houe programs are more efficient, provides an estimate of the industry's monitoring cost. Summing these costs over all the SIC's gives total costs of $78,427,000 to initiate monitoring programs in all establishments in the studied industries.

However, many firms already have extensive monitoring programs. Although precise estimates are not available, a survey of hearing conservation programs conducted by The National Institute for Occupational Safety and Health (NIOSH) (Ex. 321-14B) evaluated responses from 1,410 manufacturing firms (p. 7). Twenty-nine percent stated that their firm had a program concerned with hearing conservation (p. B-3), and 90 percent of those firms, or 26 percent of the respondents, reported that they currently monitor workplace noise (p. B-7). Since the survey sample was heavily weighted with firms of over 100 employees, the results may apply primarily to these larger firms. Table 10 indicates that there are about 33,775 establishments with more than 100 employees in the industries studied. Based on the NIOSH study, it is reasonable to conclude that 26 percent of the firms with more than 100 employees already have monitoring programs. Thus, the new annual cost of this monitoring provision falls to about $73,731,000 for the 19 SIC sectors (See Appendix B in OSHA's Final Regulatory Analysis for a detailed example of the computational procedure).

Even more important, however, is the implausibility of the assumption that every single establishment in the industries studied would have workers exposed to a TWA of 85 dB or greater. The only large-scale survey that presents estimates of the number of plants with noise levels above 85 dB is the National Occupational Hazard Survey (NOHS) prepared by the NIOSH (Ex. 321-14D). The Center of Policy Alternatives (CPA), Massachusetts Institute of Technology, presented a preliminary summary of these data, stating that "NIOSH has collected extensive data on noise exposures in workplaces representative of American industry . . ." (Ex. 138A, p. 2-6). Since NIOSH directed its staff to note "Any continuous *noise* in worker's normal environment equal to or exceeding 85 dBA . . ., regardless of exposure

[5] $260 + (10 × M/2) = $755, where M is defined as in equation (1) and equals, on average, (.30 × 8,287,026/13,265 × .531) which is 99.

[6] Table 8 indicates that the consultants fee for measuring 99 workers was estimated at $2,284. If performed biennually, the annual cost is $1,142.

duration. . . ." (NOHS, vol. 1, p. 15), it is clear that these estimates of the number of noisy firms would exceed projections made on a TWA basis. Table 12 displays the results of this survey, which indicate that only about 49 percent of the plants in the studied industries have workers exposed to noise levels of 85 dB or greater as measured by NOHS. If this survey is accurate, the monitoring costs estimated above are substantially overstated.

Table 12.—*Number of Plants With Continuous Noise Above 85dB in the National Occupational Hazard Survey*

Industry sector	Total plants [1]	Number of plants with workers exposed to continuous noise [2]	Percent of plants with continuous noise
Manufacturing	141,397	68,949	48.8
19	113	72	63.7
20	16,173	7,711	47.7
21	196	48	24.5
22	3,225	1,560	48.4
23	15,565	4,115	26.4
24	3,091	2,214	71.6
25	4,618	3,132	67.8
26	4,859	3,673	75.8
27	13,609	5,248	38.6
28	6,743	2,423	35.9
29	993	599	60.3
30	5,640	2,967	52.6
31	1,653	798	48.3
32	7,955	4,425	55.6
33	5,040	3,716	73.7
34	19,615	12,658	64.5
35	14,190	6,940	49.0
36	5,073	1,937	38.2
37	3,457	1,849	53.5
49			[3]45.8

[1] NIOSH, Table, pp. 42-43.
[2] NIOSH, Table 49, p. 290.
[3] Preliminary NOHS estimate reported in Exhibit 138A, p. 2-8

Source: National Institute of Occupational Safety and Health, *National Occupational Hazard Survey*, Vol. III (Ex. 321-140).

Moreover, the current record does not adequately indicate the widespread current or future availability of rental markets for dosimeters or sound level meters. An informal telephone survey reveals that even the relatively more expensive dosimeters can generally be leased for under $100 per month. On a biennial basis this is less than $50 per year for most of the 311,094 establishments in the industries studied, for a total yearly equipment charge of only $15.6 million. Alternatively, some firms will share noise monitoring meters rather than purchase them. Thus, the true new monitoring costs attributable to this hearing conservation amendment may be substantially below OSHA's $73.7 million estimate which was based solely on data in the noise record.

BBN's economic impact analysis (Ex. 192, p. 3-9) projected annual costs of $155.2 million for the proposed monitoring provision. This estimate overstates the cost of the final provision for several reasons. First, the BBN analysis was based on the proposed requirement for annual monitoring, whereas the final rule will generally require only biennial monitoring. Second, BBN's methodology assumed that all industrial firms employed 50 production workers and would hire noise consultants to conduct the monitoring requirements. OSHA has determined that larger firms will find it substantially more economical to obtain noise measuring instruments and to perform the monitoring themselves. Third, BBN's estimate includes the cost of recordkeeping which OSHA treats as a separate cost category. Fourth, the BBN estimates do not reflect the current monitoring activities which are already taking place. OSHA believes that these factors taken together more than offset the price increases which may have occurred since BBN's 1976 report and consequently account for the divergent estimates.

Audiometric Testing

An analysis of the record indicates that the cost of audiometric testing will vary with the size of the establishment. Very small plants are likely to send production workers who require testing to a clinic or doctor. Somewhat larger plants will contract with audiometric testing firms for the actual exam and review. Still larger plants will find it cost effective to purchase the equipment for audiometric testing, to train the industrial nurse or safety director to give the test, and to use an outside firm of doctor to review the audiograms. The largest firms will perform the entire service in-house.

Commercial specialists who evaluate worker's hearing have submitted the following per employee costs for audiometric testing, review and reporting: $7.50 to $10.65 (Ex. 317); $10.00 (Ex. 319 B-6); $3.00 or less for more than 100 (Ex. 319 B-12); $7.00 to $20.00 (Ex. 319 B-5); and $12.00 (Ex. 293). These firms generally provide this service by transporting an audiometric test booth in a mobile van directly to the commercial establishment that has contracted for the testing. Employees of the smallest firms, however, will often be sent to a clinic or doctor's office to be tested. These fees will vary greatly and some are rather high (Ex. 2C-71-3, p. 50 reported $20). However, many clinic or physician fees should ultimately be comparable to those charged by mobile units because (1) negotiated fees are a traditional practice in industrial medicine, (2) employers of small firms may group together to gain scale economies, and (3) stationary medical facilities do not bear the substantial transportation costs borne by the operators of mobile vans. (For example, the Washington Speech and Hearing Society currently charges $120 plus $10 per exam for their central mobile unit but only $7.50 per test at their facility.)

Because the current market for audiometric services is small relative to the demand that would follow the promulgation of this regulation, it is not possible to make precise estimates of the cost to all firms that would purchase these services. However, in order to estimate the regulatory cost, it is reasonable to assume that the average firm sending workers to a clinic would lose about 2 hours in lost production time plus about $15 per worker for test fees and travel expenses. For firms large enough to take advantage of mobile units, the estimated lost production time per worker would be about one-half hour, and the submissions cited above imply an average test fee of about $12.00.

For large firms, in-house programs will be substantially less expensive. A comment to the Advisory Committee (Ex. 102, Sec. 9, p. 15) estimated the cost of providing audiometric testing programs for firms with 200, 300, and 500 employees at about $6.00, $5.00, and $4.00 per audiogram, respectively. Numerous submissions in the record itemize the specific components of these costs. For example, audiometric test booths sell for about $1,700 (Ex. 319 A-44; Ex. 319 A-51; Ex. 2C-71-3, p. 47), and installation could add about $300. Audiometer price quotes average about $500 (Ex. 319 A-51; Ex. 319 A-53; Ex. 319 A-60; Ex. 319 A-62; Ex. 319 A-66; Ex. 319 A-67) and are expected to operate for 10 years (Ex. 319 A-90; Ex. 319 A-60). The calibration procedures require a coupler which costs about $130 (Ex. 319 A-16; Ex. 319 A-11) and a sound level meter with an octave filter set which costs about $1,000. The operator's certification course is good for 5 years and costs $250 plus 3 days of an employee's time (Ex. 319 B-4) which amounts to $240 at $10 per hour. The cost of calibrating the audiometer could be another $100 every other year (Ex. 102, Sec. 9, p. 16). Thus, the total capital outlay is about $4,200. Assuming that the test booths last for 20 years, the other equipment lasts for 10 years, the certification course is given every 5 years, and the interest charge is 10 percent, the total annualized cost amounts to about $650.

Since one exam takes about 10 minutes of time (Ex. 306-J5C, p. 9; Ex. 319 B-6), approximately 48 workers can be tested by a technician earning a daily rate of about $80. Thus, the cost to the firm of the technician's time amounts to $1.67 per worker tested. The cost of reviewing audiograms and reporting the findings is also dependent upon whether this service is contracted out or done in-house. Contractor fees for reviewing audiograms are reported at $2.25, $2.50, $3.00, and $4.00 per audiogram (Ex. 317; Ex. 319 B–12), whereas the in-house review by a physician or audiologist was estimated to cost only $0.25 each (Ex. 102, sec. 9, Audiometric Testing, p. 16). Thus, using $2.50 as a reasonable average cost to review the audigram, a typical cost for administering the tests as well as reviewing the audiograms would amount to $4.17 per unit ($1.67 + $2.50). Finally, a cost for one-half hour of lost production for each worker during the test procedure adds an additional one-half of the hourly wage per worker tested. In summary, the annual cost of the in-house audiometric program is estimated at about $650 per establishment for equipment and certification-related charges, and about $4.17 plus one-half of the industry hourly wage for each employee tested.

The Can Manufacturers Institute, Inc., (Ex. 2C–71–3, p. 50) stated that it would become cost-effective for a firm to develop its own audiometric testing capability when the number of audiograms it required reached about 100 per year. Dr. W. G. Thomas, (Ex. 102, sec. 9) put the break-even point between in-house and contracted audiometric testing at about 300 employees. To estimate the number of firms that would develop their own testing facilities, it is appropriate to use the Table 10 estimates of the number of production workers in the five establishment size categories for the 19 industries studied. The data in Table 10 imply that if the BBN estimate of 34.4 percent of production workers exposed to a TWA >85 dB remains constant across establishment sizes, the average number of workers per establishment in the hearing conservation program will be less than 2 employees for the smallest size category and 9, 21, 46, and 213 employees, respectively, in the larger establishment size categories.

It is likely that workers in the two smallest establishment size classes (1–19, and 20–49 employees) would travel to facilities outside the firm to take the audiometric exam. As explained above, the estimated annual cost for these establishments in each SIC sector would be the number of workers exposed to noise at or above a TWA of 85 dB × (2 hours at the industry hourly wage + $15 per test). For workers in the third and fourth largest size categories (50–99, 100–249 employees), the best assumption is that hearing conservation firms with mobile vans will service the employees. Since each employee would miss only about a half-hour or work time, the annual cost per industry for these intermediate-sized firms is the number of workers exposed to noise at or above a TWA of 85 dB × (.5 hours at the industry hourly wage + $12 per test).

Most firms in the over 250 employee size group would choose in-house audiometric programs. The annual cost for these firms, as detailed above, is estimated at ($650 × the number of establishments) + [the number of workers exposed to a TWA of 85 dB or greater in these establishments × ($4.17 + .5 hours at the industry hourly wage)].

The data needed to complete the above calculations include the percent of workers exposed to a TWA of >85 dB as shown in Table 11, the number of production workers and plants by establishment size in each industry as presented in Table 10, and the 1979 industry average hourly wage as reported by BLS (*Employment and Earnings*, March 1980). However, workers employed for less than 120 days with one firm are exempt from this provision. Employment data from the BLS as well as submissions to the record (Ex. 14–270; Ex. 14–512) indicate that SIC's 20 and 21 hire a substantial number of seasonal employees. In fact, the 1979 BLS average monthly employment estimate would fall by 17,100 and 1,400 in SIC's 20 and 21, respectively, if employment in each industry's 120-day peak employment period were adjusted downward to the level of the following month. The data from Table 10 were revised to reflect this exemption in order to estimate the cost of audiometric testing. Temporary workers in other industries will also take advantage of the exclusion, but the lack of appropriate data have prevented further adjustments to these calculations.

In addition to the annual audiogram, some workers will need to be retested during the year owing to threshold shifts, operator errors, or inconsistent test results. A number of workers will exhibit temporary threshold shifts if they are tested toward the end of the workday after being exposed to excessive noise. Wearing effective and properly inserted hearing protectors prior to the test would lower the incidence of temporary threshold shifts, whereas testing at the start of the day would substantially eliminate their detection. The number of permanent threshold shifts recorded will depend upon the intensity of the noise exposures, the worker turnover rates, and the effectiveness of the hearing protectors. In addition, the requirement for a recheck is waived if the annual test is conducted after 14 hours free from workplace noise. If as many as 20 percent of the workers require rechecks, the overall cost of audiometric testing would total $92,352,000 or about $18 per worker tested.

This discussion has assumed that no audiometric testing is currently provided. The noise record, however, indicates that many industrial establishments already offer audiometric testing to their employees. For example, a survey by the Forging Industry Association revealed that 82 percent of the 151 member firms responding do periodic testing, (Ex. 321–25), while Table 90 of the NOHS (Ex. 321–14D) shows that in their sample, 40 percent of the manufacturing workers exposed to continuous noise above 85 dB received audiometric exams. Table 13 of this same exhibit indicates that primarily the largest-sized establishments provide this service for their workers. Still another NIOSH hearing conservation survey shows that annual and biannual audiometric tests account for about 23 percent and 13 percent, respectivey, of current industry testing programs, with retesting periods in other programs ranging from 6 months to every 5 years (Ex. 321–14B, p. 30). For cost estimating purposes, it seems reasonable to assume that on average, these tests are already provided on a biennial basis to 40 percent, or on an annual basis to 20 percent of the workers in plants with more than 250 employees. Since the number of establishments providing these services is unknown, an accurate accounting of the costs already accepted by industry is not possible. Reducing only the labor-related cost of the largest firms by 20 percent to reflect current practice brings the total cost of this provision to $87,199,000 a year (See Appendix B in OSHA's Final Regualtory Analysis for an example of the calculations). This estimate is not significantly different from BBN's 1976 estimate of 89.1 million even though BBN did not adjust their data to acknowledge current programs and simply used a $20 per worker cost (Ex. 192, p. 3–33).

Hearing Protectors

Hearing protectors used in industry include ear muffs, disposable ear plugs, molded plugs, and custom-molded plugs. Unfortunately, there is no survey information on the percentage of workers who wear each type of protector. In hot, humid environments, workers are likely to choose plugs. It is probable that plugs will be chosen in more than a majority of instances as they are often associated with a lesser degree of discomfort.

Substantial data on the price of ear protectors have been collected for the record. For example, disposable foam ear plugs can be purchased for $0.15 a pair (Ex. 319 A–41) and are reusable. If employees use two pair a week, the yearly cost is $15.00. Disposable non-foam ear plugs cost only from $0.06 to $0.07 a pair (Ex. 319 A–30; Ex. 319 A–37). For a new set of plugs each day, these costs would average about $16.50 a year per employee. Molded ear plug prices are quoted at about $1.50 (Ex. 319 A–30; Ex. 319 A–37), and would cost $6.00 a year if workers used 4 pair per year. Custom molded plugs can be purchased in a kit that makes up to 50 pair of ear plugs at $3.10 a pair (Ex. 319 A–35). These plugs, with minimum care, will last 2 or 3 years (Ex. 319 A–36). Ear muff prices are listed at $9.50 (Ex. 319 A–30), $7.60 (Ex. 319 A–31), and $8.40 (Ex. 319 A–37). The estimated cost of about $10 per year per employee reported by the Industrial Fasteners Institute (Tr. 1611), Bethlehem Steel Corporation (Ex. 145), and BBN (Ex. 192, p. 3–33) appear consistent with these rates. Based on a cost of $10 per year per employee, if hearing protectors were provided to all employees exposed to noise at or above a TWA of 85 dB, the cost of this provision would be $51,290,000.

The NIOSH NOHS survey also indicates that about 20 percent of the workers exposed to continuous noise at or above 85 dB are subject to attempts to reduce exposures (See Vol. III, Table 51). Moreover, the data in Table 90 of the NOHS study show that hearing protectors are almost always the method selected to accomplish this reduction. Since the data show that 20 percent of the workers exposed above 85 dB are provided hearing protectors, this implies that more than 20 percent of those exposed above 90 dB have them. This is because it is probable that most of the current worker use of hearing protectors takes place among workers whose exposures exceed 90 dB. However, if we assume that just 20 percent of the workers exposed to noise above a TWA of 90 dB are already supplied with hearing protectors, the total cost of this provision is $45,534,000. This may be an overestimate of the cost to the extent that not all workers exposed between 85 and 90 dB are required to use the hearing protectors.

Training Program

The major cost elements for the training program will be the cost of the production lost while the workers are being trained, and the cost for the individuals providing the training. Because the training session may last about an hour, the cost for production time lost while training takes place can be estimated by multiplying the industry average hourly wage times the number of workers trained. The cost for the people conducting the training will vary with the size of the establishment. The data from Tables 10 and 11 imply that establishments with under 100 employees average less than 21 workers exposed to noise at or above a TWA of 85 dB. A training program consisting of one hour per year per establishment seems appropriate for these size classes. For establishments with more than 100 employees, it is reasonable to assume that one individual could train 30 people in one session.

Consequently, the cost of training can be estimated at (the average production worker hourly wage × the number of workers exposed to noise > a TWA of 85 dB) + (the number of establishements with less than 100 employees × the cost of providing one hour of training) + (the number of exployees exposed at >85 dB in establishments larger than 100 employees divided by 30 workers per session × the cost of providing one hour of training). If we assume that the cost for the person providing the training is $10 an hour, the cost estimating equation for each SIC is:

$$\$Tr = (W)(PW)(P) + \$10\,e + \$10/30\,(PWE)(P)$$

were:

$Tr = the cost of training
W = the hourly production worker wage
PW = the number of production workers (Table 10)
P = the fraction of workers exposed to >85 dB (Table 11)
e = the number of establishments with less than 100 employees (Table 10)
PWE = the number of production workers in establishments with over 100 employees (Table 10)

Summing over all SIC's, the total cost of training for the 19 industry sectors is estimated at $40,029,000. Although a number of comments described well organized training programs already in operation (Ex. 307, J2C, p. 11; Ex. 147C, p. 335; Ex. 147A, p. 6), and it is likely that many firms do some training, no estimates were available of the total number of such programs currently in existence. Therefore, the above estimate for the cost of this regulatory provision is overstated by the extent that industry already provides this instruction.

Warning Signs

The cost for noise warning signs will vary with the plant layout and the number of entrances into the noisy area. Signs are available for slightly over a dollar (Bilsom International, Inc., Product Order Form, etc.). If, on the average, one sign accommodates ten workers and takes 15 minutes to install, the cost to a firm for placing one sign would be about $3.50 at a $10 hourly wage, and the total cost of the provision would be $1,795,000. Although OSHA's calculations treat this estimate as an annual cost, it is probable that most signs will last for considerably longer than one year.

Recordkeeping

Updating records of noise exposure should take no longer than 10 minutes per worker measured. This amounts to 5 minutes per worker per year. Recordkeeping of audiograms, could also take about 5 minutes per employee per year. The cost of this lost work time would equal 1/6 of an hour × the industry hourly wage × the number of workers exposed to noise at a TWA of >85 dB.

In addition, recordkeeping of periodic calibration of audiometers could take 20 minutes per year. If every establishment with over 250 employees in the SIC's studied maintained an audiometer, the total cost for the activity would be 2/6 of an hour × the industry hourly wage × the number of establishments. It can reasonably be assumed that most firms that market hearing conservation services already keep these records so that their additional costs would be negligible. Thus, the total recordkeeping costs are estimated to amount to $8,033,000.

Conclusion

Overall, the above calculations show that the annual cost of compliance with all of the provisions of this regulation would amount to about $53 for each of the more than five million workers protected by the program. The total cost of hearing conservation programs, as measured in current dollars, is about $270 million a year. After adjustment for some of the compliance activities already taking place, the total new costs fall to $254 million per year.

OSHA's estimates do not appear inconsistent with industry statements. For example, testimony from the Industrial Fasteners Institute implies an annual cost of $50 per employee (Tr. 1611, 1612), and the American Boiler Manufacturers Association commented that $35 per production worker is a conservative estimate (Tr. 1573). Dupont stated that its comprehensive program cost the firm between $10 and $20 per worker per year (Ex. 306–J5c). Moreover, a study submitted by the American Textile Manufacturers Institute estimated an annual cost of $14.16 per employee (Ex. 275 B, Attachment I). BBN offered the only industry-wide calculation. However, as described above, their cost estimate of $65 per worker does not reflect significant changes from the proposal to the final rule.

Table 13 displays the new compliance costs attributable to this amendment as estimated by OSHA for each industry sector. To the extent that many establishments in the industries studied are not affected by noise, or already comply with most of the requirements, or that rental equipment is easily available for monitoring purposes, actual costs would be substantially below the estimates provided.

Table 13.—*Estimated New Annual Compliance Cost of Hearing Conservation Amendment*

SIC	Industry	Estimated cost
20	Food	$17,319,440
21	Tobacco	224,058
22	Textiles	17,756,670
23	Apparel	6,134,562
24	Lumber & Wood	30,664,350
25	Furniture & Fixtures	6,117,161
26	Paper	9,076,951
27	Printing & Publishing	22,284,030
28	Chemicals	10,944,270
29	Petroleum & Coal	4,454,069
30	Rubber & Plastics	6,721,314
31	Leather	909,641
32	Stone, Clay & Glass	7,346,522
33	Primary Metals	23,072,240
34	Fabricated Metals	23,505,250
35	Machinery, Except Electrical	25,519,800
36	Electrical Machinery	6,843,939
37	Transportation Equipment	12,914,530
49	Utilities	22,310,000
	Total	254,321,000

Source: OSHA, Office of Regulatory Analysis.

VII. Economic Impact

Introduction

The cost of the hearing conservation amendment will generate a series of economic effects on those industries that expose their employees to significant amounts of noise. It is difficult to forecast precisely the magnitude of the specific impacts that will occur because they depend in part upon decisions by individual employers on how best to respond to the costs of the amendment. However, the economic framework within which the decisions will be made can be described, and the potential range of subsequent impacts can be identified. For example, compliance costs will exert upward pressure on the prices of the products produced in those industries. Conversely, profits and employment may decline if sales cannot be maintained at the higher price levels. However, the analysis presented below indicates that the economically adverse effects of the program will be exceedingly small compared to each industry's ability to finance them. Moreover, it is shown that the most severe of these impacts will hardly influence the various financial indexes used to assess each industry's economic well-being.

The analysis that follows is based upon the assumption that the cost of production in each affected industry will rise by the full extent of the compliance costs as estimated in the previous section. However, even if these compliance cost estimates are approximately correct, it is probable that the accounting ledgers of the impacted industries will not reflect the full burden of these costs. In fact, studies cited in the Benefits section above support the view that the amendment may cause significant cost savings due to decreased rates of industrial accidents, absenteeism, and worker's compensation premiums. To the extent that dollar outlays for these business expenses are reduced following the implementation of the amendment, the net regulatory cost to industry will diminish. However, to demonstrate conclusively the economic feasibility of the amendment, this section does not adjust the above compliance cost estimates for these potentially important cost reductions.

Price Impact

Economic reasoning indicates that firms will attempt to pass on higher production costs by increasing the selling price of their products. If an industry faces a perfectly inelastic demand for its output, the manufacturers would shift the entire cost of complying with the amendment to their customers through a price increase without a contraction of industry sales. This market condition, however, is seldom the case. On the other hand, if the industry supply curve is perfectly elastic, product prices will rise by the full amount of the cost increase, but industry output will fall to the extent that sales are inversely related to price. Except for over very long time periods, this industry response would also be considered unusual.

In general, firms will try to pass on cost increases by raising product prices, and consumers will respond by reducing their purchases of the industry's products. Most firms, therefore, will find that they cannot quickly recoup all of their profits through price hikes, but must settle for price increases allowing less than a full cost passthrough. If firms could pass on their entire cost increase, however, the maximum expected price rise can be calculated by dividing the estimated compliance cost for each industry by the sales of that industry, and expressing the result as a percentage. Table 14 presents the percentage price increase that would be attributable to the amendment if the entire cost is passed on solely and exclusively in the form of price increases.

Table 14.—*Maximum Price Increase*

[In millions of dollars]

SIC	Industry	Estimated cost of amendment	1979 total shipments	Maximum price increase (percent)
20	Food	$17.32	$234,826	0.0074
21	Tobacco	0.22	12,173	.0018
22	Textiles	17.76	46,992	.0378
23	Apparel	6.13	[1] 40,080	.0153
24	Lumber and wood	30.66	[1] 39,781	.0776
25	Furniture and fixtures	6.12	[1] 16,853	.0363
26	Paper	9.08	66,033	.0136
27	Printing and publishing	22.28	[1] 49,527	.0450
28	Chemicals	10.94	149,181	.0073
29	Petroleum and coal	4.45	134,041	.0033
30	Rubber and plastics	6.72	44,742	.0150
31	Leather	0.91	[1] 7,508	.0121
32	Stone, clay, glass	7.35	48,185	.0153
33	Primary metals	23.07	140,122	0.164
34	Fabricated metals	23.51	109,463	.0215
35	Machinery, except electrical	25.52	157,695	.0162
36	Electrical machinery	6.84	110,713	.0062
37	Transportation equipment	12.91	194,461	.0066
49	Utilities	22.31	[2] 117,024	.0191
	Total	254.32	1,719,402	.0148

[1] Data for 1977. See U.S. Department of Commerce, Bureau of the Census, *Preliminary Report, 1977 Census of Manufactures*, Table 2, p. 4-23.

[2] Revenues from sales to customers for electric power and gas utilities. See U.S. Department of Commerce, *Survey of Current Business* (July 1980): S-23. This figure slightly understates total revenues for the entire SIC 49 because it does not include revenues from sanitary services.

Source: OSHA, Office of Regulatory Analysis. U.S. Department of Commerce, *Survey of Current Business* (July 1980): S-4.

The table shows that the overall impact of the proposed amendment, if all of the costs were passed on, would be to increase prices by 0.01 percent, i.e. one hundredth of a percent in the 19 industrial sectors studied. This clearly implies a negligible change to any of the nation's more aggregated price index series. While there is variation among industries, in only a few cases are the estimated price increases greater than a few hundredths of a percent. The largest increase in price, 0.078 percent, is recorded for the lumber and wood sector, an industry estimated to have over 94 percent of its production workers exposed to noise levels above 85 dB. However, even this price increase is of such a small magnitude that its effect would be hardly noticeable among all of the other cyclical factors affecting the industry product prices.

Financial Impact

The discussion above illustrates the impact on prices if the costs of the amendment were shifted entirely to industry customers through higher prices. Alternatively, the entries in Table 15 show the impact upon profits if the costs were solely and exclusively absorbed from profits. The percentage decrease in profits was calculated by dividing the cost of the amendment for each industry by its estimated 1979 profit level. Table 15 indicates that even in the highly unlikely event of no price change, overall profits would decrease by only 0.19 percent. Profits would fall by under 1 percent in all industry sectors, and in the great majority of cases, the anticipated decline is less than one-half of one percent. Moreover, to the extent that output prices rise at all, profits will fall by a smaller amount than listed. Thus, even these fractional values must be considered estimates of the maximum reduction in industry profits.

Table 15.—*Maximum Profit Reduction*

[In millions of dollars]

SIC	Industry	Estimated cost of amendment	1979 pre-tax profits	Profit reduction (percent)
20	Food	$17.32	$10,081	0.1718
21	Tobacco	0.22	2,237	.0098
22	Textiles	17.76	2,291	.7752
23	Apparel	6.13	[1]2,033	.3015
24	Lumber and wood	30.66	[2]3,140	.0828
25	Furniture and fixtures	6.12	[2]603	.6931
26	Paper	9.08	4,614	.1686
27	Printing and publishing	22.28	6,077	.3666
28	Chemicals	10.94	13,372	.0818
29	Petroleum and coal	4.45	25,239	.0176
30	Rubber and plastics	6.72	1,929	.3484
31	Leather	0.91	647	.1406
32	Stone, clay, glass	7.35	3,650	.2014
33	Primary metals	23.07	6,215	.3712
34	Fabricated metals	23.51	6,830	.3442
35	Machinery, except electrical	25.52	15,484	.1648
36	Electrical machinery	6.84	10,884	.0628
37	Transportation equipment	12.91	8,665	.1490
49	Utilities	22.31	[3]7,138	.3126
	Total	254.32	131,609	.1932

[1] The *Quarterly Financial Report* aggregates income for "Other Nondurables" (SIC's 23 and 31). The pre-tax income of $2,680 million was allocated to the respective SIC's on the basis of the 1976 Internal Revenue Service (IRS) data. The IRS survey gives 75.84 percent, of "Net Income (less deficit)" to SIC 23 and 24.16 percent to SIC 31. See Internal Revenue Service, *Preliminary Report, Statistics of Income—1976, Corporation Income Tax Returns*, (Washington, D.C., 1979), p. 6.

[2] The *Quarterly Financial Report* lists income for "Other Durable Manufacturing Products" which is composed of SIC's 24, 25, and 39. The pre-tax income of $5,934 million was also allocated on the basis of the 1976 IRS data (see[1] above). The distribution was 52.91 percent for SIC 24, 14.88 percent for SIC 25, and 32.21 percent for SIC 39. Since 39 was not included in this study, the profits from that industry are excluded from this table.

[3] This amount is also based upon the 1976 IRS data (see[1] above). The 1976 profit rate was calculated by dividing Net Income (loss deficit) by total receipts. This profit ratio, 6.1 percent, was then multiplied by the total 1979 revenues presented in Table 14.

Source: OSHA, Office of Regulatory Analysis. U.S. Federal Trade Commission, *Quarterly Financial Report*, First Quarter 1980, pp. 18-53.

The ability of the affected industries to raise sufficient compliance funds through normal commercial channels is another relevant consideration. Table 16 presents several financial indicators for U.S. manufacturing industries as presented in the *Quarterly Financial Reports* published by the U.S. Federal Trade Commission. The three indicators—cash on hand, outstanding short term loans, and net working capital—have been chosen because each helps to establish the ability of an industry to finance the costs of the amendment. Comparing the magnitude of these variables to the volume of required funds indicates whether the dollar outlays would be disruptive to the traditional financial operations of the affected industries.

Table 16 shows that for the 19 industries studied, the cost of the amendment is only about 0.6 percent of current cash on hand. The table also indicates that for those industries where data are available, compliance costs average only about 0.7 percent of the short-term debt, and 0.1 percent of the net working capital. Although some industry-to-industry variation exists, none of these ratios is above 2.66 percent. This clearly demonstrates that the cost of compliance will be small relative to each industry's ability to comply with the regulation. On this basis, the record indicates that the regulatory burden would not be an undue financial hardship for each of these sectors.

Table 16.—Compliance Cost as a Percent of Selected Financial Indicators (1979)

SIC	Industry	Cost as a percent of cash on hand	Cost as a percent of short-term loans	Cost as a percent of net working capital
20	Food	0.57	0.37	0.09
21	Tobacco	.12	.10	.01
22	Textiles	2.40	2.32	.23
31	Leather	.58 [1]	.34 [1]	.08 [1]
23	Apparel	.58 [1]	.34 [1]	.08 [1]
24	Lumber and wood	2.66 [2]	NA	NA
25	Furniture and fixtures	2.66 [2]	NA	NA
26	Paper	.60	1.92	.12
27	Printing and publishing	1.04	2.61	.26
28	Chemicals	.33	.68	.04
29	Petroleum and coal	.08	.15	.03
30	Rubber and plastics	.99	.65	.11
32	Stone, clay, glass	.58	1.59	.11
33	Primary metals	1.04	1.13	.14
34	Fabricated metals	.99	1.04	.15
35	Machinery, except electrical	.62	.57	.08
36	Electrical machinery	.18	.36	.03
37	Transportation equipment	.21	.84	.06
49	Utilities	[3].96	NA	NA
	Total	60	[4].70	[4].10

[1] FTC reports only aggregated data for the non-durables group which consists of SIC's 23 and 31.

[2] FTC reports aggregated data of $2,105 million for the Durables group consisting of SIC's 24, 25, and 39. This value was allocated according to IRS data indicating that SIC 24 had 50 percent and SIC 25 about 16 percent of the "Cash" balances reported by firms in these industries in 1975. See U.S. Department of the Treasury, Internal Revenue Service, *Source Book, Statistics of Income—1975, Corporation Income Tax Returns* (Washington, D.C., 1979), p. 52.

[3] "Cash" as defined by the IRS for tax purposes, and thus not strictly comparable to the FTC definition. See IRS, *ibid*, p. 52.

[4] Excludes SIC's 24, 25, and 49.

Source: OSHA, Office of Regulatory Analysis. U.S. Federal Trade Commission, *Quarterly Financial Report*, First Quarter 1980, pp. 18-53.

Other Sectors

The 19 industrial sectors for which detailed feasibility data were presented above include almost all manufacturing and utility industries. These sectors were initially selected by BBN (see their "Economic Impact Analysis of Proposed Noise Control Regulation," Ex. 192 p. 2-1) because they were believed to be the areas under OSHA's jurisdiction which were most likely to have occupational noise problems. However, industrial noise may also be found in some service-oriented industries. Nevertheless, there is no reason to believe that firms in other industries could not also provide adequate hearing conservation programs for the estimated average cost of $53 per exposed worker. Therefore, there is no reason to expect other major adverse economic impacts.

In addition, the industries covered by OSHA's vertical standards for the maritime industries may also be affected by this hearing conservation amendment. These industries include shipbuilding, ship repair, shipbreaking, and longshoring. Shipbuilding and ship repair are included in SIC 37 (Transportation Equipment) for which cost estimates were presented above. Shipbreaking (or the disassembly of ships) and longshoring are included in SIC 44 (Water Transportation) which was not among the 19 two-digit SIC's studied by OSHA. According to the Bureau of Labor Statistics, in 1979, there were 225,300 total employees in SIC 44.[7] Using the $53 per worker cost, even if all of these employees are exposed to noise

[7] U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, 27 (March 1980): 83.

levels ≥85 dB (TWA), the total cost of the hearing conservation amendment for this industry would be $11.9 million. Since this amounts to less than 0.2 percent of total business receipts and only 2.1 percent of net income,[9] it is clear that the hearing conservation amendment would have a minor economic impact on this industry. Moreover, this estimated cost and economic impact are substantially overstated because the total employment figure used includes white collar workers as well as those production workers who are exposed to noise levels below 85 dB (TWA). Since, for the most part, the number of workers exposed to severe noise in the nonmanufacturing sectors is small compared to the number in heavy manufacturing, it is even less probable that compliance costs in these industries would be the cause of major economic disruption.

Small business

OSHA has always attempted to minimize the regulatory burden on small business as long as it would not jeopardize worker safety and health. To conform with this practice, as well as to comply with the spirit of the Regulatory Flexibility Act, the Agency has made a concerted effort to analyze the special problems that small business might face in complying with this amendment. (The requirement for a Regulatory Flexibility Analysis applies only to proposed regulations issued after January 1, 1981, not to final regulations issued after that date.) Where possible, the proposed regulation was modified to ameliorate potential hardships. For example, the requirement for monitoring may affect smaller businesses disproportionately because they will often rely on consultants, whereas it is easier for larger firms to develop an in-house monitoring capability. After analyzing the record, OSHA drafted the present provision to allow the obligation to recur every other year in most situations, rather than at least annually as was originally proposed. Also, the proposal required that a worker repeat the audiometric exam if a significant threshold shift was detected. The final amendment deletes this requirement for workers who were tested after 14 hours away from workplace noise. Although it may not be practicable for large firms to schedule morning tests for all of their exposed workers, small businesses should be able to take full advantage of this exemption.

Despite these efforts, small business firms may find compliance more of a burden than large firms. Table 10 in the Cost of Compliance section shows that there are only 1–19 employees in almost two-thirds of the 311,094 establishments in those industries primarily affected by noise. The table implies that a firm classified in this size group hires an average of five production workers. Based on the BBN exposure data (see Table 11) an average of 34.4 percent, or only about 2 workers, would be exposed to noise at or above 85 dB in these small establishments.

Small firms will often find ways to reduce monitoring costs by working together to share equipment or by renting monitoring equipment to measure noise exposures. However, following the cost estimation procedures developed above, if these firms do hire consultants to satisfy their monitoring requirements, the annual monitoring cost would average $206 per firm. Using BLS data to calculate a weighted average hourly earnings of $6.78 for production workers in these industries, the estimated cost of sending two workers for audiometric testing is $68 per year. Annual costs for these small firms to provide training and hearing protectors come to about $24 and $20 respectively, while costs for recordkeeping and the posting of signs add $6.00 per firm. Thus, compliance costs for establishments in the smallest size category may average about $324 per year.

Costs of this magnitude are obviously significant to the smallest firms. However, except for the most marginal of these establishments, they are not likely to affect the economic viability of an otherwise profitable operation. Moreover, these costs may be substantially offset by the potential financial benefits of reduced worker absenteeism and workplace accidents. In addition, OSHA offers free onsite consultation in every state, funded under Section 7(c)(1) of the OSHA Act. This service is delivered by State governments or private sector contractors using trained and qualified professional staff. To the extent that these resources allow, OSHA will make a special effort to respond to requests from employers for professional advice and assistance. Also, OSHA is in the process of developing printed pamphlets that will assist employers in providing appropriate training to their workers. The availability of these additional resources should significantly enhance the ability of small business to comply with the provisions of the hearing conservation amendment.

VIII. Resource Availability

For the compliance activities of the hearing conservation amendment to be feasible, industry must have the specialized equipment and personnel essential to an acceptable program. As documented in the following paragraphs, the noise record indicates that industry need not develop new technologies to implement hearing conservation programs since the equipment required by the new rule is already being manufactured and sold to industrial purchasers.

A substantive issue that remains to be addressed, however, is the general accessibility of the necessary human and material resources. An assessment of the present availability of equipment and personnel would be useful but it would not provide a realistic indication of the future availability of these resources following the promulgation of the amendment. In the absence of a detailed requirement for hearing conservation programs, many employers have not felt obligated to protect workers from hearing loss. As a result, there has been little incentive for manufacturers to step up the production of appropriate equipment. Similarly, the number of properly trained hearing professionals has been limited by the demand for their services. As industry begins to implement the hearing conservation activities mandated under this rule, it is anticipated that the supply of these resources would rapidly expand to satisfy the new requirements.

Monitoring

The feasibility of the monitoring provision, which requires the determination of a representative noise exposure for each worker exposed to an 8 hour TWA of 85 dB or more, depends on the availability of appropriate instrumentation for firms performing in-house monitoring or of qualified monitoring consultants for firms that choose not to obtain the necessary noise measuring equipment. Comments to the noise record indicate that currently at least 6,000 dosimeters are manufactured each year (Ex. 319 A–1; Ex. 319 A–7; Ex. 319 A–12; Ex. 319 A–20; Ex. 319 A–69; Ex. 319 A–72). Although not all of these dosimeters meet the specifications of the final rule, some appear to comply with the amendment by meeting the range and lower threshold requirements as well as the specifications of ANSI § 1.25–1978 (Ex. 319 A–8; and OSHA telephone survey to dosimeter manufacturers). Kamperman (Ex. 321–32) has tested one of these instruments

[9] In 1974, receipts for SIC 44 totalled $6,958,280,000 while net income was $570,287,000. See U.S. Department of the Treasury, Internal Revenue Service, *Statistics of Income—1974, Corporation Income Tax Returns*, (Washington, D.C., 1978), p. 12.

and found that it meets a test OSHA believes to be more rigorous than the one this amendment requires. Other manufacturers should also have little difficulty building units that comply with the amendment as the technology is available to both domestic and foreign firms. In addition, there are at least 5,300 sound level meters manufactured each year that can be used to measure worker exposures (Ex. 319 A-1; Ex. 319 A-7; Ex. 319 A-12; Ex. 319 A-72).

The analysis described in the Cost of Compliance section concludes that only the larger industrial establishments are likely to purchase monitoring equipment. In the 19 industrial sectors studied, there are less than 34,000 establishments with over 100 employees (see table 10). It is not known how many of these firms already possess acceptable monitoring instruments. However, the rates of production listed above for units that will last a number of years imply that a substantial amount of equipment is already available. Further, because many of the smaller establishments will opt to rent or share equipment, each instrument will frequently be used by numerous employers.

The significant increase in the demand for monitoring instruments which will follow the implementation of the hearing conservation programs will provide a sharp stimulus to their production. Of the 12 companies currently manufacturing dosimeters, only 2 manufactured acoustical measurement equipment prior to the passage of the 1969 noise standard. Since that time, the remaining companies either expanded their product lines to include sound level meters and dosimeters or were established in response to the anticipated demand for noise measurement equipment. In similar fashion, existing manufacturers and new firms will be able to supply dosimeters and sound level meters to meet the new demand. To provide adequate time for this increased scale of production, OSHA is allowing a 2-year period before the more stringent specification requirements for dosimeters become effective.

In addition, the widespread occurrence of industrial noise has fostered the establishment of numerous acoustical consulting firms that will be available to accommodate those employers who choose to rely on specialized acoustical technicians to measure worker exposures (Ex. 319 B-8; Ex. 319 B-9; Ex. 319 B-11; Ex. 319 B-15). Audiometric testing firms also frequently offer monitoring services (Ex. 319 B-9; Ex. 319 B-12; Ex. 305; Ex. 321-7). This approach is acceptable as long as employers ensure that the consultants use qualified personnel and appropriate equipment and that they follow the requirements of the amendment. Each consulting firm can provide monitoring services to numerous industrial clients as the surveys do not always require a substantial degree of technical expertise (especially where dosimeters are used), and the smaller establishments can be surveyed in no more than one day (see Table 8). Although the record does not indicate the number of consulting firms that currently have the capability to conduct noise measurement surveys, the capacity of such firms would be expected to expand accordingly if the current supply of these services proves to be insufficient.

Audiometric Testing

The data developed in the cost of compliance section indicate that there will be about 5,126,000 workers in audiometric testing programs. The amendment requires that an otolaryngologist, an audiologist, or in their absence, a qualified physician oversee each program. In addition, the audiometric examination must be administered by one of these professionals or a certified technician trained in a course that contains material equivalent to that approved by the Council for Accreditation in Occupational Hearing Conservation, or The Guidelines of the Inter-Society Committee on Audiometric Technician Training.

In 1975, the American Speech and Hearing Association (ASHA) reported that course work in industrial hearing conservation was offered by 100 university and college programs. The ASHA estimated that there were 3,500 audiologists at that time and that this number would probably double in the next five years. (Ex. 15-30, p. 4). Indeed, by 1980, the American Speech-Language-Hearing Association (ASLHA) reported that there were currently 6,052 audiologists who are members of ASLHA, another 2,000 who are licensed, and an additional 1,600 students who were about to receive masters' or doctoral degrees (Ex. 319 B-7). Thus, within the near future, there will be about 9,652 audiologists who can supervise audiometric programs. Although it is unlikely since many firms will have a medical doctor to oversee the program, if only these audiologists supervised audiometric testing for all 5,126,000 workers, they would see an average of 531 workers each. The number of workers tested per audiologist, therefore, is about 2 per day, which is clearly a manageable task.

In addition to audiologists, otolaryngologists and other qualified physicians can oversee audiometric testing programs. The American Council of Otolaryngology (ACO) estimated that there were almost 5,000 practicing otolaryngologists in 1973 (Ex. 321-5, p. 17). According to the ACO, by 1985 there will be a surplus of 253 otolarynogologists (Ex. 321-5, p. 94). Moreover, in 1977 there were 382,000 professionally active M.D.'s in the U.S. (Statistical Abstract of the U.S., 1979, p. 106), and a major study recently submitted to the U.S. Department of Health and Human Services concludes that the U.S. will have an oversupply of 70,000 physicians by 1990 (Report of the Graduate Medical Education National Advisory Committee, Vol. I, GMENAC Summary Report, Sept. 1980, p. 3).

Currently, the Council for Accreditation in Occupational Hearing Conservation (CAOHC) indicates that they have certified about 6,700 audiometric technicians (Ex. 319 B-4), and there are about 700 course directors approved by the CAOHC to provide training for 20-30 technicians per course. If each course director teaches only one course per year to 20 people, this represents an additional 14,000 technicians. Thus, within a year, about 21,000 technicians could be available to perform audiometric tests, which averages to about one technician per 244 workers. However, many technicians have received training and certification by institutions and professionals other than the CAOHC, and audiologists and physicians other than those certified as instructors by the CAOHC will be able to train additional technicians. Thus, the supply of technicians is likely to be even larger than the 21,000 estimated here.

As explained in the previous section on the cost of compliance, about 829,000 workers will receive audiometric tests supervised by physicians or audiologists at clinics and in private practices. The 253 excess otolaryngologists that the ACO predicted to be available in 1985, alone, could provide 1,170,000 office visits (Ex. 321-5, p. 94). Thus, there is no indication that the total supply of otolaryngologists, audiologists, and physicians could not meet this demand.

About 1,447,000 workers were estimated to receive audiometric tests from mobile vans which can travel to virtually any plant facility. At a testing rate of 48 persons per day (Ex. 319 B-6 suggests 56 per 8-hour day), the workers could be tested in 180 days by 167 mobile vans. The use of these vans is already a common practice for many hearing conservation firms. Although the number of vans presently equipped to provide audiometric services was not submitted to the record, it is reasonable to expect that the existing audiometric firms, along with new firms entering the market will be able to supply these mobile services.

Approximately 2,850,000 workers were estimated to have their hearing tested at in-house programs in 13,285 of the largest industrial establishments. Many of these firms already offer audiometric tests to their employees. Moreover, additional audiometric technicians can be readily trained by sending employees at each facility to an appropriate institution for training. Thus, it is unlikely that these large firms will have difficulty finding appropriately qualified personnel.

In general, the trained personnel are widely disseminated throughout the nation. For example, there are about 2.1 otolaryngologists per 100,000 people in the U.S., with a range from 1.7 in the east south central region to 2.5 in the pacific region (Ex. 321-5, p. 21). By federal geographical region, the distribution of audiologists listed on the ASLHA mailing list ranges from 285 ASLHA audiologists in Region 8 to 1,186 ASLHA audiologists in Region 5. Nevertheless, one objection raised against audiometric testing was that some commercial activities, such as logging operations, would not be accessible to qualified personnel (Ex. 14-264; Ex. 14-260). However, OSHA believes the record shows that in almost all cases, the widespread availability of professional and technical personnel supplying mobile audiometric services should be adequate for even outlying industrial sites.

The major equipment required to perform audiometric examinations are audiometers and audiometric test booths. Based on 2,000 hours of use per year and a 10-minute examination period, each audiometer can potentially be used to provide 12,000 tests. If the audiometers are operated at only half this rate, it would take about 1,000 audiometers to test 5,126,000 workers. The current production of this equipment, each unit of which is expected to operate for about 10 years, is at least 5000 per year. (Ex. 319 A-51; Ex. 319 A-60; Ex. 319 A-64; Ex. 319 A-67). Moreover, all of the manufacturers who commented indicated that they could meet an increased demand, and it is likely that most of the existing audiometers currently used by industry are acceptable under the amendment.

There are three major manufacturers of audiometric test booths in the U.S. Although there is no information in the record about the number of units produced each year, manufacturers could increase their production fairly rapidly by adding second and third shifts if the current supply proves to be inadequate to meet an increased demand. In addition, other firms could expand into this area. However, some users of audiometric test booths may have difficulty complying with the maximum octave band sound pressure levels allowed in the booth during audiometric testing. This may be particularly difficult in the 500 Hz octave band. In an effort to alleviate this difficulty, OSHA has chosen to use 27 dB as the maximum sound pressure level in the 500 Hz octave band rather than the more stringent level of 21.5 dB specified in the ANSI S3.1-1977 standard. Although there is evidence on the record that the levels specified by ANSI S3.1-1977, with the adjustment at 500 Hz, can be met during industrial audiometry (Ex. 266A, p. 73; Ex. 295), some users may have to relocate their booths to a quieter location in order to comply with this provision. Since only the largest industrial establishments will develop in-house audiometric facilities, quieter enclosed areas should be generally available. Nevertheless, barrier walls could be constructed or double-walled booths purchased where a problem persists. Since this part of the requirement does not become effective until 2 years after the effective date of the amendment, most users should have sufficient time to make the necessary adjustments.

Other Provisions

The resources required to comply with the use of hearing protectors, training, the posting of warning signs, and the keeping of records will not be difficult for companies to find. The general availability of hearing protectors is amply demonstrated by the list of 175 models of hearing protectors from 48 different manufacturers or suppliers published by NIOSH in 1975 (Ex. 321-14A). Training materials, warning signs, and record forms also can be readily purchased from many safety supply houses.

IX. Additional Matters

It has been shown that this standard will result in a significant reduction of a significant risk of hearing impairment. Indeed, even assuming full compliance with the present hearing conservation requirements set forth in § 1910.95(b)(3), the new standard is reasonably necessary and appropriate to reduce a significant risk, in that it will result in 38,000 fewer cases after 10 years, 143,000 after 30 years, and 169,000 at equilibrium. It has also been shown that the costs of the standard, $53 per employee covered, and the total new costs, averaging 0.0148% of sales and less than .2% of profits, are economically feasible and that the amendment is technologically feasible. Hearing impairment reduces a worker's effectiveness on the job, makes life much more difficult and when noise-induced, is essentially nonreversible and cannot be cured through use of hearing aids. OSHA has issued this standard because of these reasons and findings. Thus, in accordance with the Agency's traditional interpretation of Sections 3(8) and 6(b)(5) of the Act, and its legislative history, the Secretary is issuing this standard to reduce a significant risk of material impairment.

OSHA rejects the view that the Agency should weigh costs and benefits in issuing this standard. OSHA believes such a course would contravene its statutory mandate. We note, however, that the question of whether OSHA must balance costs and benefits is presently pending before the Supreme Court in *American Textile Mfgs. Institute, Inc.* v. *Marshall*, U.S. Nos 79-1429, 79-1583. If required to do so as a formal finding, OSHA would find that the prevention of a year of hearing impairment is worth many times more than the cost of this standard in preventing that impairment. Losses of workplace effectiveness, inability to hear safety warnings on the job, inability to communicate with family and friends, and inability to enjoy many of the benefits of a media oriented society are very real and very substantial losses, even if exceedingly difficult to quantify in dollars. The basis for this alternative cost-benefit finding are contained in the Final Regulatory Analysis (Section VII) which contains several evaluations of the comparison between costs and benefits. That discussion is incorporated here by reference. However, we briefly summarize it below.

Some of the financial savings created by this amendment, such as reductions in absenteeism and worker's compensation payments have been estimated above. However, the value of preventing the serious hardship of hearing impairment, though large, cannot be quantified in dollars.

The data available in the noise record are much more extensive than can normally be expected to be available in the health area. It is possible to make a reasonable estimate that hearing conservation programs over the next 70 years will prevent 43.3 million person-years of hearing impairment at a cost of $436 per year of hearing impairment prevented (discounting neither costs nor benefits).

OSHA has placed a detailed numerical analysis of the benefits of the standard in the preamble because the data available permits it. But in most cases of health regulation, such detailed analysis cannot be done because data are not available. As the Supreme Court pointed out, the inability to do such detailed analysis does not inhibit the agency from issuing appropriate regulations (*I.U.D v. API, supra*, slip. op. p. 45).

As discussed above, this standard creates massive benefits, has a low cost per employee covered and creates no feasibility problems. In fact, it would even be appropriate for health and safety regulations to be issued and fully justified by the OSH Act though the reduction in risk were much less and the economic impact greater.

X. Environmental Impact

On February 19, 1974 OSHA announced in the Federal Register its intention to prepare an Environmental Impact Statement assessing the impact of a standard that would be proposed for occupational noise exposure (See 39 FR 6119). Information was solicited from the public on a variety of environmentally related issues including possible environmental impacts of the recommended standard and any irreversible commitments of resources which would be involved if the standard should be implemented.

A draft Environmental Impact Statement was made available to the public on June 16, 1975 (40 FR 25525) and environmental impact was specifically an issue at the first hearing held in 1975. Approximately 29 comments were received on the environmental impact of the proposal.

A Final Environmental Impact Statement has been prepared in accordance with the Council on Environmental Quality (CEQ) Guidelines (40 CFR § 1500 et seq.) and the Department of Labor's regulations setting out procedures to be used by Department of Labor agencies to insure compliance with the National Environmental Policy Act (29 CFR Part 11). The Final Environmental Impact Statement concluded that the hearing conservation amendment will beneficially impact the workplace environment by reducing both the incidence and the degree of hearing loss among workers. The incidence of other adverse health effects associated with noise exposure may also be reduced. In addition, the environment outside the workplace should not be significantly affected.

The Final Environmental Impact Statement discussed a number of alternatives including:

(1) Revision of the permissible exposure level for noise.

(2) Initiation of a hearing conservation program at 85 dB.

(3) Initiation of a hearing conservation program at 80 dB, and 90 dB.

(4) Revision of the monitoring, testing, and training provisions in the proposal.

(5) No regulatory action.

The alternative which would be the most preferable environmentally is the one which would result in the greatest reduction in hearing loss and other adverse non-auditory health effects associated with noise exposure in the workplace without resulting in any significant adverse environmental impact. Theoretically at least the most preferable alternative would have been to revise the permissible exposure level downward; this would have the effect of protecting more employees from suffering material impairments of hearing and of lessening the severity of the impairments that might be suffered anyway. At the other end of the continuum was the alternative of no regulatory action. This would result in approximately 5.4% of employees and retirees (940,000) suffering material impairments of hearing due to occupational noise exposure. The Agency felt that more information was needed before it could make a decision to reduce the permissible exposure level. The decision as to the appropriate permissible exposure level was deferred pending the acquisition and evaluation of the necessary data.

Various alternative monitoring, testing and training provisions were generally considered. Many of these were suggested by interested persons in comments and were discussed at the rulemaking hearing. For example, the appropriate frequency of monitoring and audiometric testing was the subject of somewhat varying opinions. While it is not possible to isolate the contribution of any particular element to the overall efficacy of an employee hearing conservation program, OSHA has endeavored to select a combination of provisions which together will provide adequate protection to employees while minimizing the burden on employers. The hearing conservation program prescribed in the final standard is consistent with the advice and recommendations of numerous experts in the field of hearing conservation.

Initiation of hearing conservation programs at employee exposure levels of both 90 dB and 80 dB was also considered. Initiation of a hearing conservation program at 90 dB was rejected because it was not considered adequate to reduce the significant risk of material impairment faced by many employees at this level. Implementation of this alternative, even assuming perfect compliance, would still result in approximately 351,000 occupationally-exposed persons suffering material impairment of hearing. Initiation of a hearing conservation program for all employees exposed to 80 dB, although it would have provided a substantial reduction in the number of hearing impairments resulting from noise exposure, was deferred. Lowering the initiation level for hearing conservation programs to 80 dB would greatly increase the number of workers and establishments included in these programs. This would increase the demand for the various resources needed to implement effective hearing conservation programs including individuals trained in the evaluation of hearing and persons trained in conducting audiometric examinations, as well as increase the demand for the equipment and supplies used in such programs. The current record does not contain enough information to enable OSHA to determine if the resources available are adequate to meet this increased demand.

After considering the various alternatives the Agency decided to mandate hearing conservation programs when workers are exposed to TWAs of 85 dB. This is an environmentally pragmatic decision and should result in preventing 898,000 persons from suffering a material impairment of hearing as a result of occupational noise exposure. This represents an additional 778,000 material impairments over the estimated number of material impairments that are being prevented by hearing conservation programs currently in effect.

The alternative selected by the Agency will not eliminate all environmental harm due to occupational noise exposure since some persons will continue to suffer material impairment of hearing even after implementation of the hearing conservation program required by the amendment. However it was chosen by the Agency because it will extend the benefits of hearing conservation programs to approximately 5.1 million U.S. workers while the Agency resolves various feasibility issues surrounding the permissible exposure level and priority of various methods of compliance. By its action in promulgating the hearing conservation amendment, the Agency has taken all practicable means to minimize environmental harm within these feasibility constraints.

This action will help to preserve the nation's human resources by protecting workers from occupational noise exposure. It has been designed to minimize the irretrievable commitments of human and physical resources needed in order to implement hearing conservation programs.

Summary and Explanation of the Standard

Exposure Monitoring

Noise monitoring is necessary for the following reasons:

(1) to identify employees who should be given audiometric tests and the other benefits of the hearing conservation program;

(2) to identify those employees for whom hearing protection is mandatory under the provisions of this amendment;

(3) to determine the amount of attenuation that hearing protectors need to provide; and

(4) to instruct both employers and employees in the degree of the noise hazard.

The monitoring requirements of this amendment are imposed pursuant to section 6(b)(7) of the Act, which mandates that standards promulgated under section 6(b) shall, where appropriate, "provide for monitoring or measuring of employee explosure at such locations and intervals, and in such a manner as may be necessary for the protection of employees." In this amendment the word "measurement" is used to mean the quantification of an employee's noise exposure. Monitoring refers to a program that includes calibration, measurement, and calculation of dose or noise exposure. Although the current standard requires noise exposures to be controlled to within specific limits, it does not explicitly require the collection of personal noise exposure data. This amendment makes monitoring requirements explicit for purposes of the hearing conservation program.

Briefly, the amendment requires employers initially to determine if any employee's exposure equals or exceeds a TWA of 85 dB. This determination must be based on the employer's good faith inquiry into any factors which would tend to indicate that noise exposures in the workplace are in the vicinity of an 8 hour TWA of 85 dB. Factors meriting a positive determination include any employee complaints about noise, any difficulties in communication at a distance of about 2 feet, or any measurements made with a sound level meter or dosimeter. If the employer's determination indicates any employees are or may be exposed to a TWA at or above 85 dB, then employers must obtain noise exposure measurements which are representative of all such employees.

This initial determination/monitoring cycle must be repeated every 2 years. Of course, the employer may, at his own option, skip the initial determination procedure entirely, and simply measure employee exposures.

Where employees have a TWA of 85 dB or more, measurements must be made at least every 2 years. Measurements must also be taken within 60 days of any change in process, equipment, or personnel assignment which increases employee exposure to the extent that some employees may be newly exposed to a TWA of 85 dB or above, or increases exposure to the extent that any personal protective equipment being used no longer provides enough attenuation. Rather than measure every worker, in such cases, employers have the option of measuring the exposure of only one member of an employee group so long as the other members are engaged in a similar kind of work and are reasonably expected to have approximately the same noise exposure. In this case the employer must select for measurement the employee in the group whom he reasonably believes has the highest exposure. The exposure of the measured employee is then attributed to the other members of the group. Measurements of new employees must be taken (or exposures must be attributed to them) within 60 days of their exposures to a TWA of 85 dB or above. Workers must be notified of their exposures in writing within 21 days of the measurement.

Expression of Noise Exposure

In the proposal, an employee's noise exposure was expressed in terms of a fraction of allowable exposure or dose, often expressed as a percentage. Noise dose is a measure of the total noise to which an employee is exposed during a workshift. It is measured directly by a noise dosimeter or it can be computed from sound levels and the amount of time of exposure to each level. In this amendment, the concept of an "8-hour time-weighted average sound level," abbreviated TWA, is used as an alternative descriptor of noise exposure. The TWA as a single numerical value is the sound level which, if experienced continuously for an 8-hour workshift, would lead to the same noise dose as was measured or calculated, even if the duration was shorter or longer than 8-hours. Since noise exposure levels vary throughout the day in most industrial establishments, the TWA represents the integration of these levels (according to the 5-dB exchange rate), referenced to a duration of 8 hours and an exposure level of 90 dB. OSHA believes that since TWA is an exposure level expressed in decibels, it may be more easily understood by workers, management, the public, and others who are not familiar with the field of acoustics. To summarize, for purposes of the hearing conservation amendment, a dose of 0.5, or 50 percent, is equal to a TWA of 85 dB, computed in accordance with Appendix A of the amended noise standard.[9]

Since noise dose and TWA are equivalent in that one can be calculated from the other, since there does not appear to be much possibility of confusion between the two terms, and since one or the other may be preferred under different circumstances, both terms are defined in this amendment and either may be used by employers. Table A-1 in Appendix A has been added as a convenience so that where the value of one descriptor is known, the value of the other may easily be found.

There were relatively few comments in the record that addressed the issue of whether to describe noise exposure in terms of dose to TWA. There were, however, some instances where witnesses and commenters seemed to confuse noise *levels* with noise *exposures* (for example Ex. 14-96, p. 1; Ex. 14-79 p.

(1) OSHA wishes to clarify the fact that both "dose" and "8-hour, time-weighted, average sound level" are descriptors of employee noise *exposure*. Noise levels are addressed by this amendment only to the extent that they are experienced by employees. Even then, it is the time integration of noise levels that is of importance.

When To Implement the Program

The hearing conservation program must be implemented when any employee's noise exposure equals or exceeds an 8-hour TWA of 85 dB,[10] or when the dose equals or exceeds 50 percent (0.5). The final standard requires the initiation of a hearing conservation program at this point because as explained earlier, a substantial

[9] Technically TWA is not a true average, either arithmetic or exponential, since it represents a theoretical value derived from an accumulated dose. To be more precise, TWA should stand for "time-weighted accumulation." However, the Agency has chosen to use the word "average" so as to be consistent with other OSHA standards, such as the asbestos standard (29 CFR 1910.1001) and the acrylonitrile standard (29 CFR 1910.1045), as well as to be more easily understood.

[10] Unless otherwise noted, where the term TWA is used in the preamble an 8-hour duration is assumed.

percentage of the population whose exposures exceed this level over a working lifetime will incur noise-induced hearing loss constituting material impairment unless preventive measures are applied. This is similar to setting an "action level" of 85 dB. Setting an action level for noise monitoring at approximately one-half the permissible exposure level (PEL) is consistent with other OSHA health standards (for example the standards on Arsenic (29 CFR 1910.1018) and Acrylonitrile (29 CFR 1910.1045)). This is done primarily because of uncertainties that can affect the employer's measuring program. The employer may not be absolutely certain that the day on which he or she measures is representative of the employee's actual exposure throughout the year. Therefore, requiring noise exposure measurements and other elements of the hearing conservation program at an action level the PEL safeguards employers against exceeding the permissible level, as well as identifies the more susceptible workers so that steps may be taken to protect their hearing. Many comments in the record supported initiating noise monitoring at a TWA of 85 dB (Ex. 162, p. 48; Ex. 189-6, p. 25; Ex. 114, p. 5; Ex. 23, p. 4; Ex. 2B, p. 6; Ex. 2C-126, p. 1). In fact, many people who opposed a PEL of 85 dB supported the idea of initiating monitoring and audiometric testing at 85 dB (Ex. 114, pp. 4–5; Ex. 175, pp. 10–11).

Dose Computation

The amendment requires noise dose to be computed in accordance with Table G–16a and the formula $D = 100\ C/T$. In cases where the measured levels are not specified in the table, noise dose may be computed using the equation given in the footnote to Table G–16a.

The sound levels to be included in the calculation of the noise dose, whether one uses a sound level meter or a dosimeter, extend from 80 to 130 dB. A-weighted sound levels are assumed throughout the standard and preamble unless otherwise specified. The term "dBA" is not used because it is technically incorrect to do so. (It is the sound level that is weighted, not the decibel). According to acoustician Dr. Robert W. Young (Ex. 2C-121, p. 1) "The decibel is not A-weighted. The quantity . . . is A-weighted sound level (dB)."

Noise dose is relatively simple to compute when the sound level is constant throughout the workshift. The dose in percent, D, is given by $D = 100\ C/T$, where C is the total length of the workshift in hours and T is the reference duration corresponding to the measured sound level L, as given in Table G–16a of the amendment.

For example, consider a worker who is exposed to a continuous sound level of 96 dB for a 7-hour workshift. As specified in Table G–16a, the reference duration for 96 dB is 3.5 hours. Entering this reference duration into the previous formula: $D = 100(7/3.5) = 100(2) = 200\%$. Two hundred percent is the dose for a 7-hour day's exposure to 96 dB.

When the employee's noise exposure level fluctuates, or consists of two or more levels, the total noise dose is computed as follows: $D = 100(C_1/T_1 + C_2/T_2 + \ldots + C_n/T_n)$, where C_n represents the total time of exposure at a specific level, and T_n represents the reference duration for that level given in Table G–16a or by the equation in the footnote to that table.

For example, if a worker is exposed for 5 hours to 85 dB, 2 hours to 87 dB, 15 minutes (0.25 hour) at 95 dB, and 45 minutes (0.75 hour) at 97 dB, the total noise dose would be:

$$D = 100\ (5/16 + 2/12.1 + .25/4 + .75/3)$$
$$D = 100\ (0.31 + 0.17 + 0.06 + 0.25)$$
$$D = 100\ (0.79) = 79\%.$$

The 8-hour time-weighted average sound level (TWA) can be computed from the employee's dose by use of the formula: $TWA = 16.61 \log_{10} (D/100) + 90$ where the dose, D, is given in percent. Conversely, the dose may be computed from TWA using: $D = 100 \times 10^{(TWA - 90)/16.61}$.

Values of TWA corresponding to various doses are tabulated in Appendix A, II. For the two examples given above, the TWA for a dose of 200 percent is approximately 95 dB, and that for a dose of 79 percent is approximately 88 dB. Since Table A–2 in Appendix A does not provide values above a dose of 999 percent or above a TWA of 106.0 dB, the formula must be used to convert from dose to TWA, or from TWA to dose in cases where exposures exceed these values.

Note that TWA is the sound level that would produce a given noise dose if an employee were exposed to that sound level continuously *over an 8-hour workday. This is true regardless of the length of the actual workshift.* OSHA requires the initiation of monitoring at a noise dose of 0.5, or 50 percent. This corresponds to a TWA of 85 dB. It is important to understand that the exposure is to be averaged over 8 hours. Thus, if an employee only works for 5 or 6 hours, the exposure can be higher during those hours than if the employee works for 8 hours. For example, for purposes of the hearing conservation amendment a 4-hour workday at a steady sound level of 90 dB, an 8-hour workday at 85 dB, and a 12-hour workday at 82 dB all correspond to a noise dose of 50 percent and to a TWA of 85 dB.

Table G–16a is essentially the same as the table presented in the proposal except that levels above 115 dB and below 85 dB are included so as to help clarify the fact that they are to be included in the determination of noise dose.

There are several reasons for the extension of Table G–16a. The current standard does not permit exposures above 115 dB, regardless of duration. This provision was not intended to preclude such levels, where they actually exist, from being included in the computation of an employee's actual total exposure. Indeed, it would be patently unreasonable to exclude the highest levels which are the most damaging (Kamperman, Ex. 321-32, p. 1; Ex. 321-21E, p. 5). The extension of the table above that level has been done to make explicit the requirement that, for purposes of the hearing conservation program, exposures above 115 are to be included in the dose. This is important so that where noise exposure levels exceed 115 dB, the actual exposures above that level are assessed accurately, so that employees will know that they need to select hearing protection with maximum attenuation capabilities, and to take steps to ensure that protectors are effectively fitted and worn. To avoid giving the impression that levels above 115 dB are permitted, values above that level in Table 16a have been added in italics.

Similarly, Table G–16a gives values below 85 dB so that such levels also can be included in the dose for purposes of the hearing conservation program. These values are primarily relevant for those employees with workshifts longer than 8 hours. To ensure that exposure measurements taken with a dosimeter are equivalent to those obtained using a standard sound level meter, and to those in Table G–16a, an operating range of 80 to 120 dB is required for dosimeters. The upper limit of 120 dB ensures that levels above 115 are included in the dose. The lower limit of 80 dB is consistent with accepted measuring techniques for dosimeters. It is generally accepted that the lower threshold of a dosimeter should be 5 dB below the level for which measurements are being taken. Evidence in the record supports this requirement.

Dr. George C. Maling, Jr., representing the Institute of Noise Control Engineering, commented that selection of the same level as the point at which integration (or accumulation of noise dose) begins may lead to serious measurement errors. He recommended setting the threshold 3 to 5 dB below the lowest "action point" (Ex. 14-334, p. 2).

Kenneth Eldred, as Chairman of the ANSI Sound Level Meter Standards Working Group, also supported this concept. He stated that should a sound level of 85 dB for 8 hours trigger the hearing conservation program, there might be considerable measurement error unless the threshold level of the dosimeter is required to be at a lower level, such as 80 dB (Ex. 321-10, p. 2). For example, with continuous noise levels that fluctuate between 84 dB and 86 dB, instruments with lower thresholds of 84.5 dB, 84.8 dB, or 85 dB could read anything from zero percent to more than 100 percent dose in exactly the same noise conditions. Setting the threshold well below 85 dB would prevent this confusing situation, and would ensure that the appropriate employees receive the benefits of the hearing conservation program.

There were some comments during the hearings that by initiating the hearing conservation program at a TWA of 85 dB, OSHA was, in effect, lowering the permissible exposure limit, thereby making new requirements for engineering controls (Ex. 14-341, p. 1; Ex. 14-280, p. 2). However, the Agency has made it clear throughout this preamble that the PEL remains unchanged at this time, and that an action level of 85 dB, calculated as set forth in the amendment, is an appropriate action level to trigger monitoring and other hearing conservation measures. The lower threshold of 80 dB for measurements merely facilitates the proper identification of employees to be included in the hearing conservation program, and does not change the requirements for engineering controls.

Monitoring Requirements

The proposal stated that employers have an obligation to determine if any employee is exposed to a daily noise dose of 0.5 or above (50 percent or above). The American Trucking Association (Ex. 14-878, p. 3) suggested that the proposal gave insufficient guidance on when monitoring is required. In order to ensure that monitoring will be conducted when necessary, OSHA has stated conditions upon which employers must base their determinations.

In order to comply with this amendment employers must determine whether or not they need to monitor workers' noise exposures. The initial determination is based on any information, observation, calculations, or exposure measurements that indicate exposures are or may be at or above 85 dB. This includes personal noise exposure surveys, area noise surveys, and other information such as manufacturer's information about noise emitted from specific machines. The employer must also consider other factors which may tend to suggest noise exposures at or above a TWA of 85 dB. Such factors include employee complaints about noise, indications that employees are losing their hearing, or are finding that normal conversation between two people is very difficult when those attempting to communicate are facing each other in the work area at a distance of 2 feet (Ex. 1, Table 5; Ex. 31, Fig. 6-1). Employers shall make this determination at least every two years so as to identify any new employees in need of periodic noise monitoring.

The Agency received a number of comments favoring an initial determination as a practical approach to monitoring. Dr. Robert Benson, representing the American Iron and Steel Institute (Ex. 64-10, p. 11), stated that a preliminary screening method should be used to determine whether or not extensive measurements must be applied. S.E. Cyc for the Timken Co. (Ex. 14-978, p. 3) suggested that employers establish "noise centers" where noise samples could be made on a regular basis to see if certain areas need further investigation. The Evaporated Milk Association (Ex. 14-295, p. 2) suggested that Type III sound level meters could be used to make cursory measurements for such determinations. OSHA agrees that all of these methods could be appropriate.

John J. Ahern of General Motors Corp. (Ex. 14-883, pp. 8-9), as well as H. Grady Gatlin of the Air Transport Association (Ex. 14-860, p. 3), recommended area monitoring as a way to estimate employee exposure. Area monitoring is a good way to determine the need for further monitoring, and it is useful for planning engineering control strategies. However, since employees move around within the workplace, and since area measurements are not made at the worker's ear, area monitoring is not sufficient to describe actual worker exposures. Area monitoring would constitute compliance with the requirement for an initial determination, but not with the actual monitoring requirement.

It is intended that the initial determination direct the employer's attention to the workplace noise exposures. Because of the ubiquity of noise, it is contemplated that all employers covered by the standard will have to make initial determinations, yet only a small fraction of them will actually have to monitor their employees' noise exposures. The initial determination is essentially a screening device which balances the need to protect employees by measuring their exposures against the undue burden on employers if the standard were to require measurement of every employee's exposure. Such a requirement would result in the monitoring of many employees who do not have significant noise exposures. The final standard does not require the initial determination to be written. While it is thought that a written initial determination might force the employer to focus more on the rationale for deciding not to monitor, it was felt that in this case imposing such a requirement would result in an extremely large amount of paperwork due to the ubiquity of noise. It should be noted, however, that initial determinations which are incorrect do not protect an employer from a citation for failure to monitor employee exposures. There is little to gain from incorrect initial determinations and it is expected that initial determinations will be carefully done.

The proposed standard required annual monitoring. However, some commenters suggested less frequent monitoring. The J.I. Case Company (Ex. 189-1, p. 3) suggested every 2 years, and John Stenmark of the American Iron and Steel Institute recommended every 3 years (Ex. 2C-126, p. 4). In the final amendment the proposed annual monitoring requirement has been relaxed to every 2 years. The Agency believes that monitoring every 2 years is sufficient, as long as additional monitoring is conducted whenever the employer has reason to believe that employees' exposures may have increased so that those not in the hearing conservation program would need to be included or that the attenuation provided by hearing protectors already in use is insufficient. Therefore the amendment requires employers to remonitor whenever there is an increase in the level or time of exposure sufficient to render an employee's hearing protectors inadequate. Monitoring more often than every 2 years will probably be unnecessary in industries where production processes change relatively little.

Some commenters opposed a requirement for periodic monitoring at all, especially in conditions where noise levels tend to be uniform over long periods of time. Groups such as the Air Transport Association (Ex. 142, p. 4-5), the American Iron and Steel Institute (Ex. 64-4, p. 3-4), and the Can Manufacturers Institute (Ex. 14-882, p.

12) believed that periodic monitoring was unnecessary unless there was a significant change in production process.

After considering these arguments OSHA has, in this amendment, required periodic monitoring for all industries, where initial determinations indicate exposures may equal or exceed a TWA of 85 dB, but has substantially reduced the frequency of the required monitoring. Periodic monitoring is necessary because noise levels tend to increase as equipment ages and wears, and in the absence of actual measurement employers are often unaware of these changes. Changes in noise level may cause workers whose exposures have been below a TWA of 85 dB to exceed that level, and therefore these workers would need the benefits of the hearing conservation program. Workers who have been exposed to a TWA between 85 and 90 dB may exceed the permissible exposure limit (PEL) and at this point the employer has an obligation to implement feasible engineering controls (or hearing protection whenever engineering controls are infeasible). Workers exposed above the PEL and whose exposures have increased may need additional hearing protection, such as an earplug with greater attenuation, or a change in type of protector. In addition, periodic monitoring is expected to serve an informational purpose since the amendment requires employers to inform employees of their exposures. Therefore workers will be reminded of the nature and extent of their exposures and will be better motivated to participate cooperatively in the hearing conservation program, and to wear properly fitted hearing protectors. (Ex. 147C, p. 335).

The monitoring procedure outlined in the final standard requires that once every 2 years the employer make an initial determination as to whether any of the employees may be exposed to a TWA of 85 dB. Even in the case of a negative initial determination, a new initial determination must be conducted every 2 years. If the initial determination is positive, then the employer must determine actual exposure through measurement.

In order to minimize the employer's burden while affording adequate protection to employees, the final amendment allows employers to measure fewer than all noise-exposed employees. The employer must select a group of employees who are engaged in a similar kind of work, and whose noise exposures are expected to be similar. The employer must then select for monitoring the worker within this group whom he or she reasonably believes has the highest noise exposure. When this employee has been monitored, his or her noise exposure is attributed to and written on the record of each member of the group. If the employer finds that the monitored employee's noise exposure is so high that it does not accurately reflect the exposure of other members of the group the employer may, of course, divide the group into smaller subgroups and pick an employee within that subgroup to monitor. This employee's exposure may be attributed to the rest of the employees in the subgroup. Of course nothing in the amendment prevents the employer from monitoring the exposures of all employees.

The proposal required additional monitoring with 30 days of any change or modification of equipment or process, or other workplace or work practice modifications affecting the noise level. There was considerable debate about this requirement. Some companies, such as the Outboard Marine Corporation, (Ex. 14-242, p. 4), pointed out that noise levels in their facilities were constantly changing from day to day. Others agreed (Air Transport Association, Ex. 14-860, Attach 2, p. 3; National Concrete Masonry Association, Ex. 14-247, p. 4; Oklahoma General Contractors, Ex. 14-306, p. 1) and stated that remonitoring should not have to occur unless there was a "significant" or "substantial" change in exposure levels. The Can Manufacturers Institute (Ex. 14-862, p. 12) equated a "significant increase" with an increase in level of 5 dB or greater. Many witnesses supported the 30-day "grace period" in which to remonitor when a significant change had occurred (Ex. 14-287, p. 2; Ex. 14-306, p. 1), but some recommended longer periods. Bill Johnson, representing Keystone Steel and Wire (Ex. 14-232, p. 1), suggested that 30 days was insufficent due to limited personnel and time constraints. William Hughes, representing the Composite Can and Tube Institute (Ex. 14-984, p. 4), supported monitoring within 90 days of a change in process so that employers could be sure that new conditions were not temporary, and that they had stabilized.

In response to these arguments the Agency has relaxed the proposed requirements for additional measurements. OSHA agrees that it is unreasonable and unnecessary for purposes of deciding who should be included in the hearing conservation program to require employers to remonitor with *any* change in exposure level since work environments will often change from day to day. The Agency does not intend employers to have to monitor workers' exposures continuously, but to monitor whenever changes in exposures are sufficiently great to require new hearing protectors or, for those employees who are not already in the hearing conservation program, to require training, audiometric testing, and the availability of hearing protectors. To minimize the need for interim monitoring, employers should take the periodic noise measurements on days when workplace conditions are noisiest, and plan the hearing conservation program accordingly. Due to potential feasibility problems, the time period for interim monitoring has been lengthened to 60 days. The Agency recognizes that employers who use consultants may have a scheduling problem and thus has provided this longer period. However, employers are urged to remonitor sooner than 60 days whenever possible, in order to minimize the time during which employees might be subjected to higher noise exposures without adequate protection.

This option of representative sampling is consistent with many comments in the record, and was generally supported by General Motors and Alcoa. Mr. Ahern of General Motors Corporation (Ex. 14-883, pp. 8-9) said that monitoring every employee was costly and unnecessary. Mr. Cyc. (Ex. 14-978, p. 3) suggested that employers could sample the noise exposures of certain groups of employees in an area and use the average of those samples. Thomas Bonney of Alcoa Corporation (Ex. 14-969, p. 2) suggested that monitoring a representative sample of employees be allowed when noise dosimeters are used. The draft California Noise Standard (Ex. 321-50A, pp. 5-6) recommended the following: "Where several employees work at the same job, the daily noise dose may be measured for a representative sample of employees and the highest noise dose thus determined shall be considered representative of all such employees in the group." OSHA believes that the provisions of the final standard are responsive to these suggestions and that a method such as this effectively reduces the monitoring burden but still provides adequate protection for employees.

The proposal did not explicitly provide how soon a new employee should be monitored. The Agency recognizes a need for such an explicit requirement so as to identify employees who need audiometric testing and ear protection. If employers wait until the regular biannual monitoring employees might not be identified for up to two years. Therefore the amendment requires new employees to be monitored within 60 days of their first exposure to noise at or above a TWA of 85 dB.

The need for actually monitoring new employee exposures would depend upon the circumstances. If the new employee replaces an employee who did the same job, the old employee's noise exposure measurement may represent the new employee's measurement until the next biannual monitoring. If the new employee is assigned to a work activity for which employee exposure measurements have been made, that exposure would then be attributed to the new employee. If the new employee does not replace anyone, and does not become part of a group with a measured representative, the employer must do an initial determination and, where the determination is positive, must measure the exposure of the new employee. In either case the new employee must be apprised of his or her noise exposure, (which is actually the representative noise exposure) within 21 days of the determination.

Initial monitoring of all employees exposed to a TWA above 85 dB shall be completed within 180 days after the effective date of the amendment. This extra time has been provided because the Agency recognizes that a great many employees will need to be monitored. Although many employers already possess noise measuring equipment, and have an ongoing monitoring program, most of the 2 million employees exposed to TWAs between 85 and 90 dB (Ex. 192, pp. 2-7) will not have been monitored previously. Those employers who have not monitored before will need to purchase or rent equipment, or engage consultants to perform the monitoring. It is felt that this extra time, when added to the delayed effective date of the standard, will not result in an undue burden on employers or tax available equipment and services. Initially OSHA will accept previous monitoring results done within the past two years if they are done in accordance with this amendment.

Employee Notification

The hearing conservation amendment requires employers to notify workers of their noise exposure individually and in writing within 21 days of the monitoring. Each worker shall be notified of his or her own exposure, or of the exposure of the measured employee who represents the group.

The proposal required the employer to notify employees within 5 days of the time the employer discovers overexposure. Comments to the hearing record generally favored longer time periods because of administrative difficulties (Ex. 105, p. 8; Ex. 145, Comments p. 5; Ex. 14-215, p. 3; Ex. 14-223, p. 8; Ex. 14-308, p. 4). Therefore the Agency has relaxed the requirement to 21 days from the time of monitoring. It is the Agency's belief that the additional time will minimize administrative difficulties without significantly lessening employee protection. For example, in the event that a consultant takes the measurements the longer period will allow for communications between the consultant and the employer. Also, this period should allow the employer sufficient time to include the written notice in the employee's pay envelope. Periods longer than 21 days are not satisfactory since employees need to know the nature and extent of the hazard as quickly as possible in order to carry out their responsibilities in the prevention of adverse effects. The grace period now extends from the time of the monitoring rather than the time the employer discovers "overexposure" so as to discourage long delays or lapses of communication between employers and their technical staffs or consultants.

The proposal required employees whose exposures exceeded the prescribed noise levels to be notified "of such excessive exposure." Employers were required to keep a record of each employee's noise dose, which would be accessible to the employee. The proposal did not specifically require that employers notify employees of their actual exposures, but the accessibility of the record partly fulfilled that function. The final amendment modifies this requirement in that the employer must notify each employee of his or her actual exposure, or of the exposure of the employee who is representative of his or her exposure.

The amendment clarifies the proposal's requirement for employee notification since it is important for workers to know more than merely whether or not they are overexposed. This is especially true for purposes of a hearing conservation program where much of the burden of protection falls on the employee. By informing workers of their actual exposures, employees will have a better understanding of the extent of the hazard, and in many cases will be better motivated to wear their hearing protectors effectively. A worker who is told that his or her TWA is 103 dB will have a better sense of the need for protection than will a worker who is only told that he or she is exposed above the permissible level (90 dB) or the action level (85 dB). Since the field use of hearing protectors shows significantly lower average attenuation values than laboratory tests would indicate (Ex. 308, p. 27; Ex. 301, p. 35; Ex. 300A, p. 91), and since the worker is the only one who can know on a continuous basis whether the protector fits snugly, it is very important that the worker be properly apprised of the hazard.

Method and Accuracy of Measurement

In order to evaluate employee noise exposure accurately, OSHA has established specific requirements for instruments and techniques to be employed in measuring noise. In some instances the amendment requires that measuring instruments adhere to, and calibrations be performed according to, consensus standards developed by the American National Standards Institute (ANSI). In other instances the amendment specifies exactly the steps that employers must follow in order to meet a certain requirement. These specifications are considered necessary in order to standardize and evaluate the measurement results.

By specifying minimum requirements for noise measuring instruments the Agency believes that it will better identify those workers needing audiometric testing and will help ensure that those workers requiring hearing protectors because of a significant threshold shift will be given protectors with proper attenuation to afford them adequate protection. Other elements of the program are also dependent upon accurate noise measuring instruments, namely measurements of sound levels inside audiometric test rooms, audiometer calibration, and the calculation of hearing protector attenuation. Moreover, it should be noted that these specifications merely provide a floor, or a minimum level of compliance. Employers are always free to use instruments that are more precise or more sophisticated than the ones specified in the amendment.

The use of consensus standards, such as those of ANSI, is supported by section 6(b)(8) of the Occupational Safety and Health Act, which calls for the Secretary of Labor to explain the reasons why any rule adopted by OSHA differs from any existing national consensus standard. Although the Agency recognizes that ANSI standards are revised periodically, the amendment refers to specific standards by number and year. In the event that a referenced ANSI standard is revised, the Agency will consider proposing a revision to the noise standard whenever the Agency believe that the revision is necessary and feasible for industry.

The hearing conservation amendment permits noise exposure measurements to be made either with a noise dosimeter or a sound level meter. Sound level meters must meet the Type 2 requirements of the American National Standard Specification for Sound Level Meters (ANSI S1.4–1971) (R1976)), and they must be set to the A-weighting network and the "slow" meter response. An appropriate sampling strategy must be used in order to measure accurately the employee noise exposure. Appendix B has been provided to advise employers of an acceptable strategy. Appendix B is intended as a guideline; reasonable alternatives that will ensure sufficient numbers of measurements for the range of sound levels encountered may also be used. All sound levels between 80 dB and 130 dB must be included, as specified in Table G–16a, in computing noise dose or TWA from measured sound levels.

The amendment also permits the use of dosimeters to measure the noise exposure of employees. The use of dosimeters is preferred in situations where there is a significant component of impulse noise, because the dosimeter can integrate all noise levels automatically, whereas individuals who use a sound level meter and a stopwatch are likely to miss certain transient sounds. Therefore, in situations where there is a significant impulse noise component, a dosimeter can be expected to result in more accurate exposure data than can be obtained using a sound level meter. It is also important to note that, in most industrial settings where the noise levels are not constant, the use of a dosimeter will be less burdensome than the use of a sound level meter. Nevertheless, employers have the option of using a sound level meter providing it is used in a manner which, like the procedures suggested in Appendix B, ensures the maximum accuracy.

Two years after the effective date of this amendment dosimeters must meet the requirements for Class 2A–90/80–5 according to the American National Standard Specifications for Personal Noise Dosimeters (ANSI S1.25–1978) (Ex. 313). "Class 2" corresponds to Type 2 tolerances of ANSI S1.4–1971 for sound level meters; "A" refers to the A-weighting network; "90" refers to the 90 dB level at which an 8-hour exposure yields 100 percent of the allowable dose; 80 refers to the lower cutoff or threshold below which the dosimeter does not respond, and "5" refers to the exchange rate between noise level and duration. Dosimeters must have an "operating range," as defined in ANSI S1.25–1978, from 80 to at least 120 dB, and in addition they must meet the requirements of section 7.5 of ANSI S1.25–1978 for a test signal at an average sound level of 90 dB, when the signal has a "crest factor," also as defined in ANSI S1.25–1978, of 30 dB.

Crest factor is the ratio of the peak sound pressure to the average sound over a specific time period. The "crest factor capability" of an instrument indicates the maximum crest factor for which the instrument meets specified tolerances. Since section 7.5 of the ANSI standard requires a crest factor of approximately 10 dB above the upper limit of the operating range (which must be at least 120 dB), such instruments will be capable of including short-duration sounds up to 130 dB in the integration. The final standard requires that dosimeters meet an additional test beyond that required by section 7.5 of the ANSI dosimeter standard. The additional test using a signal with a 90-dB average sound level and a 30-dB crest factor has been included to ensure the proper integration of short duration sounds having peak levels that are considerably higher than the average sound level. Because not all existing dosimeters can be adjusted to meet these specifications, the requirement for a lower threshold of 80 dB and a crest factor capability of 30 dB are not mandatory for 2 years. Until that time, employers may conduct monitoring with existing dosimeters using a lower threshold setting as low as the instrument permits. In addition, during this interim period dosimeters without a crest factor capability of 30 dB may be used.

The proposal permitted the use of dosimeters with accuracy and precision equivalent to that of a sound level meter, but specific performance requirements were not given, chiefly because no performance standard existed at that time. This led the Can Manufacturers Institute to point out (Ex. 14–962, p. 13) that dosimeter performance was suspect in the absence of a performance standard.

In 1978 the Acoustical Society of America completed and published an American National Standard Specification for Personal Noise Dosimeters, ANSI S1.25–1978 (Ex. 313). The standard was submitted to the public record, and the public was invited to comment on it. There were no adverse comments on the document. The existence of this concensus standard greatly facilitates the specification of noise dosimeter performance for use in conjunction with this amendment.

Considerable general support for the use of dosimeters is found in the record (Ex. 2A, p. 252, 9–25–73; Ex. 14–969, p. 2; Ex. 14–952, p. 2; Ex. 2C–117–1, p. 4; Ex. 14–247, p. 4; Ex. 315, p. 3730; Ex. 310, 40760). Dr. Floyd Van Atta (Ex. 2A, p. 2,5–9–73) pointed out the advantages of dosimeters when sound levels vary throughout the workshift. There is also specific support in the record for incorporation of the performance requirements of ANSI S1.25–1978 (Ex. 321–15, p. 3; Ex. 321–17, pp. 1, 2; Ex. 321–19, p. 1).

The American National Standard Specification for Personal Noise Dosimeters, S1.25–1978 (Ex. 313, p. 4) in itself, does not sufficiently define dosimeter performance since several operational parameters are left for the user to define. For example, the operating range can be quite different for purposes of community noise as opposed to industrial noise measurement, (such as 40–90 dB or 80–130 dB respectively). For measurements to be made in conjunction with this amendment, a Class 2A–90/80–5 dosimeter is required; this corresponds to the accuracy requirements of a Type 2 sound level meter, and to A-weighted response, and thus is consistent with the performance requirements for a sound level meter in the proposal. Similarly, the 90–dB level for 100 percent dose and the 5–dB exchange rate are consistent with the proposal. The class designation defines tolerances, frequency weighting, criterion sound level (meaning the 100 percent dose level), threshold level, and exchange rate. It is also necessary to designate the operating range—the range between the threshold level and an upper sound level within which the dosimeter operates within stated tolerances.

Noise dosimeters designed in the past few years, and particularly those designed since S1.25–1978 became available, have an operating range that extends, at least, from 90 to 115 dB if those dosimeters were intended for monitoring compliance with 29 CFR 1910.95 (a) (Ex. 319A–8, p. 22; Ex. 319A–2, p. 2).

The proposed standard did not specify a lower threshold. However, the 80–dB requirement is included in the amendment to permit reliable measurement of noise doses down to 50 percent (a TWA of 85 dB).

There are several suggestions in the record that support upper limits for dosimeters that are well in excess of 115 dB. The draft California noise standard (Ex. 321–50A, p. 6) recommends an upper limit of at least 130 dB. Mr. Eldred, as chairman of the working group that is responsible for the ANSI standards for both sound level meters and dosimeters, suggests (Ex. 321–19, p. 3) an upper limit "in the region of 115 to 140 dB." Col. Johnson introduced (Ex. 321–21E, p. 1) a draft ANSI standard on the effect on human hearing of intense (impulse or impact) noise, that considers average A-weighted sound levels of up to 142 dB. Kamperman (Ex. 321-32, p. 1) advocated a dynamic response from 80 dB to "greater than 140 dB and preferably greater than 150 dB."

OSHA has considered all of the factors and recommendations cited above. Because of the known adverse effects of high-level noise on human hearing, it would be very desirable to require dosimeters to integrate sound levels accurately up to 140 dB or higher. However, an informal survey of dosimeter manufacturers indicated that many of the instruments currently on the market could not easily be modified to operate accurately over a dynamic range from 80 to 140 dB. In order not to rule out the use of existing dosimeter designs, OSHA has decided to require dosimeters that meet the performance requirements of ANSI S1.25-1978 only over an operating range from 80 to 120 dB. (As discussed above, a dosimeter that accurately integrates average sound levels up to 120 dB should be able to handle peak instantaneous sound levels up to approximately 130 dB.) In the purchase of new dosimeters, employers are encouraged to consider instruments that have a larger operating range than that which is required by this amendment. OSHA intends to follow closely the availability of instruments having a larger operating range (e.g., 80 to 140 or 150 dB) and will consider amending the standard to require a larger operating range when such instruments become more readily available.

T. A. Rockwell (Ex. 321-47, p. 1) correctly pointed out that noise dose will, in some cases, be significantly higher when impulses are included in the calculation. He contrasts sound level meter measurements using the "fast" response mode with those using the "slow" response mode. By using the "fast" mode one is able to ignore the contribution of impulses and report only the level of the background noise.[11] The hearing conservation amendment requires that noise exposures be measured with a standard sound level meter set to the slow response or a dosimeter with a crest factor capability of at least 30 dB.

[11] The current standard indicates that employee exposure should be measured with a standard sound level meter "at slow response." Thus the PEL under 29 CFR 1910.95(a) is, by definition, that total amount of noise that is reflected by measurement with a standard sound level meter set to the slow response. A recent revision of the Industrial Hygiene Field Operations Manual directing compliance officers to use the "fast" mode to measure noise where there is both continuous and impulse noise present is clearly at variance with the present standard and is being deleted.

Use of this instrumentation will, as Mr. Rockwell asserts, include the impulsive component of the total noise exposure in the calculation of the dose. This result is intended. As stated above (see discussion of impulse noise), for purposes of determining which employees should be included in the hearing conservation program it is important to consider the employees' total noise exposure: continuous, intermittent, and impulsive. The dosimeter specified in the final standard is capable of integrating impulse noise accurately into the total dose. Appendix B provides guidance to employers on an appropriate sampling strategy when using a sound level meter to measure exposure even where impulse noise is present.

John Stenmark, for the American Iron and Steel Institute (Ex. 321-15, p. 2) and Mr. Kamperman (Ex. 296, p. 1) suggested that public hearings be held to permit consideration of the exposure requirements for impulse noise. As discussed above, the final decision has not been made on the PEL, which includes the exchange rate and any specific requirements for impulse noise. Until that time, the Agency does see the necessity of including impulses in the computation of dose for purposes of the hearing conservation program.

The evidence submitted to the record supports OSHA's conviction that implusive noise must not be ignored—that it is as harmful to hearing as continuous noise of equivalent sound energy, and that it is especially harmful when it is combined with high levels of continuous noise. Dr. Van Lee (Ex. 294, p. 1) points out that the superposition of impulsive or impact noise is very common in industrial noise environments. Dr. Lee recommends extending Table G-16 to include the computation of impulsive noise. The evidence also supports the conclusion that instrumentation that will include impulses in the noise dose is currently available. Kamperman (Ex. 321-32, p. 2) found that several units of one dosimeter model could meet a fairly rigorous test to incorporate the energy from impulses. Although he conducted the test on one model only, he stated that engineers employed by other manufacturers believed that his "dynamic response test requirement was reasonable and meaningful although they had not actually performed the test on (their) dosimeters."

In the present amendment, the total noise dose must include intermittent and impulsive contributions, as well as continuous sound levels. Instrumentation requirements must be consistent with this intent and therefore noise dosimeters and sound level meters must be capable of handling intermittent and impulsive signals with proper accuracy. Although the scope of the American National Standard Specification for Personal Noise Dosimeters, S1.25-1978, states that this standard is not intended for use with noises that are "predominantly" impulsive, the Agency recognizes, based on its experience, that most industrial impulses are superimposed on a background of continuous noise, and therefore, would not be considered *predominantly* impulsive. However, there are many industrial situations where impulses exceed the continuous background noise by more than a few decibels. Therefore, there is a need for instrumentation with crest factor capability sufficient to measure these impulses. Since such a test is not available in ANSI S1.25-1978, this amendment includes a crest factor test that is conducted according to the method described in section 7.5 of the ANSI standard. This test is necessary to ensure that dosimeters used to measure employee exposure meet the needs of the standard.

Section 7.5 of ANSI S1.25 requires that the dosimeter respond with an accuracy of ±1.5 dB to a tone burst having a crest factor of approximately 3 (which, being a ratio, translates to approximately 10 dB). For a dosimeter with an operating range of 80 to 120 dB, this test signal would be applied at an average level corresponding to 85 dB and also at 119 dB. Such a test should assure that the instrument functions properly for an average sound level of 85 dB with instantaneous peak levels up to 95 dB and for an average level of 119 dB with peaks up to 129 dB. For many instrument designs, these tests would assure proper operation for an average level of 85 dB with peak levels up to 129 dB, thus yielding reliable readings for continuous sound levels with high crest factors due to impulsive content. However, some dosimeter designs could result in an instrument that could not record a rapidly increasing sound level (such as that commonly associated with impulse noise), thus resulting in erroneously low dose readings, or an instrument that could not record the rapid decrease in sound level after an impulsive event and therefore would yield erroneously high doses. To preclude such possibilities, OSHA has added an additional test using a test method from the ANSI standard. The Agency is requiring a dosimeter that is capable of performing the function required by the standard:

namely, the integration of sound levels from 80 to 130 dB. Thus, the amendment requires that the test included in Section 7.5 of S1.25-1978 also be carried out with a signal corresponding to an average sound level of 90 dB but having a crest factor of 30 (approximately 30 dB). The instrument reading must be correct to within ±1.5 dB, which is the tolerance stated by the ANSI standard. OSHA anticipates that most instrument manufacturers will conduct the test and specify in their brochures whether the instrument meets it. According to Kamperman (Ex. 321-32, p. 2) there is currently available at least one dosimeter that meets a similar test which OSHA believes is more stringent than the test which is being required herein.

Although there are some instruments currently available that meet the new provisions, (e.g. Ex. 319A-8, p. 22), there are others where adjustments would have to be made, and still others that would not be usable for compliance with this amendment after the end of the 2-year period. OSHA advises employers who already own noise dosimeters to consult the specifications and, if necessary, the distributor or manufacturer, to learn the extent to which their dosimeter complies with the new regulations. The amendment allows employers up to 2 years in which to check their existing instruments, have them adjusted if appropriate, or obtain new ones. The Agency has provided this 2-year grace period also for the sake of manufacturers, who may need to alter the design of their instrument and manufacture new models.

There were some comments in the record that questioned the accuracy and reliability of noise dosimeter measurements (Ex. 14-46, pp. 1-3; Ex. 14-161, p. 3; Ex. 14-978, p. 3; Ex. 321-15, pp. 3, 4; Ex. 321-28A, section 18, pp. 1, 2). Stenmark cited a number of articles that describe in detail the problems of erroneous results from noise exposure evaluations using personal dosimeters (Ex. 321-15, pp. 3, 4). However, all but one of these articles were published before 1978, the date of the ANSI dosimeter standard. In fact, two of the authors cited were members of the ANSI work group that drafted the dosimeter standard. The introduction to ANSI S1.25 states that the standard should "help minimize variations between results obtained with various makes and models . . . (of dosimeters)" (Ex. 313, p. 1). Moreover, the employer has the option of using sound level meters to measure employee noise exposure, although, where noise levels fluctuate, they are admittedly more difficult to use. In addition, NIOSH made a strong case for the use of dosimeters, which will be discussed below.

OSHA believes that some of the problems experienced in the past may have been due to the fact that different models of dosimeters had slightly different lower thresholds, crest factors, and ranges. The Agency has determined that OSHA's new requirements for the 80-dB lower threshold and the 30-dB crest factor capability should minimize discrepancies among these instruments.

The DuPont Company expressed a number of concerns about the use of dosimeters (Ex. 321-28A, Section 18, pp. 1, 2). Among their concerns was the fact that dosimeters are not identical to sound level meters in such respects as meter ballistics, microphonics, and system diffraction characteristics. Naturally the two instruments are different in some ways because the dosimeter carries out a function automatically that must be done by the measurer when a sound level meter is used. Also the dosimeter is worn on the body of the individual whose exposure is to be measured, whereas the sound level meter is carried by the measurer. Therefore, the measurement locations would be slightly different with respect to the sound source. OSHA does not believe that these kinds of differences should cause significant differences in measurement results, so long as measurements with each instrument are taken properly.

DuPont was also concerned (Ex. 321-28A, Section 18, p. 1) that none of the existing hearing loss criteria are based on studies correlating dosimeter measurements with audiometric test results. Only sound level meters were used. OSHA believes that this fact should not detract from the use of dosimeters for compliance purposes since dosimeters and sound level meters are expected to produce the same results when properly used. Moreover, record evidence indicates that the company already uses dosimeters as part of their hearing conservation program (Ex. 300, Section (2B, p. 4). The company manufactures and sells dosimeters as well, claiming that their product "is designed to accurately measure and record personal noise exposure . . ." (Ex. 319, A-21, cover).

Many of the concerns about the use of dosimeters have been addressed by NIOSH in its "Findings of Fact on Use of Noise Dosimeters" (43 FR 3729 (1978)) (Ex. 315). NIOSH supported the use of dosimeters for making noise exposure measurements in coal mines. On the basis of evidence presented at its hearing, and on other available information, NIOSH made certain significant findings, which are summarized below:

1. Field and laboratory comparisons of personal noise dosimeters with other noise survey instruments or systems meeting ANSI S1.4-1971 tolerances for Type I or Type II instruments, indicate that noise dosimeters will yield comparable results to these other noise measurement instruments.

2. Inadvertent and extraneous noise may be integrated by personal noise dosimeters, thus, affecting dosimeter readings; however, this problem can be minimized by spot checking of noise levels with sound level meters, or by full-shift observation of the measurement by a "qualified" person.

3. Instrument errors (including calibrator error) are less than 1 dB, and these errors combined with other possible errors associated with microphone placement and calibration drift will be withing the ±2 dBA tolerance permitted by the Mining Enforcement and Safety Administration for purposes of citing noise violations (Ex. 315, pp. 3730, 3731).

OSHA recognizes that some people will prefer to use a sound level meter and a timing device, rather than a noise dosimeter, to determine employee noise dose. For continuous sound levels and relatively immobile workers, this is an acceptable procedure. Hess, Reed, Jensen, and Jokel (Ex. 303, p. 717) report that careful sampling techniques used in conjunction with a sound level meter can yield noise exposure data with an accuracy that approaches that of a dosimeter. However, such techniques, which involve following a worker around with a sound level meter held near his ear, taking many measurements, and making involved calculations, may necessitate expertise and time that many employers will not want to provide.

If a sound level meter is used, an appropriate sampling strategy must be used in order to determine the noise dose with adequate accuracy (Ex. 303, pp. 718-719). Appendix B has been provided to advise employers of an acceptable strategy. Since Appendix B is intended as a guideline, reasonable alternatives may be used. The number of necessary measurements will depend primarily upon the range of sound levels. In most circumstances, the greater the range, the more measurements will be needed. It is the employer's obligation to assure that the sampling procedure is adequate. The sampling procedure detailed in Appendix B is a simplification of a procedure developed by Hess, Reed, Jensen, and Jokel (Ex. 303). Except for the inclusion of impulsive sounds, Appendix B is similar to the sound level meter measurement method found in the proposed revision to the ISO standard 1999 (Ex. 321-43, pp. 11-20).

It has been stated (Ex. 321-47, pp. 1-2) that in certain conditions a noise dosimeter overestimates the noise dose relative to that which would be obtained using a sound level meter and timing device. OSHA believes that this situation should not occur for the following reasons: A dosimeter essentially consists of a sound level meter followed by a circuit that integrates the proper function of the A-weighted sound level. When only a sound level meter is used, sufficient data as to the temporal distribution of sound levels must be taken so as to enable the integration to be done numerically. Assuming that each instrument performs accurately and that the microphone positions are the same, the noise dose obtained with a dosimeter and that obtained using a sound level meter and a timing device should agree when the daily noise exposure is the result of several essentially constant sound levels, each experienced for an easily determined duration. OSHA has observed this kind of agreement in its compliance experience. In such cases, the noise dose can easily be obtained with a sound level meter using Table G-16a and the procedures given in Appendix A, I. However, if the sound level varies over a range of more than a few decibels and, particularly, if the sound level undergoes rather rapid excursions due to intermittent or impulse noises, it can be very difficult to obtain accurate noise doses using a sound level meter and a timing device. If the sound level is fluctuating more or less randomly, without sudden rapid excursions, a sampling strategy and calculation procedure such as that described in Appendix B can result in reliable determinations of noise dose.

OSHA therefore concludes that a properly calibrated dosimeter reads the correct dose but that the use of a sound level meter, for intermittent noise or noise with significant impluse content, may lead to an *underestimate* of the correct dose.

Microphone Placement

There are three popular methods for positioning a microphone to monitor noise:

(1) The microphone (typically on a dosimeter) is located near one of the employee's ears (on the shoulder), usually occupying that position for the entire workday.

(2) The microphone is maintained near the employee's head, with the measuring instrument (typically a sound level meter) usually held by an individual who follows the employee during a portion of the workshift.

(3) The microphone is placed at a fixed location in the workplace.

OSHA requires that the microphone be placed according to either Method 1 or Method 2. As mentioned earlier in this preamble, Method 3, area monitoring, cannot be used to determine personal exposure. While Method 3 may be useful for planning engineering control strategies, area monitoring alone is not sufficient to assess employees' personal exposure. Workers move around too much for this method to be accurate.

The use of either Method 1 or Method 2 requires consideration as to whether or not it is necessary to specify more precisely the actual microphone location and orientation. The NIOSH criteria document (Ex. 1, pp. 1-5) required measurement at the "appropriate head position," and the Advisory Committee (Ex. 2B, p. 1) required the microphone to be located at the point that most closely approximates the noise levels at the employee's head. The proposal required the noise to be measured at the employee's point of exposure. Comments in the record suggested a more specific location and microphone orientation than was stated in the proposal. One, for example (Ex. 2C-72, p. 1), wanted the microphone placed on the head using a free-field microphone and a random incidence corrector with the axis of the microphone perpendicular to the floor. Another (Ex. 14-231, p. 2) stated that the microphone should be positioned 12-18 inches from the head. The American Speech and Hearing Association (Ex. 2C-14, p. 3) recommended that a free-field microphone and random incidence corrector be used, and that the microphone be held at various angles of incidence and an average taken. Other comments called for OSHA to specify a standardized microphone position (for example, Ex. 166, p. 5).

In the noise exposure standard for surface and underground coal mines, (30 CFR Part 70 and Part 71; 43 FR 40760-40762 (1978)) (Ex. 316, p. 40761), the Department of Labor's Mine Safety and Health Administration (MSHA) requires dosimeter microphones to be positioned as follows:

> For the miner whose noise exposure is under consideration, noise exposure measurements shall be made with the personal noise dosimeter microphone located at the top of the shoulder, midway between the neck and the end of the shoulder with the microphone pointing in a vertical upward direction. . . .

MSHA's standard shows a diagram to facilitate compliance with the requirement. The standard's preamble justifies the requirement by citing studies that show the importance of exact and standardized microphone positioning for "limiting measurement errors associated with body baffle and absorption effects."

OSHA agrees that uniform placement of the dosimeter microphone is good measurement practice in order to minimize error. However, the Agency is aware that different kinds of microphones need to be placed at different angles of incidence with respect to the sound source. Also, the advent of newer, smaller microphones (½ inch and ¼ inch in diameter) may tend to reduce errors caused by microphone directionality, and positioning may become less critical. Miniaturization of dosimeters in the future may lead to their placement on the ear or on the top of the head (positioned on a helmet or a headband). OSHA does not want to preclude the development of more advantageous positioning techniques by requiring microphone placement only on the shoulder. However, the Agency does recognize the need for uniformity of placement of most 1-inch microphones. Therefore, unless the dosimeter manufacturer specifies otherwise, the Agency strongly recommends positioning the 1-inch microphone midway between the neck and the end of the shoulder with the microphone pointing vertically upward, as required by MSHA. In order to retain some flexibility to respond to technological advances, the amendment only requires the dosimeter microphone to be placed somewhere on the employee's shoulder or head.

In addition, because of the diversity of working situations, OSHA has decided not to specify an exact location for the microphone of the sound level meter. Instead the amendment only requires employers to position the sound level meter microphone not less than 2 inches nor more than 2 feet from the worker's ear. Care must be taken to be close enough so that the measurements are representative of what the worker actually hears, but not so close that the body acts as a baffle or a reflector. Again, OSHA advises the employer to follow the manufacturer's instructions concerning the microphone's angle of incidence with respect to the sound source.

There was some discussion in the record as to whether measurements should be made with or without the worker present. The Institute of Noise Control Engineering (Ex. 14-334, p. 2) stated that the measurements should be made without the worker. The proposal was unclear on this point but could be interpreted to mean either with or without the worker present.

Whenever an object (a worker) is placed in a sound field, it distorts the field to some extent and the measured sound level will be different from that which would be measured if the object were not there. Measuring the noise in the worker's absence may be preferred for the development of engineering solutions to the noise problem of a particular machine. However, since actual exposure takes place in the worker's presence, OSHA requires measuring the noise in the presence of the worker for purposes of the hearing conservation amendment.

Calibration

To check the calibration of a sound level meter or noise dosimeter an acoustical calibrator, of known frequency and sound pressure level output, is connected to the sound measuring instrument, and a test is made at least at a single frequency and sound level. The appropriate controls, such as amplifier gain, on the instrument are then adjusted, if necessary, so that the instrument reads correctly, within certain tolerances, for that test signal. This procedure is often called "field calibration."

The proposal required such calibration before and after each day's use. Also, the MSHA amendments to 30 CFR Part 70 state that dosimeters "shall be acoustically calibrated in accordance with the manufacturer's instructions before and after each shift on which the meter is used" (Ex. 316, p. 40761). There was some discussion in the record of the proposal's requirement for daily field calibration.

Some commentors, such as the International Paper Company (Ex. 14-345, p. 2) and the California Manufacturer's Association (Ex. 14-169, p. 2) believed that daily field calibration would take too long. Others such as Clayton Ruyle of Aerospace Industries Association of America, (Ex. 105A, p. 7) said that it was impractical to calibrate a dosimeter before and after daily use. However, OSHA's requirement was supported in comments by Dr. Bruce Karrh on behalf of the American Occupational Medicine Association (Ex. 321-34A, p. 1), and the Motor Vehicle Manufacturers Association (Ex. 2C-1, p. 6). Washington Occupational Health Associates, Inc. (Ex. 321-49, p. 1) stated: "We encourage the application of uniform calibration procedures which will work to the advantage of all parties involved." It has been the experience of OSHA personnel that field calibration of a sound level meter can be done in a matter of seconds, and that a dosimeter can be calibrated in a few minutes.

The Agency has determined that the advantages of daily field calibration warrant any inconvenience that might be experienced. Such calibrations are necessary to assure any degree of accuracy or uniformity in employee noise exposure measurements, which are a crucial and integral part of the entire hearing conservation program. Therefore, the amendment requires that an acoustical calibrator shall be used to verify the calibration of all equipment used to measure employee noise exposure prior to and after each day's measurements. In establishing this requirement OSHA believes that:

1. the accuracy of the instrument will be less subject to question when it is field calibrated at least before and after each day's measurement;

2. if meter/dosimeter performance does drift over the time between field calibrations, only one day's data will be lost;

3. it is good acoustical practice to check instrument performance as often as practical.

Although the amendment does not require calibration *immediately* prior to and following each day's use, it is good measurement practice to calibrate as close as possible to the time of instrument use.

In the broadest technical sense, the "calibration" of noise-measuring equipment involves precise evaluation of instrument performance relative to the specified ideal performance. Such calibration is a complex procedure that should be carried out in a sophisticated laboratory with specialized facilities by skilled people knowledgeable in acoustics and electronics. The amendment requires that instruments used to measure employee noise exposure—the noise dosimeter and the sound level meter—conform to ANSI S1.25-1978 for noise dosimeters, or ANSI S1.4-1971 for sound level meters. In order to ensure that instruments continue to meet the ANSI standard, it may be necessary for them to be calibrated in a laboratory.

The amendment does not specify how often the laboratory calibration should take place. Prudent practice requires that instruments, should be kept well maintained, that the manufacturer's instructions concerning maintenance and upkeep should be carefully followed, and that instruments should be carefully tested at appropriate intervals by the manufacturer or by a qualified laboratory to ascertain that their performance meets specifications. The intervals between laboratory calibration would depend upon the amount of usage. Based on the Agency's estimates of the frequency of monitoring according to the size and type of the company, OSHA estimates that employers will send noise measuring equipment for laboratory calibration approximately every 2 years. Instruments that are used often, or are inadvertently bumped or dropped, should be calibrated more frequently, as should instruments that require frequent and extensive adjustment as a result of the field calibration.

NIOSH presents support for this type of requirement in its "Findings of Fact on Use of Noise Dosimeters" (43 FR 3729 (1978)) (Ex. 315, p. 3730).

> Most failures are attributable to microphone interferences resulting in an inability of the instrument to achieve calibration tolerances. Thus, there is a need for annual recalibration of personal noise dosimeters including as a minimum frequency response testing and visual inspection of the microphone for any foreign matter or defects.

Another Federal agency, the U.S. Department of Transportation, Federal Highway Administration, recommends that "The Equipment should be checked annually by its manufacturers or other certified laboratory to verify its accuracy." (Ex. 321-42A), p. 7).

Although the proposed standard was silent on the subject, OSHA agrees with MSHA, NIOSH, and the Department of Transportation, on the merits of periodic recalibration of noise-measuring instruments. However, the Agency does not require that these tests be conducted at any particular time interval because the appropriate intervals between calibrations are highly dependent upon instrument usage. Some businesses will use the instruments only occasionally, and store them in between uses. These instruments may maintain their calibration for longer periods of time if they are cared for according to the manufacturer's instruction.

Although the proposal required acoustical calibrations to be accurate to within plus or minus 1 dB, the amendment has not made this 1-dB precision and accuracy mandatory. However, a draft American National Standard Specification for the Performance and Use of Acoustical Calibrations has been prepared (Ex. 321-17B), and when this standard is issued, employers are encouraged to use acoustical calibrators that conform to it.

Audiometric Testing Program

Audiometric testing is an integral part of hearing conservation. Since the hearing loss process tends to occur gradually, a worker often does not realize that he or she is developing a hearing loss until quite a bit of damage has occurred. Because noise-induced permanent threshold shift is not reversible, it is very important to identify it as early as possible in order to prevent further deterioration. If it is not identified, the hearing loss will continue and the resulting impairment will be even more debilitating. Audiometric testing, to identify employees who are losing their hearing and to try to prevent further hearing loss, is therefore necessary to reduce the risk of material impairment.

Not only does audiometric testing establish a baseline and a continuing record of hearing acuity, but it provides the employer a tool with which to educate employees about the importance of hearing conservation (Ex. 2A, p. 1-101 8-9-73). It also provides workers with information about their hearing acuity and the need for protection. A well run audiometric testing program will document the extent to which the entire hearing conservation program is effective.

In the words of Dr. John Fletcher, professor at the University of Tennessee Medical School:

> Another essential in hearing conservation programs is monitoring audiograms. To restate the obvious, these are periodic hearing tests after the worker has begun work or after he has started this program. These are important because they give us some feedback about the effectiveness of the program. They are necessary, we need that effectiveness. (Tr. 210).

Dr. Norman Righthand went on to say:

> The effectiveness of an industrial hearing conservation program is dependent upon proper assessment by audiometric testing. The accuracy of such testing is a function of many factors, including the training and experience of the audiometric technician, background noise levels, and the cooperation and attention of the persons being tested. Of equal importance is the state of calibration of the audiometer. (Ex. 281, attach 1, p. 1).

This amendment requires testing of employees who are exposed to an 8-hour time-weighted average sound level of 85 dB (or equivalently a dose of 50 percent) or more. Baseline audiometric tests must be administered, then retests must be performed annually. Employees who experience significant shifts of hearing thresholds with respect to the baseline test must be retested within 60 days. Baseline and retest audiograms must be preceded by at least 14 hours free from workplace noise. Follow-up procedures are required in cases where a significant threshold shift is permanent. Medical or audiological referral is required in caes where the test results are ambiguous, or where medical problems are suspected. Requirements for personnel, audiometric testing, follow-up procedures, audiometric test rooms, test frequencies, instrument specifications and calibration are specified. These requirements are addressed in the following paragraphs.

Personnel

The hearing conservation amendment requires that certain functions be performed by a licensed or certified audiologist or otolaryngologist, or in the absence of one of these specialists, a qualified physician. This professional is responsible for administering the audiometric tests or supervising the conduct of the tests by technicians, for ensuring that the audiometer is properly calibrated and that the tests are conducted in a room that is sufficiently quiet, and for reviewing audiograms, making a determination as to whether a hearing loss is work related, and determining the need to refer employees for further evaluation. Under certain circumstances employees will need to be evaluated more thoroughly than can be done on-site. Sometimes resources may not be available through the industrial audiometric program, and employees must be sent to a physician or an audiology clinic in the community. For example, although the supervising professional may be an audiologist, he or she may determine that the employee needs an otological evaluation by a physician. On the other hand, the professional supervisor may be an otolaryngologist, who may determine that the employee needs further audiological evaluation in a facility where more sophisticated audiological equipment is available.

The proposed standard did not require that an audiologist or otolaryngologist supervise the program. A wide range of opinion about this issue was expressed. Some recommended that licensed or certified otologists or audiologists supervise audiometric testing as opposed to technicians (Ex. 14-172, p. 2; Ex. 14-68, p. 4; Ex. 14-243, p. 4; Ex. 129, p. 4; Ex. 147, p. 7; Ex. 81A, p. 9). Others who regarded audiometric testing as a medical program said that only a physician should supervise (Ex. 14-156, p. 1; Ex. 2C-113, p. 1; Ex. 2A, p. 154, 5-30-73). Dr. Robert McLauchlin, of the American Speech and Hearing Association (ASHA) recommended that only audiologists supervise audiometric testing because of their extensive knowledge of audiometric testing (Ex. 2C-83, p. 3).

Either licensed or certified audiologists or otolaryngologists should supervise the audiometric testing program since these professionals are highly trained in hearing loss and are familiar with audiometric protocol. Individuals who are knowledgeable of audiometric configurations and the associated causes, are in the best position to assess the validity of audiograms and the need for medical referral, and to assess work relatedness by interpreting the results of the audiometric test. Although other physicians also may supervise the audiometric testing, it is recommended that audiologists and otolaryngologists be used because they are likely to be more knowledgeable of audiometric procedures and the patterns of hearing loss.

The amendment requires that these individuals review the audiograms to determine the existence of threshold shifts and to determine whether the shifts are due to occupational noise exposure. Since many large companies and consulting firms may wish to computerize the audiometric test results, the supervising professional does not need to review actual audiograms, so long as a professional is involved in preparing the computer program. In this way the professional will be able to determine what kinds of audiograms need to be identified for review, and review the results on a selective basis. For example, audiograms that show large losses at 500 Hz, or audiograms where there is a substantial difference in hearing thresholds between ears may need to be reviewed, as well as audiograms that show significant threshold shift, as defined below.

OSHA advises employers to see that the audiometric testing program is well supervised by either an audiologist or otolaryngologist, although the professional does not need to be present at the time of testing. Although technicians may actually conduct the audiometric tests, they must be under the direction of the professional who is responsible for the proper conduct of the tests, and the calibration of equipment. In cases where the validity of the audiogram is in question, or when problems of a medical nature are suspected, the professional must decide whether another test, or referral is necessary. Examples of cases where medical referral would be appropriate are audiograms that show large differences in hearing thresholds between the two ears, or predominantly low-frequency hearing losses. Examples of cases where retesting would be indicated would be unusual hearing loss configurations, thresholds that are not repeatable, and invalid results on self-recording audiometers. Another good use of the audiologist, otolaryngologist, or other qualified physician supervising the testing would be in the training and counseling of employees with significant hearing threshold shifts, because they will be able to answer employee questions.

The hearing conservation amendment requires that appropriate professionals or trained audiometric technicians administer the audiometric tests. This is similar to the proposal's requirement for certified audiometric technicians or individuals with at least equivalent training and experience. There was some discussion in the record concerning the qualifications of the person actually administering the test. Most commenters, such as Dr. McLauchlin (Ex. 129, p. 4) and others (Ex. 2C-22, p. 1 and attach., p. 2; Ex. 2C-31-1, p. 2; Ex. 2A, 157, 5-30-73, Ex. 2B, p. 6) stated that the tests should be conducted by physicians, audiologists, or trained audiometric technicians. OSHA's decision to require appropriate professionals or trained audiometric technicians to administer the tests is consistent with the proposal and the above comments. While OSHA believes that the quality of testing should be as professional as possible, the Agency recognizes that a well-trained technician can do a satisfactory job. Aside from the actual test procedures, the tester must recognize when the audiometer is not working properly and know what to do about it, and should be familiar with the proper testing conditions. The tester must be able to check the functional operation of the audiometer, although he or she is not necessarily required to perform an acoustical calibration.

Employers must be able to show that technicians are competent in the administration of hearing tests and in the care and use of audiometers. One of the best ways for technicians to achieve this competence is to successfully complete a course that is especially designed for the training and certification of audiometric technicians. Such courses usually will include sessions in the anatomy and physiology of the ear, the hearing mechanism, causes of hearing problems, different types of audiometric configurations, care and use of the audiometer, daily checking of the audiometer's functioning, administration of valid audiometric tests, selection and fitting of ear protection, and recordkeeping. These topics are covered by courses that are specified by the Council of Accreditation of Occupational Hearing Conservation (CAOHC) (1619 Chestnut Ave., Haddon Heights, N.J. 08035) (Ex. 319-B4) or the Guidelines of the Inter-Society Committee on Audiometric Technician Training, (see American Industrial Hygiene Association Journal, Vol. 27: 303, May-June 1966) (Ex. 4, p. 37775). The Agency recognizes that more extensive training courses are available, and therefore, that the CAOHC and Inter-Society courses should be considered minimum curricula. The Agency strongly advises that technicians be given a refresher course at least every 5 years. The frequency of retraining necessary would be dependent upon the degree of supervision provided by audiologists or otolaryngologists, with technicians who are more closely supervised needing less retraining. Professionals with advanced degrees, such as audiologists and physicians, need not be certified as technicians.

The Agency advises (but does not require) that an otoscopic examination be conducted before audiometry as well as before the fitting of hearing protectors. This examination can be conducted by a professional supervisor or a trained technician. This practice, suggested by Dr. Thomas (Ex. 102 sec. 9 pp. 26-29), is helpful to ensure that the ear canal is not blocked with excessive wax which would preclude accurate results on the hearing test and accurate fitting of hearing protectors.

Employees To Be Included in the Program

All employees who are exposed to an 8-hour time-weighted average sound level of 85 dB or greater must be included in the audiometric test program, except for those who work less than 4 months (120 days) for one employer. This 120-day delay means the length of time from the start to the termination of employment; it is not variable or dependent upon duration of exposure, that is, the number of days or hours within the 4-month period actually worked. All employees who are subject to the noise standard, including those engaged in part-time work for less than 35 hours a week, as well as temporary workers who work for a given employer for more than 4 months are required to be tested if their TWAs exceed 85 dB.

There was considerable concern over the proposal's requirement to test within 90 days, which would have required the audiometric testing of all seasonal employees (the Larsen Company, Ex. 2C-8, p. 1; the Michigan Canners and Freezers Association, Ex. 14-279, p. 1; the American Frozen Food Institute, Ex. 14-512, p. 2; and other organizations (Ex. 2C-11-1, pp. 2-4; Ex. 2C-15, p. 3; Ex. 14-867, p. 2; Ex. 15-38, p. 2; Ex. 184, p. 3; Ex. 188-4, pp. 1-2)). Commenters stated that audiometric testing for seasonal employees would not be useful or protective, because these workers are located at several job sites in a season or over the year which makes monitoring their hearing very difficult. The decision in the final amendment to allow 120 days for the baseline audiogram is in response, at least in part, to the comments and objections raised by the above groups.

The Agency believes that allowing employers 4 months in which to perform the baseline audiogram, will have the effect of excluding most temporary and seasonal emplyees. OSHA has allowed the 4-month period, at least in part, as an administrative convenience so that employers who use distant consulting services for audiometric testing need only schedule the mobile van three times a year or less. Also, the Agency believes that it would be fruitless to require a testing program for workers who move from job to job because follow-up testing would be difficult or impossible.

However, OSHA does not believe these workers should be unprotected merely by virtue of the relatively short tenure of their employment. Therefore, all workers exposed to a TWA of 85 dB or above must be offered a variety of personal protective equipment and encouraged to use it, and must be educated in the hazards of noise.

Audiometric Testing

Audiometric testing consists of measuring an individual's hearing level at various frequencies in both ears. An audiogram, which is a graph showing hearing sensitivity at each frequency, provides a record of the status of that individual's hearing. When new audiograms are compared to previous audiograms, a picture of an individual's hearing sensitivity over the course of years emerges. It is important that employers observe all of the standard's requirements concerning the various components of the testing program to ensure that the test results are valid and can be compared in a meaningful manner.

There are three types of audiograms. The first is the baseline against which all other audiograms will be compared. The second is the annual audiogram, which serves to identify individuals who are developing hearing loss, and to track the effectiveness of hearing protectors and other hearing conservation measures. The third is the retest audiogram, which is required when there appears to be a significant threshold shift, or if there is any doubt about the accuracy of an audiogram.

Baseline Audiograms

The baseline audiogram is extremely important since it is the reference against which future audiograms are compared in order to determine the extent to which an employee's hearing is deteriorating. If the baseline audiometric test is not conducted properly, it will not reflect the employee's true thresholds, and any real changes between baseline and future tests may be masked. For example, if the baseline audiogram is not taken after at least 14 hours of relative quiet, it may include some temporary threshold shift (Ex. 102, sec. 9, p. 5; Tr. 2340–2341), and hearing thresholds would be somewhat inflated. Consequently, differences between the baseline and subsequent annual audiograms would appear to be less than if the baseline had been accurate. This process would mask the true amount of hearing loss. Therefore, employers must follow the requirements of the amendment to ensure the accuracy of the baseline audiogram. OSHA requires that workers must have been away from workplace noise for at least 14 hours before the baseline audiometric test is conducted so that the baseline will accurately reflect the employee's hearing thresholds.

The hearing conservation amendment requires baseline audiograms to be established for new employees within 4 months of an employee's first exposure to noise at or above a TWA of 85 dB. The proposal required baseline audiograms to be established within 90 days for all employees. NIOSH (Ex. 1, p. I-5) and Dr. Larry Royster (Ex. 102, sec. 4, p. 12) suggested that less time be allowed before the baseline. As explained above, OSHA has chosen the 4-month grace period, which gives employers an opportunity to exclude seasonal employees. OSHA has determined that to delay audiometric testing of employees longer than 4 months, as suggested by the American Frozen Food Institute (Ex. 164, pp. 3–4) and General Foods Corporation (Ex. 2C-105, p. 2) would not be appropriate since employees might begin to incur hearing loss. To safeguard the purity of the baseline audiogram as much as possible, employers are advised to encourage all employees exposed to a TWA at or of 85 dB to wear hearing protectors until the baseline test has been performed. (All employees exposed over the PEL must already be wearing ear protectors, if engineering and administrative controls are not sufficient to reduce their exposure). Employers are encouraged to conduct pre-employment baseline audiogram where possible. Both employers as well as employees may benefit in the long run from this practice. Early testing would probably provide the employer with a more accurate indication of the effectiveness of the hearing conservation program. Early testing also will identify, at a stage where there can be no question, individuals whose hearing losses are not attributable to noise exposures within that particular workplace.

For employees presently exposed to a TWA of 85 dB or above a baseline audiogram must be obtained within 1 year of the effective date of this amendment. The Agency has allowed this amount of time because many employers will be initiating hearing conservation programs for the first time, and will need additional time to make preparations. Employers whose audiometric testing programs already meet the requirements of this standard may use audiograms taken before the effective date of the amendment to fulfill this requirement.

There are two circumstances recognized in the amendment in which the baseline audiogram must be revised. This is a change from the proposal, which had no provision for revising the baseline. Comments submitted by Dr. Royster (Ex. 321-22D, pp. 5, 47; Ex. 321-22E, p. 40), and by R. V. Durham, director of Health and Safety for the International Brotherhood of Teamsters (Ex. 81A, p. 1), discussed cases where subsequent audiograms reveal better thresholds than the original baseline. It was suggested that this might be due to a "learning effect" where an individual becomes slightly more skillful at taking the test. Or it can be caused by a reduction in temporary threshold shift due to the beneficial effects of hearing protection. The amendment requires that when a subsequent audiogram shows improved thresholds in at least two test frequencies with respect to the baseline, this later audiogram becomes the new baseline audiogram, and subsequent audiograms must be compared to it. The Agency believes that the audiogram with improved thresholds must more closely resemble an employee's true, non-noise-exposed baseline, and that significant threshold shifts would be detected that might otherwise have been overlooked by using this audiogram from as the revised baseline. Of course the old baseline audiogram must be retained, according to the recordkeeping requirements to be discussed later in the preamble.

Where the retest or annual audiogram is considered to be free of TTS, e.g., when it is conducted after 14 hours free from noise, the audiogram may show a deterioration in thresholds with respect to the baseline due to the harmful effects of noise exposure. If the change in threshold is "significant" (as defined in the amendment and discussed later in this section) the audiogram with the reduced thresholds shall become the baseline audiogram and subsequent audiograms will be compared to it. This provision is in response to a number of comments, which pointed out the futility of identifying the same significant threshold shift year after year, even though the hearing loss may have stabilized, an unintended result of the way the proposal was worded (Ex. 317, p. 3; Ex. 321-1, p. 2; Ex. 321-24A, p. 9; Ex. 321-38, p. 3). Revising the baseline each time a new significant threshold shift occurs should prevent this problem.

Annual Audiograms

The annual audiometric test has a number of purposes. It detects shifts in hearing level, indicates the need for followup procedures identifies employees who are particularly susceptible to noise-induced hearing loss, monitors the effectiveness of hearing protectors, and detects medical problems.

OSHA proposed that employers test their employees' hearing annually. Dr. McLauchlin (Ex. 2A, p. 1-101, 8-9-73), the Architectural Woodwork Institute (Ex. 127, p. 2), and many other organizations and witnesses supported annual testing (Ex. 2C-2, p. 2; Ex. 2C-31-1, p. 2; Ex. 81, p. 9; Ex. 14-166, p. 1; Ex. 102, sec. 4, p. 12; Ex. 29-2, p. 3; Ex. 110, p. 3; Ex. 321-50, p. 9). NIOSH (Ex. 1, p. I-6) and some others (Ex. 130, p. 5; Tr. 2138) favored testing every 2 years since it was postulated that a period of this length is needed to identify shifts that are truly significant.

OSHA has chosen to retain the annual audiometric test requirement because of the potential seriousness of the hearing damage that can occur within a 2-year period. For employees exposed to high levels of noise, a 2-year period between audiograms might allow too much hearing loss to occur before identifying the loss and taking remedial steps. Annual audiometric tests can aid employers and workers in detecting temporary threshold shifts before they become permanent, and they can also detect minor threshold shifts before they become significant. In both cases increased awareness of the hazard reflected by the audiometric test results will lead to more prompt protective action, and as a result more hearing will be saved.

The proposal required that all audiograms be conducted after 14 hours of quiet. This provision has been modified in the final rule to allow annual audiograms to be taken anytime during the workshift. This is consistent with the recommendation of Jeffrey

Morrill, President of Impact Hearing Conservation, Inc. (Ex. 293, p. 1), and may result in increased employee protection in that audiograms taken during the workshift are likely to show TTS. Since TTS is a harbinger of permanent threshold shift (Ex. 198–27, sec. 11, attach., p. 730), it is an important symptom or warning sign, and protective measures can then be taken before the change in threshold becomes permanent. Some employers may find this procedure more convenient than testing before the beginning of the workshift. Employers are encouraged to conduct annual audiometric tests during the workshift since the early identification of TTS can result in the prevention of permanent hearing loss.

Retest Audiograms

In cases where the annual audiogram reveals a significant threshold shift, the employee must be retested within 60 days. The retest must be performed after at least 14 hours free from workplace noise. The purpose of the retest after 14 hours of relative quiet is to determine the extent to which the significant threshold shift is permanent. Hearing protection and educational steps may be taken to prevent a temporary loss from becoming permanent, and to prevent a permanent loss from progressing. Also, the Agency recommends that a medical history be taken at the time of the retest. This may be in the form of a simple questionnaire that should contain questions relevant to the employee's work and auditory history. The purpose of the history is to aid the professional reviewer in making determinations of work relatedness, and the need for medical or audiological referral.

Although NIOSH (Ex. 1, p. I–6) had recommended a retest within 60 days, the Advisory Committee (Ex. 2B, p. 8) and the proposal required the retest within 30 days. However, OSHA received some negative comments on the 30-day retest provision. Individuals such as Dr. J. Ronald Bailey of North Carolina State University (Ex. 2C–33, p. 6) recommended a period of 60 days within which to retest employees. Companies such as the International Paper Co. (Ex. 14–344, p. 3) maintained that a 30-day retest period is impractical since it creates a hardship for employers who must rely on mobile audiometric test vans, which may not always be available. OSHA had decided that 60 days is an appropriate period within which to require retests. Professionals who must review the audiograms, might not be available within a shorter time frame; time would therefore be needed to send the audiograms to the professional, have them reviewed, and then reschedule the mobile van for any necessary retests. While some employers may choose to send employees to a local hospital or audiology clinic instead of rescheduling a mobile van, this may not always be possible in small towns or rural locations. In any event, to provide the employer maximum flexibility, 60 days are allowed for the retest audiogram.

A retest audiogram is not required if the annual audiogram is conducted after 14 hours free from workplace noise, because recovery from TTS would have occurred and the threshold shift can be presumed to be permanent under these circumstances. Although the Agency recommends the two-stage procedure, OSHA does not require annual testing during the workshift and retest in the event of significant threshold shift in order to distinguish temporary shifts from permanent shifts, since scheduling large numbers of retests may pose a feasibility problem in some cases, and employers may choose to perform all audiometric tests before the workshift. Employers may be able to use this two stage approach by scheduling the retest for the next morning before workers are exposed to noise.

Significant Threshold Shift

A definition and an understanding of what OSHA considers to be a significant shift of hearing threshold is very important in the proper implementation of the amendment's requirements. Without such a definition workers and employers are unable to know the seriousness of the noise-induced hearing loss.

Identifying a threshold shift as significant means that it is outside the range of audiometric error (±5dB), and it is serious enough to warrant prompt attention because it is a precursor to material impairment of hearing. When threshold shifts are significant, employers must provide and fit hearing protection, and take other remedial actions depending upon whether or not the shift is permanent.

The definition of the term "significant" is critical to the effective operation of the hearing conservation program. If the definition is too stringent, spurious threshold shifts may occur and workers will be identified because of audiometer or technician error. If the definition is not stringent enough, workers will be allowed to lose too much hearing before protective actions are taken. Correctly identifying significant threshold shifts of hearing is particularly important for workers who have already begun to lose their hearing, so that the progression may be stopped before the hearing loss becomes handicapping.

OSHA's proposed standard defined significant threshold shift as an average shift of more than 10 dB at the frequencies 2000, 3000, and 4000 Hz in either ear, relative to the baseline audiogram. These frequencies were selected with the understanding that hearing loss occurs earliest and most severly in the higher audiometric frequencies.

However, a number of witnesses criticized the leniency of the proposal's definition of significant threshold shift. The Environmental Protection Agency (Ex. 9, pp. 37, 41, 51; Ex. 5, p. 43802) and others (Ex. 51, pp. 10–11; Ex. 80, p. 2; Ex. 82, attach 1, p. 2) pointed out that under certain circumstances the proposal's definition would allow shifts of up to 30 dB at single frequencies.

According to Dr. McLauchlin:

> Workers should be identified when the first signs of noise induced threshold shift occur. With a more rigid criteria the risk of allowing workers to develop compensable hearing impairments is lessened. Further, a more stringent interpretation of "significant threshold shift" provides more adequate means for evaluating the performance of ear protective devices. (Ex. 129, p. 3).

Support for a more stringent definition of significant threshold shift is provided in the NIOSH Criteria Document (Ex. 1, p. I–6), which defined it as a shift that equals or exceeds 10 dB at 500, 1000, 2000, or 3000 Hz, or 15 dB at 4000 or 6000 Hz when that audiogram is compared to the most recent age-corrected audiogram. Some commentors such as John R. Franks of the Department of Audiology and Speech Services, Purdue University (Ex. 14–66, p. 3), and Donna Dickman, director of the Industrial Hearing Conservation Program at the Washington Hearing and Speech Society (Ex. 14–320, p. 2), suggested a very stringent definition, which was a 10-dB shift at any frequency from 500 to 4000 Hz. The Armstrong Rubber Company (Ex. 14–50, p. 1), Dupont Company (Ex. 306, sec. J2C, p. 6), and others (Ex. 2B, pp. 7–8; Ex. 14–289, p. 4), suggested more stringent threshold shift criteria (10 dB) at the lower frequencies of 500, 1000 and 2000 Hz, and larger values (up to 25 dB) at the higher frequencies of 3000, 4000 and 6000 Hz.

The Agency has chosen to use the more protective approach suggested by McLauchlin, Dickman, and Franks for workers who already have a hearing loss, while allowing a less stringent criterion for those with normal hearing. Thus, the amendment's definition of significant threshold shift reflects a "sliding scale" approach, with the amount of hearing loss constituting a significant threshold shift becoming smaller as the worker's hearing loss becomes greater. The use of a "sliding scale" for determining hearing loss was the result of suggestions to OSHA (Ex. 2B, pp. 7–8; Ex. 14–289, p. 4; Ex. 48, p. 16; Ex. 321–38, p. 2; Ex. 317, pp. 3–4) from various audiologists and others who were concerned about workers who have a pre-existing hearing loss or workers who have already demonstrated threshold shifts. Also, the Advisory Committee recognized the need for such an approach (Ex. 2B, pp. 7–8), by recommending a more stringent definition of significant threshold shift for employees whose hearing levels at any test frequency were worse than 25 dB.

Thus, the amendment requires that for employees whose hearing is within 25 dB of audiometric zero and who have not previously suffered a significant threshold shift, the significant threshold shift criterion is a fairly lenient one—a 20–dB shift at any frequency. For employees who have lost some hearing (more than 25 dB at any test frequency), the criterion is more strict—10 dB or greater at 1000 and 2000 Hz, 15 dB at 3000 and 4000 Hz, and 20 dB at 6000 Hz. For employees who already have a mild to moderate hearing loss (worse than 25 dB *average* at 1000, 2000, and 3000 Hz) or who have previously incurred a significant threshold shift, the criterion is a nore stringent 10 dB at any test frequency.

OSHA believes that this more complex definition of significant threshold shift will be more efficient, and more protective. Identification of spurious threshold shifts would be minimized by a fairly lenient (20–dB) criterion for workers whose hearing was within normal limits. Yet workers whose hearing had begun to deteriorate, in other words, those with less hearing left to lose, would be watched more closely as a result of the stricter criteria. In these cases employers would need to take protective measures. Making the criteria more stringent for workers who have lost some hearing would minimize the possibility of allowing progressive deterioration to go unnoticed in workers who change jobs frequently and may have constantly worsening baseline audiograms against which annual audiograms are compared.

Unlike the proposal, the amendment includes 1000 Hz in the definition of significant threshold shift because of its importance in the undertanding of speech, and the amendment also includes 6000 Hz in the definition because of its importance as an early indicator of noise-induced hearing loss. The amendment addresses each frequency separately instead of averaging them so as to avoid the situation where a worker might lose up to 30 dB at one frequency before the shift is considered "significant".

Like the proposal, the final hearing conservation amendment excludes the 500 Hz frequency form the definition of significant threshold shift. OSHA agrees with certain industrial audiologists (Ex. 317, p. 4), that the 500 Hz frequency does not need to be included in the criteria for significant threshold shift because hearing at 500 Hz is the last and least affected of any of the test frequencies (500 through 6000 Hz) as a result of noise exposure. By the time the hearing level at 500 Hz has shifted, all of the higher frequencies will have been affected more severely, and the worker would have suffered considerable hearing loss. Noise-induced hearing loss at 500 Hz alone is very unlikely to occur, even in workers who are exposed to predominantly low-frequency noise.

Aging

The hearing conservation amendment permits the application of an age (presbycusis) correction to the audiometric test results in order to discount the results of aging in determining whether a significant threshold shift has occurred. When applying an age correction, the most recent audiogram is corrected according to the procedures outlined in Appendix F. In this appendix, OSHA has adopted the procedures and the age correction tables used by NIOSH in the criteria document (Ex. 1, pp. I–14 to I–17).

Although the proposal does not address the issue, the record contains a substantial number of comments recommending the use of an age correction, many of which stated that hearing loss can occur from aging, nonoccupational noise, and other factors, and such hearing loss should not be considered part of a significant threshold shift within the context of the OSHA standard (Ex. 14–110, p. 2; Ex. 14–150, p. 2; Ex. 14–160, p. 2; Ex. 14–188, p. 1; Ex. 14–200, p. 1; Ex. 14–215, p. 3; Ex. 14–248, p. 3). Lawrence Hodge of the J. I. Case Company told OSHA that an analysis of approximately 40,000 audiograms from over 10,000 employees revealed that the proposed criterion for significant threshold shift was not appropriate without addressing presbycusis. He urged OSHA to adjust audiograms accordingly (Ex. 321–24A, p. 1).

The NIOSH criteria document (Ex. 1, pp. I–14 to I–17, III–6) recommended adjusting the baseline audiogram for hearing loss that occurs naturally due to the aging process. The adjusted baseline could then be subtracted from the most recent annual audiogram in order to determine whether or not a significant threshold shift had occurred. If employers wish to correct for aging, the amendment directs them to make the adjustment to the annual audiogram rather than to the baseline, so that the baseline will not be changed (and remain changed) by mistake. The NIOSH presbycusis values are similar to those of other well known presbycusis data bases. Although there may be slight variations at individual frequencies, the NIOSH values are generally consistent with other presbycusis data such as the U.S. Public Health Service data, and those used by Robinson and Burns, and by Passchier-Vermeer (found in "Derivation of Presbycusis and Noise Induced Permanent Threshold Shift (NIPTS) To Be Used for the Basis of a Standard on the Effects of Noise on Hearing", (Ex. 310, p. 31)). It is the differences in hearing level between age groups that actually form the age corrections.

OSHA is responding to employer's concerns that if a stringent significant threshold shift criterion is not coupled with an age correction, many people would be referred unnecessarily for follow-up. Employers need not use these corrections if they choose not to.

The Agency recognizes that many workers will be exposed to nonoccupational noise that could result in some amount of hearing loss. Most presbycusis data bases include some amount of nonoccupational hearing loss, although these populations usually are screened to avoid such cases to the extent possible. It would not be appropriate to include more than a small value for nonoccupational hearing loss in the age correction since these noise exposures vary greatly among individuals.

Follow-Up Procedures

When a significant threshold shift has been identified, the employee must be provided with and required to wear adequate hearing protection and be trained in how to use and care for this protection. If the threshold shift is shown to be temporary as a result of a retest audiogram, employees exposed to TWAs between 85 and 90 dB may discontinue the use of the hearing protection. However, OSHA advises such employees to continue to wear protectors as the fact that they have suffered TTS may indicate an increased susceptibility to noise. If the threshold shift is found to be permanent, employers must require workers to wear hearing protection. Workers exhibiting significant threshold shift have shown an increased susceptibility to noise; the permissible exposure limit is not sufficiently protective for them, and additional measures, such as ear protectors are needed to protect these individuals. In addition, the worker must be informed in writing of a permanent, significant threshold shift within 21 calendar days of the determination. Although the proposal did not require that notification be made in writing, Durham (Ex. 321-18, pp. 2-3), and those who prepared the draft California noise standard (Ex. 321-50, p. 9) recommended it. Durham stated that workers should be notified in writing "to prevent any misunderstandings or ambiguities . . ." (Ex. 321-18, pp. 2-3). A period of 21 days was chosen in order to give the professional reviewer time to interpret the test results and review previous audiograms. A period of 21 days should allow the employer the convenience of enclosing the notice with the employee's paycheck.

So as to make the notification more meaningful to employees Dr. McLauchlin (Ex. 2A, p. 103, 8-9-73) and others (Ex. 2C-83, p. 4; Ex. 81A, p. 8) urged that OSHA require employees to be informed of their hearing levels at the time of audiometric testing. Dr. Thomas (Ex. 102, sec. 9, p. 31) asserted that "this is the best time for a good individualized education program on a one-to-one basis and companies which fail to take advantage of this time are missing an excellent opportunity." At this time the employees are interested in their test results and can be shown a graphic display of their hearing sensitivity. Workers should be informed at the time of testing of *any* change in hearing level that is discovered, even if the threshold shift is not yet "significant." However, the Agency does not require this procedure in the final amendment because the individual giving the test may not have the employee's previous records available at the time.

The company must refer the employee for an audiological or otological examination under certain circumstances. The determination for this referral will usually be made on the advice of the professional reviewer. Follow-up examinations were not required by the proposal. However, the Agency agrees with suggestions from interested persons that such examinations are necessary under certain limited conditions. Employees must be referred under the following circumstances:

a. Sometimes an employee is unable to take a hearing test on a self-recording audiometer. He or she may not understand the directions, or may not be able to produce an audiogram that meets the requirement in section (ii)(E) of Appendix C, that at least six tracings or excursions must be made at each frequency for the audiogram to be considered valid. Fewer tracings would be indicative of very slow or uncertain responses, and the determination of hearing threshold would be questionable. Since the standard requires a valid audiogram, the test would have to be administered on a manual audiometer in order to obtain a valid audiogram for such an employee (Ex. 102, sec. 9; Ex. 321-1, pp. 2-3). If a manual audiometer is not available to the employer, the employee must be sent to a clinical audiologist or otolaryngologist for further testing.

b. In other cases the employee may not respond reliably to a test given on a manual audiometer (Ex. 321, p. 3). In such cases the employee must be retested. This may happen in situations where the employee has a language problem and has not understood the directions, or where an employee may have tinnitus (ringing sounds in the ears) that can interfere with taking the test, or occasionally where an employee may exaggerate the hearing loss. If upon retesting satisfactory results are not obtained, the employee must be referred to a clinical audiologist or an otolaryngologist for a diagnostic evaluation.

c. The supervising professional may feel that the audiogram is valid, but may suspect that the loss is due to a nonoccupational cause (such as ear infection or illness) (Ex. 321-1, p. 2); these suspicions may be based on an audiogram that reveals large amounts of low frequency hearing loss, large hearing threshold differences between ears, or some other audiometric configuration that is not typical of noise-induced hearing loss. Unless the employer is willing to enter the hearing loss as work related on the OSHA Form 200, the employee must be sent to an otolaryngologist or audiologist for further evaluation to attempt to ascertain whether the hearing loss is occupationally related.

OSHA recognizes that noise-induced hearing loss may not always be due to occupational exposure. Many people raised this point at the hearing (E. 14-160, p. 2; Ex. 14-188, p. 1; Ex. 14-248, p. 3; Ex. 144, pp. 2-3). However, since this amendment covers workers who are occupationally exposed to significant amounts of noise, the occupational loss can be expected to be the dominating component in most cases. Even though people may hunt or engage in noisy hobbies, most workers' NIPTS will be work related because the average person spends infinitely more time on a routine basis at work than in recreational activities.

d. A problem may arise where the employer or the supervising professional suspects that hearing protectors are either causing or aggravating an irritation or infection of the ear canal. The symptoms may include pain upon insertion of the ear plug, visible irritation of the ear canal, or draining ear, etc. The possibility of such conditions was reported by labor union witnesses (Tr. 2026-2027; Ex. 79, p. 7; Ex. 88, p. 7; Ex. 73, attach 4, p. 1). In this case the employer must refer the worker for an otological examination so that medical treatment will enable the worker to wear ear protectors comfortably and without any adverse medical consequences.

In some circumstances a medical pathology of the ear may be suspected that is clearly unrelated to the wearing of ear protectors. Examples could be infection or irritation prior to the fitting and wearing of protectors, or an otoscopically abnormal ear drum related to a cold or allergy. Regardless of the amount or kind of hearing loss, if the employer feels that an employee needs medical treatment, the employee should be informed of the need. In these cases the amendment does not require medical or audiological referral, but employers are advised to inform workers of the need for examination or treatment. (Ex. 321-1, p. 1).

Quiet periods

The amendment requires 14 hours free from workplace noise prior to conducting baseline and retest audiograms. Ear protection is not permitted as a substitute for this quiet period.

The proposed standard specified that audiometric tests (of any kind) must be preceded by at least 14 hours during which there was no exposure to workplace sound levels in excess of 80 dB. The requirement could be met by wearing hearing protectors.

OSHA received many comments favorable to requiring a quiet period prior to taking audiograms (Ex. 2A, pp. 51-54, 5-31-73; Tr. 2340-2341; Ex. 321-34, p. 2; Ex. 321-51, p. 10). Since the baseline and retest audiograms must not be influenced by temporary threshold shift, some time away from noise is necessary in order to allow the ear to recover. Therefore, baseline and retest audiograms will have to be conducted before the workshift. Morrill (Ex. 293, p. 1) supported the option of the using hearing protectors under controlled conditions to achieve the necessary quiet period. The draft California noise standard (Ex. 312-50, p. 10) also included this option. However, this amendment does not permit the use of hearing protections to fulfill the 14-hour quiet requirement since studies have shown (Ex. 300, p. 2; Ex. 300A, p. 91; Ex. 308, p. 27) that common fitting and wearing practices can greatly reduce hearing protector effectiveness. This reduction in effectiveness would contribute to the risk of contaminating the baseline and retest audiograms by temporary threshold shift, so that neither would reflect the emplyee's true hearing threshold levels.

The proposal specified a maximum workplace noise exposure level of 80 dB immediately preceding the baseline audiogram. The amendment does not specify any maximum noise exposure level for the 14-hour quiet period, since employers cannot be responsible for their employees' noise exposures away from work. If employees are in the hearing conservation program to begin with, their workplace noise levels would not meet an 80-dB exposure level without the use of hearing protectors, and therefore the testing would have to be performed before work. Employers should explain to workers why the audiometric tests must be performed after 14 hours of quiet and counsel them that it is in their best interest to avoid recreational noise exposures before baseline or retest audiometric tests.

There was some dispute about the appropriate length of quiet time necessary before the baseline and retest audiograms. The New York State Department of Labor (Ex. 2C-118, p. 2) recommended 48 hours, while most others stated that 14 hours was sufficient (Ex. 2B, p. 6; Ex. 321-34, p. 2; Tr. 2340; Ex. 2A, p. 51, 5-31-73,). While OSHA recognizes that workers with greater exposures will need longer periods of time to recover from TTS than will those who are exposed to more moderate levels, it has also been shown that the major portion of TTS disappears in the first few hours after cessation of exposure (Ex. 279, 11-6, pp. 987-990; Ex. 29, pp. 288-289; Ex. 188-27, sec. 11, p. 735). However, since it is not possible to specify an appropriate recovery time for each individual, OSHA has selected 14 hours as the most appropriate and protective period that is practical. The Agency recognized that some employees exposed to high levels of noise currently are wearing hearing protectors, and therefore they should have minimal TTS if the protectors are being worn properly. Since it is very difficult for employers to know if the ear protectors are being worn properly, and since it is very important for the baseline audiogram to be free of TTS, the amendment requires all employees to be away from workplace noise for at least 14 hours before the baseline and retest audiograms are taken.

The Agency has chosen the 14-hour period as an administrative convenience, since there are usually at least that many hours between the end of an employee's workshift and the beginning of the next shift. Employers who are unable to meet the 14-hour minimum quiet period between shifts (due to overtime or irregular schedules) may prefer to schedule the baseline or retest audiogram before work on the first day of the work week.

Audiometric Test Frequencies

This amendment requires that pure tone air conduction audiometric tests be performed for each ear at the frequencies 500, 1000, 2000, 3000, 4000, and 6000 Hz. This is consistent with the proposal, the NIOSH criteria document (Ex. 1, p. I-6) and the Advisory Committee (Ex. 2B, p. 8) recommendations.

While 500 Hz is not included in the definition of significant threshold shift, this frequency still is included among the required test frequencies in order to provide a more complete audiometric profile. The hearing threshold level at 500 Hz can be very helpful in assessing the validity of the audiogram as a whole since an unusual loss at this frequency can signal the need for a retest. Also, OSHA believes that the hearing threshold level at this frequency can provide important information about the health of employees, even though it is usually the last of the test frequencies to be affected by noise. Hearing loss at 500 Hz may be indicative of job related conductive hearing loss, which could possibly result from an adverse reaction to hearing protection, or from upper respiratory infections due to inhalation of irritating dust. Dr. Gene Del Polito of the American Speech-Language-Hearing Association explained why testing should include 500 Hz:

> 500 Hertz can add information that is useful in detecting most medical problems affecting the function of the outer and middle ears. Detecting these problems by way of hearing measurement could provide an additional measure for assuring the safety and health of the worker. Also, industrial accidents resulting in trauma to the auditory mechanism, such as punctured eardrums or disarticulated ossicles, may affect hearing more in the low frequency range than in the higher frequencies. (Ex. 291, pp. 1-2).

Dr. Joseph Sataloff (Ex. 2A, pp. 35-38, 5-10-73)) recommended the inclusion of 8000 Hz in the required audiometric test frequencies in order to more clearly delineate the characteristic noise-induced "notch," (where hearing levels at 8000 Hz are sometimes less severe than at 4000 or 6000 Hz). A number of comments to the Advisory Committee recommended against any requirement to test at 8000 Hz (Ex. 2C-41, p. 1; Ex. 2C-42, p. 1; Ex. 2C-46, p. 1; Ex. 2C-51, p. 1; Ex. 2C-52, p. 1). OSHA did not accept Dr. Sataloff's recommendation for two reasons. First, the calibration of 8000 Hz is often less stable than it is for other frequencies, and spurious results are likely to occur. Also, there are some audiometers that are incapable of testing at 8000 Hz, and the inclusion of this frequency would preclude their use under this amendment.

Audiometer Specifications

The amendment calls for equipment that meets the specifications of, and is maintained and used in accordance with the American National Standard Specification for Audiometers (ANSI S3.6—1969). Since the ANSI standard does not contain requirements for pulsed-tone and self-recording audiometers these requirements are found in Appendix C of the amendment. (Pulsed-tone and self-recording audiometers interrupt the tone signal automatically, whereas with other audiometers the interruption is performed manually). The requirements in Appendix C are essentially unchanged from those of the proposal.

The ANSI standard contains performance specifications for audiometers. It also contains calibration requirements, and specifications for audiometric zero with respect to sound pressure level at the different test frequencies. OSHA understands that microprocessor audiometers, which computerize the audiometric test are increasingly used by consultants and large companies. They are allowed by this amendment so long as they meet the performance specifications of ANSI S3.6-1969.

The proposal required that audiometers meet the specifications of ANSI S3.6-1969. There was some discussion in the record about the use of older audiometers that fail to meet the 1969 standard, but instead were calibrated to an earlier zero reference level established by the American Standard Association in 1951. Comments by Stenmark (Ex. 2C-134, p. 1) and Edwin Toothman (Ex. 145, attach 1, p. 8) expressed the opinion that industry should be allowed to continue to use existing audiometers conforming to the 1951 standard. Others, such as the American Speech and Hearing

Association (Ex. 129, attach 1, p. 2), the Environmental Defense Fund (Ex. 2C-125-1, p. 7), the Motor Vehicle Manufacturers Association (Ex. 2C-1, p. 9) and the Advisory Committee (Ex. 2B, pp. 8-9) supported adherence to the 1969 standard.

There is an average difference of 10 dB between the 1951 and the 1969 audiometric zero reference levels, the 1969 levels being lower (closer to 0 dB sound pressure level). Because the differences between the older and newer standards vary according to frequency (for example 9.5 dB at 1000 Hz and 5.5 dB at 4000 Hz), allowing both zero reference levels to be used would make it very difficult to compare an individual's audiograms that had been performed on different audiometers. It would also be very confusing for anyone wishing to assess the effectiveness of a hearing conservation program, especially since the criteria for significant threshold shift would have to be adjusted for each frequency. Since the 1969 ANSI standard has been in effect for 11 years, and since OSHA has estimated the average life of an audiometer to be about 10 years (Ex. 319A-60, p. 1; Ex. 319A-90, p. 1), the Agency assumes that there are very few audiometers in existence that are calibrated to the 1951 zero reference level. To the extent that audiometers calibrated to the 1951 zero reference level are still in use, some probably can be recalibrated to the 1969 zero reference level (Ex. 306, p. J5C-3). Therefore, the amendment requires that audiometers be calibrated to the zero reference level specified in ANSI S3.6-1969.

There was some discussion about the use of less common audiometric features, such as sweep-frequency and pulsed-tone types. Comments favored the proposal's requirements for discrete-frequency (as opposed to sweep-frequency) audiometers where the tone is presented in octave or half-octave intervals (Ex. 1, p. I-7; Ex. 2C-1, p. 9). Comments also supported the proposals's requirement that with pulsed-tone audiometers, the on-time of the test tone is at least 200 milliseconds (Ex. 1, p. I-7; Ex. 2C-1, p. 9). There was consensus that self-recording audiometers should be allowed in addition to the manual type, (Ex. 1, p. I-7; Ex. 2B, p. 9; Ex. 48, p. 12; Ex. 102, sec. 9, pp. 25-26, 51; Ex. 306, p. J1C-11; Ex. 2C-26, p. 2; Ex. 2C-30, p. 1; Ex. 2C-125-1, pp. 7-8).

NIOSH (Ex. 1, p. I-7) and the Advisory Committee (Ex. 2B, p. 9) recommended and the proposal required that self-recording audiometers should be subject to the requirements found in Appendix C. These requirements are necessary to ensure the validity of audiograms taken with self-recording audiometers.

Audiometer Rooms

Background sound levels in audiometer rooms must be quiet enough to permit valid measurements of audiometric thresholds. Too much noise can "mask" or artificially shift a subject's hearing threshold level. In other words, the tone would have to be significantly louder before the person could distinguish it from the background noise, making it seem as though the individual hears less well than he or she actually does. While this is not a good practice for any type of hearing test, it is especially serious with respect to the baseline audiogram. For example, a worker might enter a company with hearing as good as 0 dB at 1000 Hz. But background noise could mask this worker's hearing level at 1000 Hz by 15 dB, and cause the baseline to read 15 dB rather than 0 dB hearing level. In subsequent years the worker might actually lose some ability to hear at various frequencies, including 1000 Hz. Not until the worker had already lost more than 15 dB of hearing would any changes begin to show up on the audiogram. Then, the worker would have to have a hearing level of 35 dB (signifying a loss of 20 dB more), before the shift would be considered significant, under the amendment, and protective actions would be taken.

The Agency has determined that background levels in audiometer test rooms should be quiet enough to allow threshold testing to 0 dB hearing level. This is especially important in order to describe accurately the hearing levels of individuals who enter the workforce with hearing as good as 0 dB. According to the DuPont Company (Ex. 306, sect. J1C, pp. 8-9) "most young subjects will have extremely good hearing and will respond to the tone while the hearing dial is still at 0 dB threshold. In these cases it is good practice to obtain . . . responses . . . at these low levels." "Screening" audiometry, (merely registering positive responses at a specific level across frequencies) does not satisfy the requirements of this regulation because actual thresholds, and therefore valid threshold shifts, cannot be identified by this process. Baseline and periodic audiograms should reflect testing to the lowest audible level. These views have also been supported by industrial audiologists (Ex. 317, p. 2; Ex. 319B-2, p. 1; Ex. 319B-3, p. 3), and constitute good industrial audiometric practice, necessary to preserve workers' hearing.

In the proposed standard OSHA required that background levels in audiometric test rooms levels not exceed the following:

40 dB at 500 Hz
40 dB at 1000 Hz
47 dB at 2000 Hz
57 dB at 4000 Hz
62 dB at 8000 Hz

These levels, referenced to 0 dB sound pressure level, were taken from the American National Standard, Criteria for Background Noise in Audiometer Rooms, S3.1-1960.

The amendment retains the background levels specified in the proposal (as Table D-2 of Appendix D) for 2 years, and then imposes a more stringent background noise requirement for audiometric test rooms. After 2 years, background levels shall not exceed the following.

27 dB at 500 Hz
30 dB at 1000 Hz
35 dB at 2000 Hz
42 dB at 4000 Hz
41 dB at 8000 Hz

So that the professional reviewer will know that testing has been conducted in sufficiently quiet conditions, employers must record on employees' audiograms whether the test room meets the requirements of Table D-1 or Table D-2.

These background levels (with the exception of the 27-dB level at 500 Hz) are specified in the American National Standard for Permissible Ambient Noise During Audiometric Testing, S3.1-1977. This standard was submitted to the record as Exhibit 312 and public comment was invited on it (see 45 FR 26366, 4/18/80).

OSHA has required the more stringent background levels in audiometric test rooms which are outlined above to be as consistent as possible with the newer ANSI standard. In previous years, the older (1960) ANSI standard for background levels was presumed to be sufficient for allowing threshold testing to audiometric zero, based on the 1951 audiometric zero (ANSI S3.1-1960, p. 7). However, as mentioned above, audiometric zero was changed (made more stringent) in 1969, and therefore the old ANSI standard for background levels was no longer stringent enough to allow threshold testing to 0 dB. ANSI began revising the standard for background levels, but the new standard was not published until 1977. It is logical for this amendment to require the more stringent background levels so that workers may be tested to the 1969 0-dB hearing threshold level, which is now the nationally accepted norm for audiometric zero. (In fact, the proposal required the use of audiometers meeting the ANSI S3.6–1969 standard, which includes the 1969 zero reference level).

Although the 1977 ANSI standard for background levels specifies a maximum level of 21.5 dB at the 500-Hz frequency, OSHA has modified this requirement to 27 dB. This change was based in part on a number of recent submissions to the record by audiometric booth manufacturers, employers, and industrial audiologists, who maintained that they were unable to meet the new ANSI requirement of 21.5 dB at 500 Hz with existing equipment (Ex. 287, p. 2, Attach. 1, p. 1, Attach. 3, p. 1; Ex. 291, p. 2; Ex. 295, p. 1, Ex. 319–B1; Ex. 319–B2, pp. 1, 2; Ex. 321–15, pp. 1, 2). Alan Eckel, president of Noise Control Products and Materials Association (Ex. 287, p. 2) stated that ANSI S3.1–1977 was "a clinical research standard and . . . not intended for industrial hearing conservation purposes." However, there is no such distinction made by the ANSI standard (Ex. 312). While the ANSI standard maintains that the exclusion of all ambient noise is not necessary, the levels in the standard will permit measurement of hearing threshold levels as low as those specified in ANSI S3.6–1969, (as explained above) (Ex. 312, p. 1).

Also, the Agency realizes that since 500 Hz is not included in the definition of significant threshold shift, audiometric precision at this frequency is not as important as it is at the other test frequencies. However, is not appropriate to allow background noise up to 40 dB at 500 Hz, (as allowed by the older ANSI standard) since this amount of noise would be capable of masking thresholds at 1000 Hz. The decision to allow a sound pressure level of 27 dB is based on a study by Dr. James Jerger (Ex. 321–20, p. 387), which shows that background levels at 500 Hz may be raised approximately 5 dB without interfering with threshold testing at 1000 Hz.

William Vanke (Ex. 285, p. 2) referred to the statement in ANSI S3.1–1977 (Ex. 312, p. 1) to the effect that some testing programs may be met by measurements at test signal sound pressure levels higher than 0 dB referenced to ANSI S3.6–1969. The objectives of the audiometric testing program required by OSHA can be met by slightly higher levels at 500 Hz, but they cannot be met at higher levels for the test frequencies 1000 through 6000 Hz because these frequencies are used in the definition of significant threshold shift. Testing to 0 dB hearing threshold level is critical to the proper characterization of hearing level for persons with acute hearing, so as to correctly identify significant threshold shift, with the goal of preventing material impairment of hearing.

The amendment does not incorporate the entirety of ANSI S3.1–1977 by reference since the octave band levels at 500 through 8000 Hz stated above are the only ones necessary for the amendment's audiometric testing requirements (frequencies such as 125, 250, and 750 Hz are not included since testing is not required at these frequencies). Also, the amendment has rounded the levels stated in the ANSI standard to the next highest whole number, (e.g., at 1000 Hz the amendment requires 30 dB instead of 29.5 dB). Since the remainder of the ANSI standard consists mainly of appendices, which are not actually part of the standard, only the pertinent allowable levels as modified are included in the final standard.

Although the amendment does not require testing at 8000 Hz, (nor did the proposal), this frequency is included instead of 6000 Hz in the requirements for background sound levels. This is because ordinary sound level meters are not capable of measuring sound pressure levels for the octave band surrounding 6000 Hz. Therefore OSHA has listed the levels to permit testing at the 6000-Hz frequency even though they must be measured with the octave band filter set for 8000 Hz. This procedure was assumed in the proposal, since a 62-dB maximum level was required for audiometric testing at 6000 Hz, although the 8000 Hz frequency was specified for measurement with the sound level meter. The same rationale applies to the 41-dB maximum level to be measured at 8000 Hz setting after the initial 2-year period. Since most background noise tends to be predominantly low frequency, and also since high frequency sound is more efficiently attenuated by typical audiometric test booths (Ex. 312, p. 7), the amendment's requirement for maximum levels of high frequency noise are not expected to pose a feasibility problem.

Since some employers or consultants may need to retrofit their present audiometer rooms, (Ex. 319B–2, p. 2) or move them to a quieter location, the Agency has allowed them 2 years in which to make these changes. There may be cases where employers need to purchase new test booths, but OSHA believes that these cases will be rare because of the modification of allowable background noise made at 500 Hz.

Quieter booths of the double-walled variety are available but they should not usually be necessary since most factories have some kind of office space, where background noise levels are relatively low. Because none of the comments in the record mentioned difficulties at frequencies above 500 Hz, OSHA concludes that the 1977 ANSI requirements at these frequencies do not present significant problems. Measurements of background levels submitted by audiologist Sue Riggs (Ex. 295, p. 1 and Attachment) indicated some difficulties at 500 Hz, but the 1977 ANSI levels were met at other frequencies. Alan Eckel of Eckel Industries stated that "almost all audiometric booths currently used in industrial hearing conservation programs meet the requirements of the new ANSI standard at 1000 Hz and above. The lower frequencies are difficult to achieve". (Ex. 319 B–1, p. 1).

Measurements by Riggs (Ex. 295, Attachment) indicated that the 27-dB levels at 500 Hz could be met in many of the cases she cited, although the 21.5-dB level specified in ANSI S1.3–1977 could not. Reports by Berger et al. (Ex. 266A, p. 38) and NIOSH (Ex. 26–2, p. 23), showed that the 27-dB level usually was met in the conditions in which these investigators tested. The mobile audiometric van used by Burns and Robinson had a mean attenuation of 79 dB at 500 Hz from outside the vehicle to inside the booth (Ex. 12, p. 71), which when added to the 27-dB allowable level at 500 Hz, must have provided ample attenuation for any ordinary circumstances.

Audiometer Calibration

This amendment requires three types of audiometer calibration. First, the functional calibration of the audiometer must be checked before each day's use. Second, the audiometer's calibration must be checked acoustically with a sound level meter and earphone coupler at least every year. Finally, the audiometer must receive an exhaustive calibration at least every 2 years. In the first two instances the word "calibration" refers to a procedure by which the audiometer is checked to make sure that it is producing the correct level of pure tones at specific frequencies, and that the signals are free from distortion or unwanted sounds, which might lead to invalid audiograms. In the third type of calibration the instrument is thoroughly checked, and adjusted if necessary, so that it meets the ANSI specifications described below. In most cases this type of calibration must be performed in a laboratory or at the manufacturer's factory.

So as to ensure accurate audiograms, OSHA advises employers to measure the background sound pressure levels in audiometric test rooms periodically. Since the sound levels inside the room are greatly dependent upon the sound levels outside, employers should measure the room levels whenever there is an increase in outside sound levels that might adversely affect compliance with Appendix D. For example, Dr. Thomas (Ex. 102, Sect. 9, pp. 53–56) recommends making these measurements whenever a test room is relocated, or when noisy equipment is moved into the area of the test room.

Audiometer calibration is necessary in order to obtain valid audiograms, which in turn are critical since changes in hearing level initiate a number of different actions. There were many comments in the record supporting required audiometer calibrations. According to William Reich of Gen Rad Corporation, "An accurate and reliable audiometric testing program involves more than the simple purchase of a good audiometer. Periodic calibrations are an essential part of the audiometer program . . ." (Ex. 281, attach. 2, p. 86, Electro-Acoustic Audiometer Calibration). There are several studies that show that audiometers can often malfunction, and this malfunctioning can be undetected by the individual who is using the instrument (Ex. 321–51A, Ex. 281, attach. 2, p. 86). As a consequence, the audiograms that have been produced are of questionable accuracy and value. According to a study by Thomas, Preslar, Summers, and Stewart (Ex. 321–51A, p. 320), of 98 audiometers checked, none was "in condition to do satisfactorily the testing for which it was manufactured. The most frequent defect was incorrect sound level output." This study and also a study performed by the U.S. Air Force School of Aerospace Medicine (Ex. 281, attach., p. 86) indicate that a high percentage (50 percent to 100 percent) of audiometers failed to perform according to ANSI requirements when these instruments were left uncalibrated. It is for these reasons that calibration is mandatory.

The hearing conservation amendment requires that the functional operation of the audiometer be checked before each day's use. The process involves testing a person whose hearing levels are stable and do not exceed 25 dB at any test frequency. This person may be the tester himself or herself, or any other person with normal hearing. The process also includes checking the general function of the audiometer for unwanted sounds, such as clicks, static, and distortion. This functional check is quite simple, and can be done in a few minutes. If the test reveals significant deviations (greater than 5 dB), in hearing level from the subject's known audiogram or unwanted or distorted sounds, a more thorough calibration is warranted. In this case OSHA requires an acoustic calibration. In order to be sure that the audiometer's output is deviating rather than the subject's hearing level (the subject may have a headcold), the tester is advised to test additional subjects (with known stable hearing levels that do not exceed 25 dB). If these subjects confirm the deviation, use of this audiometer for testing must be discontinued until a periodic or exhaustive calibration can be performed since all of the audiograms taken that day would be suspect.

The proposal also required that the functional operation of the audiometer be checked prior to each period of use to ensure that it was in proper operating order. In addition, the proposal required a "biological" calibration at least once a month, which consisted of testing a person having known, stable audiometric thresholds. If the results of the biological calibration indicated hearing level differences greater than 5 dB, the audiometer was to be subjected to a "periodic" calibration. In the final amendment the Agency has combined the functional check and the biological calibration into the same requirement, to be performed before each day's use of the audiometer. This approach has been taken because it is extremely important to ensure that the audiometer produces correct sound pressure levels each time it is used. The process of testing one person's hearing can be done quickly, especially if the individual performing the test tests himself or herself.

This type of calibration check was supported by comments and articles submitted to the record. Even a new audiometer from the factory can lose its calibration especially if it was bumped in transit, and a functional check before each day's use would alert the operator to any malfunctions that might invalidate the test results (Ex. 102, sec. 9, p. 55–56; Ex. 306, p. J5C–8). This type of calibration appears to be accepted audiological practice, and was recommended in many comments to the record (Ex. 2C–14, p. 4; Ex. 2C–31–1, p. 2; Ex. 46, p. 14; Ex. 58, p. 2; Ex. 159, p. 6; Ex. 281, attach p. 2, p. 86; Ex. 306, pp. J5C–6, J1C–4, J1C–12).

Like the proposal, the amendment requires an acoustic calibration at least once a year, in order to check the audiometer's output with calibrated measuring equipment. This calibration is specified in Appendix E, and must be performed with a sound level meter and octave-band filter set, and a National Bureau of Standards 9–A coupler. The amendment's requirements are the same as those of the proposal, except that the listening test and the functional check are not included since they must now be performed before each day's use. The name has been changed from "periodic" to "acoustic" to more accurately characterize this particular calibration.

The amendment's requirements for acoustic calibration are given in Section 4.1.4.3 of ANSI § 3.6–1969, but the actual calibration procedures are given more explicitly in Appendix E, as they were in the proposal. Also, Appendix E gives reference sound pressure levels for both the Telephonics TDH–39 and TDH–49 earphones, which are in popular use today. (Reference levels for the TDH–49 earphone were not included in ANSI § 3.6–1969).

For the acoustic calibration, measurements must be taken acoustically at a reading of 70 dB on the audiometer's hearing threshold dial at all test frequencies (500, 1000, 2000, 3000, 4000, and 6000 Hz). Measurements must then be taken at the 1000-Hz frequency in decreasing steps of 10 dB from 70 dB to 10 dB hearing level. These latter measurements may be taken acoustically with the sound level meter or electrically with a voltmeter. The purpose of these measurements is to check the sound pressure level output at all frequencies, and to check the linearity of the attenuator, to make sure that the audiometer is producing the correct sound pressure level output at all hearing levels. Appendix E gives the following tolerances, which also are stayed in Section 4.1.4.3 of ANSI § 3.6–1969:

3 dB at 500 through 3000 Hz
4 dB at 4000 Hz
5 dB at 6000 Hz

Whenever the audiometric output deviates by more than the above levels, OSHA advises an exhaustive calibration. Until such time as the exhaustive calibration is performed, deviations that exceed these tolerances should be posted on the audiometer, so that the operator can correct the audiograms accordingly. When manual audiometers are used, deviations of 3 or 4 dB should be rounded to 5 dB when adjusting the audiogram. The amendment advises, but does not require an exhaustive calibration when small tolerances are exceeded, because posting deviations and correcting audiograms should serve as a satisfactory interim measure. However, when the deviations exceed 10 dB, an exhaustive calibration is mandatory.

This portion of the amendment reflects a slight departure from the proposal, which specified additional listening checks. The amendment limits the requirement to an assessment of sound pressure level output, since sound pressure level output is the audiometric function most frequently found to be incorrect (Ex. 321-51A, p. 326).

Comments in the hearing record supported a periodic calibration and some even specified its performance quarterly (Ex. 2C-14, p. 4; Ex. 2C-31-1, p. 2; Ex. 48, p. 14). Since not all audiometers will be in constant service and since an acoustic calibration will be triggered by a functional check that shows the necessity of further calibration, the Agency believes that a regular acoustic calibration once a year should be sufficiently frequent to assure accuracy.

The hearing conservation amendment requires an exhaustive calibration every 2 years. The content of the requirement is essentially the same as that which appeared in the proposal, although the interval between calibrations has been shortened from 5 to 2 years. This calibration will usually be performed in a laboratory or by the audiometer manufacturer because of the need for specialized equipment. (Calibration of frequencies below 500 Hz and above 6000 Hz may be omitted since they are not required test frequencies). During this calibration the audiometer is actually adjusted so that it conforms to the following sections of ANSI § 3.6-1969:

Section 4.1.2 Accuracy of Tone Frequencies. The purpose of the test is to make sure that the audiometer will actually produce tones at the frequency stated on the audiometer dial. For example, the tone should be 2000 Hz, not 2100 Hz or 1900Hz.

Section 4.1.3 Purity of Tones. In this test the audiometer is checked to make sure that harmonics of the test frequencies are not present to the extent that a test subject might respond to the harmonic rather than to the test tone.

Section 4.1.4.3 Accuracy of Sound Pressure Level. In this test the audiometer's sound pressure level output is checked in a similar manner as it is on the acoustic calibration. Reference threshold levels should be appropriate to the type of earphone, as mentioned above.

Section 4.4.1 Sound from Test Earphone. The purpose of this test is to ensure that the earphone will not emit any sound other than the test tone, which might affect the subject's threshold.

Section 4.4.2 Sound from Second Earphone. This test guards against any sound from the nontest earphone, which might affect the subject's threshold.

Section 4.4.3 Other Unwanted Sound. This test guards against any sound from the audiometer itself, which might furnish a clue to the subject being tested, thereby affecting the subject's threshold.

Section 4.5 Tone Switch. The purpose of this test is to ensure that the tone has an adequate rise and decay time, and that operation of the switch does not produce audible transient sounds or extraneous frequencies, which could influence the subject's threshold determination.

The proposal required an exhaustive calibration every 5 years. The amendment requires that the exhaustive calibration be performed every 2 years. Many comments in the hearing record supported an exhaustive (or factory) calibration every year (Dr. Righthand, Ex. 281, Attach. p. 91; Air Force Regulation Ex. 48, p. 13; Dr. Thomas, Ex. 102, Sec. 9, p. 58). Although the DuPont Company calls its yearly calibration an "acoustic" calibration, their requirements are similar to the exhaustive calibration specified in the amendment. The Company states: "This calibration shall check both frequency and intensity at each setting, rise time and overshoot and electrical and mechanical integrity." (Ex. 306, p. J5C-5). A Draft International Standard (Ex. 321-39, p. 3) suggests an exhaustive calibration every 2 years. The NIOSH criteria document (Ex. 1, p. I-19), the Advisory Committee (Ex. 2B, p. 12), and the draft California noise standard (Ex. 321-50, p. 15) supported the 5-year period between exhaustive calibrations.

Since the validity of the audiogram is highly dependent upon the calibration of the audiometer, OSHA believes that 5 years is too long an interval between exhaustive calibrations. Even though employers may find in the acoustic calibration that the sound pressure level output is correct, other malfunctions may occur, such as inaccurate tone frequencies or harmonic distortion. These malfunctions could occur without the knowledge of the operator because they can be too difficult to detect. A shorter interval is all the more important because the exhaustive calibration is advised but not required when an acoustic calibration indicates that the audiometer is up to 10 dB out of calibration. Audiometers that are not used very often (such as only a few days a year) should not need to be thoroughly calibrated more often than every 2 years. However, employers are urged to send their audiometers for exhaustive calibration more frequently when they are heavily used, or when, as a result of periodic calibration, it becomes apparent that they slip out of calibration fairly easily.

The amendment requires employers to record the date of the most recent acoustic or exhaustive calibration on employees' audiograms. This requirement will aid professional reviewers in making the determination that the tests have been conducted with properly calibrated equipment. In addition, employers must make complete calibration records available to professional reviewers, so that the reviewers will have better knowledge of actual function of the audiometer.

Hearing Protectors

The hearing conservation amendment requires employers to make hearing protectors available to all workers whose exposures equal or exceed an 8-hour time-weighted average sound level of 85 dB. When the PEL is exceeded, and employers are unable to reduce exposures through the use of engineering or administrative controls, hearing protectors must be provided and worn, as required by the current noise standard, 29 CFR 1910.95(b)(1). In addition, employers must assure that hearing protectors are provided to and worn by employees exposed to a TWA of 85 dB or greater if their audiograms have indicated a permanent significant threshold shift. Although workers who have not yet received a baseline audiogram are not required to wear protectors if their TWAs are between 85 and 90 dB employers are advised to encourage them to do so.

Employers must provide workers with a choice of hearing protectors. Employers are advised to give workers a choice between at least one type of ear plug and one type of ear muff (preferably more) since individuals may be much more comfortable in one type of protection than in the other. Ear protectors shall be supplied at the employer's expense. The employer is responsible for the proper initial fitting of hearing protection, and for regularly supervising its use to make sure that employees are wearing the protectors, and that they are worn correctly.

Employers must select hearing protectors that attenuate or reduce employee noise exposure at least to the PEL, and for employees who have suffered a significant threshold shift, to a TWA of 85 dB or below. Under the present standard, 29 CFR 1910.95(b)(1), an employee must wear hearing protection whenever his or her exposure exceeds the PEL and engineering controls are infeasible, in the process of being installed, or will not reduce the employee's exposure to within the PEL. The final hearing conservation amendment requires an additional group of employees to wear hearing protection: those exposed to TWAs of 85 dB or above if they suffer a significant threshold shift of hearing level.

The results of four recent studies indicate that the way hearing protectors are worn in real life conditions significantly reduces the manufacturer's stated estimates of attenuation (Ex. 301, p. 35; Ex. 308, pp. 1, 2; Ex. 321-14C, p. 5; Ex. 321-35E, abstract). NIOSH found that the attenuation achieved in the field was only about one-third of the attenuation achieved in the laboratory (Ex. 308, p. iii). Therefore, employers are advised to underestimate hearing protector attenuation by a few decibels when selecting protectors for employers. (This underestimate may have the effect of slightly overprotecting the employee.)

A given hearing protector must always be suitable for the frequency distribution of the noise environment in which it is to be worn. Therefore employers must estimate hearing protector attenuation for each employee's noise exposure conditions in order to be sure that the attenuation provided will be adequate. Methods for estimating hearing protector attenuation are described, and instructions for their use are given in Appendix G: *Methods for Estimating the Adequacy of Hearing Protector Attenuation*. This appendix is mandatory.

As discussed above in the section on exposure monitoring, the employer must remonitor whenever there is a change in working conditions that may cause an employee's hearing protector attenuation to be insufficient. After monitoring, the employer must re-evaluate the attenuation of the hearing protector being used and provide new protectors as necessary. These measurements could be taken as a result of either a bi-annual monitoring or monitoring due to a change in noise conditions.

The proposal required hearing protectors to be provided to and used by employees exposed to a TWA between 85 and 90 dB if their audiograms showed a significant threshold shift. OSHA has retained this very important requirement since these workers have demonstrated susceptibility to noise exposure (Ex. 310, p. 25; Ex. 5, pp. 43804, 43805; Ex. 138A, p. 1-4) and wearing hearing protectors may help prevent further hearing loss (Ex. 231, p. 11; Ex. 321-53D, p. 3; Tr. 2240; Tr. 755).

Unlike the proposed standard, the amendment also requires employers to make protectors *available* to all employees exposed to a TWA above 85 dB on a voluntary basis. The fundamental reason for this requirement is the fact that hearing loss can occur above 85 dB, as was explained earlier. A significant percentage of workers exposed to 85 dB over a working lifetime will suffer material impairment of hearing (Ex. 138A, p. I-4; Ex. 5, p. 43805; Ex. 189-5, p. 6; Ex. 88, p. 33). These workers should not have to incur significant threshold shifts or any work related diminution of hearing, for that matter, before they have access to hearing protection. Workers should be able to wear protection voluntarily, even where the use of hearing protection is not mandatory. This is fully consistent with the purposes of the Occupational Safety and Health Act (see section 2(b)(1) and 2(b)(4) of the Act).

Generally the amendment does not make the wearing of hearing protectors mandatory until exposure levels exceed the PEL since the permissible exposure level listed in 29 CFR 1910.95(a), Table G-16 has not been changed. This requirement is contained in the present noise standard and the amendment does nothing to change it. Moreover, workers sometimes find hearing protectors particularly oppressive at the more moderate exposure levels where they can cause interference with speech communication to be more noticeable. (More speech communication is likely to occur in moderate levels, especially if the noise is intermittent, allowing speech to take place in the quiet intervals (Ex. 321-35G, p. 3; Ex. 231, p. 12).) Therefore the Agency has decided to require employers to provide ear protectors to employees exposed between 85 and 90 dB, but not to make the use of these devices mandatory for those employees without significant threshold shift until the PEL is exceeded. Since the Agency recognizes that many employees dislike hearing protectors, mandatory use of protectors has been limited to those cases where they are absolutely necessary.

Acceptability of Hearing Protectors

A major issue that was addressed in the record is worker refusal to wear ear plugs because they cause discomfort (Ex. 75-5, p. 22; Ex. 321-45A, pp. 1, 11; Ex. 94, p. 9). Complaints about ear muffs included headaches, claustrophobia, excessive warmth, perspiration, interference with safety glasses and hardhats, and bulk in and around the ear (Tr. 576, 603, Tr. 1371; Ex. 94, p. 9; Ex. 2C-16B, p. 25). Hearing protectors also have been criticized because their effectiveness is so heavily dependent upon individual worker's compliance, rather than on the more consistent protection afforded by engineering controls (Tr. 794). The use of hearing protectors can be more difficult to supervise because their effectiveness depends upon many people (all employees who wear them) rather than on one or two machines (Tr. 1465). Also, supervision is difficult because it is impossible to know whether a hearing protector is being effectively worn just by looking at each employee. Finally, some stated that hearing protectors can be unacceptable for hygienic reasons (i.e., they lead to ear infections) (Ex. 79, p. 7; Ex. 94, p. 9; Ex. 88, p. 7; Tr. 2026-2027).

Leonard Woodcock, former president of the United Auto Workers Union, revealed many potential problems with ear protection:

> The effect of using ear protection shifts the burden and responsibility for compliance from the employer to employee. Ear protection is uncomfortable and irritating. Some workers easily get ear infections or drainage problems from wearing them.
>
> Moreover, experience teaches us that management often selectively enforces the wearing of ear protection. (Ex. 79, p. 7).

Joseph Hafkenschiel of the Communication Workers of America went on to say that:

> Personal protective equipment, cannot be regarded . . . as anything more than an interim control measure. Even in these temporary situations, many people cannot wear this type of protection because of medical problems of the ear. Other individuals find the effective deafness enforced by ear protectors psychologically distrubing. Finally, ear protection may mask shouts or signals and, thus, contribute to industrial accidents. (Ex. 62, p. 8).

In response to these problems many commentors pointed out the necessity to fit hearing protectors correctly and to allow for personal preference in order to assure comfort and acceptance (Tr. 3463-3464; Ex. 14-245, p. 2; Ex. 308, p. 1; Ex. 321-14A, p. 2; Ex. 321-14B, p. 2; Ex. 14-894, sec. 3, p. 6; Ex. 75-2, p. 123; Ex. 321-34A, p. 2; Ex. 321-53D, p. 3). Workers who develop ear infections or have significant amounts of wax in the ears should use muffs, if possible, instead of insert type hearing protectors (Ex. 102, sec. 8, p. 15; Tr. 1803, 1805).

In a program developed for the North Carolina Department of Labor (Ex. 2C-16B, pp. IV-6, 7), Dr. Royster provided an example of a program which emphasized that workers should be able to receive help when protectors are not satisfactory. A supervisor, a nurse, or even a health and safety committee can provide guidance "on the job." OSHA believes that if, after a trial period, (Ex. 75-2, p. 122) the discomfort associated with the use of a particular hearing protector is so great that it cannot be worn successfully, then an alternative protector should be used. The company must make a concerted effort to find the right protector for each worker—one that offers the appropriate amount of attenuation, is accepted in terms of comfort, and is *used* by the employee. The Agency requires workers to wear hearing protectors as part of the total hearing conservation program. If the protectors do not fit properly will not provide the estimated amount of protection.

There are several reasons why OSHA mandates that employers provide a variety of protectors (Ex. 147C, pp. 336–337). Plant conditions such as dust, temperature, and humidity can cause one type of protector to be more suitable than another (Ex. 102, sec. 5, p. 18). For example, ear plugs can be more comfortable in a hot, humid environment, than ear muffs. Also, individual ear canals come in all shapes and sizes. For people with unusually shaped ear canals, fitting may be difficult, and commonly-used insert protectors may be very uncomfortable (Ex. 2C–16B, p. V–3).

In a survey of industrial hearing conservation programs NIOSH found that:

> Another factor which seemed to affect the willingness of the employee to wear ear protectors was the variety of items offered to him. Many companies supplied a wide range of personal ear protector devices and permitted the employee a trial period to select the one he liked. (Ex. 321–14B, p. 2).

This finding was also supported by Dr. M. Thomas Summar (Ex. 147C, p. 335) and others (Ex. 321–14A, p. 2; Ex. 321–14B, p. 2; Tr. 3464; Ex. 321–34A, p. 2).

Another aspect of worker rejection of ear protectors is safety. The United Auto Workers, for example (Ex. 79, p. 8; Ex. 94, p. 10; Ex. 91C, p. 3), stated that hearing protectors create unsafe conditions in the workplace by reducing the audibility of shouts and warning signals. It is possible that a worker might not hear noises that indicate that machinery is malfunctioning. The Environmental Protection Agency (Ex. 231, p. 12) pointed out that hearing protectors can impede speech communication, especially in situations where the noise is highly intermittent, or in cases where the wearer has a high-frequency hearing loss. Interference with speech communication can cause a safety hazard. This issue is complex, since, in some situations protectors can actually improve hearing of speech in noisy backgrounds (Ex. 14–295, p. 1; Ex. 14–886, p. 1; Ex. 14–907, p. 21). On the basis of this evidence, OSHA concludes that although hearing protectors may in some circumstances pose a safety hazard, this is insufficient reason to abandon their use when workers are exposed to potentially damaging levels of noise and there are no other feasible means of reducing the noise exposure.

There is also some evidence that protectors provide other advantages beyond protection against NIPTS. Studies by the Raytheon Company (Ex. 20–11, p. 5–2) and another by Schmidt, Royster, and Pearson (Ex. 321–22, p. 27) showed that after the institution of a hearing protector program not only was hearing loss reduced, but lower injury rates and higher attendance rates were observed.

Administrative and Financial Responsibility

Another important issue that was raised at the hearings was the placement of administrative responsibility for this part of the program. The American Newspaper Publishers Association (Ex. 14–208, p. 2) and others (Ex. 14–173, p. 2; Ex. 14–290, p. 2; Ex. 14–276, p. 2) stated that it should be the worker's responsibility to use ear protectors. Going one step further, the Air Transport Association of America (Ex. 144, p. 10), and Dr. Raymond J. LeZak (Ex. 14–278, p. 2) felt that each worker should decide whether or not to use protection. Based on this reasoning, if the employee is not diligent in the use of protection, then any hearing loss that is incurred cannot be blamed on the company.

The Occupational Safety and Health Act does not include the concept of "assumption of risk" which would permit workers to decide which rules merit compliance. On the contrary, the Act requires employees to comply with all rules and employers have the responsibility of enforcing all of OSHA's requirements.

The proposal did not specify who should bear the expense of hearing protectors. Some comments in the record, such as those submitted by the Environmental Protection Agency (Ex. 9, p. 5) and others (Ex. 321–18, p. 2; Ex. 321–50A, p. 8; Ex. 103A, p. 4), recommended that ear protectors be provided at the employer's expense. For example, R. V. Durham, director of the Safety and Health Department of the International Brotherhood of Teamsters stated:

> A point we must raise, the burden of cost for personal ear protective devices, is one that is vital although often overlooked. Labor and most employers recognize the reponsibility of the employer to provide a safe and healthful working environment for its employees. Where, in certain circumstances, personal protective equipment is necessary to afford such an environment, it is again almost universally accepted that its purchase is the responsibility of the employer. If personal ear protective devices are necessary to the success of a hearing conservation program, it is vital that the employer provide appropriate ear protectors and maintain control over the proper issuance, maintenance, and use.
>
> An employer's attempt to require its employees to purchase their own personal ear protective devices would cause resentment among the workers and clearly demonstrate to them the lack of commitment on the part of their employer in preventing hearing loss. Such a requirement would discourage the use of ear protective devices and would create an adversarial atmosphere in regard to the hearing conservation program. Finally, requiring workers to buy their own hearing protective devices risks losing the necessary control over the organized and consistent selection, issuance, maintenance, and use of such equipment (Ex. 321–18, pp. 1–2).

On the basis of arguments such as the above, and because ear protectors are vital to the prevention of noise-induced hearing loss, the Agency has determined that employers must bear the expense of providing employees with hearing protectors, incuding the cost of replacing protectors that wear out.

Hearing protectors do wear out, and lose some of their ability to attenuate noise. Malleable inserts eventually become inflexible and unable to attenuate properly. Premolded plugs also can lose their elasticity, and custom molded plugs may shrink. Ear muffs also wear out eventually—the soft seals surrounding the ear cup can become inflexible, and the headband can lose its tension. Employers must replace all types of protectors as often as necessary so as to ensure the necessary amount of attenuation. Certain types of protectors, such as disposable plugs, may need to be replaced daily.

Dr. Royster mentioned that workers might damage or lose their protectors or just want an extra set, presumably to take home (Ex. 2C–16D, pp. IV–3, IV–6). The final standard's requirement that the employer pay for hearing protectors does not go this far. The Agency believes that employers should not have to pay for an unlimited supply of protectors or replace protectors lost due to employee negligence. The issue of how many replacement protectors to supply is up to the individual company as it is with other necessary work items, such as tools. However, if the employer refuses to replace worn out ear protectors, the employer may be subject to citation. On the other hand, the employer should not have to bear the expense if an employee has been irresponsible.

The Agency is aware that many industrialists are concerned about being held responsible for nonoccupationallyinduced hearing loss (Ex. 14-8, p. 2; Ex. 14-86, p. 1 and Ex. 14-288, pp. 3-4). To the extent that an employee's noisy hobby can contribute to noise-induced hearing loss, wearing protectors at home should diminish the loss. Therefore, OSHA suggests that employers urge workers to use protectors at home during noisy activities.

Attenuation

The value of hearing protectors lies in their ability to attenuate or reduce the noise that reaches the ear. Although the proposed standard did not specify requirements for estimating hearing protector attenuation, adequate attenuation is fundamental to worker protection, and for this reason it was suggested that OSHA make its requirements explicit (Ex. 1, pp I-11 through I-13, III-7, III-8; Ex. 2B, pp. 13-15).

The amendment requires employers to evaluate the effectiveness of particular ear protectors in specific noise environments, since the capabilities of the protectors need to be matched to the characteristics of the noise. For example, workers who are exposed to predominantly low-frequency noise levels of approximately 100 dB may need protectors that provide more attenuation in the low frequencies than those needed by workers who are exposed to predominantly high-frequency noise of the same A-weighted level.

Since hearing protectors generally provide greater attenuation in the high frequencies than in the low frequencies, (see Ex. 321-14A, pp. 4-16) and since industrial noise tends to be predominantly low-frequency, (Ex. 26-2, pp. 34-35; Ex. 266A, pp. 77-78) it is important to assess the relative contribution of low-frequency noise in order to select an appropriate hearing protector. As explained in the Introduction, the sound level meter's C-weighting network does not discriminate against (filter out) low-frequency noise, whereas the A-weighting network discriminates strongly against low-frequency noise. Thus, taking the difference between C-weighted and A-weighted sound levels is a simple method of assessing the relative contribution of low frequencies in a given noise spectrum. This method was advocated in a study submitted by DuPont Company (Ex. 188-27, part 4, p. 447) in which Dr. R. Waugh pointed out that the same ear protector could provide 20 dB more attenuation of noise with one frequency spectrum than with another. Dr. Waugh recommended selecting ear protectors according to the difference obtained by subtracting the A-weighted noise level from the C-weighted level.

NIOSH and EPA also found the difference between C-weighted and A-weighted noise levels to be useful for purposes of hearing protector selection (Ex. 321-14A, p. 28; Ex. 314, p. 501B). OSHA also recognizes the value of this approach, and recommends a method that incorporates it, which is EPA's Noise Reduction Rating (NRR) (Ex. 314). EPA requires all manufacturers of hearing protectors to label the package with the appropriate NRR for that protector. The regulation, 40 CFR Part 211, became effective Sept. 27, 1980 (44 FR 56130, 1979).

Appendix G requires the use of the NRR or one of three NIOSH methods. OSHA recommends the NRR since it is simple to use, and it appears to have been reasonably and thoughtfully developed (see NIOSH Ex. 321-14A, and EPA Ex. 314). The NRR concept has been adopted by another Federal agency (the EPA), and the NRR will appear on the label of all hearing protectors manufactured in the United States. Once the NRR of a protector is known, the employer needs to relate the NRR (or a reduction factor determined by one of the NIOSH methods), to an individual worker's exposure to assess the adequacy of the hearing protector for that individual.

Use of the NRR to predict the sound level at the ear drum is dependent upon knowledge of the C-weighted sound level to which the worker is exposed. The NRR is to be subtracted from the C-weighted sound level in the employee's environment. Since sound levels usually fluctuate throughout the day, it is necessary to obtain a C-weighted TWA so that employers can estimate the A-weighted sound level under the protector. The simplest and most efficient way to accomplish this would be to obtain a C-weighted noise dose with a dosimeter. Since contemporary dosimeters do not have C-weighting networks, this method will not be possible unless or until such dosimeters are manufactured and marketed. However, such a method has been included in Appendix C in the event that dosimeters with C-weighting networks become available. In the meantime employers may use the guidelines in Appendix B to calculate C-weighted noise dose, or they may make a correction to the A-weighted dose or TWA to allow for the uncertainty of not knowing the C-weighted exposure level.

OSHA has selected a 7 dB correction factor for cases where the difference between the C-weighted and A-weighted TWA is not known. This correction factor was suggested by NIOSH for use when information about the spectral distribution of a worker's noise environment was not available. However, the NIOSH report stated that a certain amount of caution should be exercised in using this method in workplaces where the difference between C-weighted and A-weighted sound levels might be greater than 7-dB (Ex. 321-14A, p. 31). Thus, when employers are aware of significant amounts of low-frequency noise, they are advised to take C-weighted measurements to make sure that the 7 dB correction factor is sufficient. To make the correction, 7 dB is subtracted from the NRR, and the remaining NRR value is subtracted from the A-weighted TWA in order to estimate the A-weighted sound level under the ear protector. When dosimeters are used, dose must be converted to TWA before the subtraction can be made. Appendix A, II, provides tables with which this conversion can easily be made.

As an alternative, employers may actually measure the employee's C-weighted exposure levels. They are advised to take these measurements whenever the noise is predominantly low-frequency, or whenever exposure levels are fairly high (i.e., above 95 dB). Employers should use temporal sampling procedures such as those described in Appendix B, but they may not need to take as many samples. If employers already have taken the required number of A-weighted measurements with a sound level meter, it is usually necessary only to take a few C-weighted measurements in order to obtain a good estimate of the average C-weighted sound level in each time segment. If employers have not already taken A-weighted measurements with a sound level meter, (in other words if they have used an A-weighted dosimeter), more measurements may be necessary in order to obtain a good estimate of the C-weighted TWA. Then the 8-hour time-weighted average of each segment's C-weighted sound levels must be computed using Figure B-5 in Appendix B and Table G-16a, or an equivalent method. Finally, the NRR is subtracted from the C-weighted TWA to obtain the estimated A-weighted TWA under the employee's ear protector. OSHA has not specified the exact number of measurements needed in order to estimate the level under the ear protector. However, the Agency believes that employers should attempt to assess the C-weighted exposure levels as accurately as possible.

In some instances employers may choose to use a method other than the NRR. For example, an employer may want to use a protector that is not manufactured in the United States, or a protector that for some reason does not bear the NRR label on the package. Or the noise may have an unusual spectrum, which the employer wants to evaluate by octave-band analysis. In these cases employers may use any of the three methods developed by NIOSH described in the "List of Personal Hearing Protectors and Attenuation Data," by Kroes, Fleming and Lempert, HEW Publication No. 76-120, 1975 (Ex. 321-14A). The NIOSH method #1 is the most complex, but is likely to be the most accurate method since it uses the largest amount of information from the frequency spectrum of the worker's environment.[12] It requires data for each octave band. As with the use of the NRR, employers should be careful to take enough measurements so that a representative sample is obtained for each identified time segment. When using the NIOSH methods the reduction factor, or "R" factor needs to be calculated. Since this "R" factor is already included in the NRR, use of the NRR should be more convenient. Also, OSHA recommends the NRR for the sake of uniformity as well as for simplicity.

Elliot Berger, manager of Acoustical Engineering at the E-A-R Corporation, noted that the real world performance of hearing protectors is significantly overrated by the manufacturer's laboratory data, reflected by the NRR (Ex. 321-35, p. 1). Mr. Berger noted that the NRR incorporates certain corrections that are intended to ensure that 98 percent of the population who "correctly" wear the device in 98 percent of the industrial noise environments will achieve the protection indicated by the NRR (Ex. 321-35D, p. 3). However, Berger cited studies by NIOSH (Ex. 308), Padilla (Ex. 301), Regan (Ex. 300A), and the National Acoustic Laboratory of Australia (Ex. 321-35F), which show that the NRR value is not usually realized in actual use. This occurs because the NRR does not make allowances for improper fitting, for unusually shaped ear canals, or for highly unusual noise spectra.

OSHA recognizes that the NRR is based on laboratory data taken according to standardized procedures in standardized conditions (Ex. 311). At the time of testing the plugs and muffs are new, and they are fitted carefully. Unfortunately, hearing protectors are used in conditions that are less favorable than laboratories. Field tests have revealed that workers receive far less attenuation from several types of earplugs than is predicted by the laboratory test methods. A NIOSH report, for example, found that "half of the workers tested were receiving less than one-third of the potential attenuation of the hearing protectors in terms of noise reduction in dBA" (Ex. 308, p. iii). The report attributed the reduced protection to workers wearing the wrong size plugs and inserting their plugs improperly. In a similar study, Padilla (Ex. 301, p. 35) also concluded that the average earplug was worn incorrectly and suggested a test by which employers could monitor the attenuation of plugs in field use.

A study submitted by Dr. Donald Regan also found that devices worn in the occupational setting showed significantly less attenuation than the manufacturers estimated. Dr. Regan concludes: "The results of this investigation emphasize the 'false sense of safety' that management, industrial consultants, and particularly the individual who is wearing the device is assuming, if they conclude they are being adequately protected from the possibility of hearing loss." (Ex. 300A, p. 91).

As a result of this information OSHA urges employers to use extra caution in the initial selection and fitting of ear protectors so that protectors will fit comfortably, yet snugly, and so that workers will be skilled in refitting and caring for them.

Fitting

The fitting of hearing protectors must be done very carefully. Workers shall be trained in the care and fitting of the protectors, and employers must supervise their use.

Suggestions for proper fitting procedures were offered to the hearing record. Dr. Harold R. Imbus, medical director of Burlington Industries stated:

> It is often little understood that ear canal size can vary on the same individual. We have often found it necessary to use two different sizes of plugs in order to get the proper fit in each ear. We instruct the employee to return to the nurse's office immediately should any unusual soreness develop, because a refitting with a different type of plug may be necessary. (Tr. 3403-3404).

According to Dr. Royster:

> It is not sufficient to simply make available ear protection; the company must make sure that the fitting is done by someone trained in the issuing of ear protectors. This individual, nurse, technician, etc., should be under the supervision of the company doctor, local doctor, (or) audiologist. (Ex. 2C-16B, p. 27).

There was a great deal of comment recommending that trained persons fit hearing protective devices, especially if the protector is custom molded (Ex. 2C-16B, p. 27; Ex. 56, p. 3; Ex. 321-28A-2, p. 12; Ex. 75-5, p. 24). The Agency believes that any trained person, such as most nurses and technicians, will be able to fit ear protection adequately, so long as training on the subject has been included in their short courses, and they are well acquainted with the relevant audiological and/or industrial hygiene literature.

If proper precautions are taken, and if workers and management approach the problem in a spirit of cooperation, noise induced hearing loss should be greatly reduced. Comment and testimony by Dr. Karrh of DuPont Corp. (Tr. 2237; Ex. 306, p. 1), Dr. Sataloff (Ex. 321-53, pp. 5-6), Dr. von Gierke (Tr. 755), and Dr. Kryter (Tr. 794), indicated that well managed hearing protector programs can be extremely effective in conserving workers' hearing. However, employers should not lose sight of the fact that the current standard, 29 CFR 1910.95 (a), requires them to control noise by engineering or administrative means whenever feasible. True cooperation between labor and management is most likely to occur when workers know that management is making every attempt to eliminate the hazard, and that personal protective equipment is a temporary rather than a long term solution.

Observation of Monitoring

Section 8(c)(3) of the Occupational Safety and Health Act requires OSHA to issue regulations for keeping records on employee exposures to toxic materials or harmful physical agents, "which are required to be monitored or measured under section 6." The Act goes on to say, "Such regulations shall provide employees or their representatives with an opportunity to observe such monitoring and measuring, and to have access to the records thereof." Since the hearing conservation amendment requires some monitoring of employee noise exposure, the amendment requires employers to provide workers with an opportunity to observe the process of noise exposure monitoring. The Agency believes that workers who observe the monitoring of their exposures will gain insight into the nature and extent of the noise hazard, and will become more involved in the hearing conservation program. This involvement should increase the motivation for the proper use of ear protection, and thereby increase the effectiveness of the program.

The hearing conservation amendment requires employers to provide monitored

[12] NIOSH developed two additional methods. NIOSH method #2 is very similar to the NRR and method #3 is similar to the NRR plus correction factor, which is described above.

employees or their representatives an opportunity to observe any noise exposure measurements that are conducted for compliance with the amendment. Employees may desire to have someone else observe the monitoring, such as a union health and safety representative. Under certain circumstances, an outside professional may be allowed to observe. Although employers are not obligated to notify workers of the intention to monitor in advance, the Agency recommends that they do so whenever possible.

Without interfering with the monitoring, observers are entitled to receive an explanation of the procedures, observe all the steps related to the noise measurements (with the exception of any calculations made away from the workplace), and record the results.

OSHA received some coments objecting to the observation of monitoring provisions in the proposal. For example, John Harris of the J. I. Case Company (Tr. 2611), stated that observation of monitoring would not prevent occupational hearing loss, but on the contrary would take time, manpower, and money away from the hearing conservation efforts. However, many commenters favored the concept of employee observation. Mr. Ahern of General Motors Corp. (Ex. 14-883, p. 10) said, "We recognize of course, that under 8(c)(3) of the Occupational Safety and Health Act an employee or his duly authorized representative has the right to observe monitoring under certain circumstances." Mr. Bonney of Alcoa (Ex. 14-969, p. 2) stated that "under the OSH Act employees were given the right to observe measuring or monitoring. We certainly cannot take exception to this."

Most of the objections implied that the requirements would be burdensome or disruptive. In response to these comments OSHA has made certain changes to the proposed standard that should make the requirements somewhat easier for employers to implement.

The proposal required employers to give written notice of scheduled monitoring at least 3 days before the event was to occur by posting a notice to this effect in a place regularly visited by employees. One reason why the Agency had proposed this requirement was that in certain circumstances the employees might have a desire to have someone with knowledge of noise measurement present to obseve the monitoring. However, such a person might not be on the premises and it might take some time to get there. The proposal also allowed employers to require employees to give written notification of their intent to observe the monitoring. This was an attempt to eliminate any disruption that might ensue in the event that a number of employees decided spontaneously to exercise their right to observe the monitoring.

Many commenters objected to the requirement for advance notification. Seymour Epstein of the Aluminum Association stated:

> We cannot take exception to the employees' right to observe monitoring. However, we strongly object to the requirement for posting notice of opportunity to observe the monitoring at least three working days before this is scheduled to occur and listing the time and place where the monitoring will occur. We feel this is unrealistic, will unnecessarily restrict the activities of industrial hygienists in the plant and will place an undue burden on their efforts. (Ex. 14-952, p. 2)

Mr. Harris (Tr. 2613) agreed, and described the conditions that might make advance notification impractical or even impossible: changes in production, breakdowns, shutdowns, failures of measurement equipment, or other such factors might suddenly alter the monitoring schedule. Other commenters suggested that only one day's advance notification should suffice (Ex. 14-189, p. 2; Ex. 59, p. 5; Ex. 14-290, p. 5).

On the basis of the argument presented by Mr. Harris and others, OSHA has decided that advance notification might be difficult for some employers. Therefore the Agency recommends rather than requires advance notice. In addition, the Agency recognizes that such requirements as posting advance notice and allowing the employer to require a response in writing from employees may constitute unnecessary paperwork, and employers may need to retain some flexibility in how best to inform employees of monitoring plans. OSHA does believe that it is helpful for workers or their representatives to know about the monitoring in advance so that they may plan their schedules accordingly.

A number of comments suggested that the observation provisions would be disruptive to the production process and to the monitoring itself.

Mr. Cornell of the Gypsum Association (Tr. 2664) suggested that all workers might exercise their rights to observe, and in that case no one would be available to operate the machinery in question. David Anderson of the Bethlehem Steel Corp. (Ex. 14-347, p. 3) suggested that employees might actually interfere with the monitoring process by stopping work. M. V. Truss of the Vulcan Materials Co. (Ex. 14-58, p. 3) believed that if employees stopped work and watched the monitoring it would be too expensive for the company. For these reasons some industry spokesman suggested that only employee representatives (and not employees) be allowed to observe the monitoring process (Ex. 14-58, p. 3; Ex. 14-290, p. 4).

The Agency understands that in some circumstances a cessation of work might cause the noise levels to change, and it would not be in the interest of either the worker or the employer to take measurements under conditions that did not reflect the employee's true exposure. For reasons such as these, the amendment (as did the proposal) specifies that observation shall be permitted so long as it does not interfere with the monitoring process.

OSHA does not expect that employee observation of monitoring will be disruptive of the production process or the monitoring itself. While the precise method in which this employee right is exercised will vary from workplace to workplace, it is expected that, in most cases, employees will select a single representative to act as an observer. This observer will receive the explanation of the process, observe the calibration of equipment, its placement, and the actual sampling, and report to other employees. The observer may also record the results of the monitoring. It has been OSHA's experience in the context of other health standards that the observation of monitoring by a representative employee successfully implements this provision without undue disruption. In any event, the employee right to observe monitoring must be tempered with "standard of reasonableness," and observation which seriously disrupts production or the sampling itself is not permitted.

Training Program

Section 6(b)(7) of the Occupational Safety and Health Act indicates that standards shall prescribe appropriate forms of warning to insure that employees are apprised of all hazards to which they are exposed. The final standard requires that employers provide workers whose exposures equal or exceed a TWA of 85 dB with a training program that explains the purposes and major components of the hearing conservation program. As part of employee training, the employer also has the responsibility of making certain materials and information, such as the hearing conservation amendment, available to employees.

The proposal required employers to train workers initially in the use of hearing protectors, and to reinstruct employees in the use of hearing protectors whenever employees incurred a significant threshold shift in hearing. Also the requirement for warning signs and for notification of exposure, which were included in the proposal, are considered elements of worker training. The amendment retains and clarifies these provisions (see discussion under specific subject headings). In addition, the final rule includes a separate training section with more detailed guidance than was found in the proposal. Employees must be trained according to these new requirements at least once a year, so that they will be reminded on a regular basis of the hazardous effects of noise, and the respective roles of management and workers in preventing these effects. Annual audiometric tests should be an opportune time to conduct such training programs.

It should be noted that the entire training program does not have to be accomplished at one session. For example, employers who have safety meetings biweekly may wish to work some elements of the training requirements into general safety meetings. Workers may have been given a brief overview before starting a job, with supplementary information provided later. It is not the intention of this amendment to impose a rigid and formal training program on employers. Rather, the amendment gathers in one place all of the elements deemed necessary for a good training program and allows the employer maximum flexibility in deciding how best to impart the information to the noise-exposed workers.

The new training requirements are in direct response to the many comments in the record emphasizing the importance of training and education to the success of the hearing conservation program (Ex. 75-10, p. 3, Ex. 102, Attach. 4, pp. 4-6, and Attach. 5, p. 3; Ex. 321-1, Attach. 1, p. 3; Ex. 75, p. 11; Ex. 75-2, p. 125; Ex. 306, pp. 2-3 and p. J 2 C; Ex. 307, p. 1; Ex. 2C-16A, p. 6; Ex. 305, p. 7; Ex. 147C, p. 335; Ex. 147A, p. 6; Tr. 3269, 3140; Tr. 3504-3505; Tr. 2528-2529). For example, an article submitted by Dr. M. Thomas Summar (Ex. 147A, p. 4) states that, "Personal counseling with employees and visits to work areas are necessary and important parts of the program. Some of these visits coincide with the yearly monitoring hearing tests . . . ." C. Edward Scott and Dr. Royster (Ex. 102, p. 12) maintain that "continuing education should be used as a means for improving the quality of the program whenever it is found necessary."

Although the amendment does not dictate the content of employers' training programs, certain subject areas must be included. First, workers must be informed of the requirements of the noise standard and the hearing conservation amendment. So that they are aware of the extent of the hazard, workers must be told about the effects of noise on hearing. Workers must be told to report any symptoms of TTS, such as not being able to hear very well after the end of the workshift. This is so that employers can identify TTS and implement prompt protective measures. Workers must also be told about other effects, such as speech and signal masking, which may cause a safety hazard.

So that employees can better understand the nature of their own particular noise exposures, the training program must include a discussion of specific machinery at the job site that causes hazardous exposures, including information on any noise control compliance plan in effect. An integral part of the training program is a complete discussion of hearing protectors, the advantages and disadvantages of various types, and clear instructions on the selection, fitting, use, and care of the protectors. Finally, so that employees are motivated to take the hearing test and to refrain from non-occupational noise exposure before baseline and recheck audiograms, the program must include an explanation of the purpose of audiometric testing, and of the test procedure.

Employers must post a copy of the standard and amendment in a location where employee notices are customarily posted, and they must make a copy of the standard and amendment available to employees exposed to a TWA of 85 dB or above, if they should ask for it. This requirement gives workers an opportunity to be fully informed of specific aspects of the amendment, and should provide workers with access to this information in cases where they might be afraid or reluctant to ask management for a copy. Employers must also provide these employees with any informational materials supplied by OSHA, which are meant to be distributed to affected employees. Lastly, employers must provide copies of their training materials to OSHA if they are requested to do so. This is intended to provide an objective check of compliance with the requirements of this section of the amendment.

Many comments to the record supported the concept of training programs, and emphasized the importance of motivating employees to play an active role in the hearing conservation program. As Dr. Karrh of DuPont pointed out:

> Our experience has shown that maximum effectiveness of hearing conservation results when employees understand the reasons for the program and cooperate and take initiative in its implementation and conduct on a daily basis. This cooperation is accomplished by educating them regarding the potential effects of exposure to high noise levels whether encountered at work or during leisure hours. (Ex. 306, p. 3).

Training programs are also important at the supervisory level. Personnel who conduct the training program must be well versed in all aspects of the company's hearing conservation program, so that they are prepared to answer employees' questions (Ex. 102, Sec. 5, pp. 9, 27-29). Involvement of first-line supervisors would be particularly effective. As stated by Scott and Royster, "the success of the hearing conservation program in each working area will in the end depend upon the willingness of the local supervisor to support the program and enforce its requirements." (Ex. 102, Sec. 5, p. 9). DuPont and several other companies have demonstrated that imagination, discipline, and commitment from the highest levels of management are qualities that will promote successful programs (Ex. 75-5, p. 21; Ex. 75, p. 122; Ex. 307, p. 1; Ex. 102, Sec. 5, pp. 10, 15). Simply informing workers to use hearing protectors so they "won't go deaf" is not enough.

Morrill (Ex. 305, p. 7) stressed the importance of worker education in overcoming workers' objections to wearing hearing protectors. A number of comments indicated that workers are reluctant to appear weak or ridiculous as a result of wearing personal protection (Ex. 321-13C, p. 738; Ex. 75-7, p. 20; Ex. 75-5, p. 22; Ex. 75-12, p. 24). According to Dr. Roger Maas (Ex. 75-2, p. 2) "Supervisors must sell employees on the need and value of hearing protection devices. When employees understand what the protective measure if for, it will be accepted because the employee realizes it is for his own good." Labor leadership, such as union health and safety committees, can also play an active, supportive role in answering on-the-job questions, seeing that their members are fitted satisfactorily, and encouraging workers to wear protectors.

Employers are advised to use audiologists, otolaryngologists, or industrial hygienists to aid in the training of employees. They are not required to do so because these personnel may not always be available. However, the instructor should be capable of addressing any questions on the technical, procedural, or health aspects of hearing conservation. Also, the instructor should be well versed in all aspects of hearing protectors since employees are likely to have many questions on the subject. One person does not have to perform all of the training. Different aspects of the training may be done by a variety of people with knowledge of various aspects of the hearing conservation program.

The employer is free to structure the training program any way he or she pleases as long as it contains the specific topics discussed above. Several commenters (Ex. 102, Attach. 3, p. 5, and Attach. 4, pp. 6, 12; Ex. 2C-16B, p. 17; Ex. 75-2, p. 125; Ex. 75-3, p. 6; Ex. 75-10, p. 3) offered suggestions. They recommended that companies (and also unions) regularly distribute informative literature to employees, provide periodic audiovisual presentations, hang posters and use bulletin board displays, and put articles on noise hazards and hearing protection in the company or union magazine. Audiovisual materials can often be obtained from Federal and State health agencies, insurance companies, trade union and professional associations, hearing protector and audiometric equipment suppliers, educational institutions, individual medical practioners, and audiological consulting firms.

To summarize, good training means clear content, well presented by an informed and sympathetic person, who is willing to spend the time and effort to motivate employees to participate actively in the hearing conservation program. The final element is the behavior, and implicitly the attitude, of management. According to Dr. Thomas, who submitted extensive materials to the record:

> Several companies have gone to considerable expense in developing and implementing a hearing conservation program only to end up with what can properly be called a second rate program. Why?
> . . . Lack of support by top management . . . Why spend several thousand dollars implementing the program if MR. BIG is going to walk through the plant without wearing his protective equipment. Even if the amount of exposure expected is insignificant the attitude given is what counts. MR. BIG, regardless of his position in the company, must also abide by the rules and by example educate the employees. (Ex. 2C-16, pp. IV-5).

Warning Signs

The proposal required that clearly worded warning signs be posted at the entrances to or on the periphery of areas where employees' exposures exceed the prescribed limits. These signs were to be large enough so as to be easily read by employees working in this area. The warning sign was to indicate that the area is a high noise area, and it was to specify the protective actions (usually ear protectors) that are necessary.

The final standard requires warning signs in those areas where exposures equal or exceed a TWA of 85 dB. This represents the action level for the initiation of the hearing conservation programs, and it is consistent with the concept to have warning signs in such environments.

Most entries to the hearing record favored the use of warning signs (Ex. 105, p. 8; Ex. 132, p. 6; Ex. 58, p. 2; Ex. 2C-1, p. 11 and 12; Ex. 2C-125-1, p. 9; Ex. 14-984, p. 6). Some commenters believed that the requirements for notification of exposure and posting of warning signs were redundant (Ex. 14-348, p. 4; Ex. 14-333, p. 5). The Agency believes that the requirement is not redundant with the notification of employee exposure because exposure notification occurs approximately every two years, while the warning sign presents a constant reminder that a hazard exists, and that protective action may be needed.

Certain witnesses, such as Dr. Ward (Ex. 64-6, pp. 1-2), brought up the fact that warning signs are necessarily stationary and describe noise *levels*, whereas OSHA regulates noise *exposures* for workers who move around. OSHA recognizes this problem. For this reason OSHA advises employers to post signs in areas where employees' noise exposures regularly rather than occasionally meet or exceed 85 dB. Also, the Agency is aware that not all workers who are exposed to a TWA above 85 dB are required to wear hearing protectors. Therefore the Agency advises employers to specify mandatory ear protectors on the sign in locations where employees' noise exposures are routinely above 90 dB, and in areas where employee's exposures are between 85 and 90 dB employers may specify that hearing protectors are advised, or may be needed.

Some comments recommended that OSHA put specific wording for signs into the regulation (Ex. 1, p. I-9; Ex. 48, p. 9; Ex. 110, p. 4), or provide examples of clearly worded signs (Ex. 14-152, p. 4). Although the Agency believes that employers should be free to devise their own wording, the following examples are suggested:

In work areas where employee exposure routinely exceed a TWA of 90 dB:

WARNING

HAZARDOUS NOISE AREA

Hearing Protection

Required

In work areas where employee exposures routinely exceed a TWA between 85 and 90 dB:

WARNING

HAZARDOUS NOISE AREA

Hearing Protection

May be Necessary

OSHA has not prescribed the specific wording for the warning signs. It is desirable to retain as much flexibility as possible so that employers may devise signs that are appropriate to the specific workplace environment.

Recordkeeping

Section 8(c)(1) of the Occupational Safety and Health Act gives OSHA the authority to require employers to maintain records that are: "Necessary or appropriate for the enforcement of this Act, or for developing information regarding the cause and prevention of occupational accidents and illnesses." Section 8(c)(3) requires OSHA to "issue regulations requiring employers to maintain accurate records of employee exposures to potentially toxic materials or harmful physical agents which are required to be monitored or measured under section 6."

The hearing conservation amendment requires that records of noise exposure measurements, audiometric testing and audiometer calibration be maintained. These recordkeeping requirements have been approved by the Office of Management and Budget (Approval No. 44-R 1022).

Noise exposure records require the date, location, and results of the measurements, including the number of measurements made when sound level meters are used. Although the latter requirement did not appear in the proposal, this provision provides further clarification of the proposal's requirement that the employer keep an accurate record of all noise exposure measurements. The number of sound level meter measurements is required to be recorded in order to show that the sampling procedures have been sufficient to give a reasonable estimate of the TWA for the range of noise levels encountered. The final rule also requires a description of the equipment used and the date of the most recent laboratory-type calibration. The name and job classification must be recorded for each employee measured, and for any other employees represented by the measured employee. Although not specified in the proposal, an entry for job classification (or job title) has been added so that employers and employees may see the important connection between job location and magnitude of exposure. The requirement to record the social security number has been eliminated as unnecessary paperwork unless the employer desires to keep it. Records of noise exposure monitoring must be kept for at least 2 years. This represents a relaxation of the proposal's requirement, which was to keep noise exposure records for at least 5 years. Since the employee's most recent noise exposure must be recorded on the audiometric test record, OSHA feels that it is unnecessary to keep records of noise exposure monitoring for longer than 2 years, after which they may be replaced by new monitoring records.

Records of audiometric tests must include the employee's name and job classification. They must also include the date of the audiometric test, the examiner's name and qualifications, the make and model of the audiometer, and the date of the last acoustic or exhaustive audiometer calibration. These requirements are essentially the same as those of the proposal, except for the inclusion of job classification and the deletion of social security number for the reasons stated above. The Agency has added a requirement to record the employee's most recent noise exposure (or that of the employee's representative) on the audiogram record. This will aid employers and professional reviewers in making important associations between noise exposure and hearing loss, and will permit monitoring records to be disposed of at an earlier date. Also, the amendment requires that employers indicate on the audiometric test record whether the background noise levels in the audiometer room met the levels specified on Table D-1 or Table D-2 in Appendix D. This information will be very useful to the professional reviewer, who needs to know that the audiometric test was carried out in sufficiently quiet conditions. As required in the proposal, audiometric test records must be retained for the duration of employment plus 5 years.

OSHA recommends that employers record the type of hearing protector selected, its attenuation (usually the NRR), and the procedure used to determine its attenuation, which involves identifying the method selected from Appendix C. This entry, coupled with the exposure measurement, would be useful to employers and professional reviewers in assessing the adequacy of hearing protection. However, OSHA has not made this provision a requirement because employers must provide workers with a variety of ear protectors, and workers may want to use certain protectors on a trail basis. The Agency does not want to restrict the flexibility with which employers offer and employees choose their hearing protection by requiring employers to record the make of protector before the final choice is made.

The requirements for keeping records of audiometer calibration are the same as those specified by the proposal. The record must include information on the type of calibration, whether an acoustic or exhaustive calibration, and the date the calibration was performed. The record must also include the numerical results of the acoustical calibration, which are the results of the measurements taken. These records will provide employers and professional reviewers with evidence of the proper functioning of the audiometer, and any steps that were taken to correct improper functioning. As required in the proposal, they must be kept for a minimum of 5 years.

Although the proposal did not contain this requirement, employees must record measurements of the background sound pressure levels in the audiometric test room and the date of these measurements. The Agency believes that this information must be recorded because it is critical to the requirement that valid audiograms be made. Sound pressure level measurements of audiometric test rooms must be kept at least 5 years.

OSHA has included a new requirement for the transfer of records in case an employer should cease to do business. If a new employer takes over the business the old employer must transfer the records to the new employer. This provision, which is added to safeguard the records, also is found in other OSHA standards.

Discussion in the hearing record centered on the usefulness of keeping records, the impact of recordkeeping on the affected businesses, the retention period, access to records, and recordkeeping procedures.

Some commenters questioned the usefulness of keeping records. M. V. Truss, Director of Engineering at the Vulcan Material Company (Ex. 14-58, p. 2) was joined by others (Ex. 14-88, p. 2; Ex. 14-35, p. 1) in saying that disruptive paper work would seem to outweigh any theoretical benefits. Others maintained that recordkeeping requirements have no bearing on the reduction of noise levels or on hearing loss (Ex. 14-129, p. 3; Ex. 14-190, p. 1; Ex. 14-246, p. 5; Ex. 14-791, pp. 1-2). Carroll Rogers Jr., President of the Feldspar Corporation (Ex. 14-28, p. 1), was among those who believed that the provisions would be too burdensome, especially for small business (Ex. 14-72, p. 1; Ex. 14-117, p. 1; Ex. 14-201, p. 1; Ex. 14-215, p. 4; Ex. 14-266, p. 2; Ex. 14-292, pp. 2-3).

OSHA understands that recordkeeping can be problematic; however, without this requirement the effectiveness of the amendment would be impaired. Professional reviewers need to make sure that the audiometric tests were carried out under proper conditions and that audiograms reflect employees' true hearing levels. Records are educational for employees because they enable employees to assess the continuing status of their hearing. In addition, they provide employers with a way of assessing the success or failure of the hearing conservation program.

Some industry spokesmen suggested that records should not have to be kept for short-term employees. The National Association of Manufacturers (Ex. 14-864, p. 20), and the Beet Sugar Development Foundation and the United States Beet Sugar Association (Ex. 14-867, p. 3, p. 34) suggested that records should only be kept for employees who have worked continuously for more than 180 days, whereas the National Canners Association (Ex. 188-4, p. 6) suggested 120 days. The Can Manufacturers Institute (Ex. 14-862, p. 23) thought that employees should have worked at least 1 year before records should be kept. Although no recordkeeping exemptions have been specified, OSHA believes that short-term employees should not present a significant recordkeeping problem. Audiometric testing of short-term workers is not required unless they remain at work longer than 4 months.

Since employers must monitor new employees within 60 days of exposure to a TWA of 85 dB or greater, they may have to keep noise exposure records of short-term employees. In most cases, as explained earlier, a new employee will assume a position occupied by a former employee, and therefore the former employee's noise exposure will be attributed to the new employee. Making and retaining the same information for the new employee should not be a difficult matter. Also, since the amendment permits employers to monitor representative employees rather than all employees, this procedure should reduce the recordkeeping burden in many cases. Employers may choose to write the exposure level, names, and jobs of the represented employees all on one record. Employers must, however, record the most recent exposure measurement on each individual's audiometric test record.

Following the recommendation of the Advisory Committee (Ex. 2 B, p. 17) the proposal required noise exposure measurements to be maintained for 5 years, audiometric records to be maintained for 5 years. Many comments to the record discussed this issue. Some, such as those of Dr. Ward (Ex. 64-9, p. 5), Robert Richards of the Consumers Power Company (Ex. 14-332, p. 5), and others (Ex. 14-348, p. 3, Ex. 14-329, p. 3), indicated that the proposed record retention periods were too long and too costly. Edwin Hood of the Shipbuilders Council of America (AC 53-1, p. 3) suggested that the employer determine the length of the retention period but that all records be kept for at least 5 years. On the other hand, Frank Fitzsimmons of the International Brotherhood of Teamsters (Ex. 81A, p. 9) advocated a longer retention period for exposure records, stating that exposure records should be kept for the same amount of time as audiometric records so that the relationship between noise exposure and hearing loss can be reviewed. NIOSH recommended a 10-year retention period for records of exposure monitoring, 20 years for audiometric records, and 20 years for audiometric calibration records. NIOSH's recommendations were supported by Raelyn Janssen of the Environmental Defense Fund (AC 125-1, p. 11) and by Dr. J. Ronald Bailey, Assistant Professor of Mechanical Engineering at the North Carolina State University (AC 33, p. 10). Dr. Victor Gladstone, Assistant Professor of Audiology at Towson State College (AC 31, p. 3) concurred with NIOSH, but recommended that if an employee remained in the same employment for a period longer than 20 years, audiometric records should be kept for the duration of employment.

OSHA has considered these recommendations and agrees with Mr. Fitzsimmons that both noise exposure measurements and audiometric test records should be retained at least for the duration of employment to enable employers and professional reviewers to follow the employee's audiometric thresholds in relation to the employee's noise exposure levels. This procedure has been accomplished (and simplified) by the requirement to record the employee's latest noise exposure level on the audiometric test record. OSHA believes that it is not necessary to keep the details of the noise measurements, such as a description of the equipment and the date of calibration, longer than 2 years, at which time they may be replaced by new measurements. However, the Agency does see the value in keeping audiometric test records *and* the employee's exposure levels for the duration of employment plus 5 years in order to ascertain the employee's sensitivity to noise exposure, and to judge the effectiveness of the hearing conservation program.

A minimum of 5 years was selected for the retention of audiometric calibration records and records of the sound pressure levels in audiometric test rooms. These durations are necessary so that employers and professional reviewers may be assured that a series of audiograms was carried out under proper test conditions.

Requirements for access to records are essentially the same as those of the proposal, with the exception that the proposal required employers to furnish copies of audiometric data upon *written* request by employees. The amendment specifies written requests only when employees designate another person to receive the records. The Agency does not believe that written requests are necessary for direct employee access to either noise monitoring or audiometric test records. The amendment requires employers to make records available, upon request, to the Assistant Secretary of Labor and his or her respective authorized representatives, including compliance officers. Copies of records must be made available to affected (noise-exposed) employees and former employees. If an employee or former employee should present a written request, employers must also furnish the records to any person designated by the employee, such as a physician, lawyer, or union representative. Since employees are granted access to their records, OSHA advises them to take copies with them when they leave their jobs.

OSHA's standard entitled "Access to Employee Exposure and Medical Records" (29 CFR 1910.20 (d)(i) and (ii)) requires that employee medical records be preserved and maintained for at least the duration of employment plus 30 years, that exposure records be preserved and maintained for at least 30 years, and that calibration records (which would be covered by section (d)(ii) (A), "background data") be retained for 1 year. However, the standard provides that it may be superseded by other health standards that require longer or shorter retention periods. According to the standard's preamble, the reason for the 30-year or longer retention period was the long latency periods associated with certain occupational diseases. The Agency recognizes, however, that specific substances or agents may merit longer or shorter record retention periods, in which case an individual standard's recordkeeping requirements would supersede those of 29 CFR 1910.20. This provision in the access standard is appropriate since each health standard is based on rulemaking evidence specific to the substance or agent being regulated (45 FR 35270). Since the hearing conservation amendment has undergone the rulemaking procedure on issues that are specific to noise, some provisions in the amendment are different from those in the access standard.

OSHA believes that it is unnecessary to require retention of noise exposure and audiometric test records for periods as long as 30 years. In the event that some companies and consulting firms wish to computerize these records and retain them indefinitely, the Agency would encourage this practice. However, the latency for noise-induced hearing loss is not nearly as long as it is for certain other occupational diseases, such as cancer. Although the onset of noise-induced hearing loss is gradual, its progress is not expected to continue after cessation of exposure. Therefore a long record-retention period would not aid in the diagnosis of a condition, or in the identification of a hazard that is not already recognized.

The standard also requires that employees, their designated representatives, the Assistant Secretary for Occupational Safety and Health shall have access to all records required to be maintained. In general, the employer is obliged to provide access to such records at a reasonable time, place and manner. Specifics regarding the provision of such access are found at 29 CFR 1910.20 and 29 CFR 1913.10.

It is the Agency's belief that providing employees with access to the records is a necessary component of the hearing conservation program. Such access will serve to educate employees as to the state of their hearing and the effectiveness of the program, and will encourage their conscientious participation in it. The information in the records will be invaluable to the Assistant Secretary in the enforcement of the amendment and will be useful in research into the effects of occupational noise exposure. The Director of NIOSH will also be primarily interested in the records for research purposes.

A number of commenters, such as Moyer B. Edwards of the Alabama By-Products Corporation (Ex. 14-972, p. 6), recommended restricting access to records to the employee's physician or other medical representative (Ex. 145, p. 5). Others (Ex. 233, p. 1; Ex. 14-900, p. 9; Ex. 14-965, p. 6; Ex. 14-690, p. 5) believed that because of the technical nature of the data, lay readers might misinterpret their files. Douglass Bracket of the Southern Furniture Manufacturers Association (Ex. 14-918, p. 17) and others (Ex. 14-345, p. 4) contended that records only should be made available for some justifiable reason. Lockheed-California Company (Ex. 14-312, p. 2) suggested that records should be available for exposure studies only. Some were concerned that employee access to records might result in "misuse of records" in worker compensation cases (Ex. 14-86, p. 2; Ex. 14-107, p. 1; Ex. 14-233, p. 1; Ex. 14-262, p. 3; Ex. 14-333, p. 6), and some suggested that workers might "harass" employers after they see their records (Ex. 14-107, p. 1; Ex. 14-233, p. 1; Ex. 14-262, p. 3; Ex. 14-332, p. 5). OSHA believes that proper training and education of employees should prevent misinterpretations or "misuse" of noise exposure or audiometric data. The Agency agrees with the many witnesses who stated that informed workers are better motivated and able to protect themselves, and to effectively participate in the total hearing conservation program (Ex. 305, p. 7; Ex. 306, p. J2c-11; Ex. 321-1, Section 2, p. 3; Ex. 307, p. 1; Tr. 2907). Access to their own noise exposure and audiometric test results is a necessary step in the development of informed workers.

XII. Authority

This document was prepared under the direction of Eula Bingham, Assistant Secretary for Occupational Safety and Health, 200 Constitution Avenue, N.W., Washington D.C. 20210.

Pursuant to sections 6(b) and 8(c) of the Occupational Safety and Health Act of 1970 (84 Stat. 1593, 1599, 29 U.S.C. 655, 657), Secretary of Labor's Order No. 8-76 (41 FR 25059), and 29 CFR Part 1911, Part 1910 of Title 29, Code of Federal Regulations is hereby amended by deleting paragraph (b)(3) of § 1910.95 and adding to § 1910.95 requirements for a hearing conservation program in new paragraphs (c) through (s) plus Appendices A through I.

The provision of the current occupational noise standard requiring employers who have employees exposed over the permissible exposure level to implement a continuing, effective hearing conservation program (§ 1910.95(b)(3)) will remain in effect until the new paragraphs contained in this document actually go into effect. Should the new paragraphs be stayed, judicially or administratively, or should the new paragraphs not sustain legal challenge under section 6(f) of the Act, paragraph (b)(3) of § 1910.95 will remain in effect.

Any petitions for administrative reconsideration of this amendment or for an administrative stay pending judicial review must be filed with the Assistant Secretary of Labor for Occupational Safety and Health within 45 days of the publication of this amendment in the Federal Register. Any petitions filed after this date will be considered to be untimely filed. This requirement is considered essential to permit the Agency to give full consideration to any petition filed and respond in advance of the effective date of the amendment.

Signed at Washington, D.C. this 8th day of January, 1981.

Eula Bingham,

Assistant Secretary of Labor.

1. Paragraph (b)(3) of § 1910.95 is removed.

2. Section 1910.95 is amended by adding new paragraphs (c) through (s) and Appendix A through I to read as follows:

§ 1910.95 Occupational noise exposure.

* * * * *

(c) *Hearing conservation program.* The employer shall administer a continuing, effective hearing conservation program, as described in paragraphs (c) through (s) of this section whenever employee noise exposures equal or exceed an 8-hour time-weighted average sound level (TWA) of 85 decibels measured on the A scale or, equivalently, a dose of fifty percent. For purposes of the hearing conservation program, employee noise exposures shall be computed in accordance with Appendix A and Table G-16a, and without regard to any attenuation provided by the use of personal protective equipment.

(d) *Initial determination.* (1) Each employer shall determine if any employee's exposure may equal or exceed an 8-hour time-weighted average of 85 decibels (dB) measured on the A scale. This determination shall be based on all information, observations, or calculations which indicate that employee noise exposures may be at or above that level, including the following:

(i) Any employee exposure measurements which have been taken;

(ii) Any employee complaints which may be attributable to noise exposure;

(iii) Any difficulties in understanding normal conversation in the workplace when the speaker and the listener face each other at a distance of two feet.

(2) This initial determination shall be repeated at least every two years and within sixty days of a change in production, processes, equipment, controls, or personnel which may result in new noise exposures at or above a time-weighted average of 85 decibels.

(e) *Monitoring.* (1) When any information in the initial determination conducted pursuant to paragraph (d) of this section indicates that any employee's exposure may equal or exceed an 8-hour time-weighted average of 85 decibels, the employer shall within 60 days obtain individual or representative exposure measurements for all employees who may be exposed at or above that level.

(2) In cases where a group of employees is engaged in a similar kind of work and has approximately the same noise exposure, the employer may, in lieu of measuring the exposure of each employee, measure only one member of the group. In these cases, the employer shall select for monitoring the employee who is reasonably believed to have the greatest exposure and shall attribute the selected employee's exposure measurement to all employees in the group.

(3) Monitoring of employee noise exposures shall be repeated:

(i) Every two years unless an initial determination conducted pursuant to paragraph (d)(2) of this section or actual exposure measurements indicate that employees are not exposed to a time-weighted average of 85 decibels or greater; and

(ii) Within sixty days of a change in production, processes, equipment, controls, or personnel which may render the attenuation provided by hearing protectors in use inadequate to meet the requirements of paragraph (m) of this section.

(f) *Employee notification.* (1) Within 21 days of monitoring, the employer shall notify, in writing, each employee exposed at or above a time-weighted average of 85 decibels of the results of the monitoring.

(2) Each employee shall be notified of that employee's measured exposure or the representative exposure that is attributed to that employee.

(3) New employees shall be notified of their measured exposure or the exposure attributed to them within sixty days of their first exposure at or above a time-weighted average of 85 decibels.

(g) *Method of measurement.* (1) All employee exposure measurements required by paragraph (e) of this section shall be obtained by the use of noise dosimeters which comply with the provisions of paragraph (g)(1)(i) of this section or sound level meters which comply with the provisions of paragraph (g)(1)(ii) of this section.

(i) *Dosimeters.* Dosimeters shall meet the Class 2A-90/80-5 requirements of the American National Standard Specification for Personal Noise Dosimeters, S1.25–1978, with an operating range of at least 80 dB to 120 dB. Dosimeters shall also meet the performance requirements of Section 7.5 of ANSI S1.25–1978 for a test signal at an average A-weighted sound level of 90 dB having a crest factor of 30 dB.

(ii) *Sound level meters.* Sound level meters shall meet the Type II requirements of the American National Standard Specification for Sound Level Meters, S1.4–1971 (R1976).

(2) Exposure measurements shall accurately reflect employee exposures and shall be conducted in the following manner:

(i) *Dosimeters.* The microphone of the dosimeter shall be placed on the employee's shoulder or head.

(ii) *Sound level meters.* (*a*) Sound level meters shall be set to the A scale, slow response.

(*b*) All continuous, intermittent and impulsive sound levels from 80 dB to 130 dB shall be integrated into the computation of time-weighted average.

(*c*) The employer shall use an appropriate sampling strategy to ensure that accurate results are obtained. The employer may use the sampling procedures given in Appendix B: *Temporal Sampling Procedures for Use with a Sound Level Meter,* which are provided as guidelines for compliance with this provision.

(*d*) The microphone of a sound level meter shall be positioned not less that two inches nor more than two feet from the worker's ear.

(h) *Calibration of monitoring equipment.* Dosimeters and sound level meters used to monitor employee noise exposure shall be calibrated as follows:

(1) Before and after each day's measurements, an acoustical calibrator shall be used to verify the accuracy of the measuring equipment.

(2) Whenever acoustical calibration and manual adjustments of the measuring equipment cannot verify the accuracy of the measuring instrument, laboratory calibration shall be performed to ensure conformance with the requirements of ANSI S1.25–1978 or S1.4–1971, as appropriate.

(i) *Observation of monitoring.* (1) The employer shall provide affected employees or their representatives with an opportunity to observe any measurements of employee noise exposure which are conducted pursuant to paragraph (e) of this section.

(2) Without interfering with the monitoring procedures, the observer shall be entitled to:

(i) Receive an explanation of the measurement procedures;

(ii) Observe all steps related to the noise exposure measurements performed at the place of exposure; and

(iii) Record the results obtained.

(j) *Audiometric testing program.* (1) The employer shall establish and maintain an audiometric testing program as provided in this paragraph by making audiometric testing available to all employees whose exposures equal or exceed an 8-hour time-weighted average of 85 decibels.

(2) The program shall be provided at no cost to employees.

(3) Audiometric tests shall be performed by a licensed or certified audiologist, otolaryngologist, or other qualified physician, or by a person who is certified by the Council of Accreditation in Occupational Hearing Conservation, or by an audiometric technician who has satisfactorily demonstrated competence in administering audiometric examinations, obtaining valid audiograms, and properly using, maintaining and calibrating audiometers. A technician who performs audiometric tests must be responsible to an audiologist, otolaryngologist or qualified physician.

(4) All audiograms obtained pursuant to this section shall meet the requirements of Appendix C: *Audiometric Measuring Instruments.*

(5) *Baseline audiogram.* (i) Within 4 months of an employee's first exposure to noise at or above a time-weighted average of 85 decibels, the employer shall establish for each employee so exposed a valid baseline audiogram against which subsequent audiograms can be compared.

(ii) Testing to establish a baseline audiogram shall be preceded by at least 14 hours without exposure to workplace noise.

(*a*) Hearing protectors shall not be used as a substitute for the requirement that baseline audiograms be preceded by 14 hours without exposure to workplace noise.

(*b*) The employer shall notify employees of the need to avoid high levels of non-occupational noise exposure during this 14-hour period.

(6) *Annual audiogram.* (i) At least annually after obtaining the baseline audiogram, the employer shall obtain a new audiogram for each employee exposed at or above a time-weighted average of 85 decibels.

(ii) Annual audiometric testing may be conducted at any time during the workshift.

(7) *Evaluation of audiogram.* (i) Each employee's annual audiogram shall be compared to that employee's baseline audiogram to determine if the audiogram is valid and if a significant threshold shift, as defined in paragraph (j)(10) of this section, has occurred.

(ii) Such evaluation shall be performed by an audiologist, otolaryngologist, or qualified physician. The employer shall provide to the person performing this evaluation the following information:

(*a*) A copy of the requirements for hearing conservation as set forth in paragraphs (c) through (r) of this section;

(*b*) The baseline audiogram and most recent audiogram of the employee to be evaluated;

(*c*) Measurements of background sound pressure levels in the audiometric test room as required in Appendix D: *Audiometric Test Rooms.*

(*d*) Records of audiometer calibrations required by paragraph (k)(5) of this section.

(iii) The audiologist, otolaryngologist, or qualified physician shall also review the audiograms to determine whether any significant threshold shift is work related or whether there is need for further evaluation.

(iv) If the comparison of the audiograms reveals a significant threshold shift as defined in paragraph (j)(10) of this section, a retest to obtain a new audiogram shall be performed within 60 days to determine if the shift is permanent.

(*a*) Retesting shall be preceded by at least 14 hours without exposure to workplace noise.

(*b*) Hearing protectors shall not be used as a substitute for the requirement that retesting be preceded by at least 14 hours without exposure to workplace noise.

(*c*) Retesting is not required if the annual audiogram was obtained after 14 hours without exposure to workplace noise. In this case the significant threshold shift revealed by the annual audiogram shall be considered permanent.

(*d*) If retesting also reveals a significant threshold shift as defined in paragraph (j)(10) of this section, the significant threshold shift shall be considered permanent.

(8) *Follow-up procedures.* If a comparison of the annual audiogram to the baseline audiogram indicates a significant threshold shift as defined in paragraph (j)(10) of this section, the employer shall ensure that the following steps are taken:

(i) Employees not using hearing protectors shall be fitted with hearing protectors, trained in their use and care, and required to use them.

(ii) Employees already using hearing protectors shall be refitted and retrained in the use of hearing protectors and provided with hearing protectors offering greater attenuation if necessary.

(iii) If retesting of an employee reveals that the significant threshold shift is not permanent, the use of hearing protectors by that employee may be discontinued, unless the employee is required to wear hearing protectors pursuant to paragraph (b)(1) of this section.

(iv) If a significant threshold shift has been determined to be permanent on the basis of a retest audiogram or an annual audiogram conducted after 14 hours without exposure to workplace noise, the employer shall:

(*a*) Inform the employee in writing, within 21 days of the determination, of the existence of a permanent significant threshold shift;

(*b*) Refer the employee for a clinical audiological evaluation or an otological examination, as appropriate, if additional testing is necessary to determine the cause of the permanent significant threshold shift, or if the employer suspects that a medical pathology of the ear (as defined in Appendix I) is caused or aggravated by the wearing of hearing protectors;

(*c*) Inform the employee of the need for an otological examination if a medical pathology of the ear which is unrelated to the use of hearing protectors is suspected; and

(*d*) Record the existence of the permanent significant threshold shift on the OSHA Form 200 when the audiologist, otolaryngologist or qualified physician who reviews the audiogram determines that the shift is work related.

(9) *Revised baseline.* An annual or retest audiogram shall be substituted for the baseline audiogram under the following circumstances:

(i) Where the annual or retest audiogram reveals a permanent significant threshold shift as defined in paragraph (j)(10) of this section; or

(ii) Where the annual or retest audiogram reveals improved hearing thresholds with respect to the baseline at two or more test frequencies.

(10) *Significant threshold shift.* As used in this section, a significant threshold shift is:

(i) A change in hearing threshold relative to the baseline audiogram of 20 dB or greater at any test frequency other than 500 Hz in either ear, if no previous audiograms have thresholds that exceed 25 dB with reference to audiometric zero as specified by American National Standard S3.6–1969; or

(ii) A change in hearing threshold relative to the baseline audiogram of 10 dB or greater at 1000 or 2000 Hz, 15 dB at 3000 or 4000 Hz, or 20 dB at 6000 Hz, in either ear, if any previous audiogram has one or more thresholds that exceed 25 dB with reference to audiometric zero; or

(iii) A change in hearing threshold relative to the baseline audiogram of 10 dB or greater at any test frequency other than 500 Hz in either ear, if any previous audiogram has thresholds exceeding an average of 25 dB with reference to audiometric zero at the frequencies 1000, 2000, and 3000 Hz; or

(iv) A change in hearing threshold relative to the baseline audiogram of 10 dB or greater at any test frequency other than 500 Hz in either ear, if the employee has previously suffered one or more permanent significant threshold shifts.

(v) In determining whether a significant threshold shift has occurred, allowance may be made for the contribution of aging (presbycusis) to the change in hearing level by correcting the annual or retest audiogram according to the procedure described in Appendix F: *Calculation and Application of Age Correction to Audiograms.*

(k) *Audiometric test requirements.* (1) Audiometric tests shall be pure tone, air conduction, hearing threshold examinations, with test frequencies including as a minimum 500, 1000, 2000, 3000, 4000, and 6000 Hz. Tests at each frequency shall be taken separately for each ear.

(2) Audiometric tests shall be conducted with equipment that meets the specifications of, and is maintained and used in accordance with, American National Standard Specification for Audiometers, S3.6–1969.

(3) Pulsed-tone and self-recording audiometers, if used, shall meet the requirements specified in Appendix C: *Audiometric Measuring Instruments.*

(4) Audiometric examinations shall be administered in a room meeting the requirements listed in Appendix D: *Audiometric Test Rooms.*

(5) *Audiometer calibration.* (i) The functional operation of the audiometer shall be checked before each day's use by testing a person with known, stable hearing thresholds, and by listening to the audiometer's output to make sure that the output is free from distorted or unwanted sounds. Deviations of more than 5 dB shall require an acoustic calibration.

(ii) Audiometer calibration shall be checked acoustically at least annually in accordance with Appendix E: *Acoustic Calibration of Audiometers.* Test frequencies below 500 Hz and above 6000 Hz may be omitted from this check. Deviations of more than 10 dB necessitate an exhaustive calibration.

(iii) An exhaustive calibration shall be performed at least every two years in accordance with sections 4.1.2; 4.1.3; 4.1.4.3; 4.4.1; 4.4.2; 4.4.3; and 4.5 of the American National Standard Specification for Audiometers, S3.6–1969. Test frequencies below 500 Hz may be omitted from this calibration.

(l) *Hearing protectors.* (1) Employers shall make hearing protectors available to all employees exposed to a time-weighted average of 85 decibels or greater at no cost to the employees. Hearing protectors shall be replaced as necessary.

(2) Employers shall ensure that hearing protectors are worn by all employees:

(i) Who are exposed to a time-weighted average of 85 decibels or greater and who have experienced a permanent significant threshold shift; or

(ii) Who are required by paragraph (b)(1) of this section to wear personal protective equipment.

(3) Employees shall be given the opportunity to select their hearing protectors from a variety of suitable hearing protectors provided by the employer.

(4) The employer shall provide training in the use and care of all hearing protectors provided to employees.

(5) The employer shall ensure proper initial fitting and supervise the correct use of all hearing protectors.

(m) *Hearing protector attenuation.* (1) The employer shall evaluate hearing protector attenuation for the specific noise environments in which the protector will be used by one of the methods described in Appendix G:

Methods for Estimating the Adequacy of Hearing Protector Attenuation.

(2) Hearing protectors must attenuate employee exposure at least to a time-weighted average of 90 decibels as required by paragraph (b) of this section.

(3) For employees who have experienced a significant threshold shift, hearing protectors must attenuate employee exposures to a time-weighted average of 85 decibels or below.

(4) The adequacy of hearing protector attenuation shall be re-evaluated whenever employee noise exposures increase to the extent that the hearing protectors provided may no longer provide adequate attenuation. The employer shall provide more effective hearing protectors where necessary.

(n) *Training program.* (1) The employer shall institute a training program for all employees who are exposed to noise at or above a TWA of 85 dB, and shall ensure employee participation in such program.

(2) The training program shall be repeated annually for each employee included in the hearing conservation program. Information provided in the training program shall be updated to be consistent with changes in protective equipment and work processes.

(3) The employer shall ensure that each employee is informed of the following:

(i) The contents of the noise standard including the hearing conservation program;

(ii) The effects of noise on hearing;

(iii) Specific machinery at the jobsite that could produce hazardous noise exposures;

(iv) The role of engineering and administrative controls in the reduction of noise exposure;

(v) The contents of any noise control compliance plan in effect;

(vi) The purpose of hearing protectors, the advantages, disadvantages, and attenuation of various types, and instructions on selection, fitting, use, and care; and

(vii) The purpose of audiometric testing, and an explanation of the test procedures.

(o) *Access to information and training materials.* (1) The employer shall make available to affected employees or their representatives copies of this standard and shall also post a copy in the workplace.

(2) The employer shall provide to affected employees any informational materials pertaining to this standard that are supplied to the employer by the Assistant Secretary.

(3) The employer shall provide, upon request, all materials related to the employer's training and education program pertaining to this standard to the Assistant Secretary and the Director.

(p) *Warning signs.* (1) Signs shall be posted at entrances to or on the periphery of all well-defined work areas in which employees may be exposed at or above a TWA of 85 dB.

(2) Warning signs shall clearly indicate that the area is a high noise area and shall indicate that hearing protectors may be required.

(q) *Recordkeeping.* (1) *Exposure measurements.* (i) The employer shall maintain an accurate record of all employee exposure measurements required by paragraph (e) of this section.

(ii) This exposure record shall include:

(*a*) Name and job classification of the employee measured and of all other employees whose exposure the measurement represents;

(*b*) The date, location and result of each measurement taken, and the number of measurements where sound level meters are used;

(*c*) A descripton of the noise measurement equipment used and the date of it last laboratory calibration.

(2) *Audiometric tests.* (i) The employer shall retain all employee audiograms obtained pursuant to paragraph (j) of this section;

(ii) This record shall include:

(*a*) Name and job classification of the employee;

(*b*) Date of the audiogram;

(*c*) The examiner's name and qualifications;

(*d*) Manufacturer and model of the audiometer;

(*e*) Date of the last acoustic or exhaustive calibration of the audiometer;

(*f*) Employee's most recent noise exposure assessment;

(*g*) Statement of whether the sound pressure levels in the test room in which the audiogram was taken meet the levels specified in Table D-1 or Table D-2 of Appendix D: *Audiometric Test Rooms.*

(3) *Audiometric test rooms.* (i) The employer shall maintain accurate records of the measurements of the background sound pressure levels in audiometric test rooms.

(ii) This record shall include:

(*a*) Background sound pressure level measurements at each of the following octave bands: 500, 1000, 2000, 4000, and 8000 Hz; and

(*b*) Date of measurement.

(4) *Calibration of audiometers.* (i) The employer shall maintain accurate records of all acoustical and exhaustive calibrations of audiometers required to be made pursuant to paragraph (k) of this section;

(ii) This record shall include:

(*a*) Type of calibration;

(*b*) Date performed; and

(*c*) Numerical results of the acoustical calibration.

(5) *Record retention.* The employer shall retain records required in this paragraph (q) for at least the following periods:

(i) Noise exposure measurement records shall be retained for 2 years.

(ii) Audiometric test records shall be retained for the duration of the affected employee's employment plus 5 years.

(iii) Records of background sound pressure levels in audiometric test rooms shall be retained for a period of 5 years.

(iv) Records of audiometer calibrations shall be retained for a period of 5 years.

(6) *Access to records.* All records required by this section shall be provided upon request to employees, former employees, representatives designated by the individual employee and the Assistant Secretary. The provisions of 29 CFR 1910.20(a)-(e) and (g)-(i) apply to access to records under this section.

(7) *Transfer of records.* If the employer ceases to do business, the employer shall transfer to the successor employer all records required to be maintained by this section, and the successor employer shall retain them for the remainder of the period prescribed in paragraph (q)(5) of this section.

(r) *Appendices.* (1) Appendices A, C, D, E, G, and I to this section are incorporated as part of this section and the contents of these Appendices are mandatory.

(2) Appendices B, F and H to this section are informational and are not intended to create any additional obligations not otherwise imposed or to detract from any existing obligations.

(s) *Effective dates.* (1) Paragraphs (c)-(r) of this section shall become effective April 15, 1981 unless otherwise noted below.

(2) Initial determinations and subsequent monitoring conducted pursuant to paragraphs (d) and (e) of this section shall be completed by October 15, 1981.

(3) Baseline audiograms required by paragraph (j) of this section shall be completed by April 15, 1982.

(4) In lieu of Table D-1 of Appendix D, background sound pressure levels in audiometric test rooms may conform to Table D-2 of Appendix D until April 15, 1983. After April 15, 1983, background sound pressure levels in audiometric test rooms shall comply with Table D-1 of Appendix D.

(5) Dosimeters used for employee exposure monitoring conducted pursuant to paragraph (e) of this section shall meet the requirements of paragraph (g)(1)(i) of this section by April 15, 1983.

Appendix A: Noise Exposure Computation

This Appendix is Mandatory

I. Computation of Employee Noise Exposure

(1) Noise dose is computed using Table G-16a as follows:

(i) When the sound level, L, is constant over the entire work shift, the noise dose, D, in percent, is given by: D=100 C/T where C is the total length of the work day, in hours, and T is the reference duration corresponding to the measured sound level, L, as given in Table G-16a or by the formula shown as a footnote to that table.

(ii) When the workshift noise exposure is composed of two or more periods of noise at different levels, the total noise dose over the work day is given by: $D=100\ (C_1/T_1+C_2/T_2+\ \ldots\ +C_n/T_n)$, where C_n indicates the total time of exposure at a specific noise level, and T_n indicates the reference duration for that level as given by Table G-16a.

(2) The eight-hour time-weighted average sound level (TWA), in decibels, may be computed from the dose, in percent, by means of the formula: $TWA=16.61\ \log_{10}\ (D/100)+90$. For an eight-hour workshift with the noise level constant over the entire shift, the TWA is equal to the measured sound level.

(3) A table relating dose and TWA is given in Section II.

Table G-16a

A-weighted sound level, L (decibel)	Reference duration, T (hour)
80	32
81	27.9
82	24.3
83	21.1
84	18.4
85	16
86	13.9
87	12.1
88	10.6
89	9.2
90	8
91	7.0
92	6.2
93	5.3
94	4.6
95	4
96	3.5
97	3.0
98	2.6
99	2.3
100	2
101	1.7
102	1.5
103	1.4
104	1.3
105	1
106	0.87

Table G-16a—Continued

A-weighted sound level, L (decibel)	Reference duration, T (hour)
107	0.76
108	0.66
109	0.57
110	0.5
111	0.44
112	0.38
113	0.33
114	0.29
115	0.25
116	0.22
117	0.19
118	0.16
119	0.14
120	0.125
121	0.11
122	0.095
123	0.082
124	0.072
125	0.063
126	0.054
127	0.047
128	0.041
129	0.036
130	0.031

In the above table the reference duration, T, is computed by

$$T = \frac{8}{2^{(L-90)/5}}$$

where L is the measured A-weighted sound level.

II. Conversion Between "Dose" and "8-Hour Time-Weighted Average" Sound Level

Compliance with paragraphs (c)-(r) of this regulation is determined by the amount of exposure to noise in the workplace. The amount of such exposure is usually measured with an audiodosimeter which gives a readout in terms of "dose." In order to better understand the requirements of the amendment, dosimeter readings can be converted to an "8-hour time-weighted average (TWA) sound level".

In order to convert the reading of a dosimeter into TWA, see Table A-1, below. This table applies to dosimeters that are set by the manufacturer to calculate dose or percent exposure according to the relationships in Table G-16a. So, for example, a dose of 91 percent over an eight hour day results in a TWA of 89.3 dB, and, a dose of 50 percent corresponds to a TWA of 85 dB.

If the dose as read on the dosimeter is less than or greater than the values found in Table A-1, the TWA may be calculated by using the formula: $TWA=16.61\ \log_{10}\ (D/100)+90$ where TWA=8-hour time-weighted average sound level and D=accumulated dose in percent exposure.

Table A-1.—*Conversion From "Percent Noise Exposure" or "Dose" to "8-Hour Time-Weighted Average Sound Level" (TWA)*

Dose or percent noise exposure	TWA
10	73.4
15	76.3
20	78.4
25	80.0
30	81.3
35	82.4
40	83.4
45	84.2
50	85.0
55	85.7
60	86.3
65	86.9
70	87.4
75	87.9
80	88.4
81	88.5
82	88.6
83	88.7
84	88.7
85	88.8
86	88.9
87	89.0
88	89.1
89	89.2
90	89.2
91	89.3
92	89.4
93	89.5
94	89.6
95	89.6
96	89.7
97	89.8
98	89.9
99	89.9
100	90.0
101	90.1
102	90.1
103	90.2
104	90.3
105	90.4
106	90.4
107	90.5
108	90.6
109	90.6
110	90.7
111	90.8
112	90.8
113	90.9
114	90.9
115	91.1
116	91.1
117	91.1
118	91.2
119	91.3
120	91.3
125	91.6
130	91.9
135	92.2
140	92.4
145	92.7
150	92.9
155	93.2
160	93.4
165	93.6
170	93.8
175	94.0
180	94.2
185	94.4
190	94.6
195	94.8
200	95.0
210	95.4
220	95.7
230	96.0
240	96.3
250	96.6
260	96.9
270	97.2
280	97.4
290	97.7
300	97.9
310	98.2
320	98.4
330	98.6
340	98.8
350	99.0

Table A-1.—*Conversion From "Percent Noise Exposure" or "Dose" to "8-Hour Time-Weighted Average Sound Level" (TWA)*—Continued

Dose or percent noise exposure	TWA
360	99.2
370	99.4
380	99.6
390	99.8
400	100.0
410	100.2
420	100.4
430	100.5
440	100.7
450	100.8
460	101.0
470	101.2
480	101.3
490	101.5
500	101.6
510	101.8
520	101.9
530	102.0
540	102.2
550	102.3
560	102.4
570	102.6
580	102.7
590	102.8
600	102.9
610	103.0
620	103.2
630	103.3
640	103.4
650	103.5
660	103.6
670	103.7
680	103.8
690	103.9
700	104.0
710	104.1
720	104.2
730	104.3
740	104.4
750	104.5
760	104.6
770	104.7
780	104.8
790	104.9
800	105.0
810	105.1
820	105.2
830	105.3
840	105.4
850	105.4
860	105.5
870	105.6
880	105.7
890	105.8
900	105.8
910	105.9
920	106.0
930	106.1
940	106.2
950	106.2
960	106.3
970	106.4
980	106.5
990	106.5
999	106.6

Appendix B: Temporal Sampling Procedures for Use With a Sound Level Meter

This Appendix Is Non-Mandatory

Two basic types of equipment permitted are to measure noise exposure for the purposes of paragraphs (c) through (r) of 29 CFR 1910.95: the noise dosimeter and the sound level meter. The sampling procedure for using a sound level meter described below is intended to yield accuracy comparable to that obtained by using a dosimeter meeting the requirements of paragraph (g)(1)(i) of 29 CFR 1910.95. This accuracy will only be possible when the sampled sound levels are truly representative of the total exposure. 1. Based on the nature of the workplace operations to which the employee is exposed, identify each time period for which the noise exposure is to be determined.

This identification is done by dividing the entire workday into a number of time segments, each having workplace operations where the noise environment is relatively uniform. The noise may vary with time in each time segment but except for periodic variations in sound level associated with the cyclic nature of specific machinery, there is no reason to expect consistently different sound levels in one part of this time segment as opposed to another part.

For example, in a machine shop a worker may spend the early part of the day preparing his particular machine for production and the remainder of the day actually running it. The sound level at the worker's location might exceed 80 dB during the setting up process because of nearby machines already in operation. When his own machine is running, the sound level to which he is exposed could be much greater. During each period the sound levels vary in a characteristic manner. Each of these two time periods (see Figure B–1) would be an identified time segment during which measurements should be made.

As another example, consider a factory where intermittent noise due to operation of a particular machine is superimposed on a fairly steady background noise, so that the sound level varies with time as shown in Figure B–2. The total time that the machine is on can be considered to be one time segment and the total time that the machine is off would be another time segment. The procedure described in Section 2, below, can be used in conjunction with such intermittent noise provided that the times spent in each operating cycle are sufficiently long that the duration of each on-cycle or off-cycle can be easily measured.

As a third example, consider a situation where impulsive sounds due, for example, to mechanical impacts are superimposed on continuous noise as indicated in Figure B–3. The total time that the impulses are well in excess of the general ambient noise can be considered as one time segment and the remainder of the time as another time segment. The procedure described in Section 3, below, can be used in conjunction with impulsive noises or very short bursts of noise.

2. For each time segment for which the noise is essentially continuous, determine the average sound level in the following manner:

(a) Carry out any necessary calibration to ensure proper and accurate operation of the sound level meter.

(b) Set the controls of the sound level meter for A-weighted SLOW response.

(c) Adjust the controls of the sound level meter so that the higest sound level readings that occur during the time segment will be readable on the meter scale.

(d) With the microphone located in the desired position, read the sound level at intervals and place a checkmark in the appropriate box on the data sheet (Figure B–4). The sound levels should be read to the nearest decibel. The readings may be made at any time interval of 5 seconds or longer. The readings should be instantaneous, i.e., the person taking the data should glance at the indicator of the sound level meter and read it "on the fly" rather than look for maximum or minimum levels or wait for fairly steady levels. If the noise-producing operation is cyclic, care should be taken to avoid reading sound levels at consistent times relative to the cycles in sound level; this may require taking observations at random, rather than at regular time intervals.

(e) If the time interval is not sufficiently long to take 25 readings at intervals of 5 seconds or longer, readings should be taken at 5-second intervals throughout the entire time period and steps (f), (g), and (h) may be omitted.

(f) If, after 25 sound level readings have been taken, the total range of sound levels does not exceed 3 dB, the highest reading obtained may be taken as the effective sound level, and steps (g), (h), and (i) may be omitted.

(g) If, after 25 readings have been taken, the total range of sound levels exceeds 3 dB, the total number of readings that are required is estimated as follows:

(1) On the data sheet (Figure B–4), count down four checkmarks from the top. Draw a horizontal arrow (as shown in the example on Figure B–6) from the ordinate scale marked "A-weighted sound level" to the center of the row in which the fourth checkmark appears.

(2) Count up four checkmarks from the bottom and draw an arrow in line with the center of the row in which the fourth checkmark appears.

(3) Take the difference, in decibels, between the two sound levels (rows) so identified. This is the "spread of levels" to be used below. If the spread of levels from the fourth lowest to the fourth highest exceeds 12 decibels, the identified time segment should be

divided into two or more smaller time segments such that the spread of levels in *each* time segment will not exceed 12 decibels. If this is not possible, the use of a sound level meter to determine the noise exposure is probably not advisable and a noise dosimeter should be used. (However, see Section 3, below, for circumstances under which transient or impulsive noises may be ignored).

(4) Locate the estimated duration of the time segment on the ordinate scale to the far left on the data sheet. Draw a straight line from this point to the point where the upper arrow (step (1) above) intersects the scale labeled "A-weighted sound level." Draw a second straight line from the point labeled 8 hr on the time segment scale through the intersection of the first line with the "pivot line" located midway between the two scales, extend it to the sound level scale and then draw a horizontal arrow to the right to find the "adjusted upper level."

(5) The total number of sound level readings required is given by the table at the bottom of the worksheet. The columns in this table correspond to different values of the spread of levels (from the fourth lowest to the fourth highest). The three rows correspond, respectively, to the adjusted upper level being less than 85 decibels, between 85 and 90 decibels, and greater than 90 decibels.

(h) If the "adjusted upper level" is less than 80 decibels, the contribution due to the particular time segment may be ignored and no further measurements or calculations for that time segment are required.

(i) If the required number of sound level meter readings is equal to 25, no further sound levels need be read. If the required number is greater than 25, take additional measurements, in accordance with (d), above, until the total number of readings, including the 25 original readings, exceeds the required number. (The checkmarks can be added onto the original data sheet).

(j) Compute the effective sound level using the worksheet (Figure B-5) as follows:

(1) Enter the number of counts per sound level (frequency of occurrence) in Column B. Add them to get Sum B.

(2) Multiply the counts in Column B by the number in Column C and enter the results in Column D.

(3) Add all values in Column D to determine Sum D.

(4) Divide Sum D by Sum B.

(5) Locate the value in Column C that is approximately equal to Sum D/Sum B. The corresponding value in Column A is equal to the effective sound level.

Note.—It may be desirable to use a (pre-programmed) calculator to carry out these steps rather than to use the worksheet. This is quite acceptable so long as the calculation procedure is checked to ensure correctness.

(k) Proceed to carry out steps (a) through (g) as necessary for any other identified time segments.

3. When impulsive noise or short bursts of continuous noise result in large (e.g., 10 decibels or more) increases of short duration in the sound level, care must be taken to determine properly the effective duration of the higher noise level. When such discrete events occur, with a resultant time variation of sound levels such as that shown in Figure B-3, the following procedure may be followed:

(a) Carry out steps (a), (b), and (c) of Section 2, above.

(b) With the microphone located in the desired position, read the *maximum* sound level indicated on the sound level meter during occurrence of one of the discrete events of interest and place a checkmark in the appropriate box on a data sheet (Figure B-4). The maximum sound levels should be read to the nearest decibel.

(c) Repeat step 3(b) for 25 readings of the maximum sound level.

(d) Compute the maximum effective sound level for these 25 readings using the worksheet (Figure B-5) and the procedures described in Section 2(j), above.

(e) Calculate the sound level that is 6 decibels less than the maximum effective sound level determined in step 3(d); this is designated as the "6-decibel down level."

(f) Determine the effective duration of a transient event as follows: For a minimum of 10 events, use a stop watch or other timing device to measure the time that the sound level is greater than the "6-decibel down level" that was determined in step 3(e). This can be done by noting the 6-decibel down level on the sound level meter and then, for at least 10 events, starting the stop watch when the sound level increases to the 6-decibel down level, allowing the stop watch to run while the sound level is above the 6-decibel down level, and stopping the watch when the sound level falls below the 6-decibel down level. The effective duration of a single event is the arithmetic average of at least 10 durations thereby obtained, rounded up to the next larger integer second.

(g) The duration of the time segment for all similar single events is simply the number of such events multiplied by the effective duration of a single event.

(h) Follow the procedures described in Section 2(g) to determine the total required number of sound level meter readings, using the duration of the time segment as determined in step 3(g) to enter the left-hand scale of the data sheet (Figure B-4).

(i) If the "adjusted upper level" is less than 80 decibels, the contribution due to the particular time segment may be ignored and no further measurements or calculations for that time segment are required.

(j) If the required number of sound level meter readings is equal to 25, no further readings of the maximum sound level need be taken. If the required number of readings is greater than 25, take additional measurements, in accordance with 3(b), above, until the total number of readings, including the 25 original readings, exceeds the required number.

(k) Compute the effective sound level, using the worksheet (Figure B-5) and the procedure described in Section 2(j), above.

4. The average sound levels thus determined, and the durations for each time segment, should be entered into Table G-16a to compute the total noise dose, and subsequently the 8-hour time-weighted average sound level according to the procedures required by 29 CFR 1910.95(c).

Example for Continuous Noise

(a) Twenty-five sound levels are measured and entered on a data sheet with the results shown in Figure B-6.

(b) Counting down four checkmarks from the top, the number corresponding to the row in which the fourth checkmark appears is 97 decibels. An arrow is placed in line with that row and a dot is drawn where the tail of the arrow intersects the scale labeled "A-weighted sound level."

(c) The duration of the time segment is estimated as 5 hours; a corresponding dot is placed on the (left-hand) time scale on the data sheet.

(d) A straight line is drawn connecting the dot at 5 hours on the time scale and the dot at 97 dB on the sound level scale. A dot is placed where this line intersects the "pivot line" that is parallel to and midway between the two scales.

(e) A straight line (shown dashed in Figure B-6) is drawn from the mark at 8 hours on the time scale through the dot on the pivot line and extended to intersect the sound level meter scale. An arrow (also shown dashed) is drawn from this intersection point to the right—the "adjusted upper level" is found to lie between 93 and 94 decibels.

(f) Counting up four checkmarks from the botton of the worksheet, the number corresponding to the row in which the fourth checkmark appears is 92 dB.

(g) The difference between this lower level and the (unadjusted) upper level is 5 decibels; from the table at the bottom of the worksheet, it is found that at least 75 sound level readings are required.

(h) Fifty additional sound levels are read and entered onto the data sheet with the results show in Figure B–7; the number of checkmarks in each row is summed and entered in the right hand column.

(i) The sums from the data sheet are transferred to a worksheet and the required calculations are carried out as shown in Figure B–8; the resultant average sound level for the selected time period is found to be 95 dB.

Example for Impulsive Noise

(a) Twenty-five maximum sound levels are measured and entered on a data sheet with the results shown in Figure B–9.

(b) The sums from this data sheet are transferred to a worksheet as shown in Figure B–10 and the required calculations are carried out. The resultant maximum effective sound level for these impulsive events is found to be 103 dB.

(c) The "6-decibel down level" is thus 97 decibels. Using a stop watch, the time that the sound level exceeds 97 decibels is measured for 10 events; the average effective duration is found to be 3.4 seconds, which is rounded up to 4 seconds.

(d) It is estimated that there are approximately 50 such events during a typical workshift. Thus the duration of the time segment is estimated to be 200 seconds (or 3.3 minutes).

(e) A dot is placed on the time axis on the worksheet at 3.3 minutes and a dot is placed on the sound level axis at 103 decibels. A straight line is drawn between these two dots and a dot is placed where that line intersects the pivot line. A second line (shown dashed in Figure B–9) is drawn from the mark at 8 hours on the time axis through the mark on the pivot line. It is seen that this line would intersect the sound level scale at a location well below 80 decibels. Thus the noise exposure due to the 50 impulse sounds can be ignored and no further measurements or calculations are required. (Note: If the adjusted level had exceeded 80 decibels, the remaining procedure for the impulsive noises would have been the same as for the continuous noise example given above.)

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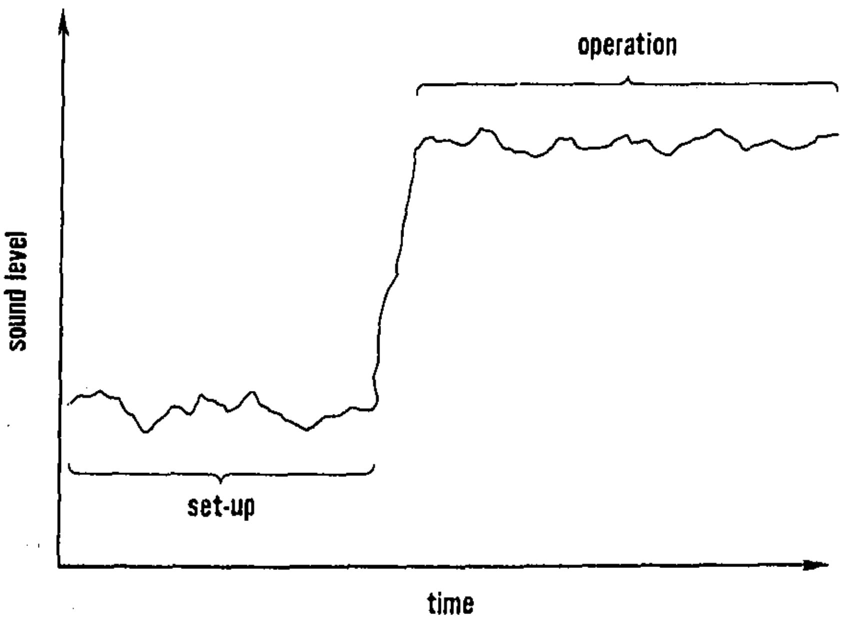


Figure B-1. Example of two discrete time segments.

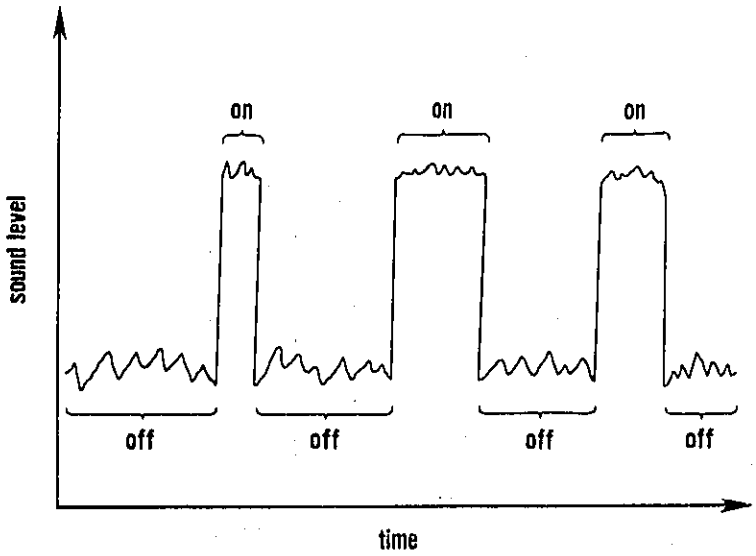


Figure B-2. Example of intermittent noise time segments.

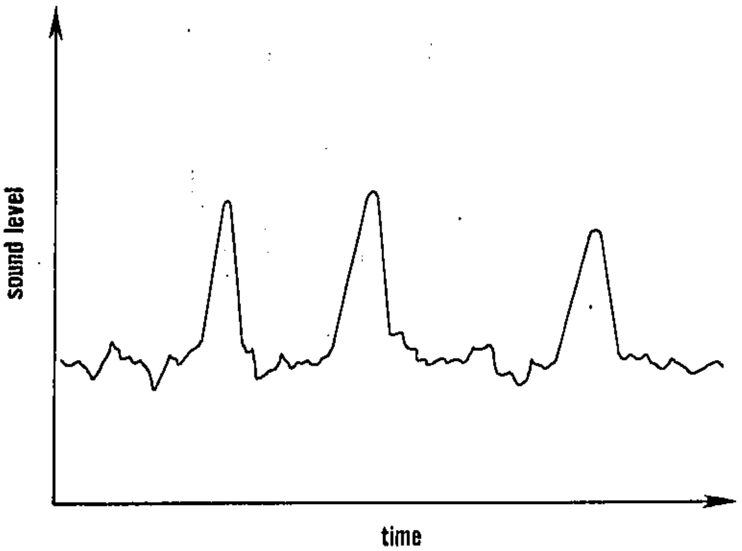
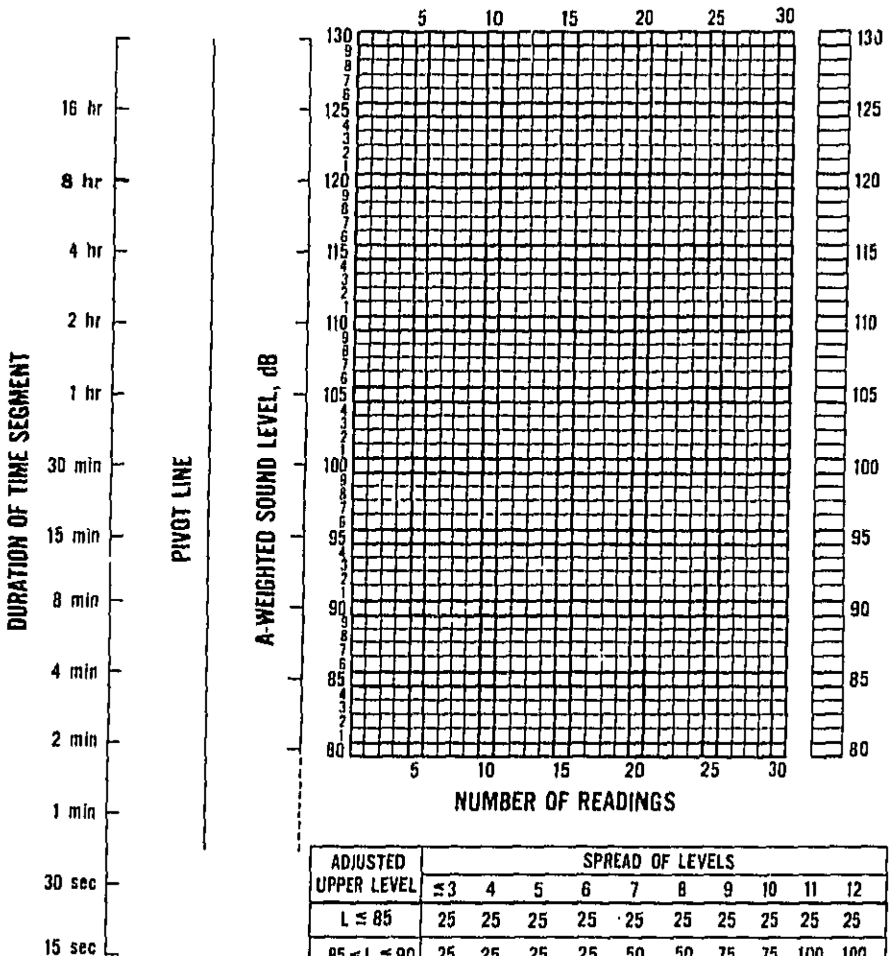


Figure B-3. Example of impulses superimposed on continuous noise.



ADJUSTED UPPER LEVEL	SPREAD OF LEVELS									
	≤3	4	5	6	7	8	9	10	11	12
L ≤ 85	25	25	25	25	25	25	25	25	25	25
85 < L ≤ 90	25	25	25	25	50	50	75	75	100	100
L > 90	25	50	75	100	150	200	250	300	350	400

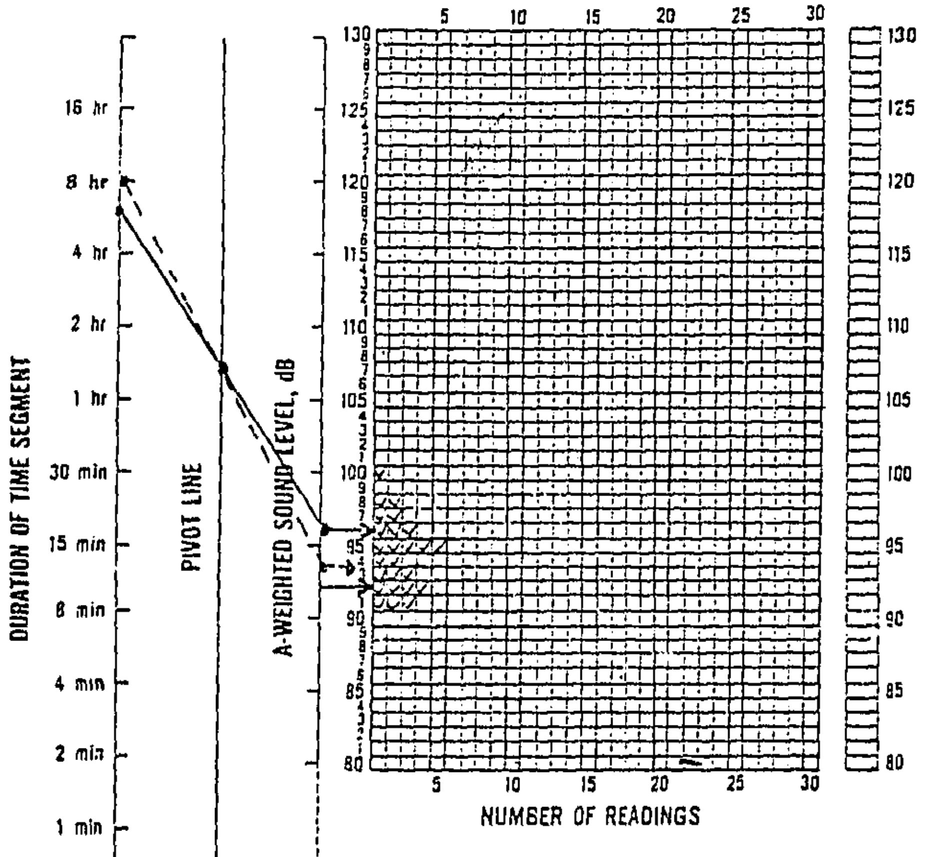
Figure B-4. Data Sheet.

A SOUND LEVEL dB	B COUNT		C RELATIVE WEIGHTING		D RELATIVE TOTAL WEIGHTING
130 or above		×	256.00	=	
129		×	222.86	=	
128		×	194.01	=	
127		×	168.91	=	
126		×	147.03	=	
125		×	128.00	=	
124		×	111.43	=	
123		×	97.01	=	
122		×	84.45	=	
121		×	73.52	=	
120		×	64.00	=	
119		×	55.72	=	
118		×	48.50	=	
117		×	42.22	=	
116		×	36.76	=	
115		×	32.00	=	
114		×	27.86	=	
113		×	24.25	=	
112		×	21.11	=	
111		×	18.38	=	
110		×	16.00	=	
109		×	13.93	=	
108		×	12.13	=	
107		×	10.56	=	
106		×	9.19	=	
105		×	8.00	=	
104		×	6.96	=	
103		×	6.06	=	
102		×	5.28	=	
101		×	4.59	=	
100		×	4.00	=	
99		×	3.48	=	
98		×	3.03	=	
97		×	2.64	=	
96		×	2.30	=	
95		×	2.00	=	
94		×	1.74	=	
93		×	1.52	=	
92		×	1.32	=	
91		×	1.15	=	
90		×	1.00	=	
89		×	0.87	=	
88		×	0.76	=	
87		×	0.66	=	
86		×	0.57	=	
85		×	0.50	=	
84		×	0.44	=	
83		×	0.38	=	
82		×	0.33	=	
81		×	0.29	=	
80		×	0.25	=	
below 80		×	0.00	=	0.00

Sum B = ______ Sum D = ______

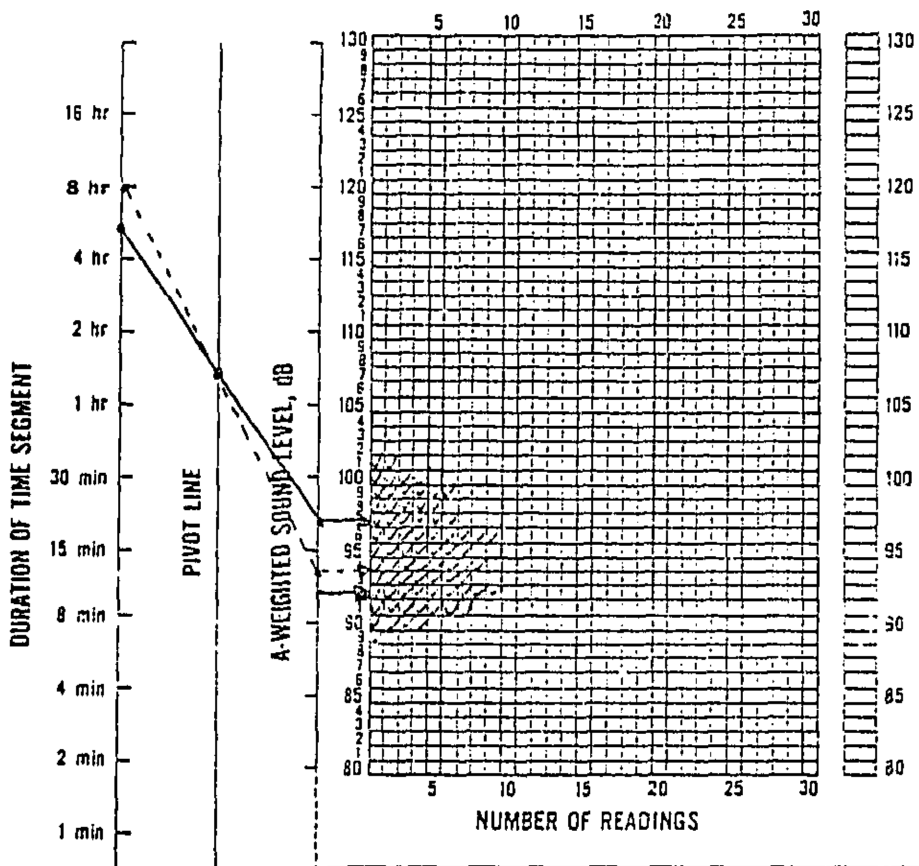
Sum D / Sum B = ______ Average Sound Level = ______

Figure B-5. Worksheet for computing average sound level.



ADJUSTED UPPER LEVEL	SPREAD OF LEVELS									
	≤3	4	5	6	7	8	9	10	11	12
L ≤ 85	25	25	25	25	25	25	25	25	25	25
85 < L ≤ 90	25	25	25	25	50	50	75	75	100	100
L > 90	25	50	75	100	150	200	250	300	350	400

Figure B-6. Sample data sheet.



ADJUSTED UPPER LEVEL	SPREAD OF LEVELS									
	≤3	4	5	6	7	8	9	10	11	12
L ≤ 85	25	25	25	25	25	25	25	25	25	25
85 < L ≤ 90	25	25	25	25	50	50	75	75	100	100
L > 90	25	50	75	100	150	200	250	300	350	400

Figure B-7. Sample data sheet.

SOUND LEVEL dB	COUNT		RELATIVE WEIGHTING		RELATIVE TOTAL WEIGHTING
130 or above		×	256.00	=	
129		×	222.86	=	
128		×	194.01	=	
127		×	168.91	=	
126		×	147.03	=	
125		×	128.00	=	
124		×	111.43	=	
123		×	97.01	=	
122		×	84.45	=	
121		×	73.52	=	
120		×	64.00	=	
119		×	55.72	=	
118		×	48.50	=	
117		×	42.22	=	
116		×	36.75	=	
115		×	32.00	=	
114		×	27.86	=	
113		×	24.25	=	
112		×	21.11	=	
111		×	18.38	=	
110		×	16.00	=	
109		×	13.93	=	
108		×	12.13	=	
107		×	10.56	=	
106		×	9.19	=	
105		×	8.00	=	
104		×	6.96	=	
103		×	6.06	=	
102		×	5.28	=	
101	1	×	4.59	=	4.59
100	2	×	4.00	=	8.00
99	4	×	3.48	=	13.92
98	5	×	3.03	=	15.15
97	7	×	2.64	=	18.48
96	11	×	2.30	=	25.30
95	9	×	2.00	=	18.00
94	12	×	1.74	=	20.39
93	7	×	1.52	=	10.64
92	7	×	1.32	=	9.24
91	6	×	1.15	=	6.90
90	4	×	1.00	=	4.00
89		×	0.87	=	
88		×	0.76	=	
87		×	0.66	=	
86		×	0.57	=	
85		×	0.50	=	
84		×	0.44	=	
83		×	0.38	=	
82		×	0.33	=	
81		×	0.29	=	
80		×	0.25	=	
below 80		×	0.00	=	0.00

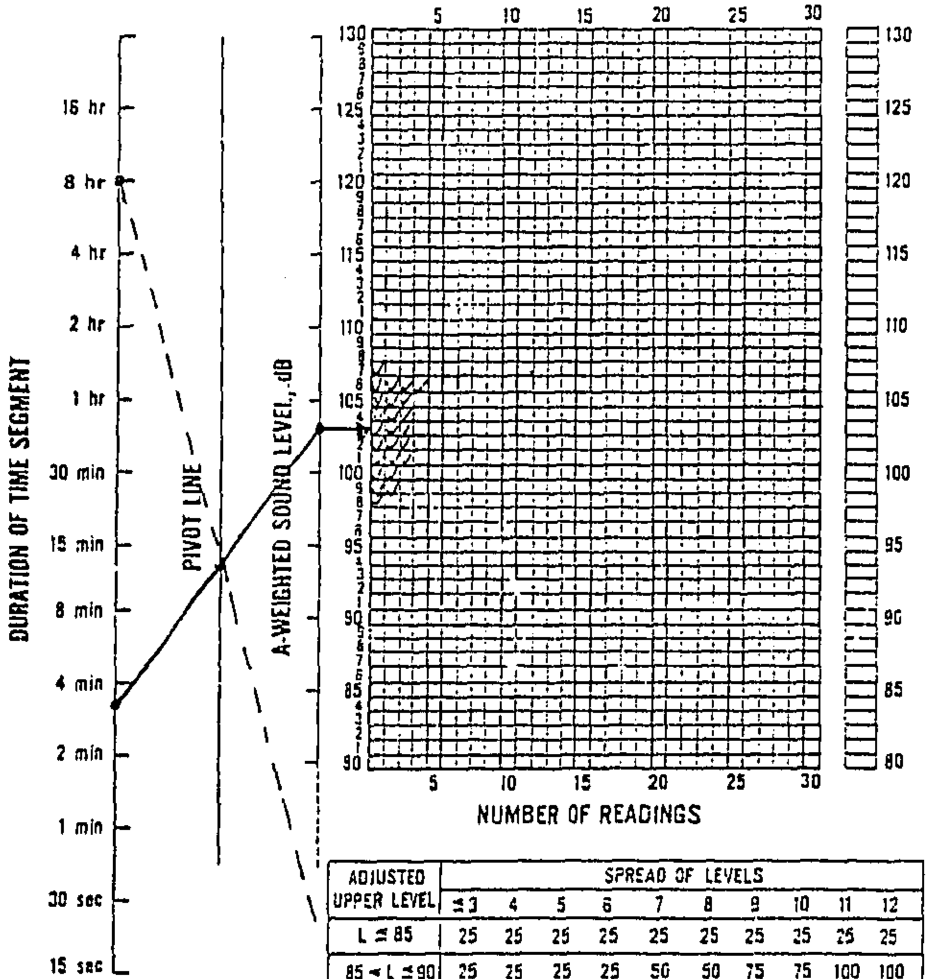
Sum B = 75

Sum D = 155.00

Sum D / Sum B = 2.07

Average Sound Level = 95+ dB

Figure B-8. Sample worksheet for computing average sound level.



ADJUSTED UPPER LEVEL	SPREAD OF LEVELS									
	≤3	4	5	6	7	8	9	10	11	12
L ≤ 85	25	25	25	25	25	25	25	25	25	25
85 < L ≤ 90	25	25	25	25	50	50	75	75	100	100
L > 90	25	50	75	100	150	200	250	300	350	400

Figure B-9. Sample data sheet.

A SOUND LEVEL dB	B COUNT		C RELATIVE WEIGHTING		D RELATIVE TOTAL WEIGHTING
130 or above		×	256.00	=	
129		×	222.86	=	
128		×	194.01	=	
127		×	168.91	=	
126		×	147.03	=	
125		×	128.00	=	
124		×	111.43	=	
123		×	97.01	=	
122		×	84.45	=	
121		×	73.52	=	
120		×	64.00	=	
119		×	55.72	=	
118		×	48.50	=	
117		×	42.22	=	
116		×	36.76	=	
115		×	32.00	=	
114		×	27.86	=	
113		×	24.25	=	
112		×	21.11	=	
111		×	18.38	=	
110		×	16.00	=	
109		×	13.93	=	
108		×	12.13	=	
107	1	×	10.56	=	10.56
106	4	×	9.19	=	36.76
105	3	×	8.00	=	24.00
104	3	×	6.96	=	20.88
103	3	×	6.06	=	18.18
102	3	×	5.28	=	15.84
101	3	×	4.59	=	13.77
100	2	×	4.00	=	8.00
99	2	×	3.48	=	6.96
98	1	×	3.03	=	3.03
97		×	2.64	=	
96		×	2.30	=	
95		×	2.00	=	
94		×	1.74	=	
93		×	1.52	=	
92		×	1.32	=	
91		×	1.15	=	
90		×	1.00	=	
89		×	0.87	=	
88		×	0.76	=	
87		×	0.66	=	
86		×	0.57	=	
85		×	0.50	=	
84		×	0.44	=	
83		×	0.38	=	
82		×	0.33	=	
81		×	0.29	=	
80		×	0.25	=	
Below 80		×	0.00	=	0.00

Sum B = 25 Sum D = 157.98

$\frac{\text{Sum D}}{\text{Sum B}}$ = 6.32 Average Sound Level = 103^{+} dB

Figure B-10. Sample worksheet for computing average sound level.

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Appendix C: Audiometric Measuring Instruments

This Appendix is Mandatory

1. In the event that pulsed-tone audiometers are used, they shall have a tone on-time of at least 200 milliseconds.

2. Self-recording audiometers shall comply with the following requirements:

(A) The chart upon which the audiogram is traced shall have lines at positions corresponding to all multiples of 10 dB hearing level within the intensity range spanned by the audiometer. The lines shall be equally spaced and shall be separated by at least 1/4 inch. Additional increments are optional. The audiogram pen tracings shall not exceed 2 dB in width.

(B) It shall be possible to set the stylus manually at the 10-dB increment lines for calibration purposes.

(C) The slewing rate for the audiometer attenuator shall not be more than 6 dB/sec except that an initial slewing rate greater than 6 dB/sec is permitted at the beginning of each new test frequency, but only until the second subject response.

(D) The audiometer shall remain at each required test frequency for 30 seconds (±3 seconds). The audiogram shall be clearly marked at each change of frequency and the actual frequency change of the audiometer shall not deviate from the frequency boundaries marked on the audiogram by more than ±3 seconds.

(E) It must be possible at each test frequency to place a horizontal line segment parallel to the time axis on the audiogram, such that the audiometric tracing crosses the line segment at least six times at that test frequency. At each test frequency the threshold shall be the average of the midpoints of the tracing excursions.

Appendix D: Audiometric Test Rooms

This Appendix is Mandatory

After April 15, 1983, rooms used for audiometric testing shall not have background sound pressure levels exceeding those in Table D-1 when measured by equipment conforming at least to the Type 2 requirements of American National Standard Specification for Sound Level Meters, S1.4-1971 (R1976), and to the Class II requirements of American National Standard Specification for Octave, Half-Octave, and Third-Octave Band Filter Sets, S1.11-1971 (R1976). Table D-2 may be used until April 15, 1983.

Table D-1.—*Maximum Allowable Octave-Band Sound Pressure Levels for Audiometric Test Rooms*

Octave-band center frequency (Hz)	500	1000	2000	4000	8000
Sound pressure level (dB)	27	30	35	42	41

Table D-2.—*Maximum Allowable Octave-Band Sound Pressure Levels for Audiometric Test Rooms (May be used in lieu of Table D-1 until Apr. 15, 1983)*

Octave-band center frequency (Hz)	500	1000	2000	4000	8000
Sound pressure level (dB)	40	40	47	57	62

Appendix E: Acoustic Calibration of Audiometers

This Appendix is Mandatory

Audiometer calibration shall be checked acoustically, at least annually, according to the procedures described in this Appendix. The equipment necessary to perform these measurements is a sound level meter, octave-band filter set, and a National Bureau of Standards 9A coupler. In making these measurements, the accuracy of the calibrating equipment shall be sufficient to determine that the audiometer is within the tolerances permitted by American National Standard Specification for Audiometers, S3.6-1969.

(1) *Sound Pressure Output Check*

A. Place the earphone coupler over the microphone of the sound level meter and place the earphone on the coupler.

B. Set the audiometer's hearing threshold level (HTL) dial to 70 dB.

C. Measure the sound pressure level of the tones at each test frequency from 500 Hz through 6000 Hz for each earphone.

D. At each frequency the readout on the sound level meter should correspond to the levels in Table E-1 or Table E-2, as appropriate, for the type of earphone, in the column entitled "sound level meter reading."

(2) *Linearity Check*

A. With the earphone in place, set the frequency to 1000 Hz and the HTL dial on the audiometer to 70 dB.

B. Measure the sound levels in the coupler at each 10-dB decrement from 70 dB to 10 dB, noting the sound level meter reading at each setting.

C. For each 10-dB decrement on the audiometer the sound level meter should indicate a corresponding 10 dB decrease.

D. This measurement may be made electrically with a voltmeter connected to the earphone terminals.

(3) *Tolerances*

When any of the measured sound levels deviate from the levels in Table E-1 or Table E-2 by ± 3 dB at any test frequency between 500 and 3000 Hz, 4 dB at 4000 Hz, or 6 dB at 6000 Hz, an exhaustive calibration is advised. An exhaustive calibration is required if the deviations are greater than 10 dB at any test frequency.

Table E-1.—*Reference Threshold Levels for Telephonics—TDH-39 Earphones*

Frequency, Hz	Reference threshold level for TDH-39 earphones, dB	Sound level meter reading, dB
500	11.5	81.5
1000	7	77
2000	9	79
3000	10	80
4000	9.5	79.5
6000	15.5	85.5

Table E-2.—*Reference Threshold Levels for Telephonics—TDH-49 Earphones*

Frequency, Hz	Reference threshold level for TDH-39 earphones, dB	Sound level meter reading, dB
500	13.5	83.5
1000	7.5	77.5
2000	11	81.0
3000	9.5	79.5
4000	10.5	80.5
6000	13.5	83.5

Appendix F: Calculations and Application of Age Corrections to Audiograms

This Appendix is Non-Mandatory

In determining whether a significant threshold shift has occurred, allowance may be made for the contribution of aging to the change in hearing level by adjusting the most recent audiogram. If the employer chooses to adjust the audiogram, the employer shall follow the procedure described below. This procedure and the age correction tables were developed by the National Institute for Occupational Safety and Health in the criteria document entitled "Criteria for a Recommended Standard . . . Occupational Exposure to Noise," (HSM)-11001).

For each audiometric test frequency;

(i) Determine from Table F-1 or F-2 the age correction values for the employee by:

(A) finding the age at which the most recent audiogram was taken and recording the corresponding values of age corrections at 1000 Hz through 6000 Hz;

(B) finding the age at which the baseline audiogram was taken and recording the corresponding values of age corrections at 1000 Hz through 6000 Hz.

(ii) Subtract the values found in step (i)(A) from the value found in step (i)(B).

(iii) The differences calculated in step (ii) represented that portion of the change in hearing that may be due to aging.

Example: Employee is a 32-year-old male. The audiometric history for his right ear is shown in decibels below.

Employee's age	Audiometric test frequency (Hz) 1000	2000	3000	4000	6000
26	10	5	5	10	5
*27	0	0	0	5	5
28	0	0	0	10	5
29	5	0	5	15	5
30	0	5	10	20	10
31	5	10	20	15	15
*32	5	10	10	25	20

The audiogram at age 27 is considered the baseline since it shows the best hearing threshold levels. Asterisks have been used to identify the baseline and most recent audiogram. A threshold shift of 20 dB exists at 4000 Hz between the audiograms taken at ages 27 and 32. (The threshold shift is computed by subtracting the hearing threshold at age 27, which was 5, from the hearing threshold at age 32, which is 25). A retest audiogram has confirmed this shift. The contribution of aging to this change in hearing may be estimated in the following manner:

Go to Table F-1 and find the age correction values (in dB) for 4000 Hz at age 27 and age 32.

	Frequency (Hz) 1000	2000	3000	4000	6000
Age 32	6	5	7	10	14
Age 27	5	4	6	7	11
Difference	1	1	1	3	3

The difference represents the amount of hearing loss that may be attributed to aging in the time period between the baseline audiogram and the most recent audiogram. In this example, the difference at 4000 Hz is 3 dB. This value is subtracted from the hearing level at 4000 Hz, which in the most recent audiogram is 25, yielding 22 after adjustment. Then the hearing threshold in the baseline audiogram at 4000 Hz (5) is subtracted from the adjusted annual audiogram hearing threshold at 4000 Hz (22). Thus the age-corrected threshold shift would be 17 dB (as opposed to a threshold shift of 20 dB without age correction).

Table F-1.—*Age Correction Values in Decibels for Males*

Years	Audiometric Test Frequencies (Hz) 1000	2000	3000	4000	6000
20 or younger	5	3	4	5	8
21	5	3	4	5	8
22	5	3	4	5	8
23	5	3	4	6	9
24	5	3	5	6	9
25	5	3	5	7	10
26	5	4	5	7	10
27	5	4	6	7	11
28	6	4	6	8	11
29	6	4	6	8	12
30	6	4	6	9	12
31	6	4	7	9	13
32	6	5	7	10	14
33	6	5	7	10	14
34	6	5	8	11	15
35	7	5	8	11	15
36	7	5	9	12	16
37	7	6	9	12	17
38	7	6	9	13	17
39	7	6	10	14	18
40	7	6	10	14	19
41	7	6	10	14	20
42	8	7	11	16	20
43	8	7	12	16	21
44	8	7	12	17	22
45	8	7	13	18	23
46	8	8	13	19	24
47	8	8	14	19	24
48	9	8	14	20	25
49	9	9	15	21	26
50	9	9	16	22	27
51	9	9	16	23	28
52	9	10	17	24	29
53	9	10	18	25	30
54	10	10	18	26	31
55	10	11	19	27	32
56	10	11	20	28	34
57	10	11	21	29	35
58	10	12	22	31	36
59	11	12	22	32	37
60 or older	11	13	23	33	38

Table F-2.—*Age Correction Values in Decibels for Females*

Years	Audiometric test frequencies (Hz) 1000	2000	3000	4000	6000
20 or younger	7	4	3	3	6
21	7	4	4	3	6
22	7	4	4	4	6
23	7	5	4	4	7
24	7	5	4	4	7
25	8	5	4	4	7
26	8	5	5	4	8
27	8	5	5	5	8
28	8	5	5	5	8
29	8	5	5	5	9
30	8	6	5	5	9
31	8	6	6	5	9
32	9	6	6	6	10
33	9	6	6	6	10
34	9	6	6	6	10
35	9	6	7	7	11
36	9	7	7	7	11
37	9	7	7	7	12
38	10	7	7	7	12
39	10	7	8	8	12
40	10	7	8	8	13
41	10	8	8	8	13
42	10	8	9	9	13
43	11	8	9	9	14
44	11	8	9	9	14
45	11	8	10	10	15
46	11	9	10	10	15
47	11	9	10	11	16
48	12	9	11	11	16
49	12	9	11	11	16
50	12	10	11	12	17
51	12	10	12	12	17
52	12	10	12	13	18
53	13	10	13	13	18
54	13	11	13	14	19
55	13	11	14	14	19
56	13	11	14	15	20
57	13	11	15	15	20
58	14	12	15	16	21

Table F-2.—*Age Correction Values in Decibels for Females*—Continued

Years	Audiometric test frequencies (Hz) 1000	2000	3000	4000	6000
59	14	12	16	16	21
60 or older	14	12	16	17	22

Appendix G: Methods for Estimating the Adequacy of Hearing Protector Attenuation

This Appendix is Mandatory

For employees who have experienced a significant threshold shift, hearing protector attenuation must be sufficient to reduce employee exposure to a TWA of 85 dB. Employers must select one of the following methods by which to estimate the adequacy of hearing protector attenuation.

The most convenient method is the Noise Reduction Rating (NRR) developed by the Environmental Protection Agency (EPA). According to EPA regulation, the NRR must be shown on the hearing protector package. The NRR is then related to an individual worker's noise environment in order to assess the adequacy of the attenuation of a given hearing protector. This Appendix describes four methods of using the NRR to determine whether a particular hearing protector provides adequate protection within a given exposure environment. Selection among the four procedures is dependent upon the employer's noise measuring instruments.

Instead of using the NRR, employers may evaluate the adequacy of hearing protector attenuation by using one of the three methods developed by the National Institute for Occupational Safety and Health (NIOSH), which are described in the "List of Personal Hearing Protectors and Attenuation Data," HEW Publication No. 76-120, 1975, pages 21-37. These methods are known as NIOSH methods #1, #2 and #3. The NRR described below is a simplification of NIOSH method #2. The most complex method is NIOSH method #1, which is probably the most accurate method since it uses the largest amount of spectral information from the individual employee's noise environment. As in the case of the NRR method described below, if one of the NIOSH methods is used, the selected method must be applied to an individual's noise environment to assess the adequacy of the attenuation. Employers should be careful to take a sufficient number of measurements in order to achieve a representative sample for each time segment.

Note.—*The employer must remember that calculated attenuation values reflect realistic values only to the extent that the protectors are properly fitted and worn.*

When using the NRR to assess hearing protector adequacy, one of the following methods must be used:

(i) When using a dosimeter that is capable of C-weighted measurements:

(A) Obtain the employee's C-weighted dose for the entire workshift, and convert to TWA (see Appendix A, II).

(B) Subtract the NRR from the C-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.

(ii) When using a dosimeter that is not capable of C-weighted measurements, the following method may be used:

(A) Convert the A-weighted dose to TWA (see Appendix A).

(B) Subtract 7 dB from the NRR.

(C) Subtract the remainder from the A-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.

(iii) When using a sound level meter set to the A-weighting network:

(A) Obtain the employee's A-weighted TWA in accordance with a procedure such as the one recommended in Appendix B.

(B) Subtract 7 dB from the NRR, and subtract the remainder from the A-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.

(iv) When using a sound level meter set on the C-weighting network:

(A) Obtain a representative sample of the C-weighted sound levels in the employee's environment for each identified time segment.[1]

(B) If there is more than one identified time segment, compute the 8-hour time-weighted average of the C-weighted sound levels using Figure B-5 and Table G-16a or an equivalent method.

(C) Subtract the NRR from the C-weighted average sound level to obtain the estimated A-weighted TWA under the ear protector.

Appendix H: Availability of Referenced Documents

Paragraphs (c) through (s) of 29 CFR 1910.95 and the accompanying appendices contain provisions which incorporate publications by reference. Generally, the publications provide criteria for instruments to be used in monitoring and audiometric testing. These criteria are intended to be mandatory when so indicated in the applicable paragraphs of Section 1910.95 and appendices.

It should be noted that OSHA does not require that employers purchase a copy of the referenced publications. Employers, however, may desire to obtain a copy of the referenced publications for their own information.

The designation of the paragraph of the standard in which the referenced publications appear, the titles of the publications, and the availability of the publications are as follows:

Paragraph designation	Referenced publication	Available from—
§ 1910.95(g)(1)(i)	"Specification for Personal Noise Dosimeters," ANSI S1.25-1978, (ASA 25-1978).	Back Numbers Department, Dept. STD, American Institute of Physics 333 E. 45th St., New York, NY 10017, American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018.
§ 1910.95(g)(1)(ii)	"Specification for Sound Level Meters," S1.4-1971 (R 1976).	American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018
§ 1910.95(k)(2), appendix E	"Specifications for Audiometers," S3.6-1969.	American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018
Appendix D	"Specification for Octve, Half-Octave and Third-Octave Band Filter Sets," S1.11-1971 (R1976).	Back Numbers Department, Dept. STD, American Institute of Physics 333 E. 45th St., New York, NY 10017; American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018
Appendix G	"List of Personal Hearing Protectors and Attenuation Data," HEW Pub. No. 76-120, 1975.	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20404.

The referenced publications (or a microfiche of the publications) are available for review at many universities and public libraries throughout the country. These publications may also be examined at the OSHA Technical Data Center, Room N2439, United States Department of Labor, 200 Constitution Avenue N.W., Washington, D.C. 20210, (202) 523-9700 or at any OSHA Regional Office (see telephone directories under United States Government—Labor Department).

Appendix I: Definitions

These definitions apply to the following terms as used in paragraphs (c) through (r) of 29 CFR 1910.95.

Audiogram—A chart, graph, or table resulting from an audiometric test showing an individual's hearing threshold levels as a function of frequency.

Audiologist—A professional, specializing in the study and habilitation of hearing, who is certified by the American Speech, Hearing, and Language Association or licensed by a state board of examiners.

Baseline audiogram—The audiogram against which future audiograms are compared.

Crest factor—Absolute value of the ratio of the peak value and the root-mean-square value measured over a specified time interval where both values are measured in reference to the arithmetic mean value of the wave.

Criterion sound level—A sound level of 90 decibels.

Decibel (dB)—Unit of measurement of sound level.

Hertz (Hz)—Unit of measurement of frequency, numerically equal to cycles per second.

Medical pathology—A disorder or disease. For purposes of this regulation, a condition or disease affecting the ear, which should be treated by a physician specialist.

Noise dose—The ratio, expressed as a percentage, of (1) the time integral, over a stated time or event, of the 0.6 power of the measured SLOW exponential time-averaged, squared A-weighted sound pressure and (2) the product of the criterion duration (8 hours) and the 0.6 power of the squared sound pressure corresponding to the criterion sound level (90 dB).

Noise dosimeter—An instrument that integrates a function of sound pressure over a period of time in such a manner that it directly indicates a noise dose.

Otolaryngologist—A physician specializing in diagnosis and treatment of disorders of the ear, nose and throat.

Representative exposure—Measurements of an employee's noise dose or 8-hour time-weighted average sound level that the employers deems to be representative of the exposures of other employees in the workplace.

Sound level—Ten times the common logarithm of the ratio of the square of the measured A-weighted sound pressure to the square of the standard reference pressure of 20 micropascals. Unit: decibels (dB). For use with this regulation, SLOW time response, in accordance with ANSI S1.4-1971 (R1976), is required.

Sound level meter—An instrument for the measurement of sound level.

Time-weighted average sound level—That sound level, which if constant over an 8-hour exposure, would result in the same noise dose as is measured.

(Sec. 4, 6, 8, 84 Stat. 1592, 1593, 1599, (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 8-76 (41 FR 25059); 29 CFR Part 1911)

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[1] Time segments should be identified according to a procedure such as the one recommended in Appendix B, but the same number of measurements may not be necessary to achieve a representative sample.

Report

Questions and Answers About OSHA'S Hearing Conservation Amendment and Industrial Audiology

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What is the Hearing Conservation Amendment?

The Hearing Conservation Amendment (29 CFR 1910.95(c)-(s) and Appendices A-I) was developed by the Occupational Safety and Health Administration (OSHA), Department of Labor, and was published in the Federal Register on August 21, 1981. The Amendment requires employers to provide a hearing conservation program to all employees who are exposed to an average of 85 dB[1] or greater. The Amendment supplements the existing standard for occupational exposure to noise (29 CFR 1910.95) and mandates the essential elements of a hearing conservation program.

How does the new Amendment compare to the Hearing Conservation Amendment published on January 16, 1981 and what are the new effective dates?

The New Hearing Conservation Amendment is an abbreviated form of the January document and went into effect August 22, 1981. Baseline audiograms called for by the new Amendment will have to be completed by August 22, 1982. The noise monitoring called for will have to be completed by February 22, 1982.

Are some of the original contents of the Amendment as written in January, 1981, stayed indefinitely?

Comments to the August 21, 1981 Hearing Conservation Amendment were due to the Department by November 23, 1981. These comments are being reviewed by the Department of Labor and it is possible that portions of the original Amendment may be included in the future or that revisions of those sections may be included.

The original Amendment was very detailed and specific. Why did ASHA support it so strenuously?

The original Amendment was very specific. ASHA realized its weakness when it was first issued, but many other groups wanted to do away with it entirely or delay it indefinitely. ASHA believed that the hearing of too many workers was unprotected. Therefore, through letters and meetings, ASHA stressed reasonable changes with the goal of promulgating a workable regulation. Among the areas ASHA questioned were the 14 hour quiet period prior to testing to be accomplished without hearing protectors, a cumbersome criteria for STS, unachievable noise levels, and less frequent noise monitoring.

What employees will be affected by this Amendment?

Employees who are exposed to noise that equals or exceeds an eight hour Time-Weighted Average (TWA) sound level of 85 dB shall be included in the hearing conservation program. The 85 dB figure does not include any attenuation by hearing protectors.

Employees engaged in construction or agriculture are not covered by the Act.

What kind of audiometric testing program is called for in the Amendment?

An audiometric testing program is to be provided at no cost to employees and shall be administered by a licensed or certified audiologist, otolaryngologist, or other qualified physician. Also, testing may be conducted by a technician who is under the supervision of the audiologist, otolaryngologist, or qualified physician. The technician must be certified by the Council of Accreditation in Occupational Hearing Conservation (CAOHC) or have satisfactorily demonstrated competence in administering audiometric examinations, obtaining valid audiograms, and properly using, maintaining, and calibrating audiometers. At least annually, after obtaining the baseline audiogram, each employee exposed to a TWA of 85 dB or more shall be retested. The audiometric tests may be conducted at any time during the workday.

Do I have to become certified by the CAOHC in order to conduct audiometric tests even though I'm a certified audiologist?

No. You are recognized as being qualified to perform the audiometric testing called for in the Amendment. The CAOHC approved programs are designed to train and certify supportive personnel as audiometric technicians.

Who evaluates the employee's annual audiogram?

According to the Amendment, a technician can compare the annual audiogram with the baseline audiogram to determine if the audiogram is valid and if a significant threshold shift (STS) has occurred. An audiologist, otolaryngologist, or qualified physician must subsequently review only those audiograms.[2] The professional doing the review must have a copy of the

[1] All references to dB in this report are relative to the A scale except those references which are frequency specific.

[2] Where validity was in question or where there might be a medical or other problem that would indicate a need for further evaluation.

Hearing Conservation Program requirements, the baseline audiogram, the most recent audiogram of the employee, the measurements of the background sound pressure levels of the audiometric test room, and the audiometer calibration record.

Is OSHA using the definition of STS as reported in the January 16, 1981, *Federal Register*?

No. The definition and the presbycusis correction factors were stayed. However, the supplementary information regarding STS included the following: ". . . it is contemplated . . . that there will be a definition of significant threshold shift in the standard before the first annual audiogram needs to be compared with the baseline."

How does OSHA define STS in the absence of that in the original proposal?

The OSHA inspectors will continue to use a 20 dB shift at any frequency for their definition of STS. This is consistent with the Industrial Hygiene Field Operations Manual. However, OSHA will accept what is termed a "reasonably protective definition" for an STS.

What is the next step once an STS is determined?

First, employees who are not using hearing protectors will be fitted with them, trained in their use and care, and required to use them. Those employees already using hearing protectors will have them refitted and be retrained in their use. If necessary, the employee will be provided with hearing protectors that offer greater attenuation. Second, the employee must receive written notification regarding a change in hearing within 21 days of the determination of an STS. Third, the employee must be referred for an audiologic evaluation or an otological examination if additional testing is necessary or if the employer suspects that a medical pathology of the ear is caused or aggravated by the wearing of hearing protectors. Lastly, the employee shall be informed of the need for an otologic examination if a medical pathology of the ear which is unrelated to the use of hearing protectors is suspected.

Who pays for all that?

The employer must pay for examinations which discover to what extent the workplace noise is affecting the employee's hearing health. Additionally, they must pay for examinations of adverse health effects due to the protective devices.

Is it true that the wearing of hearing protectors is mandatory only for those workers who are exposed to 90 dB or greater?

Yes and no. Yes in that those working in noise of a TWA of 85 dB (but not at or above a TWA of 90 dB) are not required to wear hearing protectors. No in that it becomes a mandatory program for those employees when an STS is discovered. At that point, use of hearing protectors is mandatory.

What kind of audiometric tests are necessary for the hearing conservation program?

Pure tone air conduction audiometry at the minimum test frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz is necessary. Naturally, tests shall be taken for each ear separately. The audiometer must meet the specifications of ANSI §3. 6-1969. It shall also be maintained under that standard. Appendix C of the Hearing Conservation Amendment delineates the specifications for pulse tone and self recording audiometers.

What are the maximum ambient noise levels in the audiometric test rooms?

Appendix D of the Hearing Conservation Amendment reports the maximum allowable sound pressure levels for the following octave band center frequencies: 40 dB at 500 Hz, 40 dB at 1000 Hz, 47 dB at 2000 Hz, 57 dB at 4000 Hz, and 62 dB at 8000 Hz.

What type of calibration and calibration checks does the Amendment call for?

Functional operation of the audiometer is to be checked prior to each day's use by a person with known and stable hearing thresholds and by listening to the audiometer's output to make certain that it is free from distortion or extraneous noises. If a deviation of more than 5 dB is uncovered, an acoustic calibration is required. An acoustic audiometer calibration shall be conducted at least annually according to Appendix E of the Amendment. The Amendment also calls for "an exhaustive calibration" to be performed at least every two years using ANSI §3.6-1969 as the standard.

How and when do employers make hearing protectors available to their employees?

Hearing protectors must be made available to all employees who are exposed to a TWA of 85 dB or greater at no cost to the employee. The protectors must be replaced as necessary. Employers must insure that hearing protectors are worn by all employees who are exposed to a TWA of 85 dB or greater, have experienced an STS and to those workers whose exposures are at or exceed a TWA of 90 dB. Even though OSHA does not require hearing protector use by all employees exposed to levels below 90 dB, the employer is permitted to do so since the Amendment is considered a minimum standard. Remember too, that the employer must provide a variety of suitable hearing protectors to their employees and offer training in the use and care of all hearing protectors.

How do I advise an employer on which hearing protectors to recommend?

In terms of the Amendment, employers are told to evaluate hearing protector attenuation by using the methods provided in Appendix G. Appendix G contains what OSHA believes is the most convenient method: the Noise Reduction Rating (NRR) which was developed by the Environmental Protection Agency. An alternative to the NRR is one of three methods developed by the National Institute for Occupational Safety and Health in a 1975 publication. If an audiologist can use one of these methods as well as other documentation, they would be well within the regulation's specifications.

The hearing protectors must attenuate the employee exposure to at least a TWA of 90 dB or, for those employees who have experienced an STS, the protectors must attenuate to an 85 dB TWA. The adequacy of the hearing protectors must be reevaluated if there is an increase in employee noise exposure.

What kind of training program for the employees does the Amendment call for?

The training program must be available to all employees who are exposed to noise at or above a TWA of 85 dB. The employer must insure that the employees participate in the program. The program shall be repeated annually for all covered by the Hearing Conservation Program. Information in the training program shall be updated to be consistent with administrative and legislative changes and protective equipment and work processes. As part of the training program, the employer shall insure that the employee is informed of: (1) the effects of noise on hearing, (2) the purpose of hearing protectors, their advantages, disadvantages, attenuation differences, instructions on selection fitting, use and care; and (3) the purpose of audiometric testing and an explanation of test procedures.

Does the Amendment call for an audiologist, otolaryngologist, or qualified physician to conduct the training program?

Not specifically. That is, the regulation does not mandate the participation of an audiologist or otolaryngologist in the training program nor does it preclude an audiologist or an otolaryngologist from supervising or actually administering the training program. In the January 16, 1981 Summary and Explanation of the Standard, OSHA said a good use of the audiologist, otolaryngologist, or other qualified physician supervising the testing would be in training and counseling of employees with STS.

What kind of access to the Amendment information and training materials does an employee have?

The employer must make available to affected employees, or their representatives, copies of the Hearing Conservation Amendment and shall also post a copy in the work place. Also, any information or materials developed and promulgated by the Assistant Secretary of Labor shall also be provided *to the employees.*

What type of record keeping is called for by the Amendment?

Records must be kept for exposure measurements, audiometric tests, audiometric test rooms and date of calibration. The employer shall retain noise exposure measurement records for at least two years and audiometric test records for the duration of the affected employees employment. These records shall be provided upon request to employees, former employees, and representatives designated by the individual employee and the Assistant Secretary. If the employer ceases operation, the records shall be transferred to the next employer who must retain them for the remainder of the period as described above.

What is ASHA's plan of action?

ASHA will continue to submit comments to OSHA when appropriate, monitor proposed revisions of the regulations, and develop information materials for industry as to the role of audiology in hearing conservation. Moreover, the 1981 Convention Program contained a special session on the Amendment. A workshop, "Hearing Conservation: A Legislative Challenge to the Professions," will be held on March 25-26, 1982, at the ASHA National Office in Rockville, Maryland and on September 1-3, 1982, in Scottsdale, Arizona.

Report on Issues Affecting the Communicatively Impaired

GOVERNMENTAL AFFAIRS REVIEW

Vol. 2 No. 3
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Highlights:

- OSHA Hearing Conservation Amendment Enacted
- Congressional Appropriations Debate Continues
- Hawaii Retains Licensure
- ASHA Initiates Reimbursement Division

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FEDERAL REGULATION

OSHA HEARING CONSERVATION AMENDMENT ENACTED

On August 21, 1981, OSHA lifted the administrative stay to many portions of the original January 16, 1981, OSHA Hearing Conservation Amendment. The new amendment contains certain technical corrections, invites comment on the continuation of the stay for certain provisions, asks for new information on the merits of some of the provisions within the Hearing Conservation Amendment, and lastly, through eleven pages of supplementary information, clarifies various provisions of the Amendment.

The July 1981 issue of GAR reported that the Amendment was originally scheduled to take effect April 15, 1981. However, with the postponements, the effective dates of the Amendment are now August 22, 1981, for the portions that are not stayed; February 22, 1982, for monitoring to be conducted; and August 22, 1982, for baseline audiograms to be completed.

A number of portions of the original Amendment have been stayed. For example, initial determination, individual monitoring of employee noise levels, the method of measurement, the requirements for docimeters, and requirements for sound level meters have all been stayed. The requirement for a baseline audiogram to be obtained within four months of an employee's first exposure to noise at or above a time-weighted average of 85 dB has been omitted from the Amendment. The new Amendment also allows the use of hearing protectors as a substitute for 14 hours of quiet before the baseline audiogram is obtained.

It is now possible for a technician to review the audiograms to determine whether a significant threshold shift has occurred. Regarding the definition of a significant threshold shift, this too has been eliminated in the August regulation. It now appears that any supervisor of a hearing conservation program can determine what constitutes a significant threshold shift, but field investigators will use a 20 dB shift at any frequency for their definition.

Much of the record keeping requirements have also been stayed. All of the amendments that were not required according to the January 16, 1981, Federal Register, have been removed from the Amendment.

The appendix regarding audiometric test rooms has been revised so that the more lenient maximum allowable octoband sound pressure levels for audiometric test rooms proposed are the effective ones. Therefore, the sound pressure levels that were published in Table D2 of the January 16, 1981 Amendment are the ones that are in effect. Another important aspect of the Appendix changes is the elimination of the age corrections to audiograms.

Despite these changes, the enactment of the Hearing Conservation Amendment signals improved likelihood that the American worker will be better protected from hearing impairments due to workplace noise. An important aspect of the Act is that the supervision of the hearing conservation program must be conducted by either an audiologist, otolaryngologist, or other qualified physician. An audiologist is defined in the amendment as: a professional who specializes in the study and rehabilitation of hearing, who is certified by the American Speech-Language-Hearing Association, or is licensed by a state board of examiners.

ASHA's Reaction

ASHA responded to the stay on September 22, 1981, with comments to Thorne Auchter. The letter was a compilation of comments that the National Office received from members of the Committee on Hearing Conservation and Industrial Audiology, and members who represented the National Hearing Conservation Association and the Council of Accreditation of Industrial Hearing Conservationists. The comments were primarily in regard to qualifications of personnel administering audiometric tests, qualification of supervisors, baseline audiograms, evaluation of the audiogram, significant threshold shift definition, hearing protectors, and the other alternatives listed in the Amendment. The thrust of the letter to Auchter was that: (1) anyone who would be administering audiometric examinations should have formalized training rather than on the job training; (2) only qualified individuals should be allowed to evaluate the audiogram rather than allowing technicians to perform that function; (3) a uniform definition of significant threshold shift should be within the Amendment; and (4) if hearing protectors could be used in lieu of a quiet period before baseline audiometry, those hearing protectors should be ear muffs only. Alternatives to the Amendment which were described by OSHA as possible replacements to these specific regulations governing a hearing conservation program were found by ASHA to be much too general and open for misinterpretation.

In general, ASHA is pleased that the Hearing Conservation Amendment was enacted. ASHA will continue to evaluate the hearing conservation program and will be issuing further comments before the November 22 deadline. Included below is the amendment and Appendix I: Definitions. The amendment also includes other mandatory appendices and supplementary information.

A single free copy of the entire Amendment is available from: The Department of Labor, Publications Office, Room S-1212, 200 Constitution Avenue, N.W., Washington, D.C. 20210. If you are requesting a copy, ask for Part III of the August 21, 1981, Federal Register, Vol. 46, No. 162, the "Occupational Safety and Health Administration Hearing Conservation Amendment."

The supplementary information supplied in the new Hearing Conservation Amendment asks a number of questions that are quite important in terms of the lifting of some of the stays. It is important for those interested in industrial audiology to review those questions and determine if they have any comments, or, better yet, data which will help the Occupational and Safety Health Administration come to a conclusion in a number of important areas.

Appendix I: Definitions

These definitions apply to the following terms as used in paragraphs (c) through (r) of 29 CFR 1910.95.

Audiogram - A chart, graph, or table resulting from an audiometric test showing an individual's hearing threshold levels as a function of frequency.
Audiologist - A professional, specializing in the study and rehabilitation of hearing, who is certified by the American Speech-Language-Hearing Association or licensed by a state board of examiners.
Baseline audiogram - The audiogram against which future audiograms are compared.
Crest factor - Absolute value of the ratio of the peak value and the root-mean-square value measured over a specified time interval where both values are measured in reference to the arithmetic mean value of the wave.
Criterion sound level - A sound level of 90 decibels.
Decibel (dB) - Unit of measurement of sound level.
Hertz (Hz) - Unit of measurement of frequency, numerically equal to cycles per second.
Medical pathology - A disorder or disease. For purposes of this regulation, a condition or disease affecting the ear, which should be treated by a physician specialist.
Noise dose - The ratio, expressed as a percentage, of (1) the time integral, over a stated time or event, of the 0.6 power of the measured SLOW exponential time-averaged, squared A-weighted sound presure and (2) the product of the criterion duration (8 hours) and the 0.6 power of the squared sound pressure corresponding to the criterion sound level (90 dB).
Noise dosimeter - An instrument that integrates a function of sound pressure over a period of time in such a manner that it directly indicates a noise dose.
Otolaryngologist - A physician specializing in diagnosis and treatment of disorders of the ear, nose and throat.
Representative exposure - Measurements of an employee's noise dose of 8-hour time-weighted average sound level that the employers deem to be representative of the exposures of other employees in the workplace.
Sound level - Ten times the common logarithm of the ratio of the square of the measured A-weighted sound presure to the square of the standard reference pressure of 20 micropascals. Unit decibels (dB). for use with this regulation, SLOW time response, in accordance with ANSI S1.4-1971 (R1976) is required.
Sound level meter - An instrument for the measurement of sound level.
Time-weighted average sound level - That sound level, which if constant over an 8-hour exposure, would result in the same noise dose as is measured.

REIMBURSEMENT POLICY

OSHA HEARING CONSERVATION AMENDMENT - ASHA COMMENTS

The most important regulatory event for audiologists in 1981 was the implementation of the Hearing Conservation Amendment. The Amendment mandates sound level monitoring, annual audiometric testing, hearing protection, employee training, and referral for possible medical problems.

On August 21, 1981, portions of the original January Amendment were enacted but many sections and appendices were stayed. OSHA requested general and specific comments on the stayed portions (see GAR, Vol. 2, No. 3, p. 121). The following summarizes ASHA's response in eight areas: exposure monitoring, audiometric testing program, baseline audiogram, evaluation of audiogram, significant threshold shift, audiometric test rooms, training program, and performance criteria.

Exposure Monitoring

Employee noise exposure monitoring should involve both sound level meters and personal noise dosimetry. If this is not possible, then either sound level meters or personal noise dosimetry should be considered. Repeated noise exposure monitoring at least every two years is important. This rule would accommodate changes in noise levels due to aging of equipment and/or replacement of equipment.

The advantages of area monitoring are economical. The area monitoring by necessity would have to be sophisticated in order to interpolate or extrapolate sound levels where individual employees are located during the day.

The salient advantage of personal exposure monitoring is the gathering of precise data for individuals who move from place to place during the work day. This monitoring would permit data gathering for individual employees so that their personal noise exposure is known. The disadvantages of the personal exposure monitoring would be the cost of additional equipment and personnel and time consumption.

If employees are aware of their actual exposures and that exposure exceeds 85 dB, the goal of the hearing conservation program will be made easier since the actual employee will know, without question, that hearing conservation measures are necessary for his or her situation.

Audiometric Testing Program

The experience with industrial hearing conservation programs over many years has indicated that a structured program for the training of technicians is essential. The Council for Accreditation of Industrial Hearing Conservations (CAOHC) has created an excellent model for the certification of course directors and technical personnel. The concept and practice of only on-the-job training creates the probability that technicians will not have minimally acceptable understanding and skills of hearing conservation.

The term "qualified" should proceed the word "physician." The word "qualified" should be interpreted to mean that this professional or this physician is knowledgeable in the area of noise and hearing. The identification of such physicians will not be difficult and medical societies can assist management in finding such individuals.

Baseline Audiogram

ASHA continued to support the concept that only earmuffs are acceptable if a true quiet period cannot be obtained. That is, before the audiometric baseline evaluation, earmuffs (not earplugs) should be used as a substitute for quiet during this period.

Regarding baseline testing: The prime factors that preclude baseline testing within four months of an initial exposure to noise rather than previous to noise exposure are the possibilities that a) a hearing loss could be a pre-existing condition or b) that a threshold shift could occur within those four months. These factors would cause the initial hearing test results to reflect either a non-occupationally induced hearing loss or b) contaminated with hearing loss due to current noise exposure.

The requirement to obtain the baseline audiogram within four months does not appear to be unnecessarily stringent. The employer would be well advised to accomplish a baseline audiogram as early as possible so that any pre-employment standing hearing loss could be quantified and, therefore, it would not be the responsibility of the current employer. This is not only critical in terms of the hearing conservation amendment, but it would also be important in view of workers compensation laws.

Hearing conservation programs currently exist in which audiologists have observed improvements in hearing following the inception of the program. That is, on the second test, following the use of hearing protection, hearing thresholds were better due to reduced noise levels. Therefore, an improvement in hearing might be encountered in those workplaces where a hearing conservation program was not previously implemented. In other words, the change in hearing would be the result of hearing protectors which eliminate the temporary threshold shift from the audiogram.

The requirement of notifying employees to avoid high levels of occupational noise exposure during the 14-hour period preceding the baseline audiogram is a necessary one. All steps to ensure an accurate audiogram should be taken. We envision the notification occurring both prior to the actual testing and as part of the hearing conservation training program. The notification would be the only practical measure which would request that the employee avoid high noise levels. We can think of no valid argument which would favor inclusion of a non-occupational noise-induced temporary threshold shift creating the appearance of a significant threshold shift.

Evaluation of Audiogram

It is absolutely essential to the success of this regulation that a physician or audiologist review each audiogram, understanding that an initial screening by the technician is acceptable when criteria has been established by the professional. In other words, the professional could establish criteria regarding the identification of normal audiograms. Those audiograms which would not meet that standard would be referred out.

The idea that the audiogram obtained as a part of the hearing conservation program could serve as a sole criteria for determination of a work-related hearing loss is highly questionable. This audiogram, administered by a technician rather than an audiologist or an otolaryngologist, and obtained in a non-clinical environment should not in any way be thought of as providing complete information for diagnosis. Whether or not a hearing loss is due to occupational or non-occupational reasons cannot solely be determined on the basis of a single air conduction audiogram. The only way that the work-relatedness of a significant threshold shift could be determined is on the basis of complete medical and audiologic evaluation.

Significant Threshold Shift

There is no question that there is a need for a standardized definition of significant threshold shift. The definition can be either complex or simple. A complex definition, such as the one we previously proposed, would most accurately identify shifts. However, given the size and scope of the numbers of employees to be tested, the definition presently contained in the Industrial Hygiene Field Operations Manual may be appropriate as well. Since the purpose of the testing is to identify and quantify hearing loss, the simpler procedure will have minimal test error. Further, the professional reviewer will have the opportunity to decide whether or not referral is necessary for further assessment regardless of the definition.

Audiometric Test Rooms

Three requests for information and comments were in reference to the practicality of audiometric test rooms in order to meet criteria as given in the amendment. An industrial audiometric test program and a clinical test program should not be held to the same standards. The background noise as presently allowed by the Hearing Conservation Amendment is adequate for gathering the data that is needed for an industrial hearing conservation program. Once a problem has been identified or believed to have been identified, the referral to the audiologist or otolaryngologist will allow the employee to be properly evaluated in a clinical test environment.

Training Program

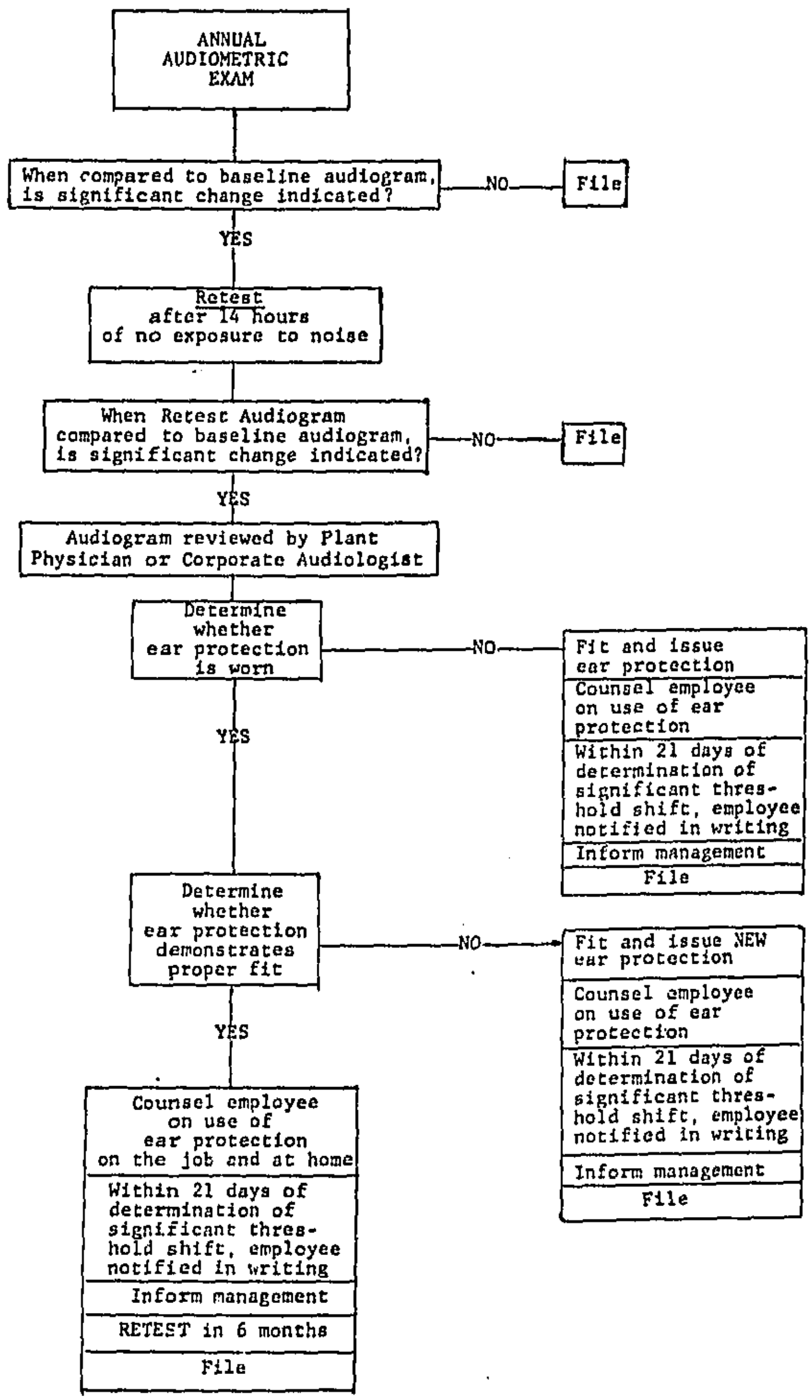
We want to emphasize here that we believe the training program for employees regarding hearing conservation may be the backbone of making such a program effective. During this time the necessity of hearing protectors and the understanding of audiometry can be communicated. Also, at this time, both management and labor would be able to show their endorsement of hearing conservation.

As part of the training program the warning signs should be used. The warning signs would be constantly visible reminders which are commonplace in safety and health areas. We feel these warning signs are as appropriate as signs mandating use of hard hats or safety glasses.

Performance Criteria

We find alternative performance criteria much too general and open for difficult interpretation. For example, a qualified technician is not defined nor does one find any reference to significant threshold shift. We believe that the approximately five page regulation is succinct and specific so that standards can be better understood than the three paragraph alternative.

FOLLOW-UP AFTER ANNUAL AUDIOMETRIC EXAM



1981-11-01

CITATIONS

NOISE, HEARING AND FEDERAL LAW: AN UPDATE

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Noise & Hearing Consultants of America
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American Speech - Language - Hearing Association (ASHA)
1981 Annual Convention - Los Angeles, California

NOISE, HEARING AND FEDERAL LAW: AN UPDATE

CONTENTS

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ABBREVIATIONS

CFR	Code of Federal Regulations
DOL	Department of Labor
EPA	Environmental Protection Agency
FR	Federal Register
MSHA	Mine Safety & Health Administration
NIOSH	National Institutes of Occupational Safety Health
OSHA	Occupational Safety & Health Administration
USC	United States Code

TO SEMINAR PARTICIPANTS

We would be very glad to receive any comments about this mini-seminar, especially comments regarding ways in which it might be further improved. Any particular experiences you have had with industrial or environmental noise and hearing regulations would be particularly welcomed.

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SAFETY REGULATIONS

41 CFR 50-204.10	Walsh-Healey Public Contracts Act Safety & Health Standards Noise Exposure Regulations
29 USC 651	Williams-Steiger (OSHA) Act of 1970
29 CFR 1910.95	OSHA Noise Exposure Regulations

Regulations Created By Extention of Established Standards

29 CFR 1910.12	Construction work.
29 CFR 1910.13	Ship repairing.
29 CFR 1910.14	Shipbuilding.
29 CFR 1910.15	Shipbreaking.
29 CFR 1910.16	Longshoring.
40 USC 333	Health & Safety Standards in Building Trades & Construction Industry
29 CFR 1926	Safety & Health Regulations for Construction
29 CFR 1926.52	Occupational noise exposure.
29 CFR 1926.101	Hearing protection.
30 CFR 55.5-50	MSHA Noise Standrads for Metal & Non-Metal Open Pit Mines
30 CFR 56.5-50	MSHA Noise Standrads for Sand, Gravel and Crushed Stone Operations
30 CFR 57.5-50	MSHA Noise Standards for Metal & Non-Metal Underground Mines
30 CFR 70.5000	MSHA Mandatory Noise Standards for Underground & Surface Coal Mines
30 CFR 71.3000	MSHA Mandatory Noise Standards for Surface Work Areas of Underground Coal Mines & Surface Coal Mines
49 CFR 393.94	DOT/FHWA Vehicle Interior Noise Levels

COMPENSATION REGULATIONS

5 USC Chapt. 81	Federal Employees Compensation Act
33 USC Chapt. 18	Longshoremen's & Harbor Workers' Compensation Act

Procedural Rules

Federal Employees Compensation Act	Federal (FECA) Procedure Manual Part 1 - Claims, and Part 3 - Disability Evaluations
Longshoremen's and Harbor Workers' Compensation Act	Longshore (LHWCA) Procedure Manual Part 2 - Case Evaluation/Adjudication Hearing Loss

ENVIRONMENTAL REGULATIONS

42 USC 1857	Noise Pollution & Abatement Act - 1970
42 USC 4901-18 49 USC 1431	Noise Control Act of 1972

Environmental Protection Agency

40 CFR 201	EPA Railroad Noise Emission Standards
40 CFR 202	EPA Final Noise Emission Standards for Motor Carriers Engaged in Interstate Commerce
40 CFR 203	EPA Certification Procedures for Low Noise Emission Products
40 CFR 204	EPA Noise Emission Standards for Portable Air Compressors
40 CFR 205	EPA Noise Emission Standards for Medium & Heavy Duty Trucks
40 CFR 210	EPA Prior Notice of Citizen Suits

Department of Transportation

23 CFR 772	DOT/FHWA Highway Noise Control

	Standards and Procedures
49 CFR 210	DOT Railroad Noise Emission Compliance Regulations
49 CFR 325	DOT Regulations for the Enforcement of Motro Carrier Noise Emission Standards

Federal Aviation Administration

49 USC 1431	FAA Control & Abatement of Aircraft Noise & Sonic Boom (a/K/a Noise Control Act of 1972)
14 CFR 36	FAA Noise Standards: AircraftType & Air Worthiness Certification
14 CFR 91.56	FAA Civil Aircraft Sonic Boom
14 CFR 91.301	FAA Operating Noise Limits

MISCELLANEOUS FEDERAL REGULATIONS

HUD Circ. # 1390.2	DHUD Noise Abatement & Control Policy
Exec. Order # 12088	Federal Compliance with Pollution Control Standards
32 CFR 650.161-175	Department of the Army - Environmental Noise Abatement
32 CFR 256.10	Department of Defense - Air Installations Compatible Use Noise Descriptors

FEDERAL DOCUMENTS OF SPECIAL INTEREST TO AUDIOLOGISTS

EPA 550/9-73-002	Public Health & Welfare Criteria for Noise
EPA 550/9-74-004	Information on Levels of Environmental Noise Requisite to Protect Health and Welfare With an Adequate Margin of Safety
46 FR 4078	DOL/OSHA Occupational Noise Exposure; Hearing Conservation Amendment (January 16, 1981)

46 FR 42622	DOL/OSHA Occupational Noise Exposure; Hearing Conservation Amendment; Rule and Proposed Rule (August 21, 1981)
HSM-73-11001	NIOSH - Criteria for Recommended Standard ... Occupational Exposure to Noise
49 CFR 391.41(b)(11)	FHWA - Physical qualifications for drivers.
49 CFR 392.9b	FHWA - Hearing aid to be worn.
21 CFR 801.420	FDA - Hearing aid devices; professional and patient labeling.
16 CFR 214	FTC - Hearing Aid Industry

HEARING IMPAIRMENT COMPUTATION METHODS

I. AAOO-1959 / AMA-1961 Method

1. Obtain average for puretone thresholds at 500 Hz, 1000 Hz and 2000 Hz for each ear.

2. Subtract the 25 dB "low fence" from each average.

3. Multiply the remainder for each ear by 1.5% in order to obtain the monaural hearing impairment for each ear.

4. To obtain the percentage binaural impairment, multiply the monaural impairment for the better ear by five (5), and then add the monaural impairment for the poorer ear, then divide this sum by six (6).

II. AAO-1979

1. Average the thresholds for 500 Hz, 1000 Hz, 2000 Hz and 3000 Hz as in step 1 above. Then continue with steps 2 through 4, as above.

III. NIOSH-1972

1. Average the thresholds for 1000 Hz, 2000 Hz, and 3000 Hz as in step 1, above. Then continue with steps 2 thru 4, as above.

PHYSIOLOGY

ASHA

EFFECTS OF NOISE ON HEARING

THE AMERICAN SPEECH-LANGUAGE-HEARING ASSOCIATION 10801 ROCKVILLE PIKE, ROCKVILLE, MARYLAND 20852

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TI - Noisy leisure time activities in teenage boys.
SO - Am Ind Hyg Assoc J 1981 Mar;42(3):229-33

2 AU - Ward WD
TI - Effects of impulse noise on hearing. Summary and overview.
SO - Scand Audiol (Suppl) 1980 Aug;(Suppl 12):339-48

3 AU - Voigt P ; Godenhielm B ; Ostlund E
TI - Impulse noise - measurement and assessment of the risk of noise induced hearing loss.
SO - Scand Audiol (Suppl) 1980 Aug;(Suppl 12):319-25

4 AU - Sulkowski WJ
TI - Hearing impairment caused by impulse noise: survey in the drop forging industry.
SO - Scand Audiol (Suppl) 1980 Aug;(Suppl 12):307-17

5 AU - Riihikangas P ; Anttonen H ; Hassi J ; Sorri M
TI - Hearing loss and impulse noise during military service.
SO - Scand Audiol (Suppl) 1980 Aug;(Suppl 12):292-7

6 AU - Ivarsson A ; Erlandsson B ; H'akanson H ; Nilsson P
TI - Advantages with a new Bekesy audiometer in the measurement of noise induced hearing loss.
SO - Scand Audiol (Suppl) 1980 Aug;(Suppl 12):265-72

7 AU - Fialkowska D ; Janczewski G ; Kochanek K ; Dawidowicz J
TI - Audiological findings in the impulse-noise induced hearing loss. Electrocochleographic (ECoG) studies. A preliminary report.
SO - Scand Audiol (Suppl) 1980 Aug;(Suppl 12):257-64

8 AU - Dieroff HG
TI - The mechanism of impulse-noise-induced hearing loss in industry and its resulting measurement problems.
SO - Scand Audiol (Suppl) 1980 Aug;(Suppl 12):249-56

9 AU - Nilsson R ; Lindgren F
TI - The effect of long term use of hearing protectors in industrial noise.
SO - Scand Audiol (Suppl) 1980 Aug;(Suppl 12):204-11

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TI - Differences in efficiency of earplugs and earmuffs measured as hearing impairments from two workshops.
SO - Scand Audiol (Suppl) 1980 Aug;(Suppl 12):194-9

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11 AU - Borchgrevink HM
TI - Practical management of impulse noise protection.
SO - Scand Audiol (Suppl) 1980 Aug;(Suppl 12):180-5

12 AU - Hamernik RP ; Henderson D ; Salvi RJ
TI - Contribution of animal studies to our understanding of impulse noise induced hearing loss.
SO - Scand Audiol (Suppl) 1980 Aug;(Suppl 12):128-46

13 AU - Coles RR
TI - Effects of impulse noise on hearing - introduction.
SO - Scand Audiol (Suppl) 1980 Aug;(Suppl 12):11-3

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TI - How deaf is deaf? A percentage evaluation method.
SO - R Soc Health J 1981 Feb;101(1):2-5

15 AU - Sisk MG ; Moul MJ ; Cochrane CR
TI - Hearing conservation at Fort Carson [editorial]
SO - Milit Med 1980 Nov;145(11):791-2

16 AU - Karam F
TI - Acoustic trauma in unprotected airport workers.
SO - J Med Liban 1980;31(3):281-5

17 AU - Jasinski C
TI - Noise-induced hearing loss in aviators.
SO - Hawaii Med J 1980 Dec;39(12):307-9

18 AU - Hamernik RP ; Henderson D ; Coling D ; Salvi R
TI - Influence of vibration on asymptotic threshold shift produced by impulse noise.
SO - Audiology 1981 May-Jun;20(3):259-69

19 AU - Lafon JC
TI - Measurement of hearing loss in occupational noise-induced hearing loss.
SO - Audiology 1981 Jan-Feb;20(1):79-85

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TI - Characteristics of tinnitus in acoustic trauma.
SO - Audiology 1981 Jan-Feb;20(1):72-8

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TI - Noise-induced hearing loss.
SO - Occup Health Saf 1981 Mar;50(3):62, 64-5, 67-8 passim

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TI - Intensive care nursery noise and its influence on newborn hearing screening.
SO - Int J Pediatr Otorhinolaryngol 1981 Jan;3(1):45-54

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TI - Asymmetrical hearing loss [letter]
SO - Hast J Hed 1980 Nov;133(5):448-9

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TI - The difference in protection efficiency between earplugs and earmuffs. An investigation performed at a workplace.
SO - Scand Audiol 1980;9(4):215-21

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TI - Effects of prestimulatory carbogen inhalation on noise-induced temporary threshold shifts in humans and chinchilla.
SO - Am J Otol 1980 Apr;1(4):227-32

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TI - Changes in summating potentials and related electro-physiological manifestations of overstimulation.
SO - J Aud Res 1979 Jul;19(3):183-200

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TI - Advances in measurement of noise and hearing.
SO - Acta Otolaryngol [Suppl] (Stockh) 1980;Suppl 366:1-67

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SO - Acta Otolaryngol (Stockh) 1980;90(1-2):61-5

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TI - Custom-molded earplug performance: a retrospective study.
SO - Scand Audiol 1980;9(2):113-7

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TI - Quiet and masked brief-tone audiometry in subjects with normal hearing and with noise-induced hearing loss.
SO - Scand Audiol 1980;9(1):43-7

AU - Chung DY
TI - Meanings of a double-notch audiogram.
SO - Scand Audiol 1980;9(1):29-32

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TI - Vestibular involvement in acoustic trauma. (An electronystagmographic study).
SO - J Laryngol Otol 1980 Dec;94(12):1395-1400

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TI - Hearing threshold shifts from prolonged exposure to noise in guinea pigs.
SO - Hear Res 1980 Oct;3(3):205-13

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TI - Noise: hearing loss and psychological effects.
SO - Br Med J 1980 Nov 15;281(6251):1325-7

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TI - Noise and hearing loss compensation.
SO - Ann Occup Hyg 1980;23(2):205-15

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TI - Hearing in an ambulance paramedic population.
SO - Ann Emerg Med 1980 Nov;9(11):557-61

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TI - Comparative method for the study of structural damage in acoustic trauma.
SO - Laryngoscope 1980 Nov;90(11 Pt 1):1887-91

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TI - Speech intelligibility in noise with ear protectors.
SO - J Otolaryngol 1980 Jun;9(3):256-65

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TI - Hearing conservation in premature infants [letter]
SO - J R Soc Med 1979 Apr;72(4):298

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TI - The risk of hearing impairment in children from mothers exposed to noise during pregnancy.
SO - Int J Pediatr Otorhinolaryngol 1979 Dec;1(3):221-9

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TI - Acoustic trauma in the guinea pig cochlea: early changes in ultrastructure and neural threshold.
SO - Hear Res 1980 Aug;3(2):167-79

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TI - Effect of intermittent sound stimulation on cochlear microphonics and the possible preventive effect of coenzyme Q10.
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TI - Incubator noise and hearing loss.
SO - Early Hum Dev 1977 Oct;1(1):113-5

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TI - Noise-induced hearing loss and vestibular dysfunction.
SO - Aviat Space Environ Med 1980 Aug;51(8):823-6

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SO - Arch Otolaryngol 1980 Oct;106(10):602-9

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TI - Comparison of the hearing levels of Nigerian textile workers and a control group.
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SO - J Laryngol Otol 1980 Apr;94(4):419-23

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SO - J Dent Educ 1980 May;44(5):261-3

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A MODEL HEARING
CONSERVATION PROGRAM

Effects of Noise on Hearing, edited by Donald Henderson, Roger P. Hamernik, Darshan S. Dosanjh, and John H. Mills. Raven Press, New York © 1976.

Industrial Hearing Conservation Programs

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The impetus for hearing conservation programs in industry can hardly be presumed to originate from industry's moral concern for the worker's health. The damaging effects of noise on hearing cannot be viewed as a recent discovery and the existence of excessive noise levels in industrial settings is commonplace knowledge. While there is concern on the part of nonindustrial groups that the noise levels in industry do impair hearing, it has been difficult to enlist the support of industry to voluntarily develop hearing conservation programs. Rather, the impetus for hearing conservation programs arises from legal pressures which stipulate that the work environment cause "no material impairment of health or functional capacity" (1). It is indeed interesting that other legal pressures, primarily those relating to workmen's compensation have been in existence considerably longer on a statewide basis than has the federal regulation for industrial noise control, and yet it is the federal regulation that is providing the primary stimulus for the development of hearing conservation programs within industry. In some respects, workmen's compensation claims constitute a far greater potential cost to industry than does noncompliance with the federal regulation. However, workmen's compensation seems to have had almost no impact in the development of hearing conservation programs and in fact, the fear of alerting the older worker to the fact that he has a compensable problem has probably been a major deterrent to the development of programs.

Federal regulations (OSHA), as we are all aware, have stimulated the development of standards for Occupational Noise Exposure (2). A considerable amount of time and debate has ensued over such factors as damage risk criteria and the minimum noise level to which employees might be exposed. Much of the dispute appears to relate to the fact that the primary means of compliance with the federal standard relates to the specification that noise control first be approached from an engineering standpoint. That is, when engineering technology is feasible, the noise should be engineered out. However, that concept of feasibility is really disputed by industry from an economic standpoint and the use of ear protection is advanced as a viable option rather than an intermediate step.

The intent of federal regulation, being one of prevention, has resulted in a series of regulations for many areas of health and safety. When it comes to the effects of noise, primary attention has focused upon the damaging effect of noise on hearing. Nonauditory effects have been generally ignored. With respect to the effects of noise on hearing, the proposed regulations specify that employees who are exposed to potentially damaging levels of noise must either be provided with sufficient nonexposure periods or alternative plans must be developed and implemented for the reduction of noise in order to achieve compliance with the regulations. Presently, the latter option is the first mandated choice. When noise exposure of employees occurs, a hearing conservation program must be established.

The process industry may use to determine whether or not it is in compliance with federal regulations is demonstrated in Fig. 1. This flow chart naturally begins with a review of the Occupational Health and Safety Guidelines on Industrial Noise and proceeds through the various stages available to achieve compliance with the regulations. Hearing conservation programs are an integral part of programs when exposure exists. In addition to the federal guidelines, other regulations may be introduced at the state level and may, in fact, be more stringent. Consequently, an industry must not only evaluate its program in terms of the federal guidelines, but when existing state guidelines exist, they must be considered as well.

In any event, the first step in achieving compliance with occupational noise guidelines and determining the need for a hearing conservation program is to conduct a noise survey. This will demonstrate either (*i*) the noise level in the workplace is below 85 dB(A), or (*ii*) in excess of 85 dB, presuming a 90 dB(A) damage risk criteria and a 5 dB doubling rule that would mandate implementation of a hearing conservation program at 85 dB(A) exposure. If the noise survey verifies that noise does not exceed that level then the program is automatically in compliance and a hearing conservation program is not necessary. However, if the noise level exceeds 85 dB(A), the next question is to establish whether or not there is personnel exposure. If employees are not exposed to noise then the noise level itself is inconsequential (3) and the company is still in compliance. On the other hand, if personnel are exposed a determination of the extent of individual exposure must be carried out. With this in hand, it is possible to determine whether or not the individual exposure exceeds the guidelines which, at the present time, specify a daily noise dose equal to or exceeding 0.5 (85 dB(A) for 8 hr). If exposures do not reach this level this material is then documented and the company is in compliance and without the need for a hearing conservation program.

Should exposure exceed the damage risk criteria, a comprehensive sound survey is necessary in order to begin to determine whether engineering controls which can reduce noise levels are feasible. If they are, they should be implemented and the track returns to a repeat noise survey which would establish

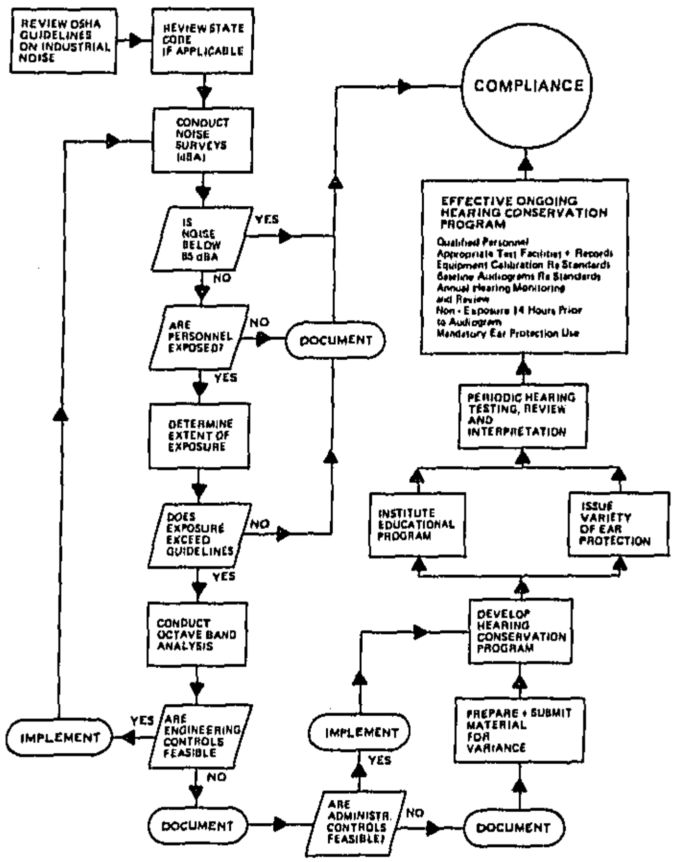

FIG. 1. *Flow chart to be followed to determine compliance with occupational noise exposure regulations and determining the need for a hearing conservation program. (Reproduced by courtesy of Environmental Hearing and Vision Consultants, Ltd.)*

whether or not the level of noise has been reduced to a point of compliance. If engineering controls are not feasible or still result in potentially damaging exposure, this material must be documented and the feasibility of administrative controls such as work schedule modification and machinery on time modification must be reviewed and, if feasible, implemented.

Administrative and engineering controls may not prove to be feasible and employee exposure may still persist. For example, a weaving mill noise level will generally be well in excess of 100 dB and administrative controls such as employee rotation and intermittent equipment on time are not feasible. In addition, there is both economical and technological lack of feasibility for engineering a significant noise reduction. These facts must be documented and the company could prepare an application for a variance. In any event, whether engineering controls are or are not feasible and whether administrative controls are or are not feasible, as long as the exposure time exceeds the guidelines a hearing conservation program must be established.

The hearing conservation program may be viewed as multifaceted. It should include an educational program which provides personnel education for both management and labor as to the effects of noise on hearing and the prevention of impairment. In addition to this a variety of ear protection should be made available for exposed employees. Hearing protection is presently viewed as a temporary substitute in lieu of feasible engineering and administrative controls. The ear protection issued to the employee in conjunction with the educational program would be presumed to reduce the effective exposure to levels below those cited in the damage risk criteria. The effectiveness of the program in achieving this goal is then validated by a periodic hearing testing program with professional review and interpretation. This package would then provide the company with an effective ongoing hearing conservation program leading to compliance with the federal occupational noise exposure guidelines. Compliance then, means either the elimination of (*i*) potentially hazardous noise; (*ii*) the effective reduction of exposure to existing hazardous noise; and (*iii*) audiometric monitoring of the overall effectiveness of the noise control program.

The detailed components of an effective hearing conservation program are:

1. Qualified personnel and professional surveillance
2. Appropriate test facilities and records
3. Equipment calibration policies
4. Baseline audiograms
5. Annual hearing monitoring and review
6. A 14-hr nonexposure period prior to audiometry
7. Mandatory ear protection use

These components are specified in the occupational noise-exposure standard (2). There are, of course, several approaches that industry may elect to follow in order to establish the hearing conservation program. A major criticism by industry of the requirement for such a program involves its expense. It is indeed costly to train personnel, obtain equipment, and test all employees on a regular schedule. However, hearing impairment is also costly. In order to establish that hearing impairment is not occurring as a consequence of employee exposure to potentially hazardous noise levels, the companies have the option of either internally organizing, equipping, and training personnel to carry out an effective hearing conservation program, or employing outside professional consultants to establish and run the program. The former instance would include the training of someone within the company to function as an industrial hearing conservationist. This would provide the company with someone who can test, issue, and fit ear protection and cooperate with the educational program. Administration of the hearing conservation program itself could be in any number of channels. This could be a program that is coordinated under the medical department or, as is more common in smaller plants, under safety personnel or some other administration structure. What would be important would be that the people involved in the program are appropriately trained and credentialled professionals.

The audiometric data which is obtained provides only a baseline audiogram which serves as a reference audiogram against which future hearing tests are checked for a significant shift as stipulated by law. Should the company wish to go further, the audiogram may serve as a potential health screening device, and employees may be referred for additional and more elaborate investigation of their apparent hearing problem. This latter, however, is not currently mandated, and consequently, is not a stipulated requirement of the hearing conservation program. All that is mandated is that a baseline audiogram be established and that the testing be carried out on at least an annual basis. The employee is to be notified when a significant change in hearing occurs. Hopefully, additional followup beyond reinstruction in the use of ear protection will be incorporated into the program.

An effective hearing conservation program would be one which goes beyond the identification of shifts in hearing level and monitoring of ear protection use and effectiveness. It should also encourage evaluation of significant hearing losses which are detected by the hearing screening program. Whether companies elect to develop internal programs or contract out to consulting firms, the technical and professional aspects of the hearing conservation program should be the responsibility of appropriately credentialled professionals.

SUMMARY

Hearing conservation programs are the mechanism for monitoring hearing health of the employee who is exposed to potentially hazardous noise levels. These programs are necessary when the workplace noise levels and exposures cannot be reduced below hazardous levels. The programs minimally provide valid threshold audiograms in specified test environments with calibrated instrumentation generated by appropriately trained personnel. This audiometric data serves as the means of validating that noise control and ear protection are effective in preventing noise-induced hearing loss. The additional dimension of identification of other kinds of hearing loss and referring for appropriate evaluations is an as yet optional but desirable feature of many programs.

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SESSION

CONDUCTING NOISE SURVEY AND MONITORING PROGRAMS

- OSHA Requirements
- Noise Survey
  - organization
  - conduct
  - report
- Monitoring
  - operations
  - follow-up

* * * * * *

AN OUTLINE

CONDUCTING NOISE SURVEY AND MONITORING PROGRAMS

I Introduction

Dr. Suter detailed both the physiological threat to the worker, and the status of hearing conservation as viewed by OSHA.

Briefly, continued long term exposure to noise at or above 85 dBA is seen to pose a significant threat to the hearing of workers. Based on that fact, employers are then required to make an initial determination of whether or not their workplace is in compliance with the Williams-Steiger Act - OSHA 1970 (OSHA). Note that the permissable exposure level (PEL) is 90 dBA for 8 hours, with a 5 dB doubling or halving rate; however, certain things must be done once the level of 85 dBA for 8 hours or more (called an action level, as opposed to PEL) is reached. Thus, an initial noise survey is called for to determine whether or not the workplace is in compliance. If no time weighted average levels of 85 dBA or higher can be found in the entire plant, then obviously the plant is in compliance, report can be made and documented, and all is fine. If levels of 85 dBA or higher TWA are found, then, with regard to noise, employers are required to measure personal noise doses for representative employees using equipment meeting minimum specifications and calibrated to ensure accuracy. This monitoring must be conducted at least every 2 years and within 60 days of a change of process which changed noise exposures to the extent that employees previously exposed below 85 dBA TWA would be exposed above that level, or if the change was such that it rendered inadequate the hearing protectors used.

The OSHA regulation would first require a Noise Survey to determine the nature and magnitude of the noise problem in the plant. Then, if levels of 85 dBA TWA or higher are found, it requires periodic noise monitoring. What is required for the Noise Survey?

A. Equipment - 1. SLM
 2. Calibrator

B. Organization and Technique

C. Summary of results and recommendations

Equipment - Have Type I, Type II SLM, Type I more precise - called precision SLM - used for research, legal or forensic uses, acoustical engineering, and other uses demanding precision. Type II - less strict specifications, is a survey meter, cheaper than Type I, adequate for noise surveys, general use not requiring great precision. Calibrator - Two types of calibration are possible with SLM's - Electrical - essentially a check to determine all electrical circuits are working properly. Acoustical - is an acoustical check of electrical circuits plus microphone - involves putting a signal of known frequency and intensity through the microphone.

Organization - Organization of the noise survey is a critical aspect of the survey. First, if the person doing the noise survey does not have intimate and detailed knowledge of the innermost workings of the plant - such as who works where, when, for how long, with what machinery operating, processing what material - then some one who has such knowledge must be found to accompany him on his survey to provide the necessary information required to do a proper noise survey.

Once provided with a knowledgable guide, briefly look over the plant. In general, I examine plant layout, ruling out any areas with obviously low noise levels (which should be just monitored in passing) and usually systematically proceed through a plant, starting with the area where to-be-processed materials arrive, and follow them through their various phases of processing, warehousing to shipping. This type of organization of the survey can help assure that you do not overlook anything, as well as save you time. Also, in advance, prepare data sheets appropriate for the data you will be collecting, and assemble clip boards, SLM, Calibrator, etc., preparatory for the survey.

Technique - The first thing to do is to check the battery output levels on both the SLM and Calibrator. Be sure to have spare batteries that fit the units you will use. Then, check the Calibration status of the SLM. This is important. I check before I leave the office because it is embarrassing and expensive to arrive at a plant and start out with problems. Then, at the plant, just before you begin the survey, calibrate, and record calibration results to include date, time, place, model and serial number of SLM and calibrator, and calibration level. This should be a permanent part of your record of the noise survey. Proceed through the plant, measuring noise levels at worker's ear level with worker absent in dBA, slow setting. Determine time of exposure for each worker and times and levels for each worker, and times and levels for each worker at any other workplace or workplaces he might staff, in order to arrive at his total noise exposure. If the worker does work for different lengths of time at different locations involving different noise levels, you must sum fractional exposures to arrive at the total. For example, if he works for 4 hours at 90 dBA, that is 50% PEL; if he then works for 2 hours at 95 dBA, that worker could not be in any area whose level was as high as 90 dBA.

At the worksite, as you check noise levels, get a first reading and look to see if it varies. If it varies regularly, determine the mid-point of the range of variation and use that. If it varies more widely and intermittantly, take a series of 10 readings over time (1 - 2 minutes apart) and average, noting that that is what you did. Check to see what equipment is operating, what material is being processed, and rate of process, if relevant. I have a philosophy of trying to do a Noise Survey with as much equipment operating as possible - <u>All</u>, if it can be done. Thus, if a plant is in compliance at a maximum output, it will be in compliance at all other lesser operating periods. Also, check worker exposure site times and for multiple sites, not only with the worker (get estimates of average time), but with his supervisor. Then proceed on through the plant, covering each piece of equipment and worker station. Note that some workers can work in a noisy area where there is no specific piece of equipment they attend. If they <u>move about</u> in the area, need to know how SL varies in the area and where in the area they spend their time. At breaks in time - lunch, etc., re-check calibration and note results on record. This is important for two reasons: it lets you know all is O.K., and provides official record of check and validity of results.

try worst case test

Once SL's and exposure duration are determined for all workers, then a plant layout should be outlined, not necessarily to scale, but one where the equipment and levels can be depicted for all areas of the plant. Then results and a recommendation section must be prepared, stating whether or not the plant is in compliance in its various operating areas, and what procedures can be put into effect to minimize noise and/or protect the worker. Note that information should be available for all workers or all groups of workers, if relevant, regarding whether or not their exposures are in compliance, and what steps are necessary to provide them with adequate protection.

Thus, we end up with a Noise Survey Report, dated, with the name and location of the plant and identity of the person compiling the survey. An outline of the plant area, with equipment identified and noise levels shown, should follow, with a description of the equipment and procedures used. Follow with a written summary of results and recommendations, with individual workers exposure levels and recommendations detailed in an Appendix, where relevant.

<u>Monitoring</u> - Arrangements should be made with the plant manager and/or plant engineer, or in their absence, with whoever is responsible for modification of existing equipment or installation of new equipment to be notified of such activities promptly. Then, within 60 days of such change, check levels under the changed condition and make an addendum to the original Noise Survey Report.

The use of Noise Dosimeters has been approved and they may be used to monitor worker exposure to determine whether or not work day exposure exceeds the compliance level. This is probably a more accurate quantification of exposure level than estimating time of exposure with multiple exposures, then preparing and summing duration-level data for the final exposure level. One caution however: most dosimeters do not perform well with impulse noise, and therefore, if significant impulse noise exposure is involved, figures read off the dosimeter can be off, usually too low.

Industrial noise measurement

By Robert J. Wurm

Industry is under pressure to establish and maintain a formal hearing conservation program, not only from OSHA, but also because workman's compensation claims continue to rise. Many companies are already deeply involved in such a program, while others are just beginning. An understanding of noise measurement as pertains to instrumentation versus type of noise (continuous, variable or impulsive) is important to a proper program.

The type of noise with which one must deal determines the type of instrument needed for its proper measurement. The sound level meter is the most basic and most used sound instrument in the world today. It is used literally in most all applications, such as, general industry, community, vehicle, airport construction, mining, product noise evaluation and for calibrating audiometers and hearing aids.

The sound level meter also forms the basis of most other sound measuring devices. Many of the more specialized and complicated sound instruments merely consist of a sound level meter with additions or adaptations. A noise dosimeter is essentially a sound level meter with an added integrator. An octave band analyzer is formed merely by adding a frequency filter set, and a peak hold meter, by adding a peak hold module. Chart recorders can be plugged into the meter for making permanent records. Add an earphone coupler and an audiometer calibration system is made.

ANSI (American National Standards Institute) as well as International standards specify that a general full purpose sound level meter contains a switch for A, B and C weighting scales, a fast-slow response switch and a means to check battery strength (Fig. 1).

Fig. 1. Type 2 sound level meter with A, B, C and LIN weighting, fast-slow response.

Robert J. Wurm is general manager, Quest Electronics, Oconomowoc, WI.

The A scale is the most commonly used measurement. With A scale weighting the meter measures sound essentially as it is heard. The human ear does not respond well to low frequencies or tones. The meter electronically alters the measured sound to approximate the sound heard by the ear. The alteration is accomplished by suppressing the lower frequencies so that the meter reading usually is less than the actual sound pressure level, but essentially equal to how the ear is affected. The change in indicated decibels on the A scale from the actual decibel level at various frequencies is shown in Fig. 2.

B scale rarely is used today unless there is a necessity to compare readings of perhaps 20 years ago. B scale might occasionally be used today in audiometer calibration where no octave band filter is available to isolate the tones. B scale produces some attenuation to often bothersome low frequency vibrations that can disturb the meter reading in closed 6 cc coupler tests.

C scale (also shown in Fig. 2) is a near linear (flat) response weighting used for more scientific measurements or for comparison to A scale readings. This comparison will give some relative frequency content information. Actually a true Linear scale measurement is replacing C scale readings for most applications. Some newer meters are offering only A and Linear scales. Linear is used for true sound pressure readings (unweighted), and for plotting frequency response curves for such things as microphones, speakers and hearing aids.

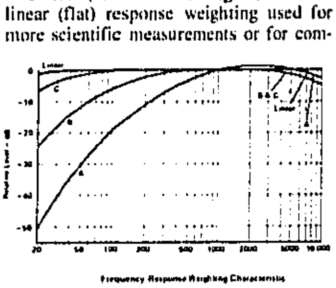


Fig. 2. Frequency response weighting characteristics.

The term fast-slow response refers to the speed of the meter needle in indicating changes in sound levels. When the meter is set to slow response, the needle deflection is damped to produce a more stable deflection which is easy to read. When a meter is set for fast response, the needle moves quickly in variable noise environments and can be difficult to read. The effective steady state meter indication is not affected by the response selection, but with slow response is easier to read.

Sound level meter types

The present ANSI Standard S1.4-1971 categorizes sound level meters into 3 types: type 1, 2 and 3. (In two or three years, ANSI will likely adopt most of the new International IEC standard and categorize meters into 4 types: 0, 1, 2 and 3).

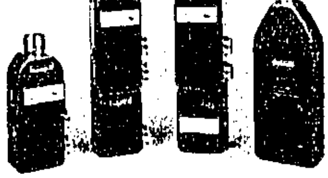


Fig. 3. Measuring instruments (l to r): sound level meter, octave band analyzer, impact-impulse hold meter and integrating sound level meter.

Type 1 is a precision meter; type 2 is a general purpose meter; and type 3 is a survey meter. Essentially type 1 is the most accurate and is intended primarily for laboratory use and other critical measurements. Type 2 is intended for most all field or plant use (OSHA requires type 2). Type 3 has the lowest accuracy and generally should not be used for accurate measurements.

A sound level meter which does not utilize a meter needle is the digital sound level meter. This meter has a number display of decibel level instead of a meter needle. The display may be of the LCD or LED type. Fixed number displays are ideal and easy to read when the number stands still as in constant noise, impact or impulse hold or in an averaging type meter (Leq). However, a digital readout used in a standard sound level meter becomes difficult to read in a variable noise environment. Changing numbers flashing at the operator are confusing. A moving needle type meter is considered to be easier to visually understand and average than are rapidly changing numbers.

The types of noise environments encountered in industry include: continuous, variable, impulsive or special application such as audiometer calibration.

Continuous noise

In relatively constant noise environments a sound level meter is very adequate to obtain good readings. A rule of thumb is that the meter needle should not vary more than about 3 dB. For sounds that stay within this 3 dB span, the higher value is the closest to the actual average. Remember that decibels are log functions, and you do not arithmetic average them. As noise variations become more severe it becomes increasingly difficult to eyeball average values, particularly when also trying to apply OSHA's 5 dB rule.

Variable noise

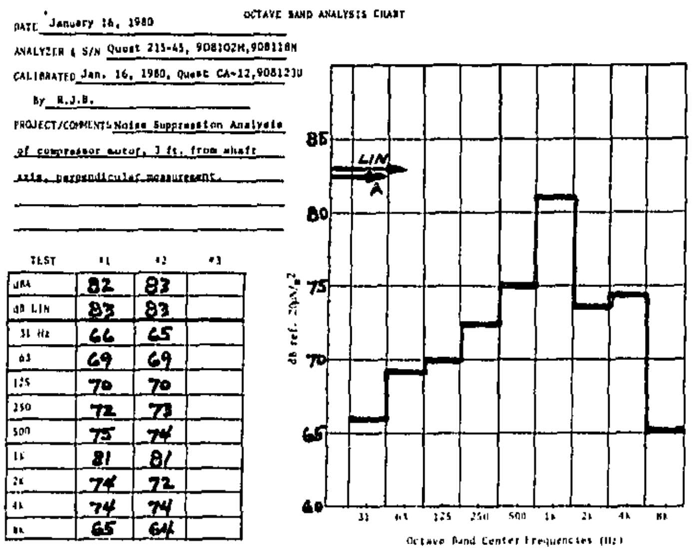
When noise variations become the rule rather than the exception, use of a sound level meter to determine workers exposure becomes a tedious task and produces questionable results. Most often the results are underestimated. A noise dosimeter of an integrating sound level meter affords the only practical alternative. Dosimeters are basically the same in performance as sound level meters with the added integrating circuit providing the advantage of eliminating the human error in trying to interpolate a moving meter needle and also attempting to assess the 5 dB time weighting of sound levels. In the presence of impulsive noise the actual energy is picked up and integrated in a dosimeter as long as the slow response time constant permits the signal level to exceed the dosimeter threshold level. In a sound level meter, the meter ballistics and judgment factor generally cause a person to read the meter low, particularly with high impulsive, low duty cycle noise.

In the new OSHA requirements for hearing conservation (Federal Register Jan. 16, 1981), the noise dosimeter has its threshold level set down to 80 dB (8 hour criteria level is still 90 dB). This effectively removes the abrupt discontinuity of the 90 dB threshold setting and permits direct conversion of percent exposure to OSHA equivalent decibel level.

The alternative instrument to a noise dosimeter is the integrating sound level meter (Fig. 3); either equal energy (Leq) type or the OSHA equivalent ^{L}OSHA (5dB) integrating meter. The only basic difference between the dosimeter and the ^{L}OSHA meter is that the dosimeter reads out in percent exposure while the integrating meter reads directly in average decibels. Both instruments measure impulse noise correctly to the extent of their crest factor capability (peak noise compared to average level). Some Leq meters will produce a

Fig. 4. Measurement and chart recording of industrial noise with an integrating sound level meter.

single average noise level over any period of time. But other meters will automatically measure equal time increment periods and can be plotted on a recorder to produce a time-history profile of noise throughout a work shift or even over a 24 hour day. This is shown in Fig. 4, where in this case average industrial noise is chart recorded in two minute increments over a workshift.



TEST	#1	#2	#3
dBA	82	83	
dB LIN	83	83	
31 Hz	66	65	
63	69	69	
125	70	70	
250	72	73	
500	75	74	
1k	81	81	
2k	74	72	
4k	74	74	
8k	65	64	

Fig. 5. Octave band analysis plot of a compressor motor system.

Impulsive-impact noise

Repetitive, impulsive noise, where true averages or exposure levels are to be measured, are covered above. Where actual peak magnitudes are to be measured, a special meter with this capability is necessary. This is an impulse or peak-hold feature added to some meters (Fig. 3). The normal response of a meter even set to fast response is still far too slow to capture and read impulsive noise. The peak-hold addition to the meter captures the impact level electronically, drives the meter reading up to that level and holds it to take the reading.

Absolute impact peak noise levels can be read, and also the international impulsive method based on 35 millisecond risetime can be read.

Special applications

Often a more detailed understanding of a noise problem is needed requiring the use of an octave band analyzer. This type of instrument provides a convenient means to analyze noise in frequency bands to aid in determining methods to control noise. Generally, the results of measuring sound levels in octave frequency bands are plotted on a chart for analysis to visually see the noise profile of the noisy environment or object (Fig. 5). If the intent is to quiet an industrial machine, then another octave band analysis can be taken after application of the sound suppression methods to determine the effectiveness of the techniques.

The octave band analyzer has an additional major role in the hearing conservation program. The new regulation requires audiometric testing of all employees exposed to 85 dBA or more. These tests must be given in a room or sound booth that has specific background room noise limitations spelled out in octave bands. Any company that sets up their own testing program must measure and record background noise levels. Therefore, the octave band analyzer now has a triple role to play in industry. The same octave band analyzer can now perform:

1) Octave band analysis of all noisy machines and plant areas to aid in engineering quieting efforts.

2) Measurement of audiometric room background noise.

3) Actual audiometric calibration of the audiometer to insure its continued accuracy.

Audiometer decibel levels are accurately checked with the octave band analyzer with the addition of a 6 cc earphone coupler to match the microphone. A pressure response plot of the particular microphone characteristic is also necessary for accuracy.

Conclusion

The field of sound measurement instrumentation continues each year to grow more complex and more sophisticated. Implementation of a good hearing conservation program will involve a good understanding of noise measurement, of the types of noise being measured and of the various sound measuring devices available. □

SESSION

HEARING PROTECTION DEVICES

- OSHA Philosophy
- Types
  - insert
  - over the ear
- Criteria for selection
- Education and Supervision

* * * * * *

John L. Fletcher, Ph.D.
ASHA Workshop

PERSONAL PROTECTIVE DEVICES

I. Types --- A. Insert (earplugs)

B. Over-the-ear (muffs)

II. Considerations in type recommended:

A. Length of time to be worn

B. Temporal pattern of wear

C. Temperature, humidity

D. Physical factors - scar tissue, head shape, skull rashes, infections, etc.

E. Personal Preference

F. Cost

G. Sanitation

III. Pros and Cons - Plugs -vs- Muff

<u>In General</u>

1. Use cheapest device that will do job

2. Give worker some choice in device used, but <u>not</u> in use of device.

3. For short term use, in and out of noise (2 hours or less) - use muffs

4. Long term use - Plugs

5. No plugs in inflamed or infected ear

6. No muffs with scalp infection, wound, etc.

7. Muff easier to put on - take off - keep clean, fits better most time, easier to see, but can be "sprung" - then don't protect

8. Molded usually more expensive, don't do any better job - may "age"

9. Plugs insert - must be re-set - must be carefully inserted to seal properly - insert with talking - chewing

10. Must get workers to take time to get accustomed to pressure from devices - necessary for proper attenuation.

E·A·RLOG 1

first in a comprehensive series of technical monographs covering topics related to hearing and hearing protection.

The Threshold Shift Method Of Measuring Hearing Protector Attenuation

BY ELLIOTT H. BERGER,
Manager Acoustical Engineering, E-A-R Division Cabot Corporation

One of the most common methods of reducing employee noise exposure is the utilization of hearing protective devices (HPDs). Selection of a suitable HPD is influenced by many parameters, one of the foremost being the protector's attenuation. In the discussion that follows, information will be presented that will explain some of the details of HPD attenuation measurements.

The most common method of measuring the attenuation of HPDs has been an absolute threshold shift procedure. Virtually all available manufacturers' reported data is derived via this method. Conceptually the idea is very simple – determine the minimum level of a sound that a subject can hear without wearing a HPD (open threshold) and then measure how much louder the sound needs to be for the subject to hear it while wearing the HPD (occluded threshold). The difference in these two thresholds, the threshold shift, is a measure of the attenuation afforded by the device.

Two American National Standards

Two American National Standards have been written describing the absolute threshold shift technique of testing HPDs. Both standards require testing 10 subjects, 3 times each, at nine different frequencies. Since this results in 30 data points at each frequency, a measure of the dispersion of the measured attenuations at each frequency is available. Thus both the mean attenuations and the standard deviations are reported. The original standard ANSI[1] Z24.22 – 1957 (R1971) required the subject be seated in a directional sound field, usually achieved by testing in an anechoic chamber with a loudspeaker in front of, and facing the subject. The test sounds used were pure tones.

EARMUFF ATTENUATION MEASURED VIA TWO METHODS

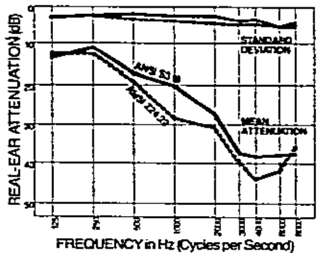


Figure 1

It is apparent that pure tones at frontal incidence are not characteristic of typical industrial environments. Furthermore, earmuff attenuation can vary as much as 15 dB as the angle of sound incidence varies. Additionally, since resonances in the protector can cause attenuation to vary rapidly over small frequency increments, pure tone attenuations at octave band center frequencies may not accurately reflect the noise reduction afforded by the HPD in those octave bands.

The new standard, ANSI S3.19 – 1974 (ASA[2] STD1-1975), specifies stimuli that are ⅓ octave wide bands of noise, presented in a uniform, non-directional (diffuse) sound field. This circumvents the problems mentioned above, by more closely approximating typical industrial noise exposure conditions.

S3.19 and Z24.22 – Data Compared

Attenuation measured via the two methods on the same HPD using the same subjects yields results which may differ by as much as 10 dB or more. Typically the agreement is closer. In Fig. 1, the results for a representative muff are shown[3]. The S3.19 attenuation is poorer than the Z24.22 values in the 1–4 kHz region, especially at 1 kHz and 4 kHz, where the differences are ≥ 5 dB.[4,5] Notice that the trend also indicates slightly smaller standard deviations using the S3.19 test.

E-A-R PLUG ATTENUATION DATA (1978) MEASURED VIA TWO METHODS

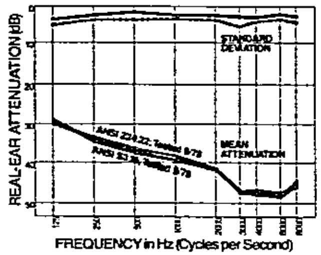


Figure 2

E-A-R PLUG ATTENUATION DATA (1974/75) MEASURED VIA TWO METHODS

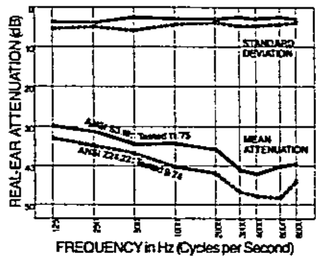


Figure 3

In Figs. 2 and 3, two sets of S3.19/Z24.22 comparisons are shown for the E-A-R™ Plugs, a user molded foam insert.

In Fig. 2, recent (9/78) E-A-R data are presented. Both of these tests were performed in one, 2 week period using identical subjects. Notice the attenuation is virtually identical for the two tests with smaller standard deviations for the S3.19 data. Generally insert protectors show closer agreement between S3.19 and Z24.22 than do earmuffs, but usually the mean attenuations are 2-4 dB less using S3.19. Thus the agreement between the two sets of data shown in Fig. 2 is somewhat better than is normally found.

In Fig. 3, the currently advertised data for the E-A-R Plug is plotted. The Z24.22 test was performed in late 1974 and the S3.19 test about 1 year later. Thus the subjects were not identical for the two tests. Notice that now the S3.19 attenuation data is uniformly lower than the Z24.22 data. These differences, larger than those shown in Fig. 2, are not due to the different test methods, but due to other variables that can arise over a period of one year.

Variability in data is an important aspect of measurements involving human subjects, such as threshold shift tests. Only the intra-laboratory part of this variability is reflected in the reported standard deviations. Variability among different laboratories is not included in the reported standard deviations and may be greater than that found between the two sets of S3.19 data shown above. E-A-R Corporation recognizes this and therefore advertises the S3.19 data shown in Fig. 3, the lowest ever measured[3] on the currently produced E-A-R Plugs.

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EARLOG 2

second in a comprehensive series of technical monographs covering topics related to hearing and hearing protection.

Single Number Measures of Hearing Protector Noise Reduction

BY ELLIOTT H. BERGER,
Manager Acoustical Engineering, E-A-R Corporation

In EARLog #1[1] we discussed the threshold shift method of measuring hearing protector attenuation. The results of such a laboratory hearing protector test consist of attenuation and standard deviation values at nine frequencies. Reduction of this data to a single number rating provides a simple and efficient means of choosing hearing protection devices and determining their suitability for particular applications. This EARLog will discuss single number ratings, their accuracy, calculation, and utilization.

The most accurate method of determining an employee's noise exposure under the protector (effective exposure) is to utilize an octave band analysis of the actual sound spectrum to which the employee is exposed, in conjunction with the attenuation and standard deviation data mentioned above. This will be labeled the long method.[2,3] It involves computations similar to those necessary to determine a device's single number rating. The long method noise reduction must be individually calculated for each noise environment, whereas the single number rating provides a noise reduction value that can be supplied by the manufacturer and simply subtracted from the measured A or C-weighted sound level in question.

There have been at least eleven[4] single number rating descriptors proposed since 1970. Johnson[5] and Waugh[6] among others have statistically evaluated the accuracy of these ratings vs. the long method by examining the resulting predictions for large numbers of industrial noise spectra. The data indicate that a good single number rating scheme will provide a successful compromise between under-protecting a minority and over-protecting a majority of wearers in most environments.

The Noise Reduction Rating (NRR)

The Noise Reduction Rating (NRR)[7], a variant of the NIOSH R_c factor[8], is the current EPA proposed single number descriptor. A sample NRR calculation is demonstrated in Table 1. The key point to consider is that the NRR is subtracted from the measured (unprotected) C-weighted sound level to yield an effective A-weighted sound exposure for the employee. The idea of subtracting a noise reduction factor from a C-weighted sound level to find an A-weighted exposure was first proposed by Botsford[9] in 1973. This "C-A concept" is the important common ingredient in all of the successful single number descriptors proposed in recent years.[10,11]

As can be seen in Table 1, the NRR is the difference between the overall C-weighted sound level of a pink (flat by octaves) noise spectrum and the resulting A-weighted noise levels under the protector. The attenuation values used in the calculation are the measured laboratory attenuation values minus two standard deviations. This correction assures that the attenuation values used in the calculation procedure are actually realizable by the majority of employees who conscientiously and correctly wear their protectors. This correction will not account for employee misuse or abuse of the protectors.

TABLE 1 - HOW TO CALCULATE THE NRR

Octave Band Frequency (Hz)	125	250	500	1000	2000	4000	8000
1. Hypothetical noise spectrum OB† sound levels (pink noise)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
(level assumed is not significant)							
2. C-weighted OB sound levels unprotected ear	99.8	100.0	100.0	100.0	99.8	99.2	97.0
3. Overall C-weighted sound level 108.0 dBC (logarithmic sum of the seven OB sound levels in step 2)							
4. A-weighted OB sound levels unprotected ear	83.9	91.4	96.8	100.0	101.2	101.0	98.9
5. E-A-R™Plug mean attenuation	29.6	31.3	34.1	34.0	35.5	41.4*	39.6**
6. E-A-R Plug standard deviations x 2	6.4	6.6	4.2	4.6	5.4	3.9*	4.8**
7. Protected A-weighted OB sound levels [Step 4 − Step 5 + Step 6]	60.7	66.7	66.9	70.6	71.1	63.5	64.1

8. Overall A-weighted sound level under the protector (effective exposure) · · 76.0 dBA (logarithmic sum of the seven OB sound levels in step 7)

9. NRR = Step 3 − Step 8 − 3 dB††
NRR = 108.0 − 76.0 − 3 = **29 dB**

†OB-Octave band
††This is a correction (safety) factor to protect against over estimating the device's noise reduction because of possible variations in the spectra of actual industrial noises.

*Numerical average of the 3000 Hz and 4000 Hz data
**Numerical average of the 6000 Hz and 8000 Hz data

ATTENUATION DATA FOR THREE TYPES OF HEARING PROTECTORS[16] (ANSI S3.19)

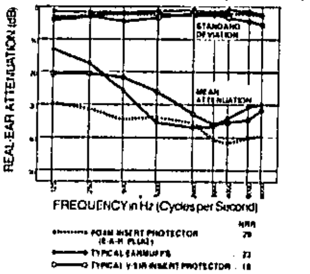

FIGURE 1

In Figure 1, the ANSI S3.19 laboratory data for three protectors are plotted. The associated NRRs are listed at the bottom of the graph. Although the NRR is most correctly computed using ANSI S3.19 (noise band) data, it can be useful to look at the range of NRRs computed from ANSI Z24.22 (pure tone) data since this is available in an existing NIOSH document.[8] The range is approximately 7-31. The NRR = 31 is the value for E-A-R™ Plugs tested according to ANSI Z24:22. That it is higher than the currently reported (ANSI S3.19) E-A-R Plug NRR of 29 is due primarily to laboratory testing variability.

Further perspective on the meaning of NRR values can be gained by calculating the maximum theoretical NRR possible. Zwislocki[12] has conducted considerable experimentation to determine bone conduction thresholds, i.e., if the ear were perfectly sealed and covered, how effectively could a device attenuate noise before sound conducted through the skull itself would become audible? Calculations based on this data, assuming a very low standard deviation of 1.5 dB at each frequency, yield an NRR of 45. To the best of our knowledge, the highest NRR ever measured on a production protector was found in a 1980 test of E-A-R™ Plugs. It was 35, or about 6 dB greater than the currently reported (conservative) E-A-R Plug attenuation data.

How to Use the NRR

As previously mentioned, the NRR is a dB noise reduction value that must be subtracted from the measured dBC sound level in the workplace. Thus we have:

Effective exposure (dBA) = noise level (dBC) – NRR

According to existing federal regulations, employee noise exposure must be limited to an equivalent level of 90 dBA for 8 hours. Nevertheless there is ample data to substantiate the fact that levels of 85 dBA will not be innocuous to all people.[13,14] Furthermore it is likely that many employees will not fit hearing protectors as carefully as do laboratory subjects. Therefore we suggest targeting for an 80 dBA effective exposure level. Thus for the protectors illustrated in Figure 1 the values in Table 2 are our suggested maximum workplace noise levels for 8 hour exposures.

TABLE 2 – Suggested maximum 8 hr. equivalent noise levels for 3 protectors.

Protector	Max. noise level
Foam Insert Protector (E-A-R™ Plug)	109 dBC
Typical Earmuffs	103 dBC
Typical V-51R Insert Protector	98 dBC

Royster and Lilley[15] have recently developed new techniques of evaluating the performance of hearing conservation programs. Analysis of their data verifies that V-51Rs are only marginally suitable for noise levels of ~ 96-98 dBA. On the other hand, informal data, personal communications, and ongoing research indicate that the foam insert protectors (E-A-R™ Plugs) are, as laboratory NRR values would suggest, measurably more effective in actual industrial noise environments.

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16. All data in this graph is from one independent U.S. testing laboratory.

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E·A·RLOG 2

A Summary Table of Proposed Single Number Measures of Hearing Protector Noise Reduction

Single Number Rating	Proposed By	Date	Weighting Network For Noise Measurement[1]	Hypothetical Noise Spectrum[2]	User Variability Correction[3]	Spectral Safety Factor[4]	Sample Calculation[5]
R	NIOSH Criteria Document	1972	dBA	Pink	10 dB[6]	—[6]	26
AES[7]	R. Camp	1972	—	—	None	—	88%
K	ANSI Z137.1 Draft 3	1973	dBA	Pink	10 dB[8]	—[8]	36
SLC[9]	J. Botsford	1973	dBC	6 typical noise spectra	Optional	—	42
Two Number Method	D. Johnson C. Nixon	1974	dBA and dBC	6 typical noise spectra	Optional	—	—
R_c	NIOSH 76-120	1975	dBC	Pink	2σ	3 dB	29
R[10]	NIOSH 76-120	1975	dBA	Pink	2σ	8.5 dB	22
P-AR[11]	J. Tobias	1975	dBC	TTN[12]	$0, 1\sigma, 2\sigma$	Accounted for by shaped spectrum	1-1-1
SLC_{80}	R. Waugh	1976	dBC	Shaped spectrum[13]	1σ	Accounted for by shaped spectrum	34
NRR[14]	EPA 40CFR Part 211	1977	dBC	Pink	2σ	3 dB	29
S	ANSI Z137.1 Draft - 1979	1979	dBC	NNS[15]	2σ	4 dB	28

1. Specifies whether the single number rating is subtracted from an A or C-weighted unprotected sound level, in order to arrive at the effective A-weighted exposure.
2. Specifies the type of noise spectrum used for the single number calculation.
3. Specifies how many standard deviations (σ) or decibels are subtracted from the mean attenuation values to account for user variability.
4. Specifies how large a safety factor is incorporated to account for the difference between the actual sound spectra encountered and the hypothetical noise spectrum utilized for calculations.
5. Sample calculation for currently reported E·A·R'® Plug S3.19 data. (Tested 11/75.)
6. This 10 dB correction, included in the calculated R, accounts for "possible noise spectrum irregularities and noise leakage which might be caused by long hair, safety glasses, head movement, or various other factors"
7. The Attenuation Efficiency Score is a relative ranking based on Fort Rucker Aero Medical Research Laboratory data. It does not yield a noise reduction figure. No device has an AES = 100%, since this would mean it had the highest attenuation ever measured at Fort Rucker at all of the test frequencies. The range of AES values for currently available devices is 2%-88%.
8. Similar concept as footnote 6, *except* this correction factor is not included in K but must be subtracted from the dBA level for each calculation. Obviously the K and R (1972) factors are essentially identical.
9. Sound Level Conversion.
10. Note that the R value for E·A·R'® Plugs is 7 dB lower than R_c value. This reflects the extra safety factor that must be included since a dBA instead of a dBC sound level is used in the calculation.
11. Protector Attenuation Rating – This, like the AES is a relative ranking. It is based on Tobias' measurements of over 40 different protectors. 1 is best, 6 is worst. The three numbers represent the relative ranking with zero, one standard deviation and two standard deviation corrections respectively. The best possible P-AR is 1-1-1.
12. The Typical Noise is a shaped spectrum resembling pink noise, but sloping gently downwards from 63 Hz – 8 kHz.
13. Similar to TTN.
14. Noise Reduction Rating
15. Nominal Noise Spectrum is similar to TTN

E·A·RLOG 3

third in a comprehensive series of technical monographs covering topics related to hearing and hearing protection.

The Effects of Hearing Protectors on Auditory Communications

BY ELLIOTT H. BERGER,
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In EARLogs[1] #1 and #2 we have demonstrated and discussed the fact that hearing protective devices (HPDs) reduce user sound exposures when properly worn. This means that all sounds may be attenuated, both unwanted sounds (noise) and useful sounds such as speech and warning signals. Thus wearing HPDs may affect speech discrimination, and the perception of warning signals. The magnitude and quality of these effects as a function of hearing level and hearing protector type are summarized in this, EARLog #3.

Speech Discrimination

Speech discrimination (SD) is a measure of one's ability to understand speech. It is greatly affected by such factors as a person's hearing acuity, the signal (speech) – to – noise ratio, the absolute signal levels, visual cues (lip and hand motion), and the context of the message set. SD is measured by presenting to subjects one of a number of prepared word lists (available in the literature), and determining what percentage correct responses they achieve.[2] The effects of HPDs on SD can be evaluated by establishing a set of test conditions, and measuring SD with and without HPDs on the subjects. The results of such tests conducted by many investigators may be summarized as follows:

1. HPDs have little or no effect on the ability of normal hearing listeners to understand speech in moderate background noise[3,4,5,6,7], $\approx$ 75 dBA, but HPDs begin to decrease SD as the background noise is reduced even further. HPDs will decrease SD for hearing impaired listener's[8] in low-to-moderate noise situations.
2. At high noise levels $\gtrsim$ 85 dBA HPDs actually improve SD for normal hearing listeners[3,5,9,10,11,12] This is clearly demonstrated in Figure 1.[7] For hearing impaired listeners the effect of HPDs on SD at these high noise levels is not unequivocal, but the results seem to indicate no significant effect.[13]
3. The literature is not extensive enough to differentiate between the effects of earmuffs and earplugs on SD. Nevertheless it may be said that the higher attenuation devices, be they earmuffs or earplugs, offer greater potential for degrading SD at lower sound levels.

The beneficial effects of HPDs on SD can be partially explained by referring to Figure 2 in which the spectrum of a male voice is superimposed upon a typical industrial noise spectrum of 91 dBA. Note that although the HPD's attenuation increases with increasing frequency, at any one frequency both the speech and the noise are reduced equally. The signal to noise ratio is constant, but importantly the overall signal level is reduced. This prevents the ear itself from distorting the signal, a phenomenon which occurs even at levels well below 90 dBA.[14] Thus as long as the speech signal is maintained above audibility, intelligibility can be improved by restricting signal levels to those that will not overload the ear.

The preceeding generalizations may be modified in practice by three important factors. Typically, in real work environments, communications will be accompanied by visual cues and/or be limited in scope. Missed words can be "filled in" and intelligibility maintained. Howell and Martin[5] have shown that when the person speaking wears HPDs his speech quality is degraded and this will adversely effect communications. And finally, Acton[15] has demonstrated that employees get accustomed to listening in noise and can perform better with respect to SD than do laboratory subjects with equivalent hearing levels. The interaction of these three effects has not been fully evaluated by any one author, but Rink[3] has shown that visual cues do improve SD for hearing impaired persons wearing HPDs, especially in noise.

Localization

Another effect that HPDs can have is to confuse one's ability to locate the direction of origin of sounds.[16,17] The data indicate that earmuffs, which necessarily cover the entire ear, can interfere with this localization accuracy whereas inserts, which generally leave virtually the entire outer ear exposed, do so to a much lesser extent. Furthermore, experiments with earmuffs[18] indicate that subjects cannot adapt to this effect, i.e., they cannot learn to compensate for the adverse effects of the muff.

Amplitude Sensitive Insert Hearing Protectors

Amplitude sensitive or nonlinear inserts are designed to provide attenuation that increases with increasing sound level, so that for low level noise conditions there is little attenuation and SD can be improved. Basically these devices are insert protectors provided with a small orifice running longitudinally through the body of the plug. The orifice may contain valves or acoustical damping materials.

At sound levels below $\approx$ 110 dB[19] these devices simply behave as a vented earmold with almost no attenuation below 1 kHz and attenuation increasing to as much as 30 dB at higher frequencies.[20] At high sound levels ($\gtrsim$ 140 dB), steady-state *or* impulsive sound waves generate turbulent air flow in the orifice which impedes the passage of sound. Measurements[19] of gunfire impulses in

SPEECH DISCRIMINATION AS A FUNCTION OF NOISE LEVEL AND SPEECH LEVEL, FOR EARPLUGS vs. NO EARPLUGS

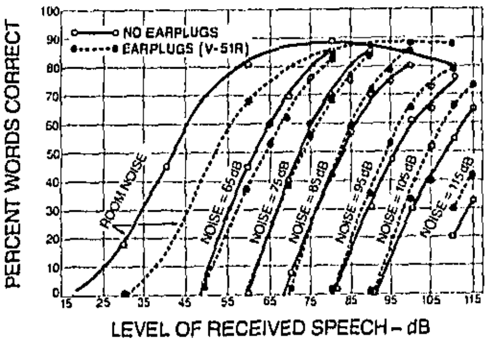

Figure 1

The relationship between speech discrimination and speech level with noise level as a parameter. Each point represents an average of the % correct responses for 8 subjects to a list of 200 words read over a PA system in a reverberant room. From Kryter[7]

EXAMPLE OF THE REDUCTION OF SPEECH AND NOISE LEVELS THROUGH THE USE OF A PRE-MOLDED INSERT HEARING PROTECTOR

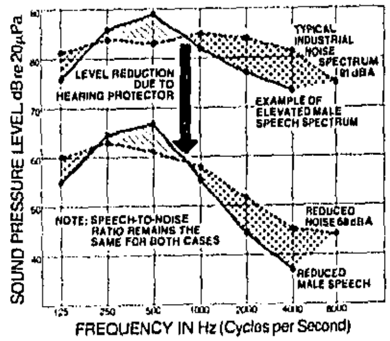

Figure 2

cadaver ears have verified that the peak noise reduction increases from approximately 10 dB for 140 dB peaks to 20 dB for 180 dB peaks, for one particular nonlinear device. Combining this information with impulse noise damage risk criteria[10-21] indicates that these devices should be effective for limited exposures (≤ 20 rounds per session) to gunfire noise up to ≈ 175 dB peak SPL. Measurements[19,22,23,24] of the temporary (hearing) threshold shifts of human subjects exposed to such noise, in non-reverberant spaces, verify this supposition. Unfortunately these devices are of little value for many occupational and recreational noise exposures wherein the noise levels are rarely the appropriate type or of sufficient level for these devices to become functional.[25]

Summary

The preceeding data indicate that HPDs can be effectively utilized for the preservation of hearing in high noise level environments with minimal effects on SD. For hearing impaired persons, the utilization of HPDs in lower noise level environments should be carefully considered. If localization capabilities are important then inserts should be chosen instead of earmuffs. And finally, the use of amplitude sensitive devices may be advantageous for use on firing ranges where they have been shown to provide adequate protection for limited exposures.

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E·A·RLOG 4

Fourth in a comprehensive series of technical monographs covering topics related to hearing and hearing protection.

The Performance of Hearing Protectors in Industrial Noise Environments

BY ELLIOTT H. BERGER,
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Characterization of the attenuation properties of hearing protection devices (HPDs) is most often accomplished in the laboratory[1] by examining the performance of trained and motivated subjects using optimally fitted HPDs. The crucial question is – How does this relate to the real world? And the obvious answer – poorly. Employees are seldom adequately instructed in the correct utilization of HPDs and even less often properly motivated to wear them. And if devices come in multiple sizes or are uncomfortable to wear, the problem is compounded.

In the past few years a number of studies have been conducted that shed some light on the matter of real world (RW) performance, i.e. performance for employees in industrial noise environments. In this, EARLog #4, we will discuss some of the more significant findings, and integrate the data to yield some interesting conclusions.

Laboratory Approximations of Real World Performance

When a HPD is tested in a laboratory, the procedures, if modeled after actual usage conditions, can yield results indicative of RW performance. Waugh, of the National Acoustic Laboratories (NAL) in Australia, has attempted to do just that. In a recent publication[2], the NAL reports attenuation data for 75 earmuffs and 19 inserts that were all tested at that facility.

The NAL has a subject pool consisting of 35-40 of its employees. The HPDs are tested on 15 people, 1 time each. Devices undergo a series of physical tests (vibration, impact, temperature cycling, etc.) prior to being tested for attenuation. Subjects are given the manufacturers' instructions and very little experimenter supervision. The test procedure is an absolute threshold shift method similar in detail to the ANSI Z24.22[3] standard, with the data corrected[4] to ⅓ octave-band values.

The NAL tests yield lower mean attenuations and higher standard deviations than data gathered for manufacturers in U.S. testing laboratories. As the following discussion will show, the data from NAL can be used to make good engineering approximations of the RW performance of HPDs.

In-Field Measurements of Real World Performance

An alternative approach to answering the question of how well HPDs actually perform in use, is to take the threshold shift experiment to the subject. At least three experimenters have done this[5-9] by setting up their measurement facilities at industrial plant sites and using noise exposed employees as their subjects. Although the employees were aware that they would be subjects, they were not aware of the exact times of their tests and were carefully monitored to assure that they did not readjust their protectors once they had been notified to proceed to the test booth.

The three studies that will be considered included 613 subjects at 7 different plant sites using 5 inserts and 1 earmuff. Although the 3 studies varied in their exact measurement techniques, appropriate controls were incorporated to insure the validity of the results.

In Figures 1-4 mean attenuation data for 4 devices as measured via different methods is presented. In Figure 1 we see very good agreement between the NIOSH[5,6] and Padilla[9] field studies at 500 Hz (Padilla only measured at 500 Hz). We see that the field attenuation data are only about 40-60% of the decibel values of the manufacturer's reported attenuation data. NAL's data fall between these two data sets, only about 5 dB above the field data, except at the two highest frequencies. Remember, al-

ATTENUATION DATA FOR V-51R INSERT PROTECTOR BY FOUR METHODS

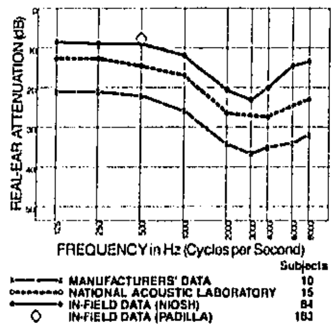


Figure 1

ATTENUATION DATA FOR SWEDISH WOOL INSERT PROTECTOR BY THREE METHODS

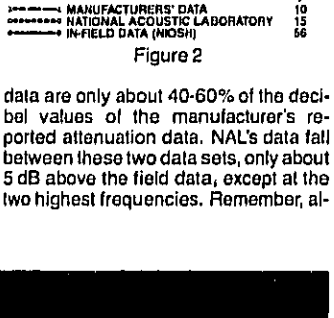
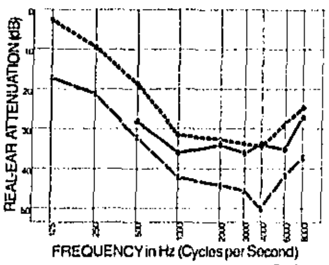


Figure 2

ATTENUATION DATA
FOR EARMUFF PROTECTOR
BY THREE METHODS



Subjects
MANUFACTURERS' DATA 10
NATIONAL ACOUSTIC LABORATORY 15
IN-FIELD (REGAN) 5

Figure 3

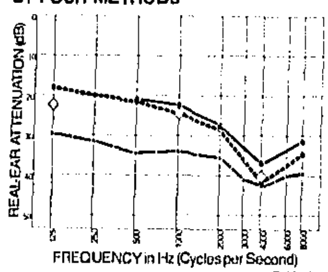
though NAL uses very minimal subject instruction, they do fit multi-sized plugs correctly whereas it is likely that mis-sizing often occurs in the field.

Figure 2 shows similar results, this time for Swedish wool, with very good agreement between NAL and field data, except again at 4 kHz and 8 kHz.

Figure 3 compares Regan's[7,8] field data for an earmuff to NAL data. This time, agreement is again good (within 4 dB) except at 500 Hz where NAL data are low. It is important to note that this result shows that standard laboratory data also overestimate the RW performance of earmuffs. This has also been confirmed in a soon to be released MSHA[10] study that used miniature microphones to measure earmuff performance in the field. The results indicated performance at only 20-75% of the decibel values of the laboratory data with larger discrepancies at lower frequencies.

Figure 4 shows comparison data for

ATTENUATION DATA
FOR FOAM INSERT PROTECTOR
BY FOUR METHODS

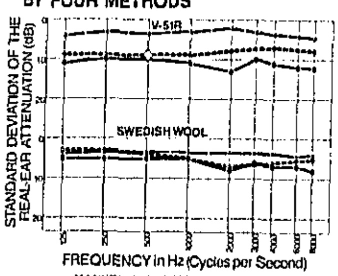


Subjects
MANUFACTURERS' DATA 10
NATIONAL ACOUSTIC LABORATORY 15
IN-FIELD* (REGAN) 15
◇ E-A-R CORP. ACOUSTIC LABORATORY IN-FIELD ESTIMATE 30

*This data has been "corrected" – See text.

Figure 4

STANDARD DEVIATION DATA
FOR TWO INSERT PROTECTORS
BY FOUR METHODS

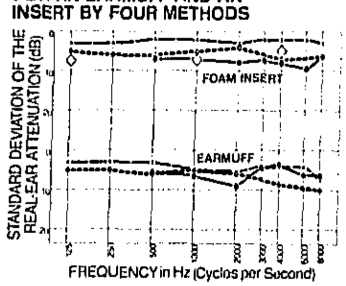


MANUFACTURERS' DATA
NATIONAL ACOUSTIC LABORATORY
IN-FIELD (NIOSH)
◇ IN-FIELD (PADILLA)

Figure 5

foam earplugs (E·A·R™ Plugs). The field data, from Regan, are for foam earplugs that were early prototypes, sold in limited quantities, and considerably more difficult to use than the present model,

STANDARD DEVIATION DATA
FOR AN EARMUFF AND AN
INSERT BY FOUR METHODS



MANUFACTURERS' DATA
NATIONAL ACOUSTIC LABORATORY
IN-FIELD (REGAN)
◇ E-A-R CORP. ACOUSTIC LABORATORY IN-FIELD ESTIMATE

Figure 6

available since 1974. His data were corrected by 1 to 5 dB, by using laboratory data comparing the prototype and current model foam plugs. The "corrected" foam data agree well with NAL data and demonstrate attenuation of 60-90% of the manufacturer's reported data. Also of interest in Figure 4 are the three points marked by diamonds. These are preliminary data for 30 subjects from the E-A-R Corporation Acoustics Laboratory. The data were gathered in strict accordance with ANSI S3.19[11] procedures but with instructions and subject selection intended to simulate RW conditions. Note the excellent agreement with the NAL data and very good agreement with Regan's field data.

Figures 5 and 6 depict standard deviation data for the various devices measured via the four test methods. The general trend is for the field and NAL data to be in reasonable agreement and both somewhat higher than manufacturer's laboratory data. That this is not always the case, is partially explained by the fact that the standard deviation tends to vary in proportion to the mean attenuation, so that devices with lower mean attenuations have a reduced expected range of attenuation values as well.

Observations

1. Manufacturers' laboratory data overrate the RW performance of HPDs. For a comfortable protector, this data can indicate the protection that conscientious, well trained users will receive. For an uncomfortable device it is virtually meaningless.
2. Manufacturers' laboratory data are useful for research and development and may yield an indication of the rank ordering of various HPDs.
3. Laboratory experiments, such as the NAL work, which are designed to simulate RW performance can provide useful indications of the actual attenuation typically provided by HPDs.

Another Estimate of Real World Performance

Another method of investigating the actual protection afforded employees by the HPDs that they are using, is to measure their hearing levels before and after a workday's noise exposure. Royster[12,13] has just completed and reported on such work. His subject population consisted of 101 employees in two very different acoustical environments at two different plant sites. Seventy of the subjects (Population A) worked in a textile plant with steady noise levels at an L_{eq} = 95 dBA. The other thirty-one subjects (Population B) worked in a steel plant with intermittent noise levels, but the same L_{eq} = 95 dBA. During the experiments, the textile workers wore either a V-51R type insert (American Optical) or a foam plug (E-A-R Plugs). The steel workers wore either a 3-flange plug (Norton) or a foam plug (E-A-R Plugs) for the first four hours of each

HEARING LEVEL CHANGE BETWEEN THE BEGINNING AND END OF AN 8 HOUR WORK SHIFT

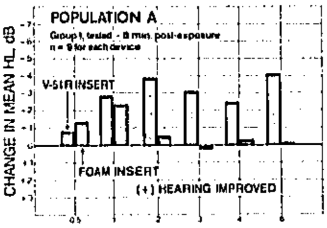


Figure 7

HEARING LEVEL CHANGE BETWEEN THE BEGINNING AND END OF A 4 HOUR WORK SHIFT

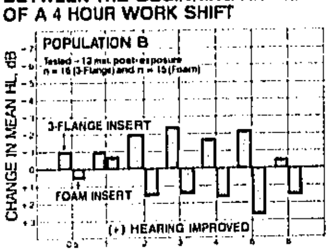


Figure 8

work shift. Population B employees wore no hearing protection in the afternoons as per company policy.

All subjects participating in the study had been wearing the pre-molded inserts for at least 4 years as part of the ongoing hearing conservation programs at these two companies. On the day of the test, the subjects that were selected to wear E-A-R Plugs instead of their standard HPDs, were handed the plugs and given only 15-30 seconds of instruction on utilization of the device.

A comparison of the measured change in mean hearing level over an 8 hour shift [i.e. temporary threshold shift (TTS)] for Population A for the two HPDs is shown in Figure 7. The comparison for Population B is shown in Figure 8, this time using data for a 4 hour shift. Notice the differences between the performance of the foam plug and the pre-molded inserts, which are significant at 2, 3, and 6 kHz for Population A and at 2, 3, 4, and 6 kHz for Population B ($P<.05$). The fact that Population B employees who used the foam ear plug show improved hearing levels at many frequencies may be partially due to the elimination of TTS. This small residual TTS could be due to the inadequate protection received from the 3-flange inserts combined with the unprotected 4 hour afternoon exposures which these employees received.

Royster concluded from this data that the V-51R and 3-flange inserts were unacceptable for use in noise environments with daily A-weighted L_{eq}s equal to or greater than 95 dB. Analysis of the existing 4-9 years of audiometric data for these two populations supported this contention.[13,14] Furthermore, Royster determined that the foam earplug would be acceptable for use in these 95 dB environments and is currently conducting a longitudinal survey at one of the plants to verify this supposition.

Single Number Ratings Applied to Real World Data

In EARLog #2,[15] the concept of single number HPD ratings was discussed and an explanation of the EPA proposed[16] NRR values was presented. The NRR incorporates a 2 standard deviation (2σ) correction and a 3 dB spectral safety factor. These corrections are intended to insure protection for 98% of the population who "correctly" wear the HPD in 98% of the environments where the devices will be used. By "correctly" we mean, wear the HPD in the same manner as did the subjects who were used to generate the test results.

TABLE 1

NRR VALUES BASED ON MANUFACTURERS' LABORATORY DATA AND NAL DATA

HEARING PROTECTOR	NRR^{*}_{MFG}	NRR^{**}_{NAL}	$NRR^{***}_{NAL, 1\sigma}$
V-51R	18	0	9
Swedish Wool	16	1	6
Earmuff	25	6	13
Foam Insert (E-A-R Plug)	29	14	19

*NRR based on manufacturers' laboratory data with 2σ correction.
**NRR based on NAL data with 2σ correction.
***NRR based on NAL data with 1σ correction.

In Table 1, the NRRs for the four HPDs that have been discussed, are presented. These NRRs were calculated using the manufacturers' laboratory data as well as the NAL data. Note that for two devices the NRR based on the NAL data is ≤1. This simply says that if we wish to examine the least possible protection we are likely to find (i.e. only 2% of the population will receive less protection than this) that the overall protection provided by these two devices is virtually zero.

It may be that with RW or estimated RW data, a 2σ correction is too severe and that we should examine a 1σ correction (84% protection, i.e. 16% will get less than this number). These values are also shown in Table 1. (In fact, the single number rating listed in the NAL report is the SLC_{80}, which is very similar in concept[15,17] to the NRR, except that it uses a 1σ correction and lacks a spectral safety factor.) Even these more "optimistic" values demonstrate that certain insert protectors may be suitable for noise exposures only slightly greater than 90 dBA, a supposition substantiated by the Royster study cited above.

Conclusions

There appears to be a less than adequate correlation between manufacturers' (laboratory) attenuation data and the RW performance of HPDs. Suitably designed laboratory tests, such as the work performed by the NAL, can provide reasonable estimates of RW performance. Comparison between NAL data and in-field data from three authors substantiates this fact. This is an important point, because it suggests that existing HPD test methodologies, such as ANSI S3.19-1974[11], can be effectively utilized with only simple modifications regarding subject selection, training, fitting and HPD preparation procedures.

The NAL and in-field data suggest, for example, that the E-A-R foam earplug should be more effective in use than other insert hearing protectors. This was confirmed independently by an in-field TTS study which found that E-A-R Plugs performed significantly better than V-51R and 3-flange inserts in a 95 dBA noise environment.

Finally, if a single number rating is to be used with RW type data, such as the NAL data, perhaps a 1σ instead of a 2σ correction is more appropriate. This suggestion is reasonable, since an attempted 98% protection criterion may be feasible if unrealistically high laboratory data are utilized, but is certainly extreme if RW estimated data are developed and used for NRR calculations.

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E·A·RLOG 5

fifth in a comprehensive series of technical monographs covering topics related to hearing and hearing protection.

Hearing Protector Performance: How They Work - and - What Goes Wrong in the Real World

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In previous EARLogs[1] we have discussed how to measure and rate the attenuation of hearing protection devices (HPDs) in the laboratory, how these devices affect auditory communications, and perhaps most importantly how HPDs perform in real world (RW) environments. It was found that laboratory attenuation measurements significantly overestimate the RW performance of HPDs, due to the unrealistic, optimized manner in which experimental subjects can wear these devices for short duration tests. In this, EARLog #5, we will examine these concepts further by analyzing how a correctly worn HPD operates and how its effectiveness is compromised by misuse, misfitting, HPD aging, and abuse.

Sound Transmission to the Unoccluded Ear

The hearing mechanism can be divided into three parts as shown in Figure 1. These are the outer, middle and inner ear. Sound (airborne vibration) is received by the outer ear. The incident sound propagates along the auditory canal, setting the eardrum (tympanic membrane) into motion. The eardrum motion is transmitted via the tiny middle ear bones (ossicular chain) to the inner ear, a liquid filled cavity of complex shape lying within the bony structure of the skull. This causes the liquid in a portion of the inner ear, the cochlea, to vibrate. Membranes and hair cells inside the cochlea, which are very sensitive to this vibration, generate electrical impulses when appropriately stimulated. The impulses are transmitted along the auditory nerve to the brain, where they are "decoded". The result is the sensation, sound.

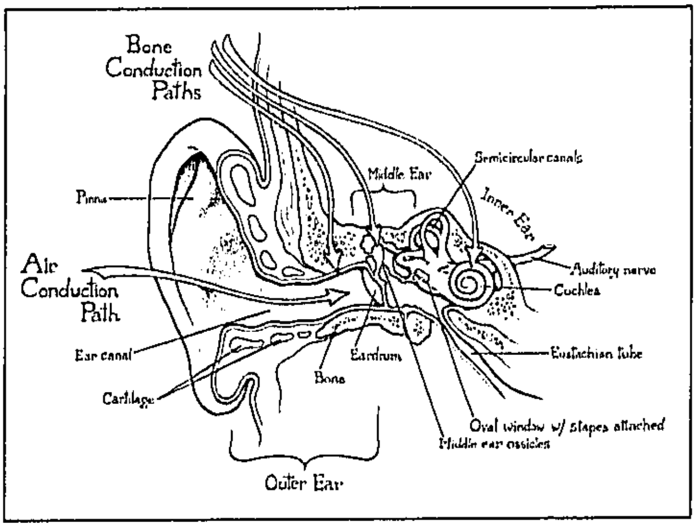
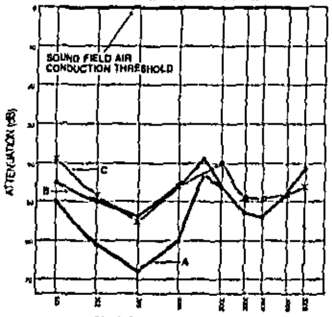


FIGURE 1. Basic Anatomy of the Ear with Illustration of the Air Conduction and Bone Conduction Sound Paths.

When the vibration that excites the cochlear hair cells is the result of the chain of events described above, this is called air conduction. When sound directly vibrates the skull and/or excites vibration of the ear canal walls, which in turn stimulates the cochlea, it is called bone conduction. The final sense organ, the cochlea, is the same in either case, only the path of excitation has changed. Since most sound and/or vibration sources will excite both transmission paths, the ear will usually receive both air conducted and bone conducted signals simultaneously.

For the normal hearing individual, the unoccluded ear's bone conduction (BC) sensitivity is much poorer than its corresponding air conduction (AC) sensitivity as shown in Figure 2, curve A. For example at 1000 Hz the sensitivity of the ear is 60 dB poorer for the BC path than for the AC path. This means that even if the AC path were totally eliminated by a HPD, that the ear's sensitivity would only be approximately 60 dB worse, i.e. a "perfect" HPD could only offer 60 dB of attenuation at 1 kHz. Even if the entire head was acoustically shielded, the loudness level of the sound would only be

BONE CONDUCTION TO AIR CONDUCTION RATIO IN dB AND THE ATTENUATION FOR AN EARPLUG/EARMUFF COMBINATION.



A — Ratio of Bone Conduction to Air Conduction Thresholds for Open Ear Canals (after Zwislocki[4]).

B — Ratio of Bone Conduction to Air Conduction Thresholds for Occluded Ear Canals (after Zwislocki[4]).

C — Real-Ear Attenuation (ANSI S3.19-1974) for Deeply Inserted E-A-R Plug in Combination with David Clark 19A Earmuff, 5 Subjects.[9]

Figure 2

reduced by an additional 10 dB to ≃ 70 dB below the unoccluded AC threshold.[2] In this latter case, the conduction path would be from the chest cavity thru the neck to the head.

Sound Transmission to the Occluded Ear

The utilization of a HPD modifies the AC and BC paths discussed in the previous section. Four distinct sound pathways can now be distinguished as shown in Figure 3. There are:

1. Air Leaks – For maximum protection the device must make a virtual air tight seal with the canal or the side of the head. Inserts must accurately fit the contours of the ear canal and earmuff cushions must accurately fit the areas surrounding the external ear (pinna). Air leaks can typically reduce attenuation by 5-15 dB over a broad frequency range.[3]
2. Vibration of the HPD – Due to the flexibility of the ear canal flesh, earplugs can vibrate in a piston-like manner within the ear canal. This limits their low frequency attenuation. Likewise an earmuff cannot be attached to the head in a totally rigid manner. Its cup will vibrate against the head as a mass/spring system, with an effective stiffness governed by the flexibility of the muff cushion and the flesh surrounding the ear, as well as the air volume entrapped under the cup. For earmuffs, premolded inserts and foam inserts these limits of attenuation at 125 Hz are approximately 25 dB, 30 dB and 40 dB, respectively.
3. Transmission thru the Material of the HPD – For most inserts this is generally not significant, although with lower attenuation devices such as cotton or glassdown, this path is a factor to be considered. Because of the much larger surface areas involved with earmuffs, sound transmission thru the cup material and thru the earmuff cushion is significant, and can limit the achievable attenuation at certain frequencies.
4. Bone Conduction – Since a HPD is designed to effectively reduce the AC path and not the BC path, BC may become a significant factor for the protected ear.

When the ear is occluded with an insert or a muff the BC path is enhanced relative to the unoccluded ear for frequencies below 2 kHz. This is called the earplug effect[4,5] or more generally the occlusion effect.[6,7] This can be easily demonstrated by plugging one's ear canals while speaking aloud. When the canals are properly sealed or covered, one's own voice takes on a bassy, resonant quality due to the amplification of the BC path by which a talker partially hears his own speech. This amplification of BC vibrations results in the differences between curves A and B in Figure 2. Curve A represents the threshold of hearing for BC vibrations with open ear canals, whereas curve B is the threshold of hearing for BC vibrations with the ear canals tightly covered or plugged. *Thus, curve B gives the estimated maximum protection achievable by covering and/or plugging the ears.*

A common myth concerning HPDs, is that as the sound level increases, BC sound becomes more important, and therefore an earmuff will provide better protection than an earplug at higher sound levels. The inaccuracy of this statement is demonstrated by the fact that the relationship between the AC and BC thresholds, as shown in Figure 2, is *not* dependent on sound level. Any BC advantage that muffs may have over inserts will be independent of sound level, and will be apparent in a standard threshold level attenuation test such as ANSI S3.19-1974.

Due to the occlusion effects and BC limitations described above, as well as other physical considerations, using muffs and inserts in combination does *not* yield attenuation values that are merely the arithmetic sum of their individual values. In some cases, at some frequencies, almost no improvement will be noted when inserting a pre-molded insert under a muff.[8] Alternatively for other combinations, not fully defined at this time, better results may be achieved. Curve C in Figure 2 demonstrates performance for a deeply inserted E-A-R™ Plug used in conjunction with a David Clark 19A earmuff.[9] This combination probably represents the highest practical attenuation achievable with currently available HPDs.

Why HPDs Fail in the Real World

When a HPD is properly sized and carefully fitted and adjusted for optimum performance on a laboratory subject, air leaks will be minimized and paths 2, 3 and 4 will be the primary sound transmission paths. In the RW work environment, this is usually not the case, and path 1, sound transmission thru air leaks, often dominates. Air leaks arise when plugs do not seal properly in the ear canal or muffs do not seal uniformly against the head around the pinna. The causes of poor HPD sealing are:

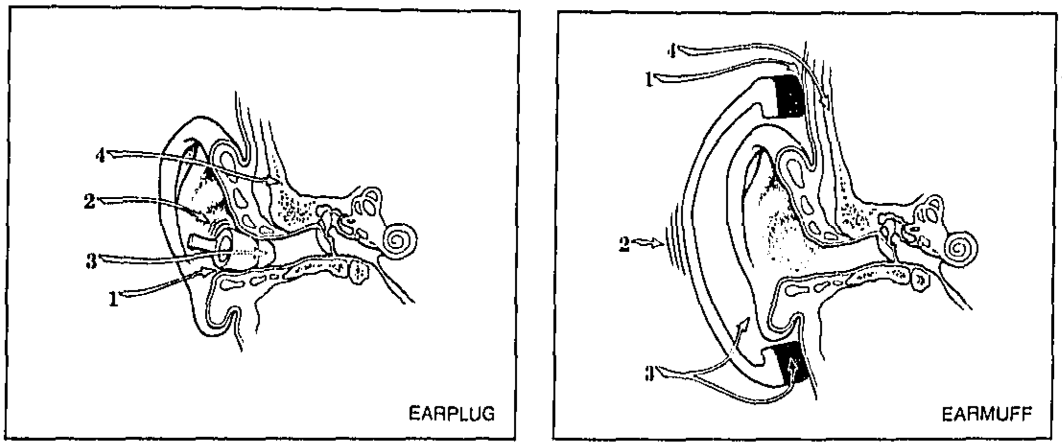


FIGURE 3. Illustrations of the 4 Paths by Which Sound Reaches the Occluded Ear.

1. Comfort – In most situations the better the fit of a HPD, the poorer the comfort. Inserts must be snugly fitted into the canal and earmuff cups must be tightly pressed against the head. This is not conducive to comfort and although some employees may adapt, many will not. This is why it is important to select several hearing protectors (generally 1 muff and 2 earplugs) from the more comfortable available HPDs and to encourage the employee to make the final decision as to which he will use.
2. Utilization – Due to poor comfort, poor motivation or poor training, or user problems, earplugs may be improperly inserted and earmuffs may be improperly adjusted.
3. Readjustment – HPDs can work loose or be jarred out of position during the day. It must be remembered that laboratory tests require the subject to carefully adjust a device prior to testing. Under typical use, wearers will eat, talk, move about and may be bumped or jostled, resulting in jaw motion and possible perspiration. These activities can cause muff cushions to break their seal with the head and cause certain inserts to work loose.[10,11] Pre-molded inserts tend to exhibit this problem, whereas custom molded and expandable foam plugs tend to more effectively maintain their position in the ear canal.
4. Fit – All HPDs must be properly fitted when they are initially dispensed. For multi-sized pre-molded inserts a suitably sized earplug must also be selected during this fitting procedure. Companies must stock all available sizes of multi-sized earplugs and must be willing to use different size plugs for an employee's two ears, this latter situation occurring in perhaps 2-10% of the population. For example, stocking only 3 of the 5 available sizes of the V51-R will reduce the percentage of the population fitable with that device from ≈ 95% to ≈ 85%. The correct size pre-molded insert will always be a compromise between a device that is too large and therefore uncomfortable, and a device that is too small and therefore provides poor protection. The appropriate compromise can often times be achieved, but only with care and skill.
5. Compatibility – Not all HPDs are equally suited for all ear canal and head shapes. Certain head contours cannot be fitted by any available muffs and some ear canals have shapes that may only be fitable with certain inserts or canal caps or sometimes not at all. Earmuffs can only work well when their cushions properly seal on the head. Eyeglasses, sideburns, or long or bushy hair underneath cushions will prevent this and will reduce attenuation by varying amounts.
6. Deterioration – Even when properly used, hearing protectors wear out. Some pre-molded plugs shrink and/or harden when continuously exposed to ear canal wax and perspiration. This may occur in as little as three weeks. Flanges can break off and plugs may crack.[12,13] Custom earmolds may crack, or the ear

TIME CORRECTED NRR
AS A FUNCTION OF WEARING TIME
(USING OSHA 5 dB TRADING RELATIONSHIP).

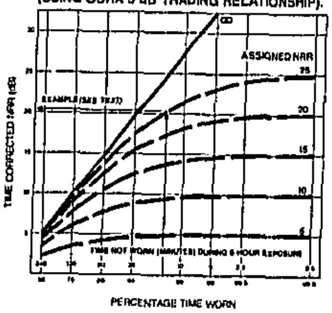


Figure 4

canal may gradually change shape with time, so that the molds no longer fit properly. Earmuff cushions also harden and crack or can become permanently deformed and headbands may lose their tension. Therefore it is important to inspect or reissue "permanent" HPDs on a regular basis. This may be 2-12 times per year or more, depending upon the HPDs that are utilized.

7. Abuse – Employees often modify HPDs to improve comfort at the expense of protection.[12,13,14] These techniques include springing earmuff headbands to reduce the tension, cutting flanges off of premolded inserts, drilling holes thru plugs or muffs, removing the canal portion of custom earmolds, or deliberately obtaining undersized HPDs.

Protection vs. Percentage Time Worn

The HPD RW utilization problems outlined in the preceding section explain why the RW attenuation of HPDs is so much lower than typical manufacturers' laboratory data would indicate (as was extensively discussed in EARLog # 4[1]). In addition to this problem we must contend with the possibility that employees, regardless of how well they wear a HPD, may not wear it during their entire work-shift or period of noise exposure. This will reduce their effective daily protection.

Noise induced hearing loss has been shown to be a function of the cumulative A-weighted noise exposure incident upon the ears.[15,16] Adherents of this theory propose that the hearing levels of a noise exposed population can be estimated from a knowledge of their equivalent continuous noise exposure level (L_{eq}). The L_{eq} is the level of continuous A-weighted noise that would cause the same sound energy to be experienced in an 8-hour day, as resulted from the actual noise exposure. This leads to the 3 dB trading relationship, that is, if the exposure level is increased by 3 dB, the exposure duration must be reduced by ½. A similar approach is embodied in the U.S. Occupational and Safety Health Act[17], except that the trading relationship is 5 dB. The implications of the cumulative energy theory with regards to the protection afforded by HPDs, were first discussed by Else.[18] They are presented graphically in Figure 4, with suitable modifications to conform with the OSHA 5 dB trading relationship.

The data in Figure 4 can be utilized to determine the Time Corrected Noise Reduction Rating (NRR) as a function of the percentage of time that the HPD is worn in the noise. We first assign an NRR value to the HPD in question – either the manufacturers' labeled NRR or preferably a RW estimated NRR. If, for example, the HPD had an assigned NRR = 25, then its Time Corrected NRR would be only 20 dB if it was not worn for just 15 minutes during each 8 hour noise exposure. This clearly demonstrates that HPDs must be comfortable enough to be worn properly for extended periods. Attenuation *and* comfort must both be considered when selecting a HPD.

Neither low attenuation nor low comfort devices are acceptable for standard industrial use. Comfortable, user acceptable HPDs, with real world NRRs suitable for the prevailing environmental sound levels will be necessary to protect your employees' hearing.

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EARLOG 6

Sixth in a comprehensive series of technical monographs covering topics related to hearing and hearing protection.

Extra-Auditory Benefits of a Hearing Conservation Program

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Thus far, the EARLog[1] series has discussed laboratory and real world performance aspects of hearing protection devices (HPDs). The most recent EARLog, #5, analyzed how a hearing protector operates and examined seven factors that contribute to poor HPD performance in the real world. One of the most significant problem areas is misuse and abuse of HPDs, attributed in large part to poor employee training and motivation. This situation can be rectified by developing an effective hearing conservation program (HCP); one that includes (but is not limited to) appropriate managerial, educational, and motivation techniques.

Proper operation of any program requires the active support of all concerned. Not only must employees be convinced of the program's merit, but so too must *all* levels of management. Therefore, we will direct our attention towards the functionality of HCPs and begin in this, EARLog #6, by examining their beneficial extra-auditory aspects. We will present information suggesting that an effective HCP may not only prevent industrial noise-induced hearing loss, but also improve general employee productivity and safety.

Extra-Auditory Effects of Noise

It has been clearly established[2,3] that habitual exposures to noise levels in excess of 90 dBA will cause significant hearing loss in a sizeable portion of the exposed population. Additionally, there are ample data to suggest that levels of 85 dBA or even 75 dBA will be injurious to some[4,5,6]. Beyond these obvious and well-documented deleterious effects, noise has been linked to many other physiological and behavioral effects, although the evidence is inconclusive. These extra-auditory effects are very difficult to quantify since they are often nonspecific in nature and since many other noxious stimuli and/or stressful circumstances often coexist with high sound levels.

Analysis of the proceedings of the 1973 and 1980 International Congresses on Noise as a Public Health Problem[7,8] leads one to conclude that although extra-auditory effects have been frequently hypothesized, there is widespread disagreement as to the validity and interpretation of the supporting data. Often, for every study that correlates noise exposure with a particular extra-auditory effect, another study finds contradictory results.[9,10] In general, the data tend to support the following statements, applicable to the industrial setting:[11,12,13]

1. Levels of noise necessary to produce adverse psychological effects are high, ≃ 95 dB.
2. Noise affects tasks requiring accuracy rather than speed.
3. Noise detrimentally affects demanding tasks, especially those requiring attention to multiple signal sources, however, it may actually improve the performance of monotonous, routine tasks.

Studies which tend to demonstrate the extra-auditory benefits of HCPs[14,15,16] have been conducted on a number of industrial populations. For example, Jansen[14] examined the health records of 1,005 iron and steel workers in "very noisy" and "less noisy" industries. He found from 5 to 15% greater occurrence of peripheral circulation problems, heart problems, and equilibrium disturbance in the "very noisy" group. It is useful to highlight these possible advantages to management, since, of course, they too must be motivated to actively participate in the HCP.

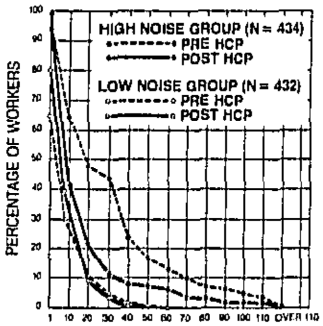
Recent Industrial Studies

An even more direct approach to substantiate the beneficial aspects of reduced employee noise exposures is to examine employee health and safety records before and after the advent of an HCP. Cohen[15] reported on such a study involving 434 noise exposed (≃ 95 dBA) boiler plant workers. Data were compared for two-year periods, before and after the advent of an HCP involving the use of HPDs. Results indicated fewer job injuries, medical problems, and absences in the post-HCP period, as typified by the results in Figure 1. For comparison, the data for a control population of 432 low noise (≤ 80 dBA) workers from the same plant are also shown. Since the control population exhibited no pre/post HCP reduction in absenteeism, but the high noise group did, it is likely that reduced noise exposure, as a result of HPD usage, was the controlling variable.

Cohen also attempted to rate each employee's degree of HPD usage and correlate these findings with the degree of reduction of the various problems. That analysis indicated no significant relationship, and thus tempered somewhat the strength of any conclusions relating HPD usage to decreased extra-auditory problems.

Another significant finding in Cohen's study was that comparisons of injury data, before and after the advent of the HCP, evidenced that the use of HPDs reduced rather than increased the number of mishaps. "This appears to counter the notion that wearing HPDs could increase the likelihood of accidents by attenuating not only noise, but also the audibility of sound signals depicting danger." (c.f. EARLog #3[1]).

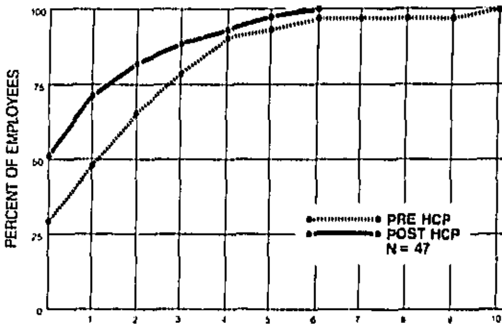
CUMULATIVE FREQUENCY DISTRIBUTION OF WORKERS FROM HIGH AND LOW NOISE GROUPS WITH SPECIFIABLE NUMBER OF DAYS ABSENT



This curve is plotted in an inverse manner. Each point represents percentage of workers having had *as many or more* days absent as read off the abscissa. After Cohen.[15]

FIGURE 1

COMPARISON OF THE CUMULATIVE FREQUENCY DISTRIBUTION OF REPORTED INJURIES FOR THE SELECT GROUP DURING TWO 5-YEAR PERIODS



Each point represents percentage of workers having had *as many or less* reported injuries as read off the abscissa. After Schmidt et al.[16]

FIGURE 2

Recently, Schmidt et al.[16] conducted a study very similar to Cohen's, wherein they examined industrial injury data for five years preceeding and five years following the institution of an HCP at a North Carolina cotton yarn manufacturing plant. They utilized two test groups totaling approximately 150 subjects. No hygenic or other major environmental changes other than the HCP occurred during the study years. They found a significant reduction in reported injuries for both groups after the advent of the HCP. The data for the "select group" are shown in Figure 2. (The select group consisted of 47 permanent full-time employees with at least six months of service prior to the ten-year study period, and an average length of service of 22 years).

Schmidt et al, reported a significant observation that provides additional support for their results. They had access to employee audiometric records for the ten years that were studied. Analyses of these data indicated that the females were wearing their HPDs more effectively and receiving better protection than were the males. Therefore, it would be expected that they should show a greater reduction in industrial injuries than did the males. The data confirmed this hypothesis, thus closely linking HPD usage to the rate of industrial injuries.

CONCLUSION

Only tentative conclusions may be drawn from the available literature, but the inference exists that elevated noise exposures may cause extra-auditory physiological and/or psychological disorders. This suggests that effective HCPs may not only prevent noise induced hearing loss, but also improve general employee health and productivity.

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E·A·R LOG 7

Seventh in a comprehensive series of technical monographs covering topics related to hearing and hearing protection.

Motivating Employees to Wear Hearing Protection Devices

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The preceding EARLog, #6[1], presented evidence suggesting that reduced employee noise exposures could have tangible health and safety benefits in addition to protecting employee hearing. Although this could provide an incentive for stronger management support of hearing conservation programs (HCPs), other approaches are necessary to motivate employees to conscientiously utilize hearing protection devices (HPDs). A review of the Literature[2–10] suggests that the pivotal characteristics of a successful HCP are:

- support of management
- enforcement
- education
- motivation
- comfortable and effective HPDs

Support by all levels of management is crucial since it sets the tone for the entire program. It demonstrates to employees that hearing conservation is important to their company and to their jobs. Hearing conservation should be viewed as an important and integral part of the overall safety program. Furthermore, management must be responsive to employee problems and complaints so that they can be sincerely and effectively answered.

The next three elements of an HCP are inextricably related. Education and motivation modify employee's behavior, and enforcement provides a constant reminder about that which is deemed acceptable. Enforcement alone can engender resentment and attempts to circumvent HCP requirements, as for example, modifying HPDs for greater comfort and less protection.

Enforcement must be firm and consistent. A four step disciplinary procedure for failure to wear HPDs might consist of

FIGURE 1

(1) verbal warning, (2) written warning, (3) brief suspension, no pay, and (4) termination. Although the latter steps are necessarily a form of discipline, the verbal warning can and should be handled in a positive manner. Front line supervisors should also be held responsible for the performance of their employees and must set a good example by regularly wearing their HPDs when in posted area. In fact, all personnel in hearing protection posted areas should wear HPDs, be they visitors, managers, or temporary employees.

Education should consist of topics pertaining to the function of the ear, how it is damaged by noise, and training on use of HPDs. Many short films[11] are available which are useful to highlight these topics and maintain employee interest.

Posters[12] are also useful as reminders and training aids. These are generally available from HPD manufacturers. An example appears in Figure 1.

Unfortunately, education alone is of little value unless it is integrated into the employees' daily experiences. This can be accomplished by making their education personally relevant, either by demonstrating how noise directly affects them or by inducing them to use hearing protection for a long enough time to become adapted, and to appreciate its benefits.

Motivational Techniques

The best motivational resource is the person or persons in the HCP who are responsible for direct employee contact, those who fit HPDs and administer monitoring audiograms. The annual or biannual audiometric examination provides an excellent opportunity for this person to reinforce good HPD utilization habits. The employees should bring, or preferably wear, their hearing protectors to the test where they can be examined for fit, cleanliness, and signs of deterioration or abuse. After the audiogram is administered, it should be shown to the individual and the results explained. If, for example, the hearing levels are normal and unchanged from previous tests, and the HPDs are in good condition, the individual should be complimented. On the other hand, significant hearing level shifts, should they occur, can be pointed out. This provides an ideal opportunity for reinstruction of HPD fitting procedures and a reminder of the importance of their use. Worn out or abused HPDs should also be replaced at this time (and generally more often).

A very successful behavioral modification approach utilizing employee audiograms has been discussed by Zohar, et

EARPLUG USAGE LEVELS FOR AN EXPERIMENTAL GROUP IN AN ISRAELI STEEL PLANT (After Zohar, et al.[2,3])

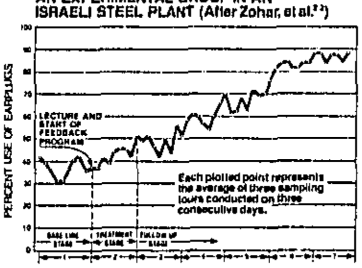

FIGURE 2

al.[2,3] Workers underwent audiometric testing at 500, 2000, 4000, and 6000 Hz. Testing occurred on randomly selected dates, at the beginning and end of regular shifts. Results were discussed with the employees immediately after the second test, with significant shifts being explained as representing a temporary noise-induced hearing loss. Employees participated in these tests on two separate days, wearing hearing protection one day and none on the other. Audiometric results were also posted on the department bulletin board. This information feedback procedure demonstrated to the employees the effects of noise on their hearing. The feedback lasted only one month, but successfully modified employee behavior and continued working after cessation of the treatments as shown in Figure 2. A control group at the same plant, which received only educational sessions without feedback, showed no change in their HPD utilization rate.

The authors stressed the fact that feedback was maintained for only a limited period of time. The improved performance of the experimental group was attributed to a permanent modification of the work environment, so that HPD usage emerged as a behavior that was continually reinforced by peer pressure and supervisor expectations. It became "respectable" to wear HPDs, whereas previously it was not. The program became a self-sustaining activity.

An alternative method of clearly relating an employee's hearing loss to his own personal noise exposure[6,13] is to ask him to set the volume on his car radio to a *just audible level* upon arriving at work. He should then turn off the ignition, leaving the volume untouched. After returning to his car for the trip home, he should carefully listen to see if he can still hear the radio. If he cannot, this is evidence that his ears have been fatigued by the day's noise exposure. Another motivational approach that has worked for Zohar[3] and others[8] is to reward HPD usage by distributing tokens or lottery tickets to those who correctly wear the devices.

A final motivational tip is to use good public relations and promotion to sell the program, as for example, offering free audiometric testing to the immediate families of employees.[14] Discovering hearing impairment in an employee's child, an impairment that could cause early and difficult to detect learning disabilities, is a good deed that strongly emphasizes the importance of preserving one's hearing.

Comfortable and Effective HPDs

Finally, we must consider that all efforts will come to naught unless comfortable and effective HPDs are available for distribution. Articles are available[1] that provide information useful in the determination of the assets and liabilities of various devices. Not all devices are wearable or provide adequate protection. Therefore, the HCP coordinator must research the available products and pre-select the best. More than one HPD, preferably at least an earmuff and two types of earplugs should be available so that employees can choose a device that appeals to them. Providing workers with this input increases their involvement with the program and enhances the likelihood of achieving their willing participation.

CONCLUSION

Hearing conservation is a concept that is viable, but to work it must be vigorously supported by management, and couched in a holistic framework that includes enforcement, education, motivation, and the availability of comfortable, effective HPDs.

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E·A·RLOG 8

Eighth in a comprehensive series of technical monographs covering topics related to hearing and hearing protection.

Responses to Questions and Complaints Regarding Hearing and Hearing Protection (Part I)

BY ELLIOTT H. BERGER,
Manager Acoustical Engineering, E-A-R Division

The most recent installments of the EARLog series #6 and #7[1], focused on concepts and techniques that have been successfully used to motivate management and employees alike, to actively support and participate in hearing conservation programs. We stressed that the program administrators must sincerely and accurately deal with questions and complaints regarding the utilization of hearing protection devices (HPDs) and the purpose of the hearing conservation program. What follows is a summary of the more common areas of concern that are expressed by supervisors and employees, and information that can provide the basis for appropriate responses.

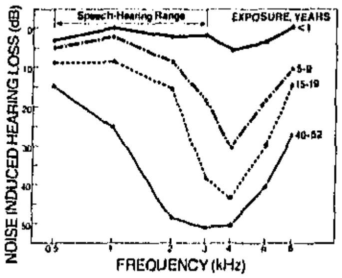
Complaint:
Hearing protectors are uncomfortable.

Response:
HPDs are often uncomfortable initially, but hearing loss due to noise exposure is "uncomfortable" permanently. Like a new pair of shoes or glasses, hearing protectors do require a reasonable period of adjustment. Since not all hearing protectors adapt equally well to all head shapes and ear canals, it is important to give the employee the final choice in what he or she will wear. If after a couple of weeks of daily use the employee is still experiencing difficulties or discomfort, the protector should be resized and/or refitted, or another hearing protector should be issued.

Excuse:
I don't need hearing protection; I am used to the noise.

Response:
Ears do not get used to noise – they "get deaf" (and unfortunately a deafened ear may often *seem* to get used to the noise). Repeated exposure to noise does not toughen ears nor does having an existing noise induced hearing loss prevent you from losing the hearing you have left. Although individual susceptibility to hearing loss from noise exposure varies widely, there are currently no standardized tests that can detect the more noise sensitive members of the population.

ILLUSTRATION OF THE DEVELOPMENT OF NOISE INDUCED HEARING LOSS*



*All exposure levels were approximately 100 dB SPL (After Taylor, et al [2])

Figure 1

Question:
I've already lost some or most of my hearing; why should I have to wear hearing protection?

Response:
The existence of a noise induced hearing loss does not protect one from losing further hearing due to noise exposure. In Figure 1, we have illustrated the typical progressive nature of noise induced hearing loss. Initially we see that hearing is damaged in the higher frequencies and as the unprotected exposures continue, this damage spreads to the lower frequencies, eventually affecting those essential to the understanding of speech (500 Hz to approximately 3000 Hz). Although HPDs cannot restore a noise induced hearing loss, which by its nature is permanent and irreversible, they should prevent additional losses from being incurred. Furthermore, proper use of HPDs will prevent employees from developing a temporary hearing loss, and allow existing temporary losses to recover before they become permanent.

Complaint:
I can't hear my fellow workers if I wear hearing protectors.

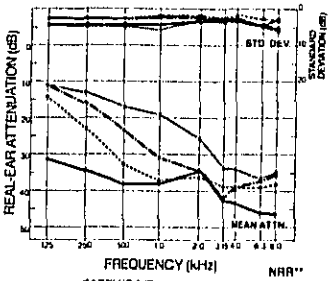
Response[3]:
When the ear is bombarded with high level sound, it overloads and distorts, reducing its ability to accurately discriminate different sounds. Wearing HPDs reduces the overall sound levels so that the ear can operate more efficiently. The effect is similar to the improved vision that sunglasses provide in very bright, high-glare conditions.

For those with normal hearing, HPDs will usually provide improved communications when sound levels are greater than approximately 85 dBA. For moderate to severely hearing impaired individuals, the situation is more complicated; for them, hearing protectors may not provide a communications benefit and actually be a liability. But, if these individuals do not protect their hearing, they may suffer additional impairment and then will have even greater difficulty communicating regardless of noise level.

Complaint:
My machine sounds different to me when I wear hearing protectors.

Response:
True, machines will sound different, but for the reasons outlined above, most employees will still be able to effectively monitor their operation. Once employees become accustomed to the new sound of their machine, changes in its

REAL-EAR ATTENUATION OF TWO EARPLUGS AND TWO EARMUFFS*



	NRR**
EARPLUG A (Foam plug)	28
EARPLUG B (Fiberglass down)	9
EARMUFF A (High performance muff)	25
EARMUFF B (Popular muff)	10

*All data from E·A·R Division Acoustical Laboratory
**Noise Reduction Rating per U.S. EPA

Figure 2

operation will usually be as easy to detect as without the HPD. Also, since they won't be acquiring progressively increasing amounts of temporary hearing loss throughout the day, employees will be able to hear their machines as well at the end of their shift as when they started in the morning.

Question:
Do earmuffs block out noise better than earplugs?

Response:
No. The misconception that earmuffs are better than earplugs at reducing noise is partly due to the "bigger is better" school of thought. Actually, whether or not an earmuff or an earplug is better is dependent upon the device and user in question.

In Figure 2, the real-ear attenuation data for two muffs and two plugs are plotted. The data are all from one laboratory. Earplug A and earmuff A are among the best commercially available HPDs this facility has ever tested, whereas earplug B is a low attenuation insert and earmuff B is a typical "popular" model. Notice that the better earplug outperforms the better earmuff at all frequencies except 2.0 kHz, where the earmuff offers approximately a 2 dB advantage. But both earmuffs outperform earplug B at all frequencies. Thus although some earmuffs do outperform some earplugs, it is not true to state that all earmuffs outperform all earplugs.

It is important to remember that although the above discussion focused on attenuation, other factors such as comfort and the intended application significantly affect the choice of a muff or a plug for a particular situation.

Question:
Can earplugs cause ear infection?

Response:
Based on our experience during the past decade, and information gleaned from consultation with experts in the field of otology and audiology[4, 5] as well as preliminary data from an ongoing survey of U.S. industries[6] it appears that the likelihood of earplugs causing outer ear infections (otitis externa) is minimal. Although it would seem that placing a dirty or gritty foreign object in the ear canal could easily lead to irritation or infection, the data from existing HCPs seem to indicate that the external ear is fairly resistant to such abuse. Nevertheless, cleanliness should be stressed and certain individuals such as diabetics or others who are prone to infection should be more carefully monitored.

When an ear infection is reported, earplugs should not necessarily be assigned the blame. Other causative agents may be[7] excessive cleaning of the ear, recreational water sports, habitual scratching and digging at the ears with fingernails or other objects, environmental contaminants, and systemic conditions such as anemia, vitamin deficiencies, endocrine disorders, and various forms of dermatitis.

Question:
Once I put on my hearing protector, can I forget about it until I take it out for my break?

Response:
No. Hearing protectors may work loose or be jostled out of position and need readjustment. Certain pre-molded and user molded inserts are particularly prone to this problem and must be periodically reinserted or reseated[8, 9] Properly fitted custom ear molds and user formable foam earplugs are among those devices that are best at maintaining position throughout the use period.

Question:
Will I hurt my ears if I blow my nose while wearing an earplug?

Response:
No. Since an earplug is inserted in the external ear canal, which is separated from the middle ear by a membrane (the eardrum), it will not affect the pressure changes in the middle ear which may arise due to blowing of the nose. Sometimes, if the eustachian tube, which vents the middle ear to the back of the throat, is blocked or otherwise not functioning properly, air or fluids can be forced into the middle ear and cause discomfort or other problems. However, this will not be affected or aggravated by the use of earplugs.

In EARLog #9 we will continue this dialogue. Additional reference materials are listed below[9, 10, 11]

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Premolded insert hearing protection: concerns and considerations

By Curtis R. Smith, PhD, and Thomas E. Borton, PhD

The hearing of industrial workers can be protected from damage caused by hazardous noise in three principal ways. These include engineering noise controls, administrative noise controls and use of personal hearing protectors.

Engineering controls typically include such maneuvers as treating the noise source in some fashion or interrupting the path of noise transmission from the source to the worker. Although control is usually the most effective method of reducing the effects of hazardous noise, the high costs often associated with it frequently cause companies to choose other solutions. Moreover, some manufacturing and other processes are particularly resistant to controls at the source and technical remedies are not feasible.

Administrative measures usually include attempts to systematically control each worker's exposure to noise. This often can be accomplished by rotating workers from high to low noise areas or by varying their work schedules in such a way as to reduce the duration of exposure to noise. Frequently, this represents a viable alternative to engineering controls because of minimal costs. However, there are a number of problems associated with this approach. First, some union contracts prohibit the movement of workers to different job locations during working shifts. Second, adequately documenting the duration of each worker's noise exposure on a daily basis can become a difficult task. Further, the entire concept of manipulating noise exposure durations to prevent noise induced permanent threshold shift (NIPTS) for an individual is suspect.[7-9,11]

Because of the problems often associated with engineering and administrative noise controls, the use of personal hearing protectors is considered a useful alternative to these methods for preventing damage to the ear from exposure to hazardous noise.

Types of hearing protectors

Personal hearing protection devices can be divided into four different categories: helmets, insert earplugs, ear canal caps and earmuffs. Within each category, the devices come in several varieties, and, currently, there are over 200 different brands of hearing protection commercially available. Insert hearing protectors are among the most commonly utilized devices designed to reduce the harmful effects of intense noise. This paper focuses on the use of solid premolded insert earplugs and outlines some of the limitations associated with these devices as well as schemes for measuring their effectiveness.

Hearing protector selection

Traditionally, workers have been given a choice of personal hearing protectors to wear. In general, this practice appears to have flourished for at least three reasons. First, it seems to be commonly accepted that workers are more likely to wear protection when it is personally selected. Although this notion has intuitive appeal, there is little evidence to suggest that this is a crucial variable in the selection process and the whole notion awaits detailed investigation. Second, and perhaps more important, workers themselves are thought to know "what feels best" when it comes to personal hearing protectors. They cannot be expected, so the reasoning goes, to choose uncomfortable forms of protection; and since criteria for personal comfort vary considerably from person to person, a wide variety of devices from which to choose is desirable. Finally, a diverse menu of hearing protectors offers supervisors and administrators a formidable psychological weapon when enforcing protection programs. If the worker has protective equipment problems, blame is usually laid at his feet since he is the one who selected the device in question. If he fails to wear the devices or complains that they are uncomfortable, he can be made to feel as though it were his "fault" and guilt feelings or anger are often typical worker reactions.

In cases where insert hearing protectors are chosen, they usually are issued to users in one of three ways: 1) the person in charge of issuing hearing protection asks the wearer what size he wants (i.e., small, medium, large), 2) ear canal dimensions are assessed to determine the most appropriate earplug size or 3) earplugs are randomly selected and issued. Popular insert earplugs come in two principal types: solid devices that come in specific sizes with or without flanges, thought to provide a universal fit in any ear canal, and polyvinylchloride or polyurethane foam.

Insert hearing protector effectiveness

The US Environmental Protection Agency (EPA) recently issued a regulation requiring the labeling of hearing protectors in order to provide prospective users with information regarding their effectiveness in reducing noise actually reaching the wearer's hearing mechanism.[5] According to the regulation (40 CFR Part 211, Subpart B), each label on new hearing protectors must bear a number designating its Noise Reduction Rating (NRR). The basis for the NRR is the theoretical difference in decibels (A scale) between the level of noise to which the wearer is exposed and the noise level that actually reaches the wearer's eardrum. As a result, the NRR is thought to represent the minimum attenuation provided when the protector is worn according to the manufacturer's instructions. For example, if a protector with an NRR of 10 is worn properly, the wearer could expect the sound pressure level (SPL) actually reaching the hearing mechanism to be reduced by 10 dBA.

The NRR value is derived from data obtained using the American National Standards Institute (ANSI) Method for the Measurement of Real-ear Protection of Hearing Protectors and Physical Attenuation of Earmuffs.[1] The ANSI S3.19-1974 procedure relies on the differences in sound levels perceived by a group of at least 10 human subjects in a controlled noise environment, with and without a given set of hearing protectors. Each subject is tested three times using nine different frequency bands of noise with identical sets of hearing protectors. Thus, 30 tests are required to obtain a single NRR for a given category of hearing protector. The actual NRR value ultimately is calculated using the National Institute of Occupational Safety and Health (NIOSH) computational formula, method two.[12]

The EPA determined that NRR values for hearing protectors on the market in 1975 ranged from approximately 0 to 30, and in this system, higher numbers indicate greater effectiveness. The NRR of each commercially available hearing protector must appear on the label of the respective device. According to the EPA, NRR data will be updated from time to time as new hearing protectors are introduced into the marketplace and label ratings will be verified through the agency's random selection and testing procedures. The EPA may require compliance audit testing (additional testing of products by the manufacturer) when it has reason to believe a product is being mislabeled. The agency has the authority to recall all products found to be mislabeled and require that they be relabeled appropriately.

Advantages of NRR

On the surface, the EPA system for rating and labeling hearing

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protectors is appealing for at least three reasons. First, persons without training in acoustics (i.e., safety officers, etc.) could employ the NRR method using instrumentation no more sophisticated than a Type II sound level meter. Second, the method appears to insure that appropriate devices can be selected to best protect the hearing of workers and assure compliance with Occupational Safety and Health Administration (OSHA) regulations.[13] Third, the method is simple and virtually eliminates the need for involvement of audiologists, industrial hygienists or other highly trained professionals in hearing protection programs.

Disadvantages of NRR

1. **A versus C scale measures**—Traditionally, the NRR system has emphasized the importance of A-weighted SPL values for determining the effectiveness of hearing protectors. However, when the spectral composition of noise is concentrated below 500 Hz, dBA SPL measurements are likely to be spurious.[2,3,10] As a result, C-weighted scale measurements are needed under these circumstances. Unfortunately, many sound level meters in current use do not have the capacity to measure anything other than A-scale values and use of the NRR system can be compromised in such instances. Thus, use of a sound level meter with both A and C weighting networks is indicated when the NRR system is utilized. Further, since untrained ears or even trained ones often cannot determine the spectral distribution of the noise being considered, both A and C scale measurements ordinarily must be obtained.

2. **Earplug selection**—There are two options available when utilizing the ANSI 1974 standard for the fitting of hearing protectors to test subjects.[1] They include "experimenter fit," in which the hearing protector is fitted to the test subject by the experimenter, and "subject fit," where the subject fits himself with the device to be tested. The EPA has selected "experimenter fit" data for use under the labeling regulation. However, in actual field conditions, employees frequently select the hearing protectors they will wear and experimental evidence suggests that they may not do so very effectively, especially when the hearing protectors are solid-type insert earplugs premolded to specific sizes.

Smith, et al,[16-19] permitted 100 adult subjects to select the "best fitting earplugs" for each ear from a wide variety of premolded, solid, insert-type earplugs. Sixty-eight percent of the subjects selected earplugs smaller than their measured ear canal diameter. Twenty-three percent of these subjects demonstrated different sized ear canals, but only 17% selected the "correct" size for each ear. Since most employees may be no more successful than this in choosing appropriately-sized premolded earplugs, at least initially, the effectiveness of these deivces seems likely to be compromised. As a result, no system for rating the effectiveness of this commonly used form of hearing protection is likely to be very useful whenever wearer's select their own earplugs (a common practice in industrial settings). Unfortunately, these problems are unlikely to improve, even if premolded hearing protectors are originally selected by a specially trained and experienced fitter, for reasons cited below.

3. **Hearing protector fit**—Data obtained using the "experimenter fit" option proposed by the EPA may not be very relevant when considering the performance of premolded earplugs under actual field conditions. In such circumstances, the hearing protectors are actually fitted (inserted) by the wearer. The process is ordinarily repeated several times during the workday, due to the fact that earplugs are removed during rest periods or slowly work themselves loose, and it would be impractical for any one other than the wearer to apply his own hearing protectors. Previous research[4,14,15] has suggested that in conditions where employees are responsible for the insertion of their own hearing protective devices, serious questions have arisen over the performance of the devices. In summary, inappropriately-sized premolded earplugs cannot be expected to perform satisfactorily, and the NRR value assigned to ill-fitting equipment is not likely to prove very meaningful.

Common sense suggests that any hearing protector must fit adequately in order to attenuate the SPL reaching the eardrum. Nevertheless, little has been written emphasizing the importance of an occluding seal between the eardrum and noisy surroundings, perhaps because the point seems elementary and can be taken for granted. Although several recent reports have stressed the value of the proper fit of hearing protectors,[9,18] little data has been published regarding this basic issue. Recently, Smith, et al,[19] described the reduction in attenuation due to lack of an effective seal between solid insert earplugs and a simulated ear canal. Premolded earplugs were inserted into the external auditory canal of a Knowles Electronics Manikin for Acoustic Research (KEMAR) and broadband noise was generated in the surrounding sound field. The investigators found that use of a pre-molded hearing protector with a nominal diameter only 0.5 mm smaller than that of the external auditory canal obviated the potential attenuation offered by the device throughout the frequency range from 10 Hz to 10 KHz. Since individuals utilizing premolded insert hearing protectors may be likely to choose devices smaller than their real ear canal dimensions, perhaps for reasons of comfort, the NRR value of the earplugs in such circumstances would have little meaning.

Finally, the new EPA regulation specifies that hearing protectors should be worn according to the manufacturer's instructions. Although this specification appears logical, it can be expected to create confusion. Consider the following manufacturer's instruction for use of a premolded earplug: "To wear it, put the plug in the hollow behind the ear." The EPA's insistence on following such instructions is likely to cause misunderstanding among wearers and those responsible for the management of hearing conservation programs.

In summary, industry and governmental focus on a single number effectiveness ratings, such as the NRR value, may be misplaced when dealing with solid premolded insert hearing protectors. In our view, the NRR value of nearly any modern hearing protection device is trivial when compared with its fit on the wearer because without adequate fit, the potential of the device never can be realized. Increased attention needs to be focused on the importance of good fitting protection and on the factors which compromise fit. Anything which jeopardizes the fit of a hearing protector (incorrect use, damage, deterioration of materials, etc.) poses a serious threat to the wearer and to the goals of the hearing conservation program itself.

4. **Manufacturer versus government data**—The NRR value for any hearing protector is calculated using the NIOSH method described earlier.[12] As a result, consumers, and even professionals, may be led to believe that this value has been approved in some way by the Federal government. It is not difficult to imagine comments to the effect that if the government indicates a hearing protector has a certain NRR value, then that device must be correspondingly more or less effective, as the case may be. Actually, most of the data upon which the NRR depends comes directly from the manufacturers of hearing protectors themselves. Manufacturers are required to submit attenuation values at several frequencies, gathered at their own or other private laboratories, for each product. It is from these data that the NRR values are calculated by the EPA. Since there is no "control" over the attenuation data submitted, there would be little to prevent manufacturers from reporting only the most favorable set of attenuation values for each product to be placed on the market.

Several concerns are readily apparent. A recent informal survey has indicated that there are perhaps less than a dozen laboratories in the United States which are alleged to meet ANSI-1974 specifications for measurement of hearing protector attenuation, and considerable pressure will be placed on these facilities to handle the required testing. At the same time, heavy pressure could fall on laboratory facilities to produce "good" data. The testing is not likely to be conducted without charge, and a laboratory could request renumeration according to "whatever the market will bear." It may not be opportunistic to fear that advantages could accrue to manufacturers in excellent corporate financial health, and it is not hard to imagine that any laboratory which might produce favorable data could be backed up with requests for tests. Of interest is the fact that there are virtually no safeguards against the development of unscrupulous or "fly-by-night" laboratories.

In summary, there seems to be serious limitations to systems similar to the one described above for rating the effectiveness of hearing protectors. Chief among them is the assumption of adequate fit, an assumption which is, at best, shaky. In particular, the EPA's

Continued on page 42

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NRR system has serious implications for those settings in which premolded insert hearing protectors are utilized. In view of evidence which questions the efficacy of these devices, the NRR can be expected to further cloud issues already misunderstood by professionals as well as those in industry responsible for implementing hearing conservation programs. The false sense of security engendered by printing NRR values on the labels of hearing protectors does little except lead to the mismanagement of the very persons whom hearing conservation programs originally were designed to protect.

The future

As indicated in the previous discussion, there appears to be sufficient reason to question the value of traditionally popular solid premolded insert earplugs in serious hearing conservation programs. A newer form of insert hearing protection device made of foam materials, and described earlier in this paper, has become increasingly popular in the last few years. It appears to offer potential solutions to many of the problems affecting other forms of hearing protection, especially solid insert earplugs, and there is evidence that these foam devices can provide substantial protection against hazardous noise.[19] Some preliminary findings even suggest that the physical characteristics of the foam from which these earplugs are made can differentially affect the attenuation provided by the devices as a function of frequency.[20] In the future, it may become feasible to deliberately alter the structure of such foam materials to take full advantage of the potential for attenuation offered by these devices.

As progress is made toward the goal of protecting human ears from the effects of hazardous noise by utilizing devices which provide an acoustic seal between the eardrum and the environment, the problems of maintaining the communication performance of the wearer correspondingly increase. Although some evidence exists which suggests that hearing protectors improve the speech discrimination performance of normal listeners against a background of noise, a similar situation does not appear to exist for those already suffering sensorineural hearing impairment.[21] In situations where the needs for effective verbal communication are as great as are the hazards of noise, new approaches must be considered. Coupling wireless FM and infrared communication units directly to hearing protectors seems feasible, and one such FM system is already commercially available. FM systems have the potential disadvantage of "spill-over," but could be expected to operate well under many circumstances. Infrared units should not be subject to acoustic "leaks," but are typically limited to indoor settings where interference from sunlight is not a problem. Published data detailing the effectiveness of such systems under actual field conditions is not available, but research has been already begun by the authors to explore the feasibility of several alternatives along this line with a view toward simultaneously enhancing communication performance in the presence of noise and protecting the ear. □

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SESSION

AUDIOMETRIC TESTING, REVIEW AND REFERRAL

- Regs Re: Audiometry

    - How Often
    - Who Tests
    - When Tested
    - Supervision
    - Training of Audiometrician
    - Baseline and Followup Audiograms
    - Manual - Automatic Audiometry
    - Calibration and Test Area Background
    - Forms - Test - History - Signatures
    - Medicolegal Usefulness of Audiograms
    - The Real Cost of Testing
    - Interpretation or Review and Referral
    - Who Interprets
    - Perspective of Review - Purpose of Test
    - Categorization of Results of Test
    - Criteria for Referral
    - Informing the Employee - Sample Letters
    - Changing Baselines
    - Work Relatedness of STS
    - Computer vs. Individual Personal Review

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SESSION

MOBILE HEARING TESTING PROGRAMS

- Why On-Site Mobile Hearing Testing

- Costs in Developing Physical Unit
  - Size - Pros and cons of Individual vs. Group Testing
  - How Moved - Van - Trailer
  - Equipping Unit(s) Audiometers, Booths, Ventilation

- Program Maintenance Costs
  - Travel
  - Upkeep

- Advantages of Mobile On-Site Testing
  - Time
  - Organization
  - Education Opportunity
  - Cost

- Disadvantages of Mobile On-Site Testing
  - Cost of Travel - Minimum Numbers of Tests
  - Reliance upon Plant Personnel for Coordination
  - Scheduling Hazards - Weather, Equipment Breakdown
  - Retesting Scheduling Difficult

- Who Can Best Benefit from Mobile Programs

- On-Line Mobile Programs

- Who Should Do the Testing

* * * * * *

REVIEW AND REFERRAL OF INDUSTRIAL AUDIOGRAMS: A PROFESSIONAL DILEMMA

ALAN S. FELDMAN*
CHARLES T. GRIMES

State University of New York, Upstate Medical Center, Syracuse

The experience of reviewing industrial audiograms over the past four years has brought to light some interesting problems. For example, we have found that employees referred for follow-up of significant high-frequency hearing loss are sometimes informed by physicians that referral was unnecessary. The paper addresses these problems in terms of the possible effect on hearing conservation programs in general and presents a system of categorization for industrial audiograms based on air-conduction sensitivity and configuration.

The implementation of industrial hearing conservation programs poses some interesting problems for the hearing health care professional.

As the federal occupational safety and health as well as most state compensation regulations are currently constituted, preemployment baseline and periodic follow-up hearing tests have inherent value to both the employer and employee. The cornerstone of most industrial hearing conservation programs is an identification audiogram. This document is essential for several reasons. It serves to identify preexisting hearing loss prior to placement in a work environment having noise levels that may damage hearing. As such, it functions to protect the employer against the responsibility for preexisting hearing loss which could lead to a considerable saving in compensation liability. In addition, the initial audiogram obtained on any employee serves to establish a baseline against which future hearing tests are compared. This aspect of hearing conservation programs is vital because it is the only proven way of assuring that the techniques for control of noise exposure are effective in preventing hearing impairment. Whenever employees are exposed to hazardous noise levels, administrative controls and personal ear protection must be relied upon to reduce exposure below damaging levels. Monitoring audiometry is the verification mechanism.

Identification audiometry is traditionally viewed as the first step of a hearing conservation program. The potential value of the identification or baseline and follow-up audiograms extends far beyond the usual industrial and compensation frame of reference when appropriate professional measures are used to review and evaluate the data. It is to this review and evaluation aspect of audiograms that we wish to address ourselves.

The conflict the professional faces relates to the awareness that air conduction audiograms, in and of themselves, do not contain sufficient information that can lead to the appropriate evaluation of a hearing loss, let alone to a definitive diagnosis. These audiograms do only one thing as far as the hearing health professional is concerned, and that is to identify the existence of a hearing impairment. The impairment may or may not be real, it may or may not be related to the noise exposure, and it may or may not be amenable to one or another form of treatment or rehabilitation. These factors can only be determined following audiologic and otologic evaluation.

The problem faced in the review and interpretation of industrial audiograms becomes apparent when one reviews initial audiograms in a newly established hearing conservation program. Most employees in these programs have been exposed to damaging noise levels for many years and, by the usual criteria, will exhibit a significant hearing loss. Also, some audiograms may be quite atypical of a noise-induced hearing loss. For example, a marked difference may exist between the two ears.

Our professional ethic says to refer employees with a significant hearing loss that is detected on identification audiometry for a more comprehensive evaluation. But which ones should be referred? Criteria for referral following screening programs dictate that we should, on the one hand, not over-refer while, on the

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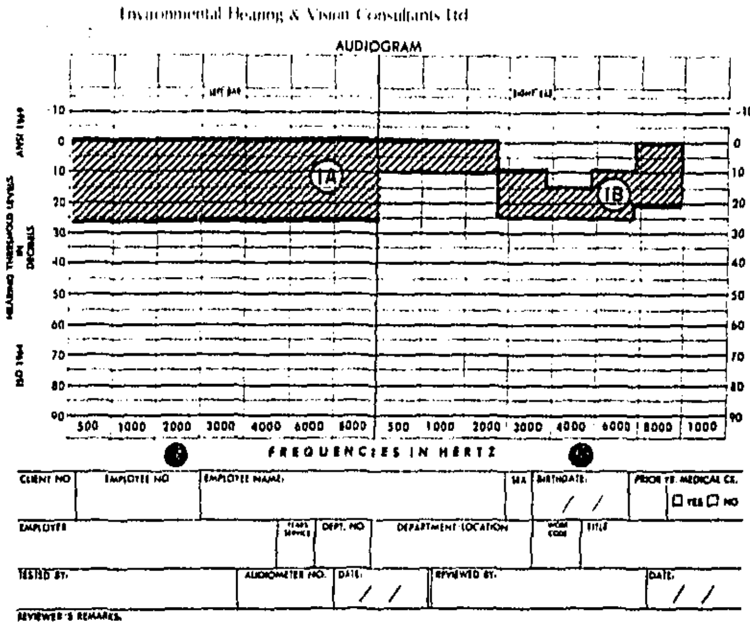

FIGURE 1. Category 1A and 1B—All thresholds are contained within the shaded area.

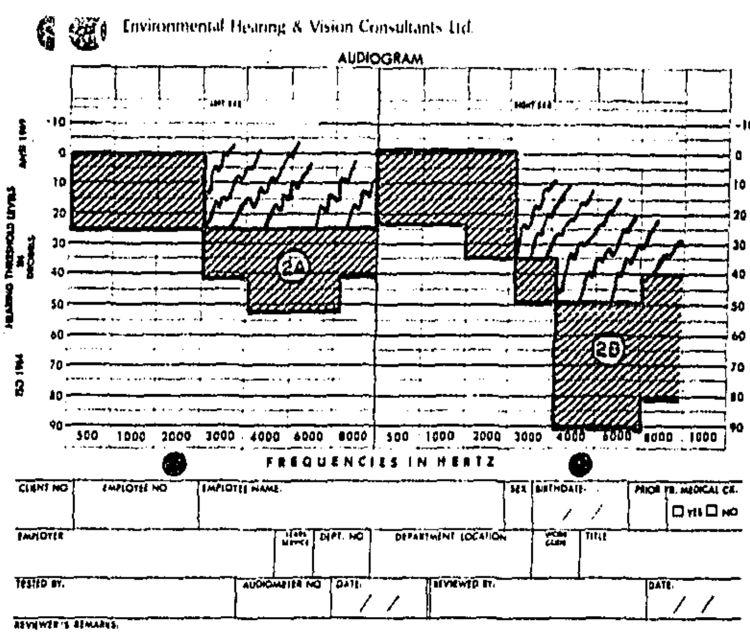

FIGURE 2. Category 2A and 2B—All thresholds are contained within the shaded area.

the other hand, we should not miss any significant problems. We know from experience that hearing losses confined to the high frequencies, with typical notching in the 3000-6000 Hz range, are likely to be noise induced and irreversible and will also be subjectively minimized by the employee. The employee, as a rule, resists evaluation for these problems. Faced with the question of who is going to pay for a comprehensive evaluation, the professional must acknowledge that referral of all employees with this type of hearing loss is probably unwarranted. The company providing the hearing conservation program is generally unwilling to cover the costs of these evaluations. The employees not only don't want to pay the costs, but they generally feel the examination is unwarranted. This sentiment is frequently corroborated by the physician who may not be well versed in noise-induced permanent threshold shift. In fact, in our experience the physician has, on some occasions, indicated to the employee that the visit was unwarranted. This can be extremely damaging to the success of the industrial hearing conservation program by diminishing employee support.

Roger Maas, who devoted a working lifetime to hearing conservation in industry recommended the use of the guidelines of the Industrial Medical Association and the American Academy of Ophthalmology and Otolaryngology for distinguishing normal from abnormal hearing. Those criteria are based on an average hearing loss of more than 25 dB in the speech frequencies. Referral is recommended when this criterion is failed or when an unusual irregularity or abrupt loss beginning at 2000 Hz is noted (Maas in Katz, p. 795). It is those unusual irregularities upon which we need to reach some professional agreement. When one considers the multiplicity of audiometric configurations that may be generated by exposures to various noise spectra under, in some cases, highly idiosyncratic modes of exposure, what may be perfectly predictable in one case, if all the specifics of a certain job were known to the reviewer, may indeed be an irregularity in another.

The questions posed are (1) How and where does one strike the balance between an industrial approach and a clinical approach in the review of industrial audiograms? (2) How much license does the audiologist and/or physician permit himself in reviewing these data? and (3) What are the ethical and possible legal implications if a person experiences irreversible damage due to pathology that, with hindsight, was evident in an industrial hearing test but was not called to attention by the reviewer? (4) On the other hand,

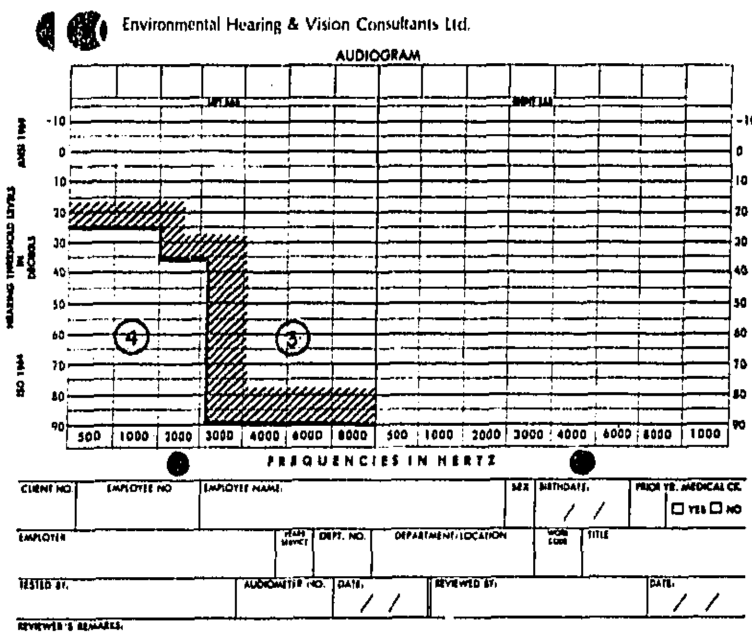

Figure 3. Category 3—All thresholds are in or above the shaded area. Category 4—Thresholds at 500, 1,000 and 2,000 Hz are below the shaded area.

what are the possibilities of seriously weakening the effectiveness of professional review by consistent over-referral?

The program that we have developed requires the taking of history information prior to each audiogram. The history questionnaire consists of items intended to identify such things as, ear disease, ear surgery, tinnitus, dizziness, hereditary hearing loss, noise exposure, previous hearing tests and medical examination, and some indication of how the employee evaluates the adequacy of his/her own hearing. A threshold audiogram is then obtained, usually with a self-recording audiometer. The audiograms are then categorized according to the following criteria:

CATEGORY

1A—Pass—Hearing is within normal limits. (Figure 1)

1B—Pass—Hearing is within normal limits but the high frequencies (6K and 8K Hz) show improvement of at least 5 dB which may be suggestive of a notch in the audiogram possibly related to early noise-induced threshold shift.

2A—Pass—Hearing loss that appears to be of noise-induced origin is present in the high frequencies. Hearing for communication purposes is essentially unimpaired. The need for hearing protection is unquestionable. (Figure 2)

2B—Pass—Hearing loss in excess of 50 dB is present in the frequencies of 4K and 6K or 8K Hz. Impairment of hearing for communication purposes is imminent. Hearing protection is essential to prevent further threshold shift.

3 —Provisional Pass—This is essentially a holding category. Significant hearing loss exists that appears to be of noise-induced origin. The adequacy of hearing for communication purposes is questionable. The individual is borderline for aural rehabilitation and should have his hearing monitored at least every six months. Any worsening of thresholds on follow-up tests indicates the need for referral for complete audiological testing. (Figure 3)

4 —Fail—Significant hearing loss exists of undetermined type and origin. The individual should be referred for complete examination. (Figure 3)

5 —Fail—Test responses inconsistent. For one reason or another the individual was not able to perform the test adequately. The individual may have adequate hearing but for some reason was not able to respond properly to the test. A referral is indicated since better test results are necessary for the reviewer to make a reliable interpretation. This category includes bilateral differences of 50 dB or more.

6 —Fail—Significant hearing loss exists, which is known to the individual. Records of previous test and examination should be obtained from the attending physician.

7 —Significant change from baseline test or most recent previous test. Significant change is defined as follows:

(1) Average shift of 11 dB or more in the frequencies of 2,000, 3,000, 4,000 Hz or a 15 dB or more shift at any single frequency.

(2) If the comparison indicates a shift as described above, the employee shall be retested within one month. If the shift persists:

(A) If the employee needs personal protective equipment or devices, insure that he has the appropriate effective equipment and that he is instructed in the proper use and care of the equipment.

(B) Employee shall be notified of his hearing level and provided a copy of his audiogram.

(C) The employee shall be referred for appropriate medical evaluation.

These criteria are not proposed as final answers to these questions simply because, as we have repeatedly experienced ambiguous situations, we have continued to refine our approach. We do not feel that completely satisfactory answers have been forthcoming. We would like to propose that this is an area that needs immediate attention, for every day the number of industrial audiograms being generated grows larger. In addition, we would like to inject a note of caution. As do many others who process large volumes of industrial audiograms, we rapidly reached the conclusion that automated data processing offered many advantages. However, until the questions posed earlier have been resolved, computerized audiogram review contains some inherent shortcomings. We urge that computer programs for industrial audiogram review contain sufficient safeguards to identify those persons who manifest unusual irregularities, and that those audiograms, along with failures and significant changes, continue to be personally reviewed by responsible parties in addition to whatever data processing techniques are being used.

The review program which we have developed encourages employee notification of the result of his/her test result and establishes the basis for referral, usually by notification of the employee of the need for more thorough evaluation. Criteria for referral are based on (1) unexplainable audiogram, (2) possible medically rehabilitative condition, (3) significant hearing impairment that would be amenable to aural rehabilitation.

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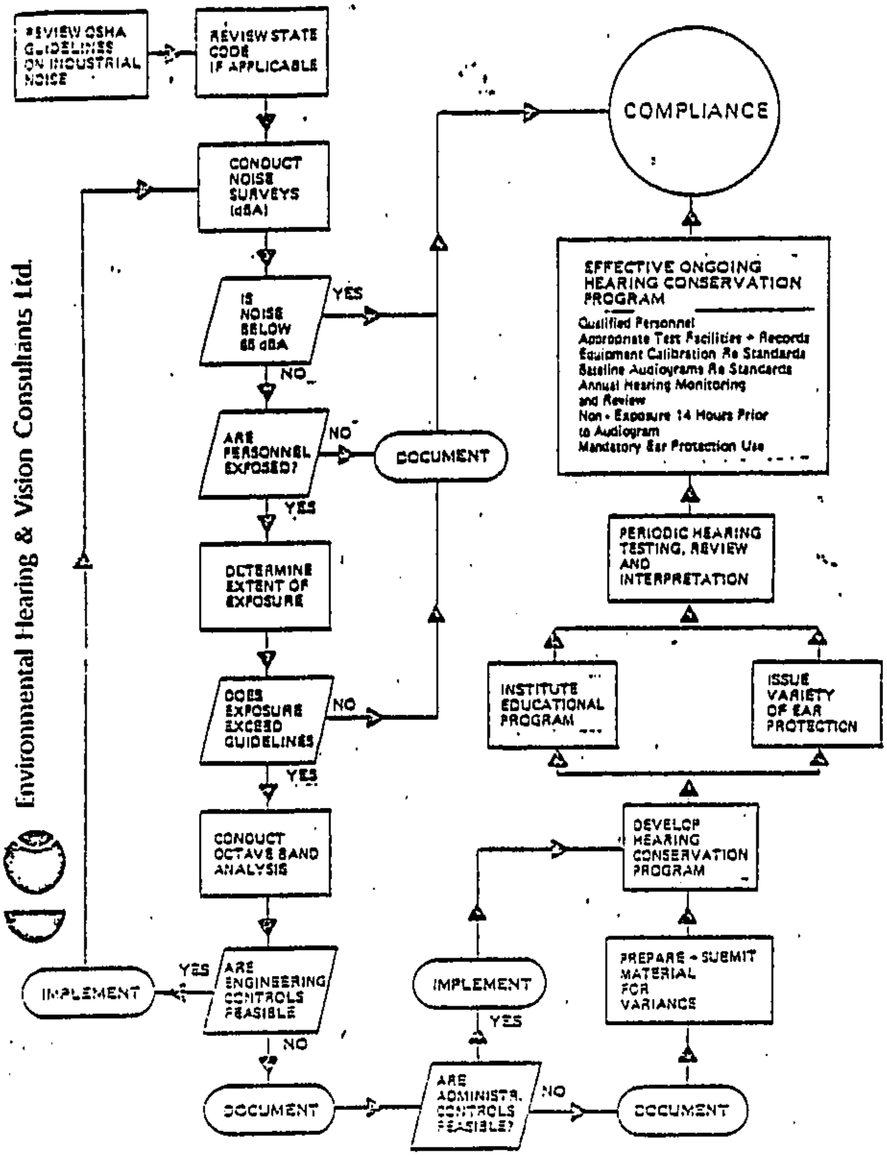
Environmental Hearing & Vision Consultants Ltd.



AL REPORT

		EMPLOYEE NO	SEX	BIRTHDATE
CHRISTMAS	ROBERT	101124290	M	05/15/25

AUDIOGRAM

	LEFT EAR							RIGHT EAR								
12/74	00	00	05	10	15	15	50	15	20	30	35	40	55	50		ORIGINAL
03/80	00	00	00	15	10	20	30	00	00	00	10	10	10	15		PREVIOUS
12/74	00	00	05	10	15	15	50	15	20	30	35	40	55	50		BASELINE
03/81	05	00	00	15	20	10	10	00	00	00	15	10	15	30	2A	CURRENT
	[illegible]	1000	2000	3000	4000	6000	8000	500	1000	2000	3000	4000	6000	8000		

ABC CORPORATION

Environmental Hearing & Vision

6600 Joy Road
East Syracuse, New York 13057
315/437-8439

Environmental Health Screening Services Div.
Environmental Hearing & Vision Consultants

ABOUT YOUR AUDIOMETRIC SCREENING REPORT

The audiograms recently performed at your company, have been reviewed and processed by Environmental Hearing & Vision Consultants Ltd. Enclosed is your report.

The enclosed report consists of two parts:.

(1) An individual report for each Employee.

(2) An administrative listing of all audiograms included in the report.

The administrative listing is made available so that you will have easy access to the names of all employees who have a current audiogram.

The individual report is provided to:

(1) Give you an individual report to be placed in the Employee, Personnel or Medical file.

(2) Give you the necessary information for further action to be taken with regard to the Employee's hearing status.

Revised: 3/1980

THE INDIVIDUAL REPORT

You will note that the individual report provides for four audiogram THRESHOLDS.

(1) ORIGINAL AUDIOGRAM: First audiogram conducted that the company has access to.

(2) BASELINE: The first audiogram that the company has access to THAT MEETS THE CRITERIA described in OSHA'S Guidelines: (may be the same as the original).

(3) PREVIOUS: The immediately previous audiogram (usually last year's).

(4) CURRENT: This year's audiogram.

Additionally, the report provides for a category number (this is an arbitrary numbering system developed by Environmental Hearing & Vision Consultants Ltd. to better enable you to administer your Hearing Conservation Program. IT IS NOT A SEQUENTIAL LISTING, which would indicate 2 is twice as good as 4 etc.). The category number is NOT to be interpreted as a level of hearing ability.

NOTE: Following some category numbers, there appears a sub category number or letter eg: 1A, 1B, 2A, 2B1, these sub categories were designed for finer definition of hearing loss. You may disregard anything but the main category designation.

WHAT THE CATEGORIES MEAN

Category (1) Hearing thresholds are within limits established for normal hearing.

Category (2) Hearing for communication purposes is essentially unimpaired. There is hearing loss present in the high frequencies.

Category (3) Provisional Pass: This is essentially a holding category. Significant hearing loss exists. The adequacy of hearing for communication purposes is questionable but individual is borderline for aural rehabilitation. Any increase in loss on future tests will indicate the need for referral for a complete evaluation. Retest in six months.

Category (4) Fail: Significant hearing loss exists of undetermined type and origin. The individual should be referred for complete examination.

Category (5) Test responses inconsistent. For one reason or another the individual was not able to perform the test adequately. A retest is indicated since better test results are necessary for the reviewer to make reliable interpretations.

Category (6) Fail: Significant hearing loss exists which is known to the individual. The Employee has seen a physician about his or her hearing status and has indicated to us that he is aware of his loss. A copy of the Physician/Audiologist report should be obtained for his or her record.

Category (7) Significant change from baseline test or most recent previous test.

ADDENDUM

WHAT SHOULD YOU TELL THE EMPLOYEE

RECOMMENDED SAMPLE NOTICE FOR ALL CATEGORY 1's

SUBJECT: Your recent audiometric screening

Your recent audiometric screening conducted as part of (Your Company) Hearing Conservation Program indicated that your hearing falls within the generally accepted limits of normal for communication purposes.

Annual audiometric screening is conducted by (Your Company) as part of it's overall Health & Safety Program, in keeping with the specified guidelines of the Occupational Safety & Health Administration.

Hearing is a valued asset, not to be taked for granted by anyone, for this reason you are urged to wear your hearing protection whenever you are exposed to excessive noise levels, whatever the source.

RECOMMENDED SAMPLE NOTICE FOR ALL CATEGORY 2's

Your recent audiometric screening conducted as part of (Your Company) Hearing Conservation Program indicated that your hearing is within normal limits in the speech range frequencies. When compared to the normal population there is indication that you have a hearing loss in the high frequencies of which you may or may not be aware. Because the loss appears in the high frequencies only, we are not recommending a referral for follow up.

You may consult your physician, if you wish. We recommend that you see a physician if any change occurs in your hearing prior to your next regularly scheduled audiometric screening.

Annual audiometric screening is conducted by (Your Company) as part of its overall Health & Safety Program, in keeping with the specified guidelines of the Occupational Safety & Health Administration.

Hearing is a valued asset, not to be taken for granted by anyone. For this reason you are urged to wear your hearing protection whenever you are exposed to excessive noise levels whatever the source.

ADDENDUM

WHAT SHOULD YOU TELL THE EMPLOYEE

RECOMMENDED SAMPLE NOTICE FOR ALL CATEGORY 3's

Your recent audiometric screening conducted as part of (Your Company) Hearing Conservation Program indicated that when compared to the normal population you have a hearing loss of which you may or may not be aware. Because the greater part of the loss occurs in the high frequencies, we are not recommending a referral for follow up at this time.

You may consult your physician, if you wish. We recommend that you see a physician if any change occurs in your hearing prior to your next regularly scheduled audiometric screening.

Annual audiometric screening is conducted by (Your Company) as part of it's overall Health & Safety Program, in keeping with the specified guidelines of the Occupational Safety & Health Administration.

Hearing is a valued asset, not to be taken for granted by anyone. For this reason you are urged to wear your hearing protection whenever you are exposed to excessive noise levels whatever the source.

ADDENDUM

WHAT SHOULD YOU TELL THE EMPLOYEE

RECOMMENDED SAMPLE NOTICE FOR ALL CATEGORY 4's

SUBJECT: Your recent audiometric screening

Your recent audiometric screening conducted as part of (Your Company) Hearing Conservation Program indicated that you may have a loss of hearing when compared to the normal population.

Although you may not be aware of difficulty, your hearing at the present time is not within normal limits for the purpose of communication. You may be developing an auditory problem which is correctible.

It is our recommendation that you make your own arrangement to have a qualified physician (preferably an ear specialist) administera complete evaluation.

Annual audiometric screening is conducted by (Your Company) as part of it's overall Health & Safety Program, in keeping with the specified guidelines of the Occupational Safety and Health Administration.

Hearing is a valued asset, not to be taken for granted by anyone, for this reason you are urged to wear your hearing protection whenever you are exposed to excessive noise levels whatever the source.

RECOMMENDED SAMPLE NOTICE FOR ALL CATEGORY 5's

Your recent audiometric screening test indicated that the test was inconclusive. Your hearing threshold was not accurately determined. For this reason you will be rescheduled and notified when the next screening will take place.

ADDENDUM

WHAT SHOULD YOU TELL THE EMPLOYEE

RECOMMENDED SAMPLE NOTICE FOR ALL CATEGORY 6's

Your recent audiometric screening conducted as part of (Your Company) Hearing Conservation Program indicated that you may have a loss of hearing when compared to the normal population.

On the audiogram questionnaire you indicated to the technician that you are aware that some loss exists.

If you have not seen a physician recently (within the past 2 years), it is our recommendation that you make your own arrangements to have a qualified physician (preferably an ear specialist) administer a complete evaluation.

Annual audiometric screening is conducted by (Your Company) as part of it's overall Health & Safety Program, in keeping with the specified guidelines of the Occupational Safety & Health Administration.

Hearing is a valued asset, not to be taken for granted by anyone, for this reason you are urged to wear your hearing protection whenever you are exposed to excessive noise levels whatever the source.

ADDENDUM

WHAT SHOULD YOU TELL THE EMPLOYEE

RECOMMENDED SAMPLE NOTICE FOR ALL CATEGORY 7's

Your recent audiometric screening conducted as part of (Your Company) Hearing Conservation Program indicated that you have experienced a significant change when compared to your baseline screening.

Industrial safety regulations require that you be informed of this change. Without further testing the meaning of this shift cannot be completely evaluated. We recommend that you make your own arrangement to have a qualified physician (preferably an ear specialist or an audiologist) administer a complete evaluation of your hearing.

Annual audiometric screening is conducted by (Your Company) as part of it's overall Health & Safety Program, in keeping with the specified guidelines of the Occupational Safety & Health Administration.

Hearing is a valued asset, not to be taken for granted by anyone, for this reason you are urged to wear your hearing protection whenever you are exposed to excessive noise levels whatever the source.

IF THE EMPLOYEE WANTS A COPY OF HIS AUDIOGRAM

If the employee wishes to have a copy of his audiogram for a visit to the physician or some other reason, the request should be made to you in writing along with the name and address of the recipient. A request to forward the employee's audiometric records should be sent to:

Environmental Hearing & Vision Consultants Lts.
6600 Joy Road
East Syracuse, New York 13057

A duplicate copy of the current audiogram will be forwarded as instructed.

PRE-EMPLOYMENT AUDIOGRAMS

Pre-employment audiogram's will be conducted in the following manner:

(1) Periodically (within 90 days of employment) by Environmental Hearing & Vision Consultants Ltd., mobile unit during its routine visit to your facility.

(2) Pre-employment examinations can be arranged prior to employment at our offices -

Environmental Hearing & Vision Consultants
6600 Joy Road
East Syracuse, New York 13057
315-437-8439

NOTE: Your Personnel Department should contact Environmental Hearing & Vision Consultants Ltd., regarding which of the above options is most desirable.

If the audiogram is returned to you as a Category 4 or 6, it is our recommendation that you notify the individual's previous employer(s) by registered mail. Enclose a copy of the results along with a brief letter explaining that you hired this person with a hearing loss for which you will not be responsible.

Environmental Hearing & Vision Consultants

CLIENT ABC CORP PAGE 1

	EMPLOYEE	TST D		.5K	1K	2K	3K	4K	6K	8K	CAT	DEPARTMENT
000002033	WALTHER	C 12/78	LE	10	00	00	05	00	05	00	1A	81
	DAVID 2033		RE	05	00	00	00	10	10	00		
053264922	JODOIN	C 12/78	LE	20	15	30	30	25	25	15	4	500
	MILDRED 2192		RE	20	10	20	15	10	30	25		
054120034	FANTON	C 12/78	LE	10	20	20	60	NR	75	65	4	7700
	JAMES 3367		RE	25	40	10	70	NR	NR	NR		
059542523	PAPPANO	C 12/78	LE	00	00	00	00	05	00	00	1B	19
	STEPHEN 2195		RE	05	00	00	05	00	15	10		
061421576	PEASE JR	C 12/78	LE	05	00	00	05	00	00	10	1A	1100
	CHARLES 2194		RE	05	00	00	05	00	00	10		
064288167	ROGERS JR	C 12/78	LE	05	00	05	45	45	30	20	2B	8400
	WILLIE JR 6842		RE	05	05	15	30	40	50	35		
067321812	FREIDA	C 12/78	LE	10	15	10	10	30	10	15	2A	8100
	KENNETH P 3397		RE	15	10	05	10	45	20	10		
067322697	BAGDONAS	C 12/78	LE	00	00	05	15	55	40	20	2B	8400
	VINCENT 3376		RE	05	05	05	10	50	35	15		
069446508	HUNTER	C 12/78	LE	10	10	05	15	20	00	20	1A	8100
	EDMUND 5967		RE	05	05	05	10	15	05	05		
073142768	GUION	C 12/78	LE	10	15	10	15	50	75	55	2B	7200
	WILLIAM 3314		RE	15	10	10	15	65	65	35		
079141904	KENDRICK	C 12/78	LE	20	10	25	40	45	65	75	7	7200
	WESLEY L 4827		RE	15	05	15	30	40	50	60		
079426017	ARENA	C 12/78	LE	05	10	05	45	45	70	40	7	7700
	FRANCESCO 3373		RE	10	10	10	55	55	50	45		
083127694	PAIGE	C 12/78	LE	20	25	20	40	45	35	30	4	7700
	CLARENCE 0165		RE	35	30	30	35	45	50	50		
083449286	SEYMOUR	C 12/78	LE	25	05	45	65	75	65	50	7	21
	JAMES 1719		RE	10	00	10	25	50	10	15		

EXAMPLE

COURSE SUPPLEMENT

Basic BASIC

An Introduction to the Microcomputer and to Programming

Marc B. Kramer, Ph.D.
Joan M. Armbruster, M.S.
Noise & Hearing Consultants of America
New York City, New York

American Academy of Otolaryngology - Head and Neck Surgery

1981 Instruction Section - September 24, 1981 - Course 337

Basic BASIC
An Introduction to the Microcomputer and to Programming

CONTENTS

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TO THE COURSE PARTICIPANTS

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I would be very glad to receive any comments about this course, especially comments regarding ways in which it might be further improved. Any experiences you have had with microprocessing, especially as they apply to medical and office problems would be welcomed.

Marc B. Kramer, Ph.D.
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159 East 69th Street
New York City, New York 10021
(212) 734-8900

SOME USEFUL DEFINITIONS

ALGORITHM A set of well defined rules for solving a problem in a definite number of steps - in contrast with heuristic.

CONSTANT A value that does not change during the execution of a program.

EXPRESSION A combination of one or more operations; i.e., a formula. (e.g., A=(X+Y)*Z)

HARDWARE The tangible physical devices (electronic, magnetic or mechanical)- in contrast with software.

HEURISTIC An exploratory method of attacking a problem; i.e., guided trial and error - in contrast with algorithm.

INTEGER A whole number which may be positive, negative or zero. It does not have a fractional part. (e.g., 26, -17, 0)

LIBRARY FUNCTION A collection of precoded processes that can be performed on numbers or character strings. (e.g. SQR(X) takes the square root of the variable X.)

PROGRAM A set of sequenced instructions to cause a computer to perform particular operations.

PROM An acronym for Programmable Read Only Memory. A computer memory that lets a user permanently store a program or data inside the computer memory.

RAM An acronym for Random Access Memory. A computer memory whose contents can be changed. Also referred to as Read-Write memory or user memory.

ROM An acronym for Read Only Memory. A computer memory whose contents cannot be changed.

SOFTWARE The programs and other documentation such as lists of information, operating instructions, etc.- in contrast with hardware.

STATEMENT A line in a computer program (e.g., 10 X = 100).

STRING VARIABLE A set of characters that is not to be treated as a number but is otherwise manipulated by the computer. Variable names are followed by a "$". (e.g., A$, AX$, A3$)

VARIABLE A quantity that can assume any of a given set of values. In BASIC, a letter of the alphabet (or two), or a letter and a number assigned to a memory location than can contain any designated number (e.g., A= , AX= , A3=)

BASIC OPERATORS AND LIBRARY FUNCTIONS

Arithmetic Operators

+	addition
-	subtraction
*	multiplication
/	division
↑	exponentiation
=	equals

Order of Precedence

1. operations within parenthesis are performed first.
   . if more than one pair of parentheses - expression is evaluated left to right.
   . if parentheses are nested - innermost is evaluated first
2. exponentiation
3. unary minus

*4. multiplication
*4 division
5. addition
6. subtraction

* multiplication and division have equal weight and are evaluated left to right.

Relational Operators

<	less than
>	more than
<>	not equal (><)
<=	less than or equal to (=<)
>=	greater than or equal to (=>)
=	equal

Miscellaneous Operators

" " pairs of quotation marks are used in PRINT statements to enclose letters, numbers or characters to be printed.

, comma causes items to be printed in pre-established horizontal zones.

- . period, the decimal point
- ; semi-colon allows several printed sections to be joined together (concatenated) onto the same line.
- : colon allows placing more than one statement on a single program line.
- ( ) parentheses are used in arithmetic operations to determine the order in which mathematic operations are performed. Mathematic operations enclosed within parentheses are performed before those outside the parentheses.
- $ The $ symbol following a letter or letter/number combination is used to declare that variable to be a string variable. Information declared a string variable in a program statement must usually be enclosed in quotation marks. This is not the case with INPUT statements.
- ? question mark is an abbreviation of PRINT. When the program is listed PRINT is seen.

Mathematic Library Functions

SQR(n)	square root of any positive number (n)
SIN(A)	sine of angle A in radians (e.g., X=SIN(A))
COS(A)	cosine of angle A in radians (e.g., X=COS(A))
TAN(A)	tangent of angle A in radians (e.g., X=TAN(A))
ATN(A)	arctangent of angle A in radians (e.g., X=ATN(A))
LOG(n)	natural logarithm of any number whose value >0.
EXP(n)	natural logarithm base value raised to power (n)
ABS(n)	absolute value of a number or numeric value. (i.e., no + or - sign)
SGN(n)	sign of a number if negative, -1; if positive, 1 if 0, 0.
INT(X)	integer value of a number (rounded down to the whole number)
RND(n)	random number generator
LOG10(n)	computes value of common log (base 10) from any number > 0.

N.B. to convert angles from radians to degrees:
degrees = 57.29578 radians
to convert angles from degrees to radians:
radians = 0.0174533 degrees
to convert natural logs (LOG) to common logs (LOG10):
LOG10(X) = LOG(X) * 0.4342945

HARDWARE MANUFACTURERS

APF ELECTRONICS 444 Madison Avenue New York City, New York 10022	APF Imagination Machine
APPLE COMPUTER, Inc. 10260 Bandley Drive Cupertino, California 95014	Apple II Apple III
ATARI Inc. Computer Division 1196 Borregas Avenue Sunnydale, California	400/800
COMMODORE BUSINESS MACHINES Inc. Computer Systems Division 681 Moore Road King of Prussia, Pennsylvania 19406	PET
HITACHI SALES CORP OF AMERICA 401 West Artesia Blvd. Comptom, California 90220	HITACHI
MATELL, Inc. 5150 W. Rosecrans Avenue Hawthorne, California 90250	Intellivision
NEC AMERICA, Inc. 1401 Estes Avenue Elk Grove, Illinois 60007	NEC
OHIO SCIENTIFIC 1333 South Chillicothe Road Aurora, Ohio 44202	Challenger
RADIO SHACK 1300 One Tandy Center Fort Wort, Texas 76102	TRS-80
SINCLAIR RESEARCH Ltd. 50 Stamford Street Boston, Mass. 02114	ZX-80
TEXAS INSTRUMENTS, Inc. Personal Computer Division Post Office Box #53 Lubbock, Texas 79408	TI

SOFTWARE PUBLISHERS AND/OR SUPPLIERS

Computronics, Inc. 50 N. Pascack Road Spring Valley, New York 10977 800-431-2818	Business & Utility
Creative Computing Software Morris Plains, New Jersey 800-631-8112	Everything
Dankins Corp. Post Office Box #21187 Denver, Colorado 80221 800-525-0463	Business & Utility
Dyna Corp. 1427 Monroe Avenue Rochester, New York 14618	
Edu-Ware 22222 Sherman Way Canoga Park, California 91303	Educational
Krell Software Corp. 21 Milbrook Drive Stony Brook, New York 11790	Examination Prep. Games
Lifeboat Associates 1651 Third Avenue New York City, New York 10028	Business Word Processing
Microsoft Computer Products 400 108 Avenue, N.E. Bellevue, Washington 98004	Utilities
MUSE Software 300 North Charles Street Baltimore, Maryland 21201	Word Processing General

BOOKS ON BASIC

Coan, James S. BASIC BASIC: An Introduction to Computer Programming in BASIC Language (2 ed). Haden Book Co. Rochelle Park, New Jersey.

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Schoman, Kenneth E.,Jr. THE BASIC WORKBOOK: Creative Techniques for Beginning Programmers. Hayden Book Co. Rochelle Park, New Jersey.

Simon, David E. BASIC FROM THE GROUND UP. Hayden Book Co., Rochelle Park, New Jersey.

Smith, Robert E., DISCOVERING BASIC: A Problem Solving Approach. Hayden Book Co., Rochelle Park, New Jersey.

Spencer, Donald, COMPUTER DICTIONARY. Camelot Publishing Co., Ormond Beach, Florida

Walter, Russ, THE SECRET GUIDES TO COMPUTERS (in 6 parts) (soft covered and extremely useful, complete set is only $ 16.25). Author/Publisher: 92 St. Botolph Street, Boston, Mass.

READABLE PERSONAL COMPUTING PERIODICALS

APPLE ORCHARD — Shared experiences
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Post Office Box # 976
Daly City, California 94017

Call A.P.P.L.E. — Slightly more complex Shared experiences
Apple Pugetsound Program Library Exchange
304 Main Avenue South - Suite 300
Renton, Washington 98055

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800-631-8112

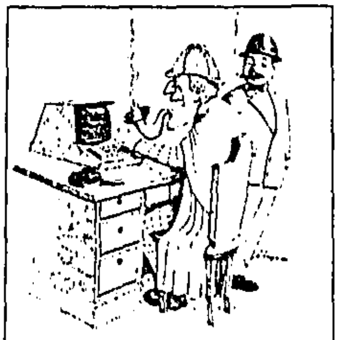
NIBBLE: The Reference for Apple Computing
Micro-Sparc, Inc.
Post Office Box # 325
Lincoln, Mass. 01773

ON COMPUTING
70 Main Street
Peterborough, New Hampshire 03458

PERSONAL COMPUTING — *** Highly Recommended
50 Essex Street
Rochelle Park, New Jersey 07662

RECREATIONAL COMPUTING
People's Computer Company
1263 El Camino Real, Box E
Menlo Park, California 94025

SOFTSIDE — Many program listings
6 Saith Street
Milford, New Hampshire 03055



"Basic, my dear Watson, Basic!"

Comparison of Basics

● means the feature is in this BASIC.

	ATARI	APPLE INTEGER	APPLESOFT	EXIDY	TRS 80 LEVEL I	TRS 80 LEVEL II	TRS 80 DOS	PET
BASICALLY BASIC								
VARIABLES								
NAMES								
Long Names	●	●						
Short Names			●	●	●	●	●	●
TYPES-NUMERIC								
Integer		●	●	●		●	●	●
Floating Point	●		●	●	●	●	●	●
Double precision						●	●	
TYPES-STRING								
DEC Style			●	●		●	●	●
HP Style	●	●						
TYPE DECLARATIONS								
DEFINT						●	●	
DEFSNG						●	●	
DEFDBL						●	●	
DEFSTR						●	●	
ARRAYS								
DIM	●	●	●	●		●	●	●
Numeric	●	●	●	●		●	●	●
String			●	●		●	●	●
INITIALIZATION								
Set to Ø or null			●	●		●	●	●
Memory trash					●			
Unknown	●	●						
ARITHMETIC								
COMPUTATION								
Binary Float point			●	●	●	●	●	●
16 bit integer		●	●	●		●	●	●
BCD Float point	●							
ASSIGNMENT								
LET	●	●	●	●	●	●	●	●
MID$ on left							●	
OPERATORS								
Arithmetic (^/+-etc)	●	●	●	●	●	●	●	●
Relational (gt, lt, etc)	●	●	●	●	●	●	●	●
Logical (AND, OR, NOT)	●	●	●	●	●	●	●	●
Boolean	●	●			●			
16 bits			●	●		●	●	●
String relational	●	●	●	●		●	●	●
Concatenation	●	●	●	●		●	●	●
FUNCTIONS								
ARITHMETIC								
ABS	●	●	●	●	●	●	●	●
EXP	●		●	●		●	●	●
FIX						●	●	
INT	●		●	●	●	●	●	●
LOG	●		●	●		●	●	●
LN	●							
MOD		●						
RND	●	●	●	●	●	●	●	●
RANDOM						●	●	
SGN	●	●	●	●		●	●	●
SQR	●		●	●		●	●	●
TRIGNOMETRIC								
DEG	●							
RAD	●							
ATN	●		●	●		●	●	●
COS	●		●	●		●	●	●
SIN	●		●	●		●	●	●
TAN			●	●		●	●	●

	ATARI	APPLE INTEGER	APPLESOFT	EXIDY	TRS 80 LEVEL I	TRS 80 LEVEL II	TRS 80 DOS	PET
STRING								
ASC	●	●	●	●		●	●	●
CHR$	●		●	●		●	●	●
INSTR							●	
LEFT$			●	●		●	●	●
LEN	●	●	●	●		●	●	●
MID$			●	●		●	●	●
RIGHT$			●	●		●	●	●
STRING$						●	●	
STR$	●		●	●		●	●	●
VAL	●		●	●		●	●	●
OTHERS								
DEF_FN			●	●			●	●
FRE	●		●	●		●	●	●
MEM					●	●	●	
TI								●
TI$								●
TIME$							●	
CONTROL OF PGM FLOW								
BRANCHES								
GOTO	●	●	●	●	●	●	●	●
IF-THEN	●	●	●	●	●	●	●	●
ELSE						●	●	
ON-GOTO	●		●	●		●	●	●
SUBROUTINES								
GOSUB	●	●	●	●	●	●	●	●
RETURN	●	●	●	●	●	●	●	●
POP	●	●	●					
ON-GOSUB	●		●	●		●	●	●
LOOPS								
FOR	●	●	●	●	●	●	●	●
NEXT	●	●	●	●	●	●	●	●
STEP	●	●	●	●	●	●	●	●
OTHER								
END	●	●	●	●	●	●	●	●
STOP	●		●	●	●	●	●	●
REM	●	●	●	●	●	●	●	●
INPUT / OUTPUT								
INTERNAL								
DATA	●		●	●	●	●	●	●
READ	●		●	●	●	●	●	●
RESTORE	●		●	●	●	●	●	●
KEYBOARD								
GET			●					●
INKEY$						●	●	
INPUT	●	●	●	●	●	●	●	●
LINE INPUT							●	
TO SCREEN								
PRINTING								
PRINT	●	●	●	●	●	●	●	●
PRINT AT, @					●	●	●	
PRINT USING						●	●	
SPEED			●					
NULL				●				
TABULATION								
HTAB			●					
VTAB		●	●					
POS			●	●		●	●	●
SPC			●	●				●
TAB			●	●	●	●	●	●
MODES, MOTION								
Cursor Movements	●	●	●	●		●	●	●
CLS					●	●	●	
HOME			●					
FLASH			●					
INVERSE			●					
NORMAL			●					
TEXT		●	●					

	ATARI	APPLE INTEGER	APPLESOFT	EXIDY	TRS 80 LEVEL I	TRS 80 LEVEL II	TRS 80 DOS	PET
FILES								
GENERAL								
CLOSE	●						●	●
CMD								●
GET#								●
INPUT#	●				●	●	●	●
OPEN	●						●	●
PRINT#	●				●	●	●	●
STATUS	●							
STORE			●					
RECALL			●					
DISC								
Type Conversions								
CVD							●	
CVI							●	
CVS							●	
CDBL						●	●	
CINT						●	●	
CSNG						●	●	
MKD$							●	
MKI$							●	
MKS$							●	
Pointers								
EOF							●	
KILL							●	
LOC							●	
LOF							●	
NOTE	●							
POINT	●							
XIO	●							
Data Xfers								
FIELD							●	
GET	●						●	
PUT	●							
LSET							●	
RSET							●	
COMMANDS								
PROGRAM CONTROL								
CLEAR			●	●		●	●	
CLEAR n				●		●	●	
CLR	●	●						●
CON		●						
CONT	●		●	●	●	●	●	●
NEW	●	●	●	●	●	●	●	●
RUN	●	●	●	●	●	●	●	●
DISPLAY								
LIST	●	●	●	●	●	●	●	●
LLIST						●	●	
LPRINT	●					●	●	
OFF-LINE STORE								
CLOAD	●			●	●	●	●	
CLOAD?						●	●	
CSAVE	●			●	●	●	●	
ENTER	●							
LOAD	●	●	●					●
MERGE							●	
SAVE	●	●	●					●
VERIFY								●
EXITING								
BYE	●			●				
DOS	●							
EDITING								
Abbreviations	●				●			●
AUTO		●				●	●	
DEL		●	●					
DELETE						●	●	
EDIT						●	●	
MAN		●						
Multistatement Lines		●	●	●	●	●	●	●
Screen Editor	●							●
Line Editor		●	●			●	●	
DEBUGGING AIDS								
Direct Mode	●	●	●	●	●	●	●	●
DSP		●						
NO DSP		●						
TRACE		●	●					
NO TRACE		●	●					
TRON						●	●	
TROFF						●	●	

	ATARI	APPLE INTEGER	APPLESOFT	EXIDY	TRS 80 LEVEL I	TRS 80 LEVEL II	TRS 80 DOS	PET
ERRORS								
MESSAGES								
English		●	●					●
Cryptic	●			●	●	●	●	
TRAPS								
ON ERR GOTO			●			●	●	
RESUME			●			●	●	
TRAP	●							
ERR						●	●	
ERROR #						●	●	
ERL						●	●	
NOT SO BASIC								
MACHINE LANGUAGE HOOKS								
CALL		●	●					
SYS								
SYSTEM								●
USR	●		●	●		●	●	●
ADR	●							
VARPTR						●	●	
WAIT			●	●				●
DEFUSR							●	
HIMEM		●	●					
LOMEM		●	●					
INP				●		●	●	
OUT				●		●	●	
IN#		●	●					
PR#		●	●					
PEEK	●	●	●	●		●	●	●
POKE	●	●	●	●		●	●	●
GRAPHICS								
DIRECT CONTROL								
PEEK/POKE		●		●		●	●	●
ROM ROUTINES		●						
DISPLAY MODES								
GR		●	●					
GRAPHICS	●							
HGR			●					
HGR 2			●					
COLORS								
COLOR	●	●	●					
SETCOLOR	●							
HCOLOR								
DRAWING								
HLIN		●	●					
VLIN		●	●					
PLOT	●	●	●					
HPLOT			●					
HPLOT TO			●					
DRAW TO	●							
DRAW AT			●					
XDRAW			●					
ROT			●					
SCALE			●					
SHLOAD			●					
SET					●	●	●	
RESET					●	●	●	
SCREEN SENSES								
LOCATE	●							
POSITION	●							
POINT					●	●	●	
SOUND								
PEEK/POKE		●	●					●
Additional hardware								●
SOUND	●							
SENSING THE WORLD								
PEEK/POKE + hardware								●
PADDLE	●							
PTRIG	●							
PDL		●	●					
STICK	●							
STRIG	●							

Summary of BASIC Statements

	Purpose	*Example*
1. Elementary BASIC		
READ	Reads data from data block	17 READ X, Y1, M(J + 2, 3)
DATA	Storage area for data	17 DATA −1, 2.07, 31416E − 4, 127829
PRINT	Types numbers and labels	17 PRINT "ANSWER =" X, A • B
LET	Computes and assigns value	17 LET X2 = X + Y ↑ 2
GØ TØ	Transfers control	17 GØ TØ 175
IF	Conditional transfer	17 IF T(I, J) <= 25 THEN 175
FØR	Sets up and operates a loop	17 FØR N = 10 TØ 1 STEP − 1
NEXT	Closes loop	17 NEXT N
END	Final statement in program	17 END
2. Advanced BASIC		
INPUT	Reads data from the teletype	17 INPUT X, Y4, Z
DEF	Defines a function	17 DEF FNG (X) = 2 • SIN (X) • EXP (−X)
GØSUB	Transfers to a subroutine	17 GØSUB 800
RETURN	Returns to statement following GØSUB	17 RETURN
RESTØRE	Restores data to beginning	17 RESTØRE
REM	Permits comments	17 REM BEGINNING ØF SUBRØUTINE
DIM	Declares dimensions of lists and tables	17 DIM A(12), B(3, 5)
STØP	Stops program	17 STØP
3. Matrix instructions		
MAT READ	Reads a matrix from the data block	17 MAT READ Z(M, N)
MAT PRINT	Types a vector or matrix	17 MAT PRINT A
MAT +	Matrix addition	17 MAT C = A + B
MAT −	Matrix subtraction	17 MAT C = A − B
MAT •	Matrix multiplication	17 MAT C = A • B
MAT ( ) •	Scalar multiplication	17 MAT C = (CØS (X)) • A
MAT INV	Matrix inverse	17 MAT C = INV (A)
MAT TRN	Matrix transpose	17 MAT C = TRN (A)
MAT ZER	Matrix of all zeroes	17 MAT C = ZER
MAT CØN	Matrix of all ones	17 MAT C = CØN (15)
MAT IDN	Identity matrix	17 MAT C = IDN

NOISE & HEARING CONSULTANTS OF AMERICA
159 East 69 Street - New York City - 10021 - (212) 734-8900

Baseline Report

Name: Patient J Q Age: 34 Test Date: 10-29-81 Job Code: 123
Soc. Sec. #: 123-45-6789 Sex: 1 Ear Protection: 04 Test Type: 1
Employer Code: 850 Audiometer - Make: 01 Model: 03 Ser. No: 000123
Examiner Code: 9 Date of Last Calibration: 10-15-81 Testing Method: 1

Complaints of: Tinnitus? Y Vertigo? N Pain? N Sudden Loss? N

Air Conduction Thresholds

Frequency	Right Ear	Left Ear
500 HZ	10	15
1000 HZ	20	25
2000 HZ	30	35
3000 HZ	40	45
4000 HZ	40	45
6000 HZ	30	35
8000 HZ	25	30
Pure Tone Aver.	20	25
High Freq Aver.	37	42
NIOSH % IMP.	8	15
Binaural	9	

IMPRESSIONS:

Puretone audiometric configuration is not unlike that commonly observed in patients with histories of excessive noise exposure and /or head trauma.

Code: 51

Reviewer 1

FORENSIC AUDIOLOGY ASSOCIATES
Marc B. Kramer, Ph.D.
Joan M. Armbruster, M.S.
159 East 69 Street - New York City - 10021 - (212) 734-8900

Standard Hearing Impairment Calculations

Name: John Q. Patient **Age:** 34 **Date of Evaluation:** 10-20-80

NOTE: All Audiometric Data Re: ANSI S3.6-1969 Audiometric Zero

* * * * *

( ) New York State (1981) Hearing Compensation Calculation:

RIGHT EAR = 7.5% LEFT EAR = 15% BINAURAL = 9%

( ) New Jersey (1980) Hearing Compensation Calculation:

RIGHT EAR = 0% LEFT EAR = 7.5% BINAURAL = 1%

( ) NIOSH (1972) Hearing Impairment Calculation utilized for the Federal Employees' Compensation Act and the Longshoremen's and Harbor Worker's Compensation Act:

RIGHT EAR = 7.5% LEFT EAR = 15% BINAURAL = 9%

( ) American Academy of Otolaryngology (AAO-1979) Calculation:

RIGHT EAR = 0% LEFT EAR = 7.5% BINAURAL = 1%

( ) American Academy of Ophthalmology & Otolaryngology (AAOO-1959) Calculation:

RIGHT EAR = 0% LEFT EAR = 0% BINAURAL = 0%

The following thresholds were utilized for the calculations found above:

	RIGHT EAR	LEFT EAR
500 HZ	10	15
1000 HZ	20	25
2000 HZ	30	35
3000 HZ	40	45

The thresholds utilized for these calculations (are) (are not) considered to be valid and reliable measures of this patient's true audiometric sensitivity. Therefore they (should) (should not) be utilized as a basis for scheduled compensation awards.

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signature	printed or typed	N.Y.S. Lic. No	date

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CHAPTER 12

ELECTRONIC DATA PROCESSING IN INDUSTRIAL HEARING CONSERVATION

Marc B. Kramer

CONTENTS

This chapter provides a basic orientation to electronic data processing (*EDP*) to those without previous computer experience who find that manual methods of record keeping have become too cumbersome and time consuming. Through the italicizing of new terms, readers will be introduced to the terminology of EDP and will be able to utilize this chapter as a point of departure for further investigation of this timely subject.

The chapter is divided into three parts. The first deals with the basic functions of the computer and their relationship to hearing conservation programs. The second and third pertain to the practical considerations that must be faced when exploring the actual acquisition of computer equipment and services. Illustrative examples are drawn from audiology and industrial hearing conservation applications.

COMPUTER CAPABILITIES

Operation

The primary aspect of the computer's operation that concerns us is its ability to take in data (*input function*) and retain it (*storage function*) for some form of manipulation (*arithmetic function*) for later retrieval (*output function*). The input and output functions (*I/O*) are dealt with later when considering the computer and its peripheral electronic and mechanical devices (*hardware*).

Storage of data by the computer may be thought of as a series of cells or pigeon holes, each with an arbitrary name assigned to it by a set of instructions given to the computer (*program*). For example, one can conceive of a series of seven cells, identified as "A" through "G," respectively, which would have assigned to them the values of the thresholds in the right ear for the frequencies 500 Hz through 8000 Hz (see Figure 1). Once these values have been assigned, these data can be retrieved at any time by interrogating the computer for the value of any or all of the variables. It is important to note that these values will be maintained in these storage areas until the computer is instructed to change them. For example, a subsequent instruction of "A = −5" would change the contents of cell "A" from 0 to −5.

Once data are stored in the computer, the calculating or arithmetic function plays a significant role. Someone who wanted to calculate the pure tone average for the set of data used in Figure 1 would instruct the computer to assign to cell "H" the resultant value obtained after retrieving the values assigned to "A," "B," and "C," adding them together, and dividing the sum by 3 (see Figure 2).

A slightly more complex example, but one of even more applicability, necessitates the use of the *matrix* or the *array*. In the two-dimensional array found in Figure 3 the columns can be assigned alphabetic variable notations, and the rows can be assigned numeric subscripts. Each cell can thereafter be identified by a combination of a column and row designation. In this example, row 1 can be the baseline audiometric values for the right ear, and row 2 can be assigned the values for the first annual retest. Program instructions can then be issued to subtract the threshold values in row 1 from the corresponding threshold values in row 2. The resulting values are then assigned to their respective cells in row 5.

Location	A	B	C	D	E	F	G
Value	00	10	15	40	45	35	30
Represents	500	1K	2K	3K	4K	6K	8K

Right Ear

Figure 1. Hypothetical model of the manner in which threshold values are assigned to variable locations in a computer.

Location	A	B	C	D	E	F	G	H
Value	00	10	15	40	45	35	30	(8.3)
Represents	500	1K	2K	3K	4K	6K	8K	(PTA)

Right Ear

$$H = (A + B + C) / 3$$

Figure 2. Hypothetical model of the manner in which the pure tone average is calculated and assigned to a variable location in the computer.

Figure 4 demonstrates the most basic form of decision making in *FØRTRAN*, *BASIC*, and several other programming languages; this form is called the *conditional branching*. In essence the computer is asked to compare some variable value against a predetermined value. If a given logical condition is met, the computer is directed to follow one programming route; if not, it follows another. This example utilizes the "significant shift" formula that has been proposed by the Department of Labor and is under consideration at the time of writing of this chapter, as well as a segment of a FØRTRAN program that contains the required logical *if* statement.

Line by line examination of the program segment reveals that in the first line the average loss /I(5)/ is computed by adding the shift at 2 kHz /C(5)/, the shift at 3kHz /D(5)/, and the shift at 4 kHz /E(5)/, and then dividing the sum by 3. Utilizing the data from the last example, the value for I(5) would be 3.3. The second line of the program segment compares

	500	1K	2K	3K	4K	6K	8K	PTA
	A	B	C	D	E	F	G	H
1. BASELINE	00	10	15	40	45	35	30	8.3
2. ANNUAL	00	15	15	40	55	40	25	10
3.								
4.								
5. DIFFERENCE	(00)	(05)	(00)	(00)	(10)	(05)	(−5)	1.7

Figure 3. Two-dimensional array for recording annual audiometric test data and calculating threshold shifts.

$$\text{AVERAGE LOSS (OSHA)} = \frac{\text{SHIFT (2000 Hz)} + \text{SHIFT (3000 Hz)} + \text{SHIFT (4000 Hz)}}{3}$$

```
      I(5) = (C(5) + D(5) + E(5)) / 3
      IF (I(5). GT. 10) GOTO 99
      WRITE (6,2)
  2   FORMAT ('SHIFT IS INSIGNIFICANT BY OSHA STANDARDS')
      GOTO 100
 99   WRITE (6,3)
  3   FORMAT ('A SIGNIFICANT SHIFT HAS OCCURRED BY OSHA STANDARDS')
100   END
```

Figure 4. FØRTRAN program segment demonstrating the use of the logical decision-making process.

the present value of I(5) to 10. If this value is "greater than" 10, the next instruction the computer will follow is on the line numbered 99. If it is not, the computer follows the instruction that is given in the third line. Since 3.3 is not greater than 10, the program does continue onto the third line where it is instructed to *write* or print the literal message which appears within the quotation marks on the line numbered 2. Having completed this instruction, the computer is directed to the line numbered 100, thereby skipping an improper write statement on the line numbered 99. If, on the other hand, the value of I(5) were 23, the route from the *if* statement would be different. The three lines following the second line would be skipped, with the next step being the line numbered 99, where the computer is instructed to write the literal message which appears within the quotation marks on the line numbered 3. The next line in the sequence is the line numbered 100, which is the *end* of this program segment.

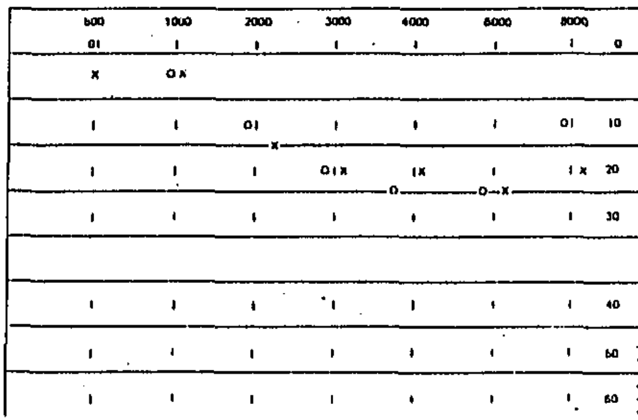
Application

Utilizing these basic computer functions, the industrial audiologist can expand the role of the computer to numerous aspects of the hearing conservation program. Second only to the record keeping potentials of EDP, the arithmetic capabilities of the computer play a critical role in the management of the hearing conservation program. Since the goal is to be effective in preventing loss of hearing sensitivity, analysis of data generated by monitoring audiometry is essential to the evaluation of the efficacy of the program. Computer programs (*software*) can be obtained in the form of commercially available statistical packages, or they can be customized by a programmer. Obvious applications include the use of descriptive and/or inferential statistics to analyze relationships between two or more parameters of the hearing conservation program. These might include level of exposure and hearing loss, length of exposure and audiometric configuration, or specific ear protectors in use and degree of hearing sensitivity shift. Significant variations in the degree of loss suffered by a specific individual relative to that suffered by an entire group with similar exposures could also be determined. More sophisticated programming could provide an analysis of a series of periodic audiograms obtained from the same patient. Such an analysis could evaluate the presence or absence of a monotonic pattern in the loss of sensitivity over the years, with acceptable deviations from this pattern accounting for test-retest variations included in the program.

The arithmetic capabilities of the computer can be utilized in conjunction with its logical decision-making features. In Figure 5, the bottom line of the computer-generated audiometric record illustrates a statement that has been provided by the computer after the arithmetic process of determining change in threshold preceded the comparison against the predetermined standard. Since the computer can be programmed to ascertain if a series of conditions are met simultaneously, it is possible to analyze the audiometric record taking into consideration such factors as age, sex, exposure history, otologic history, etc. Trial data taken from actual industrial programs that were processed utilizing such strategies (*algorithms*) prepared by this author revealed agreement with manual examination methods in approximately 95% to 98% of the cases. While a gross grouping of configuration types may be useful under certain circumstances, this author believes that the evaluation of audiograms should continue to be done by a professional on a record by record basis.

The computer-generated audiometric record shown in Figure 5 also shows many other features that can be programmed into EDP record keeping systems. Federal Occupational Safety and Health Administration (OSHA) regulations presently under consideration would require that each test record contain no less than 22 separate pieces of information (*data points*). Ten of these deal with the identification of the employee, the test equipment, and the tester, while the other twelve are the test thresholds. The figure illustrates how one particular program takes this basic information and presents it in a convenient format along with indicators that have been generated by arithmetic calculations, as the pure tone average and percentage hearing impairment. The early loss

EMPLOYEE A   BIRTH: 3 – 7 – 48   TEST DATE: 7 – 10 – 77   JOB CODE: 123   PROTECTOR: 9   TEST: ( )BASELINE (X) ANNUAL ( ) RETEST
123 – 45 – 6789   XYZ   G/S   1703   0070   CAL: JULY 4, 1977   EXAMINER: 9   EVALUATOR: DR. M. B. KRAMER



AIR CONDUCTION THRESHOLDS

FREQUENCY	RIGHT EAR	LEFT EAR
500	0	5
1000	5	5
2000	10	15
3000	20	20
4000	25	20
6000	25	25
8000	15	20

PURE TONE AVERAGE

RIGHT EAR = 5   LEFT EAR = 8

AAOO – 1959 PERCENTAGE HEARING IMPAIRMENT

	RIGHT EAR • 0% LEFT EAR • 0% BINAURAL • 0%
| | | | | | | 70	
| | | | | | | 80	
| | | | | | | 80	

N. S. C. EARLY LOSS INDEX: CODE D – SUSPECT NOISE INDUCED HEARING LOSS

COMMENTS: 03 – HEARING SENSITIVITY IS APPARENTLY WITHIN GENERALLY ACCEPTED LIMITS, BILATERALLY – ALTHOUGH SOME INDICATION OF A HIGH FREQUENCY NOTCH – NOT UNLIKE THAT CAUSED BY NOISE EXPOSURE OR HEAD TRAUMA.

COMPARISON WITH BASELINE TEST

TEST	DATE	RIGHT EAR							LEFT EAR							
		.5	1K	2K	3K	4K	6K	8K	.5	1K	2K	3K	4K	6K	8K	TYPE
BASELINE	7 10 76	0	5	5	10	0	5	0	5	10	5	5	10	10	5	AUTO
CURRENT	7 10 77	0	5	10	20	25	25	15	5	5	15	20	20	25	20	AUTO
CHANGE		0	0	5	10	25	20	15	0	–5	10	15	10	15	15	

* * * CHANGE EXCEEDS THE PROPOSED OSHA REGULATIONS FOR SIGNIFICANT SHIFT * * *

Figure 5. Computer-generated employee test report. (Courtesy of Noise & Hearing Consultants of America, Inc.)

index (ELI), which was developed by the National Safety Council and takes into account the employee's age, sex, and threshold at 4000 Hz in the poorer ear, had been added to this program at clients' request. The integration of these three ELI factors and their assessment against the index is carried out by the program.

The comments found directly below the ELI are not generated through a computer-based decision-making process. A series of descriptive statements have been formulated, coded, and supplied to the computer. The audiologist who evaluates the raw audiogram selects the most appropriate statement for the given audiogram and then provides its code to the computer as a data point in the employee's record.

Other hearing conservation program management applications of the computer become apparent. Since testing is usually done annually, a list can be printed of all employees who are due for their annual tests each month. In addition, the computer is capable of preparing lists of employees who have significant shifts of hearing sensitivity, or whose pure tone configurations call attention to themselves. When necessary, the computer can retrieve all of the audiograms of a particular employee, or group of employees, and, as previously described, evaluate the progression of the employee's loss. The applications are limited only by the user's own ingenuity and understanding of EDP capabilities.

For many reading this chapter, the storage function of the computer is its most important asset. Manual operations required to retrieve employee files, enter new data, make mathematical comparisons, list those who have failed the criteria for acceptable hearing, etc., have become cumbersome and costly operations.

As mentioned earlier, certain federal rules under consideration required at least 22 data points per individual audiogram (*record*). A person who tested 300 employees in a factory every year for 20 years (or 600 for 10 years) would have over ¼-million data points. As the amount of data in these files grows quite rapidly, consideration should be given to EDP techniques when the number of employees tested annually approaches the range of 150 to 200. It is at about this point that the time and expense of "hands-on" manual manipulation exceeds the costs of some EDP processing.

ELECTRONIC DATA PROCESSING SYSTEMS

Since programming software is described in the preceding section, this section deals with the actual computer itself and its peripheral electronic and mechanical hardware. Figure 6 illustrates the several elements that

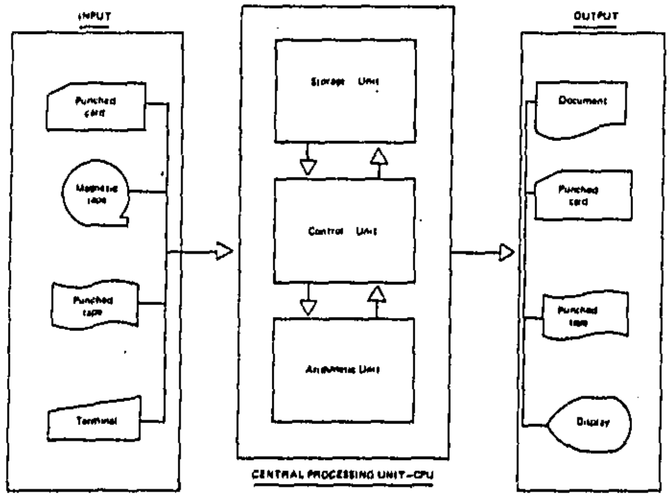


Figure 6. Block diagram of typical EDP system.

EDP systems have in common. These include some input device, the central processing unit (*CPU*), and some output device. The CPU can be further broken down into three interacting functional units: the storage unit, the control unit, and the arithmetic unit. The CPU is that part of the system usually thought of as the computer itself, or the "brain." The functional subdivisions operate interdependently to process the programs and data which are provided to them. The function of the storage unit is to store information that is provided to the computer in the form of a set of instructions (*program*) or data. This information is maintained there until it is retrieved (*called-up*) for manipulation (*processing*), or directed to the output device. This retrieval from the storage unit directs the operation of the CPU by taking the program steps found in the storage unit and following (*executing*) them as directed. Data are taken from storage by the control unit in the same manner. Depending upon the program instructions, the control unit can utilize the functional operations of the arithmetic unit which performs all of the mathematical functions as well as making comparisons and logical decisions. Finally, the control unit returns processed data to the storage unit or directs it to some output device. While the operating characteristics of the CPU are primarily in the domain of the systems analyst and the programmer, the input and output devices are very much of interest to the industrial audiologist.

Users of any EDP system are concerned with the manner in which they are going to get their data into the computer. Starting with the original audiogram (*source document*), one must decide what is the most efficient method of getting the information into the computer for processing. Often this decision will depend upon the type of input device that is available on the particular EDP system one anticipates using. At other times the decision will depend upon the proximity of the user to the computer itself. At still other times, the programming language utilized will restrict the options available with respect to the format of the data and the device that can be used. Notwithstanding these possible obstacles, several widely used devices are described along with some of their respective advantages and disadvantages. The discussion deals with the input and output devices and their modes of operation, making the assumption that the software necessary to process the data is already available in storage.

Input Devices

A factor which must always be borne in mind when considering I/O devices relates to their relative intimacy with the CPU. Input devices which communicate directly with the CPU, such as punched card and punched paper tape readers, and various types of teletype terminals, are considered to be *on-line* devices because the operational function relates directly to the ongoing operation of the computer. Peripherals which operate independently, such as card and paper tape punches, and key-to-disk systems, are called *off-line* devices. Similar distinctions are made regarding output devices. For example, line printers can be operated on-line directly from the CPU, or off-line coming from magnetic tape produced by the CPU as output. In EDP, to borrow an old phrase, "Time is money." The CPU is the most expensive component of the processing system, and therefore consideration should be given to the most economic methods of on-line I/O functions, with time-consuming processes for program and data preparation and printing handled on an off-line basis.

Punched Cards The oldest and most common form of computer input device is the punched card. This format was originally developed by Hollerith in 1880, and consequently bears his name. This familiar piece of cardboard, 7⅜ inches long and 3¼ inches wide, has 80 columns in which data, either in alphabetic or numeric (*alphanumeric*), can be punched. The punched card's finite size (limited to 80 columns) makes it suitable for use as a *unit record*, meaning that one card has all of the information for a single unit of information. In terms of its use in a hearing conservation program, the unit record includes all of the identifying information as well as the audiometric data from a single employee's audiogram. This unit record concept is especially useful when transfering information from the source document to the input media since any error in a particular unit record can be corrected simply by preparing a new card. The use of punched cards obviously necessitates the use of a keypunch machine, whose operation is essentially not unlike that of an electric typewriter. The cardboard punched card is favored by many users because of one's ready access to interpretation of the material punched upon it, since most key punch machines not only punch holes in the card but also print the corresponding characters. Punched cards can also be sorted utilizing mechanical or electromechanical sorting machines. This is useful when one wants to tabulate the frequencies of occurrences in certain data columns on the cards (*fields*). Such counts may include the proportion of each type of hearing protector used, number of employees tested on each date, number of employees in each diagnostic category, etc. When stored under proper environmental conditions, the punched card is excellent documentation for future use and reference.

Adding to the utility of this input format are the facilities on the key punch machine itself. They make it possible to tabulate the columns on the card much like on a typewriter, along with the capability of duplicating fields of recurring data from the previous card.

Major drawbacks to the use of the punched card relate to its bulkiness when utilized in sizable numbers and the relatively slow speed with which it is prepared and processed. The time consumed in its preparation will depend primarily upon the number of punches on each card. Punching can take place at about the same rate as typing in the hands of an experienced keypunch machine operator. Once the cards have been prepared, the typical card reader is capable of reading data from the cards at a rate of approximately 1300 characters per second. Needless to say, the punched card may not be reused for different data, so that the cost of the card itself must be considered when anticipating its use.

Paper Tapes Paper tape is another medium commonly used for EDP. Since it is continuous, and not limited to a finite number of data fields or columns like the punch card, it is not suited for unit record formats. Paper tape is relatively inexpensive to use (again, not reusable for new data) but quite difficult to edit when entry errors are made. While the keyboards for the card punch and the paper tape punch are very similar, the paper tape cannot be formated in the manner that was described for the card punch, nor can the format be tabulated like the keypunch. In addition there are no symbols printed onto the paper tape itself, although a copy is often provided on a separate listing as the tape is punched. As with the punched card, the paper tape can be prepared at rates roughly equivalent to typing speeds on one of the slower electric typewriters. The paper tape is read by its input device at a rate significantly slower than the average card reader, typical rates being approximately 500 characters per second. Because of its continuity of format and the lack of direct printing, it is extremely difficult to find a specific record on the paper tape itself. Therefore, correction of entry errors must be made in special editing routines after the tape has been read into the computer.

Teletype Terminals A third type of device for the entry of input data is the teletype style of terminal. This form of entry has become more common along with the increased popularity of mini- and microcomputers. The design of these on-line systems very often utilize languages which are *interactive* with the user. An example of this approach would be the software that would have a question printed on the terminal by the computer, such as, "SOCIAL SECURITY NUMBER ? . . . .", and wait for a response to be entered by the user at the keyboard. Entry of data in this manner is extremely slow, limited by the speed of the typing of the user, the typing speed of the teletype printer itself (usually 10 characters per second), and the time needed for the computer to respond. When a printed copy (*hard copy*) of the input is not required, terminals that utilize cathode ray tube (*CRT*) screens may be utilized. The transient copy (*soft copy*) that appears on the screen appears there much more rapidly because its operation is entirely electronic, without time-consuming mechanical printing mechanisms. The specific roles that terminals play in modern EDP are further discussed in the section that deals with the acquisition of EDP services.

Magnetic Tapes and Disks Devices which enter data directly onto a magnetic material which is compatible with the computer is still another category. Utilizing a standard keyboard, the information is electronically encoded onto magnetic tape or onto a magnetic disk. The magnetic tape may be in a reel to reel or cassette configuration. Magnetic disks are usually in the form of large computer disk packages and, more recently, on small vinyl-based disks which look very much like the common 45 rpm phonograph record, and because of their pliable form, are called *floppy-disks*. Systems that encode materials directly onto magnetic media rather than using intermediaries such as punched cards or punched paper tape are commonly called *key-to-disk* or *key-to-tape* devices.

Other Devices Modalities that make it possible to utilize the source document itself as input for the computer may also be found to be extremely useful in some applications. Included in this category are the mark-sensing devices, magnetic ink readers, and optical character readers (*OCR*). The mark-sensing device is probably the best known to the student, because this is the method used for the administration of "computer-graded" examinations. The locations of areas marked with graphite material from #2 pencils are sensed by the reader and converted to the appropriate coding on magnetic tape for introduction to the computer. Since this method would obviate the need for an intermediate step in the preparation of data for input, this would appear to be a significant saver of time and labor in an industrial hearing conservation program. Unfortunately, this method is more expensive in terms of the specially printed forms themselves and the instrumentation needed to read them. In addition, the system itself often lacks adequate reliability because of errors created through the sensing of stray marks, smudged forms, user errors, etc.

Magnetic ink readers are capable of reading materials printed in specially formulated magnetic inks. Several type faces or fonts have been developed for "machine reading." Coded information at the bottom of bank cheques is a good example of the use of this process. The optical character reader is the most advanced device in this category. It is able to identify a wide variety of hand-written characters, as well as typed and printed materials. Devices are currently under development to read script entries, and ultimately this might become one of the optimal forms of data entry for hearing conservation programs.

Audiologic Adaptations Direct or indirect communication between two electronic devices, the audiometer and the computer, with as little intervention as possible is obviously a very desirable goal. Since the early days of military audiology, attempts have been made to link the audiometer to the computer. An audiometer developed by the U.S. Air Force produced standard punched cards with the test results punched upon them. This was possible by adding logic circuits to the basic automatic audiometer design of the day, and having it determine a logical threshold based upon the average of the trace excursions at each frequency. When this threshold was determined it was punched onto the card. While interest in this type of instrumentation waned over the years, the automatic audiometer itself was continually refined.

Two primary approaches in automatic audiometry are being made at present, the data cassette and on-line processing. The data cassette uses a rationale that is similar to the early Air Force audiometer in that the outcome of the automatic audiometry is electronically recorded onto a magnetic tape cassette. Provisions are made to enter the appropriate identifying information electronically along with the thresholds. The cassette can then be forwarded to a central location point for processing by computer.

On-line processing implies that the automatic audiometer is connected directly to the computer, and is continually feeding in data from tests in progress. In addition to this direct data input, the process gives the audiologist the advantage of having immediate access to a comparison of the present test with that of the baseline data stored in the computer. On-the-spot decisions could be made based upon shifts in hearing sensitivity and observed audiometric configurations. As discussed in the final section, in many configurations one computer is quite capable of having many audiometers feeding and requesting information at virtually the same time.

Summary Many formats are available for inputing data into the computer. They range from machine reading of hand-written materials to direct interaction from machine to machine. Each method has its advantages and disadvantages, most of which are related to speed, efficiency, and cost. One must also consider human intervention factors such as time, training, and prerequisite skills, as well as the availability of specific peripherals to the user. Other factors to note in the choice of input devices are the need for hard copy of input data, anticipated editing, plans for retention and storage of source documents, and the original input data.

While it would be reflected in additional costs, it is possible, in most cases, to convert input data from one form to another. For example, punched paper tape and punched card data can be converted to magnetic tape or disk and then read into the computer at much greater speeds.

All decisions pertaining to formats and devices to be utilized for the input of data should be made only after careful study of all of the factors previously mentioned, and possible consultation with a computer systems analyst.

Output Devices

Much like the great variety available in input devices, is the multiplicity of devices that are available at the computer's output.

Line Printers The line printer is the best known of all of the output devices. It prints out literal statements and the values assigned to variables in formats that are part of the program. The speed at which this is accomplished will depend upon the particular printer, but most speeds range between 200 and 1200 lines per minute. Entire report formats, as in Figure 5, can be printed out by the computer, or forms can be preprinted and the computer provides only the necessary output for each record.

While the printed output from the line printer is optimal for communication with humans, it does not provide the results of processing for further utilization (i.e., printed material cannot be directly reread by a computer). To set up computer files necessary for comparing employees' hearing tests from one year to the next, some other output device must be utilized. Magnetic media are primarily utilized for this purpose. Magnetic tapes, disks, and cassettes are utilized to *spool out* the contents of the computer storage after processing has taken place. This output can now be utilized as input for subsequent processing with new data.

Punched Tapes and Cards Punched paper tape and punched cards may also be used as output media although, again, these are extremely slow modes of operation. Punched cards have the advantage of printed symbols above the punched codes, while punched paper tapes have the advantage of the continuous format.

Teletype Terminals The teletype also produces a typed copy, but at a rather puny rate of 10 characters per second. While this may at times be acceptable for data summaries, it cannot be considered for complicated formats such as that seen in Figure 5. Many teletypewriter units also have paper tape punches and readers which operate at the same rate as the printing element. These should not be confused with relatively high speed paper tape punches and readers which are available as separate peripherals for use with the computer. The terminals utilizing CRTs are able to produce output on their screens in substantially faster times than the printer terminal. Again, these are transient displays and can be retained only if a hard-copy accessory is available.

Summary As with the input devices, choices must be made regarding the output device primarily with respect to the form the user wants the output to take, and with respect to the nature of the data files that will be established. Fortunately, most computer systems have the capability of producing outputs at several different devices almost simultaneously. For example, in such systems output can be produced at a line printer with results of the present test and the comparisons against baseline tests on file at the same time that cards are being punched with information concerning threshold shifts in each patient, with a magnetic tape also being produced with updated files. Some of the decisions to make regarding output devices will be dictated by acquisition considerations discussed in the next section.

HARDWARE AND SOFTWARE

EDP necessitates two major elements, the computer and the program, or as they are termed, the hardware and the software. Since the availability of the hardware is usually the greater problem, the options open in dealing with this are described first.

Hardware

Computers come in a great variety of sizes, from models that easily fit into the pocket to multiple units that require many square feet of space and special environmental conditions, e.g., electrical services. The size of the computer needed for the management of a hearing conservation program will depend upon the programming language desired, the complexity of the program being processed, the storage demands placed upon it, and other intervening factors. The author's experience suggests that many of these programs can be processed on currently available minicomputers, and contemporary product literature suggests that the great strides now being made in the storage capabilities of the micro-computer will soon make their utilization possible.

Computers can be acquired through direct purchase. This is usually an extremely costly course of action, since the price of a full sized computer with its requisite peripheral apparatus may range from tens to hundreds of thousands and possibly millions of dollars. Substantial savings can be realized by finding a used computer that is for sale. Perusal of the price lists of several companies that sell used hardware reveals that savings can run from 20 to 90% of the original new equipment list prices. It should be noted that used equipment usually does not come guaranteed, and computer service contracts can cost hundreds and even thousands of dollars per month. It should be further noted that modern electronic technology seems to make hardware obsolete almost as soon as it is manufactured. The physical size of the unit becomes smaller, even while the power and the capabilities become greater, and even the prices are declining in some areas. If one still wants to have his or her own computer, the other alternative is to lease one. While this method reduces the initial outlay of one's capital against a direct purchase, and divides it over monthly or annual payments, lease costs are generally substantially higher than bank business loan interest rates.

Unless a very large volume is being continuously processed, the use of someone else's computer is usually a less costly route to follow. Three major categories are usually found when using a computer that is not one's own. First is the rental of computer time, where one provides all of the software, including the program and the data, to the supplier and is charged for the actual time taken to process the *run* from input through the output. The processing of the run is scheduled with those of other users, often this is referred to as *batch-runs*, because runs of various users are batched together for system economy. The second type of service availability is called the *service bureau*, where the program has been written for the customer and possibly for other similar users. In this case, one supplies the data (either as source documents or in some computer ready form) and is billed for the number of records that are processed.

The third option, which is gaining increasing popularity, is called *time-sharing*. The availability of this type of processing relates to the amazing speed at which the computer operates. In essence, a multiplexer makes it possible for the computer to process the programs of many users at virtually the same time. This method is particularly suited to operations where there is a constant updating of data files and a need for immediate access to data in the computer. With such a system, the computer is always available, but now it becomes necessary to have some way to communicate with it. This means the acquisition of a teletype terminal, punched card reader, or punched paper tape reader at one's location. If it is desirable to have a substantial number of print-outs readily available, rather than having them forwarded from the central processing point, it will also be necessary to acquire a line printer.

Costs for time-sharing usage vary greatly. In general, there are separate charges for at least three different aspects of their services. First, the hook-up or connection time, which is the actual time that one is connected to the system through telephone lines each month. (This does not include the price of the telephone service itself or the special data-set adapter that one must rent from the telephone company.) Since this time includes the time consumed entering data and printing outputs, the speed of these peripherals is a very important consideration. For this reason the more preparation of data that can be performed on an off-line basis, the greater the savings in hook-up charges.

The second charge is for the CPU time or the actual amount of time the processing capabilities of the computer are used. The third charge is for storage. Since one will have a program and an increasing amount of data that must always be kept available on the system, the customer is charged for the storage space utilized in the computer. Service bureaus, mentioned before, often provide their services through time-sharing systems. Their only difference from other time-sharing systems is that they provide the software for the processing of data for which one pays an additional royalty for each record processed.

Software

The last factor to consider is the software, the program itself. Obviously the hardware is of little value without a program to process the data. Anyone who knows a computer language can write his or her own programs. This may save preparation costs, but it may also add to operational expenses if the program is not economical in terms of computer storage space and processing time requirements. Commercial programmers are available to write programs, but their fees vary so greatly that no general estimate can be suggested here. One must keep in mind that most programmers do not have any idea of what audiology or industrial hearing conservation is all about. Programmers are trained to write computer programs to solve problems that are presented to them in terms they understand. It is likely that one might have to seek out a systems analyst to act as an intermediary between the audiologist with the hearing conservation program and the programmer with the task of programming the computer to do what is needed and wanted.

To many persons who have been practicing industrial audiology and providing hearing conservation programs utilizing EDP, it becomes apparent that the greatest expense in EDP is the initial development of the software and the acquisition of some form of computer access; from that point the addition of larger data bases do not substantially increase costs. For this reason many who have operating and documented programs for industrial hearing conservation management operate as a type of service bureau for other professionals. This author feels that anyone who is processing fewer than 5000 to 10,000 records per year should consider investigating such services until increased loads justify alternative methods.

RECENT DEVELOPMENTS

During the relatively short time that elapsed between the writing of the previous portions of this chapter and the time this book was in proof stage, a development of truly significant proportions occurred relative to the availability of EDP hardware. Specifically, small microprocessing systems have become available at relatively low purchase prices, many selling for less than $1000 for basic systems. These systems are currently entering the retail market under the generic name of "home computers." It is believed that their moderate price will make these units attractive for use in both the home and in small business applications. Since the development of a large range of reasonably priced peripheral devices is anticipated for the near future, a short overview of these systems with respect to their utility in industrial hearing conservation programs will follow.

While not an insurmountable obstacle, most of the microsystems are utilizing BASIC (Beginners All-Purpose Symbolic Instruction Code) in an interactive model. The current forms of the language itself are far less efficient than other programming languages in providing the operations and output required by hearing conservation programs. It is hoped that the development of new and expanded forms of BASIC will reduce these problems. Conversely, BASIC is an extremely easy language to learn, making use of commands which take the form of English words providing clearly apparent program meaning. The fundamentals of the language can be learned in relatively little time utilizing a variety of educational techniques, with mastery achieved through advanced texts and perusal of other documented programs. Since BASIC and FORTRAN logic are quite similar, programs written in one can be converted into the other without significant difficulty.

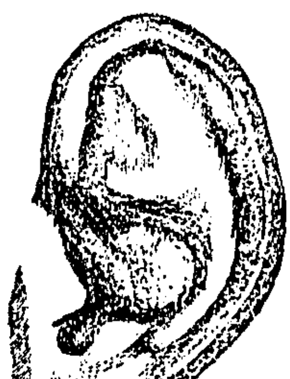
The present configuration of available basic microsystems consists of the CPU, a CRT, a keyboard, and a magnetic tape device. Obvious input and output limitations become apparent. At present, input is limited to keyboard entries directly into an executing program (*input statement* format), or as formated data into the program itself (*read-data statement* format). The simple cassette recorder that is found in many of these systems is handy for saving programs and storing data, but it lacks any utility in file management. This is a very serious problem in adapting these systems to hearing conservation programs at this time. The promise of a mini-floppy disk system that is both electronically and economically compatible with the CPU will overcome the shortcomings that the system suffers in file management.

The output that is offered is through the CRT, whose primary disadvantage is the absence of a printed document (*hard copy*). The price of the least costly line printer at the time of this writing is in excess of the cost of the basic CPU. A new unit to be offered will electrostatically copy the display from the CRT onto special paper. While the cost of this unit is less than half that of the line printer, the cost of electrostatic paper and the time needed to take images from the CRT will probably exclude it from production use at present.

Another area of primary concern is the program and data storage capabilities of the CPU itself. Many of these systems provide only 4K (4096 bytes) of random access memory (*RAM*) in their basic designs. (The programming language itself, i.e., BASIC, resides in the read only memory, *ROM*.) A memory of this size should not be expected to hold even a very modest industrial hearing conservation management program, and certainly not its incoming data. While currently available literature on these systems describes expansions up into the range of 48K of RAM, these expansions are at additional cost for both the CPU and an additional interface for its use.

So it can be seen that at present we are on the brink of a whole new era in the availability of EDP hardware at reasonable prices that can be utilized in industrial hearing conservation. It is also apparent that careful investigation of the utility of these systems must be made before one is captivated by an attractive offering price. Factors relating to input and output devices, storage capabilities, level of BASIC complexity, and costs of additional modules and interfaces must be carefully studied. The acquisition of software must also still be considered. Careful planning will go a long way in the successful utilization of an EDP operation as part of an industrial hearing conservation program.

Course Outline For Course Leading To Accreditation As An Occupational Hearing Conservationist



Course Outline For Course Leading To Accreditation As An Occupational Hearing Conservationist

This Guide is a revised edition of "Guide for Training Courses for Audiometric Technicians in Industry"-March 10, 1965. This edition was prepared by a Subcommittee and was approved by the Council for Accreditation in Occupational Hearing Conservation.

COUNCIL FOR ACCREDITATION IN OCCUPATIONAL HEARING CONSERVATION

Course Outline For Course Leading To Accreditation As An Occupational Hearing Conservationist

A. Definition of the Occupational Hearing Conservationist (Industrial Audiometric Technician): A person who can conduct a pure tone audiometric examination and other associated duties and who can function with other members of the industrial hearing conservation program.

B. The Training Program shall equip the occupational hearing conservationist with background knowledge and understanding of the following:
   1. his/her own limitations in the program
   2. his/her responsibilities as an occupational hearing conservationist
   3. the responsibilities of the others in the hearing conservation program
   4. the parameters of sound as they relate to hearing conservation
   5. basic anatomy and physiology as they relate to hearing testing
   6. the concept of compensable hearing loss and state compensation legislation
   7. the concept of the Federal Occupational Safety and Health Act legislation
   8. types of audiometric instrumentation
   9. performance check and calibration of audiometric instrumentation
      a. biological
      b. electroacoustic (in concept)
   10. care of instrumentation
   11. pure tone threshold testing techniques
   12. basics of record keeping
   13. ear protection
      a. selection
      b. fitting
   14. employee hearing conservation education
   15. principles of noise measurement and control

C. The course is not intended to prepare the occupational hearing conservationist to be a:
   1. program manager
   2. acoustical engineer
   3. audiologist
   4. instructor of other conservationists

D. This course in Occupational Hearing Conservation does not qualify an individual to perform (unless otherwise qualified):
   1. interpretation of audiograms
   2. responsibility for noise analysis
   3. diagnosing hearing problems
   4. administration of the hearing conservation program
   5. responsibility for noise control problems

E. Specific Requirements of the Course
   1. Director and coordinator of the course must be accredited by the Council for Accreditation in Occupational Hearing Conservation
   2. There should be a ratio of at least one instructor for each six registrants
   3. The ratio of audiometers to students for practicum should not exceed 1 to 3
   4. Course instructors should represent a variety of professional disciplines such as: medicine, industrial hygiene, acoustical engineering, nursing, audiology, etc.

5. The following topics shall be covered. The time allocations are minimum times with the remainder up to a minimum of 20 hours to be allocated among those other areas at the discretion of the course instructor. As it is possible that some students will not qualify for certification it is recommended that awarding of certificates *not* be included in the 20 hour curriculum.

A. **Topic:** *Hearing Conservation in Noise* (60 min.)
   a. Overview of Industrial Noise as a Problem
   b. Effects of Noise on Man
   c. Social, Economic and Legal Ramifications Including Community Noise
   d. Objectives of Training Program
      1) Valid Baseline and Monitoring Audiograms
      2) Effective Ear Protection Program
      3) Identification and Referral
      4) Employee Education Program
      5) Other Areas
   e. Responsibilities and Limitations of Occupational Hearing Conservationists

B. **Topic:** *Anatomy and Physiology of the Human Ear* (60 min.)
   a. Structure and Function—Lecture
   b. Visual Inspection of the Ear--What to look for
   c. Causes and Types of Hearing Loss

C. **Topic:** *Sound, Psychophysics and Audition* (60 min.)
   a. Parameters of Sound and Definitions
      1) Pure and Complex Signals
      2) Frequency
      3) The decibel
      4) Audiometric Standards
      5) Other Definitions--HL vs Lp, etc.

D. **Topic:** *Federal and State Industrial Noise Regulations* (60 min.)
   a. OSHA
   b. Compensation
   c. State Labor Dept.
   d. Environmental Noise

E. **Topic:** *The Audiometer* (90 min.)
   a. Description and Demonstration of Instruments
   b. Operation of the Audiometer
   c. Audiometer Performance Check
   d. Methods of Calibration
   e. Review of Terminology

F. **Topic:** *Audiometric Techniques* (60 min.)
   a. Instructions to Subject
   b. Test Procedure—Demonstration
   c. Special Situations
   d. Record Keeping
   e. Testing Environment

G. **Topic:** *The Audiogram* (30 min.)

H. **Topic:** *Review—Questions and Answers* (60 min.)

I. Topic: *Supervised Audiometric Testing* (150 min.)
   a. Automatic Audiometer
   b. Manual Audiometer
   c. Normal Hearing and Hearing Loss
   d. Audiometer—Simulator (Optional)

J. Topic: *Review of Audiometric Techniques* (60 min.)
   a. Additional Practicum

K. Topic: *Principles of Noise Analysis* (60 min.)
   a. Description of Instrumentation
   b. Procedures and Demonstration of Noise Measurement

L. Topic: *The Hearing Conservationist in the Industrial Setting* (60 min.)
   a. Responsibility to Employee
   b. Role in Plant Educational Program
   c. Role in Overall Hearing Conservation Program

M. Topic: *Personal Ear Protection* (90 min.)
   a. Attenuation Characteristics of Ear Protection
   b. Ear Muffs, Plugs
   c. Practicum in Fitting Procedures

N. Topic: *Review of Hearing Conservation Program* (60 min.)
   a. Summary of Total Program
   b. Question and Answer Period

O. Topic: *Examination* (60 min.)
   a. Practicum and Written

Films

The Sound of Sound
Hearing, It Takes Two
Noise and Its Effect on Man
The Ear and Hearing—Encyclopedia Britannica

BIBLIOGRAPHY

Guide for Conservation of Hearing in Noise (AAOO)
Industrial Noise Manual, Second Edition. Published by American Industrial Hygiene Association
Industrial Noise and Hearing Protection. Guide for Industrial Audiometric Technicians, Published and distributed by Employers Mutual Insurance of Wausau
Sataloff, J., and Michael, P.: *Hearing Conservation.* Charles C Thomas, Publishers

APPLICATION FOR CERTIFICATION AS AN OCCUPATIONAL HEARING CONSERVATIONIST

NAME (PLEASE PRINT IT AS YOU PREFER IT TO APPEAR)

First Initial Last Title/Degree Social Security No.

Home Address

City State Zip Code

Area Code — Home Phone

Business Affiliation

Work Address

City State Zip Code

Area Code — Business Phone

PLEASE INDICATE BY * WHICH IS YOUR PREFERRED ADDRESS

Profession / Occupation Degree/Job Title

Graduate of Year

City State Zip Code

SOURCE OF OCCUPATIONAL HEARING CONSERVATION TRAINING:

Place Date

Name of Course Hours Director

PLEASE COMPLETE ALL OF THE ABOVE INFORMATION

SEND COMPLETE WITH CHECK MADE IN THE AMOUNT OF $30 MADE PAYABLE TO:
COUNCIL FOR ACCREDITATION IN OCCUPATIONAL HEARING CONSERVATION

MAIL TO: Mildred A. Sittner, R.N.
1619 Chestnut Avenue
Haddon Heights, N.J. 08035

IT IS IMPORTANT THAT YOU COMPLETE ALL INFORMATION REQUESTED

1. Please identify the Course you took

   Name

   Place

   Date   Director

2. Which of the following professions were represented on faculty?

   Physician ______   Audiologist ______

   R.N. ______   Industrial Hygienist ______

   Other ________________________

3. Which of the following subjects were covered at the course? Check them off.

   a. Hearing conservation in Industry
   b. How the ear functions
   c. Physics of sound
   d. Noise measurements
   e. Audiometric technique
   f. Care and Calibration of audiometer
   g. Conservationists responsibility
   h. Audiogram interpretation
   i. Medico-legal aspects - compensation
   j. Hearing-protective devices and fitting
   k. Record keeping
   l. Lab practice on audiometers

4. How many hours did you spend doing hearing testing?

   a. 1 – 2 hours ______   c. 4 – 6 hours ______

   b. 2 – 4 hours ______   d. more than 6 hours ______

5. Who was responsible for supervising your testing? Profession?

6. What was the teacher/trainee ratio for audiometric practice?

   a. 1/1   c. 6/1
   b. 3/1   d. more than 6/1

7. How many audiometers were available?

   ________ manuals   ________ "self recording"   ________ both kinds

   a. 1 for every 2 trainees   c. 1 for every 6 trainees

   b. 1 for every 3 trainees   d. less than 1 for every 6 trainees

8. Did you have examinations?

   a. Written

   b. Oral

   c. Practical performance

9. If this was for Refresher Course, what items were covered?

10. Did the course fill your needs?

CAOHC ACCREDITING REQUIREMENTS

The Council for Accreditation in Occupational Hearing Conservation (CAOHC) accredits individuals on two levels:

(1) the occupational hearing conservationist.

(2) the course director.

The occupational hearing conservationist (OHC) is qualified to perform the following services:

(1) pure tone air conduction baseline and follow-up hearing tests on employees in industry.

(2) other closely associated responsibilities with other members of occupational hearing conservation team.

For additional information consult the Occupational Hearing Conservation Manual prepared by CAOHC.

The Course Director is the individual responsible for planning and conducting training courses for OHC's. The Director is responsible for ensuring that specific CAOHC course guidelines are carefuly followed and for determining the qualifications and competence of individual faculty members participating in the training courses.

Requirements

Specific requirements in each category which must be met for CAOHC approval are:

Occupational Hearing Conservationist: Certification by the Council is awarded following (1) successful completion of a minimum 20 hour course following the course outline developed by CAOHC which includes practical and written examinations, and (2) submission to CAOHC of application and related materials including required fees.

Course Director. The requirements which must be met for CAOHC approval include (1) completion of an application form including required fees, (2) demonstration of an adequate educational background, and (3) participation in occupational hearing conservation programs or participation as a faculty member in previous training programs.

The educational requirement may be fulfilled by individuals who currently hold or are eligible for certification by one of the certifying boards who represent the professions on the Council (the American Academy of Occupational Medicine, the American Association of Occupational Health Nurses, the American Council of Otolaryngology, the American Industrial Hygiene Association, the American Occupational Medical Association, the American Speech-Language-Hearing Association, and the National Safety Council), or are licensed to practice in one of the professions represented by the above organizations.

The experience requirement may be satisfied by individuals who provide evidence of full-time employment in an occupational hearing conservation program for a period of one year or part-time service as a consultant to industry in an area related to hearing conservation for three years.

This requirement may also be fulfilled by those individuals who have served as a faculty member in programs for training occupational hearing conservationists (audiometric technicians) which follow the guidelines approved by the Council. In this case, the applicant should have served as faculty in four separate training sessions prior to submitting application for approval as a course director. The application must be reviewed for compliance and approved by CAOHC.

Recertification

Recertification of occupational hearing conservationists is required every five years. This requirement can be met by completion of an eight hour CAOHC approved Refresher Course.

Recertification of course directors is required within 5 years of the original certification. This requirement can be met by completion of an eight hour CAOHC sponsored workshop or an equivalent course reviewed and approved by the CAOHC Board

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Report of Committee for Recertification for Course Directors

In November, 1979, an ad hoc committee was appointed and charged with exploring the advisibility of recertification for Course Directors and, if advisable, to develop proposed guidelines for this recertification. In July, 1977, CAOHC announced a shift in accrediting emphasis from professionals serving as faculty for occupational hearing conservation training programs, to the approval of Course Directors for these programs. Therefore, CAOHC's responsibility for maintaining the level of training for Occupational Hearing Conservationists certified by the Council, rests almost entirely with Course Directors. The questions of periodic recertification of Course Directors has been raised by Council on several occasions. The report of the ad hoc committee, received in May, 1980, made the following recommendations:

1. CAOHC should require periodic recertification of Course Directors and establish guidelines and course content for this recertification.

2. Course Directors should be recertified every five years, regardless of the number of courses directed prior to recertification.

3. Recertification of Course Directors should be in the form of a workshop with a minimum of eight hours of instruction.

4. The workshops should concentrate on material to be covered in the areas contained in the CAOHC Guidelines for Training Courses, new information currently available, practical, information on conducting an OHC training course and information regarding administrative structure of such courses.

5. These workshops should be offered at least once and perhaps twice, per year. For convenience, they should in conjunction with other groups such as ASHA, AAOHN, AAOM, AIHA, AOMA, etc.

6. Cost to the Course Directors for recertification should be based on actual expenses incurred by CAOHC to arrange and conduct workshops and to issue recertification.

This report was accepted by Council in the May Board meeting. A second ad hoc committee was appointed to work through the summer to establish guidelines and course content for Course Directors Workshops. This committee is to bring final recommendations to Council during the Fall Board Meeting. It is anticipated that the first Course Directors Workshop will be given in the Spring of 1981.

CAOHC

Update

SUMMER 1980 ISSUE #6

Message From The Chairman

The Board members of CAOHC are representatives of the major national professional organizations, interested in, and involved in Occupational Hearing Conservation. The unique composition of the Board provides for an excellent multi-disciplinary approach to hearing conservation problems. Even though each Board member represents a parent group, the Board as a whole needs and welcomes input from all of you who are engaged on a daily basis with the multiple facets of hearing conservation.

Tom Doyle, in his message of Spring '78 in the *Update*, stated that our new *Manual* was to be published in a looseleaf form so that corrections, additions and deletions could be facilitated. The Board members labored many hours, individually, and as a group, to produce a quality publication but we realize that changes will have to be made and we welcome your comments. It would be appropriate for you to channel your comments to the Board member who represents your parent organization so that the Board member may study your suggestions prior to the next Board meeting. Or send your suggestions on to me and I will pass them to the appropriate representative.

If CAOHC is to continue to be recognized as the official accrediting agency for Occupational Hearing Conservationists it must maintain uniform and reliable standards. This is why the CAOHC Course Directors must strictly adhere to the Course Guidelines both in topic and time allotments . . . This is also one of the reasons why the *Manual* must be fully utilized in the training of conservationists and in their future activities.

The Course Directors' Workshop which was held prior to the ASHA meeting in Atlanta (Nov. '79) was poorly attended in spite of an excellent program. It is imperative that we continue to have these workshops but without your input and support we cannot develop meaningful and valuable programs.

I truly feel that CAOHC is a very valuable and important organization. At a time when all levels of our society and government are taking a long overdue interest in hearing conservation, it is imperative that your Council maintain a strong, realistic leadership. Your involvement is essential. *GET INVOLVED!*

Donald J. Joseph, M.D.

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CAOHC update

SPRING 1981 ISSUE #7

Message From The Chairman

Due to popular request, the Council has drawn up the following guidelines for MOBILE VAN UNITS.

The following are minimum requirements for a mobile van when conducting hearing tests:

I. Ambient noise levels in the test chamber of the van must measure within OSHA and ANSI prescribed standards at each test location. Ambient readings must be *taken and documented:*
   1. each time the van is moved.
   2. at a time when the surrounding noise atmosphere is at its peak. (Example: if in or near a manufacturing facility, all equipment and/or vehicular movement scheduled for the day should be in operation at the time of measurement; e.g., maximum outside ambient exposure.)
   3. Octave band certification and calibration of the audiometer(s) must be completed and documented daily by a certified technician.
   4. The audiometric technician must be qualified to administer and validate the tests. CAOHC certification as a certified occupational hearing conservationist within the last five years and/or certification as an audiologist is required.
   5. The van service must provide (as a minimum):
      a. Analysis, interpretation and "sign off" by a qualified audiologist and/or otolaryngologist.
      b. The audiometric data generated in the testing program shall be made available to the employee in accordance with management policy.
      c. Surveillance and referral recommendation(s) must be made as appropriate to the audiogram findings.
      d. Minimum record systems and comparison data to meet legal standards must be supplied and maintained for the appropriate statutory periods.

II. Other provisions that are desirable, but not mandatory, are:
   1. an otoscopic examination.
   2. detailed print-out of comparison data and correlations.
   3. data on Workers' Compensation (by appropriate State and/or Federal standards).
   4. liaison to the test location in advance of the test date to assure compliance with all requirements.
   5. consultation service on personal hearing protection programs, medical/legal opinions on other professional matters.
   6. expert testimony for liability and/or Workers' Compensation hearings.

Donald J. Joseph, M.D.

Session

WORKERS' COMPENSATION

- Occupational Injury vs. Occupational Disease
- Hearing Loss vs. Hearing Handicap
- Factors Contributing to a Handicap
- Hearing Impairment, Hearing Handicap, Hearing Disability
- Hearing Handicap and Compensation
- Low Fence-High Fence - The Concept of Maximum Hearing Loss
- The Professional's Role in the Determination of Handicap and Compensation
- Inconsistency in Workers' Compensation Programs - Federal and State
- The Black Box - What Does It Really Cost?
- New Definitions of Hearing Handicap
- What Does Industry Want to Know About Compensation?
- The Worker's Impression of a Handicap

* * * * * *

Noise induced hearing loss—how much is it worth?

By Junius C. McElveen, Jr., JD

Since the topic of workers' compensation for noise-induced hearing loss was last discussed in this publication in 1977 (Vol. 28, No. 3, pages 14-15, 18), the landscape of this rapidly developing area of the law has changed dramatically. The purpose of this article will be to discuss some of these recent developments and to suggest some areas in which hearing health professionals can help policymakers deal with the issue of how hearing loss should be compensated.

Although rules fixing the amount of compensation allowable for a given percentage of hearing loss exist in all federal and state compensation programs, under several of these programs no particular formula is prescribed for calculating the percentage of hearing loss suffered in individual cases. Therefore, in proceedings conducted under these programs it is necessary to present evidence regarding the formula to be used. For example, under the Longshoremen's and Harbor Workers' Compensation Act, 33 U.S.C. § 901, et seq., the statute provides a maximum 50 weeks of compensation for unilateral loss of hearing and 200 weeks of compensation for bilateral loss of hearing, 33 U.S.C. § 908 (C) (13) and (19). However, neither the statute nor Labor Dept. regulations prescribe the method by which the percentage of hearing loss shall be calculated. As well, the states which do have prescribed formulae periodically review and revise them in light of current scientific evidence. New York and Illinois, for example, both modified their formulae in 1980.

Over the past 30 years, there have been several formulae which have purported to provide an objective measure of the impairment, or handicap, a person suffers as a result of loss of hearing. The first of these formulae, commonly known as the Fowler-Sabine formula, was proposed in 1947. (Actually, the 1947 formula was a modification of a 1942 American Medical Assn. formula.) It measured the loss of hearing at four frequencies, 512, 1024, 2048 and 4096 Hz and weighted each of these frequencies according to the importance of that frequency in the hearing of speech. The frequency weighting was 15% at 512 Hz, 30% at 1024 Hz, 40% at 2048 Hz and 15% at 4096 Hz.

Perhaps because the Fowler-Sabine formula was difficult to apply, it did not gain wide acceptance. Accordingly, in 1959 after a period of study, the American Academy of Opthalmology and Otolaryngology (AAOO),[1] proposed a new formula. (In 1978 opthalmologists formed a separate professional organization and the AAOO is now known as the AAO.) That formula was adopted by the American Medical Assn. (AMA) in 1961.[4] The formula was based on the assumption that hearing impairment should be evaluated in terms of ability to hear everyday speech under everyday conditions. The ability to hear sentences and repeat them correctly in a quiet environment was deemed the best evidence of accurate hearing of everyday speech. Because of limitations in speech audiometry, however, the AAOO concluded that the hearing level for speech should be estimated from measurements with a pure tone audiometer. The AAOO recommended using the frequencies of 500, 1000 and 2000 Hz, and recording the losses experienced by individuals in excess of 25 dB at each hertz level. This 25 dB "low fence" was used because it was felt that individuals began to suffer a real handicap at 25 dB. The cutoff point for total handicap was 92 dB, with 1.5% impairment (handicap) given for each decibel loss between 25 and 92. The formula provided further that the better ear be given five times the weight of the poorer ear in determining binaural loss.

After the AAOO acted, a number of state legislatures and compensation agencies adopted the AAOO formula as the formula to be used in calculating the percentage of hearing loss. Some of those statutes and rules also provided a deduction from the hearing loss percentage for presbycusis. The AAOO formula made no such allowance. In addition, many of the newly enacted state statutes and regulations required that claimants be removed from noise for certain periods of time, prior to testing, in order to exclude from the calculation of permanent hearing impairment any temporary threshold shift attributable to recent noise exposure.

Both at the time of the publication of the AAOO formula and subsequent to that time, certain professionals concerned with hearing handicap expressed reservations about the AAOO formula, arguing that it did not accurately reflect the handicap imposed on someone suffering a hearing loss. Those critics reasoned that people listen to the human voice not only in quiet surroundings, but also in surroundings where there is background noise which tends to mask the speech sound. Thus, they said, the assumption underlying the AAOO formula, i.e., that hearing impairment should be evaluated in terms of ability to hear speech in a quiet environment, was misguided. They also argued that because speech sounds commonly occur at frequencies higher than 2000 Hz, it was inappropriate to disregard hearing loss at frequencies above 2000 Hz, as the AAOO formula did.

As a result of these arguments, the AAOO Subcommittee on the Conservation of Hearing began to re-evaluate the AAOO formula. At about the same time, the American Council of Otolaryngology, through its Medical Aspects of Noise Committee, began similar deliberations.

The document produced jointly by the two above-mentioned Committees, and sanctioned by their respective organizations, was approved by the Scientific Council of the American Medical Assn. Ultimately, the revised formula was published in the Journal of the American Medical Assn.

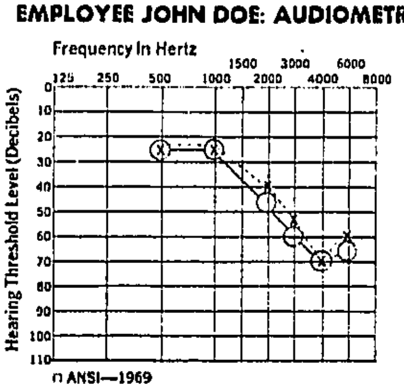
In contrast to the 1959 AAOO formula, the new AMA formula takes into account hearing loss at four frequencies rather than just three. In other words, although identical in all other respects to the original AAOO formula, the revised formula adds the frequency of 3000 Hz to the computation of hearing loss.

Though the 1959 AAOO formula was accepted widely as the definitive method of computing impairment/handicap due to hearing loss, no such general consensus exists as to the validity of the new AAO formula. In 1972, for example, the National Institute of Occupational Safety and Health published "Criteria for a Recommended Standard, Occupational Exposure to Noise." In that document's section on measurement of hearing loss, the recommendation was made that hearing loss be measured using the frequencies of 1000, 2000 and 3000 Hz. Although the criteria document provided no formula in which to place the values obtained at these three hertz levels, and, although it is unlikely that NIOSH was actually proposing a compensation formula, the Dept. of Labor's Office of Workers' Compensation Programs (OWCP) approved the NIOSH recommendation as the basis on which to compensate federal employees for hearing loss. Since the NIOSH recommendation does not contain a formula, the Labor Dept. determined the percentage hearing loss by substituting the decibel losses experienced at 1000, 2000 and 3000 Hz into the AAOO formula.

In part because of complaints regarding the use of the 1000, 2000 and 3000 Hz formula,[7] the Labor Dept. contracted with researchers at Ohio State University to review the literature and to determine the most appropriate formula for measuring hearing loss. The Ohio State researchers recommnded that hearing loss be measured at the levels of 500, 1000, 2000, 3000 and

Junius C. McElveen, Jr., JD, is a law partner with Seyfarth, Shaw, Fairweather & Geraldson, Washington, DC.

EMPLOYEE JOHN DOE: AUDIOMETRIC EXAMINATION



RIGHT EAR

500	1K	2K	3K	4K	6K
25	25	45	60	70	65

LEFT EAR

500	1K	2K	3K	4K	6K
25	25	40	55	70	60

BINAURAL IMPAIRMENT

Old AMA (AAOO) Formula	7.915%
New AMA (AAO) Formula	17.5%
NIOSH Formula	23.33%
ASHA Formula	35.83%
Ohio State Formula	52.2%

Table 1

4000 Hz, that a 15 dB low fence and a 70 dB high fence be used, and that equal weight be assigned to the loss in each ear in the determination of binaural hearing loss.[5] Though this report is currently considered only a proposal by the Labor Dept., two of its conclusions bear mentioning. The report summary concludes:

1) Little research support is available for the OWCP formula (1000, 2000 and 3000 Hz) or that recommended by the American Medical Assn.

2) Much additional research remains to be done in areas relevant to hearing loss compensation.

During the time the Ohio State study was being conducted, a "Task Force on the Definition of Hearing Handicap" of the American Speech-Language-Hearing Assn. (ASLHA) was appointed to develop a definition of hearing handicap to be used in workers' compensation proceedings. The recommendation of that task force was that hearing loss be measured using the frequencies of 1000, 2000, 3000 and 4000 Hz, with a 30 dB low fence and an 80 dB high fence.[3] In 1980, the Illinois legislature adopted a modified version of this proposal, which utilizes 1000, 2000 and 3000 Hz, a 30 dB low fence and an 85 dB high fence.[6] For purposes of comparison, Table 1 shows the percentage loss for a theoretical employee under the old AAOO formula and each of the four newer formulae (NIOSH, New AAO, ASLHA and Ohio State).

As employees become more aware of their rights and more aware of the employment hazards that may result in the diminution of their hearing ability, state legislatures and compensation authorities, such as the Office of Workers' Compensation Programs of the Labor Dept., will continue to devote time to the development of formulae for compensation of hearing loss. In so doing, there are a variety of audiological issues they will need to address. Research regarding most of these issues is still sorely needed.

These issues include:

1) What frequencies should be utilized in determining hearing loss impairment? If the determination is made that speech frequencies should still be the criteria for determining impairment, what speech frequencies should be utilized to determine that impairment? Some researchers suggest 500 Hz should be excluded from the formula because very little noise-induced hearing loss occurs at 500 Hz. Others argue that 500 Hz is not an important frequency for speech understanding. Proponents of the inclusion of 500 Hz argue that frequency does contribute substantial power to the speech signal. Similar arguments are made with respect to the inclusion or exclusion of 4000 Hz.

2) Should the frequencies which are used be weighted in any way? The Fowler-Sabine formula, which weighted values at the different frequencies, proved too difficult to

Old AMA (AAOO) Formula	$2,374.50
New AMA (AAO) Formula	$5,250.00
NIOSH Formula	$6,999.00
ASHA Formula	$10,749.00
Ohio State Formula	$15,660.00

Table 2. Assuming a compensation rate of $200.00 and a maximum period of compensation of 150 weeks, the compensation costs would be as above.

use. Nevertheless, a number of researchers agree with the assumption implicit in the Fowler-Sabine formula, that some frequencies in the speech range are more important than others.

3) Since the decision about what frequencies to use for compensation purposes is often based on experiments designed to test the correlation between speech discrimination and pure tone audiometry, to what extent should a correction be made for factors, totally unconnected with hearing impairment, which enter into scores obtained in those experiments? These factors include: 1) the intelligence of the subjects; b) phonetic regression, the phenomenon by which older people, by virtue of age alone, have more trouble with speech discrimination than do younger people; c) the distractability index, which results in lowered speech discrimination scores, even for normal hearing people, based only on the distraction caused by the background noise; d) the use of monaural hearing in experiments, which reduces the person's ability to respond to a directional signal; and e) the types of test materials used (e.g. the use of phonetically balanced words may overstate inability to understand everyday speech because speech is running discourse and has great redundancy).

4) How long should people be removed from noise exposure before audiometric testing for permanent threshold shift can be considered valid? Should the wearing of hearing protection be considered sufficient removal from noise?

5) Where should the "low fence" and "high fence" be set?

6) How should factors such as presbycusis, sensorineural hearing loss due to disease and hearing loss occasioned by leisure-time activities be taken into account?

In summary, the debate concerning the proper formula for use in compensating victims of hearing loss seems sure to continue. If public policy is to follow science, rather than lead it, research into these problem areas of hearing handicap must be conducted.

One thing seems certain, however. Compensation for hearing loss will continue to increase. The only way for business to limit the costs of such compensation in the future is to institute and enforce effective hearing conservation programs. ☐

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6. S.H.A. Ch. 48, ¶ 138.4 (P.A. 81-1482).
7. US General Accounting Office: To provide proper compensation for hearing impairments, the Labor Dept. should change its criteria. Report to the Congress of the United States by the Comptroller General, 1978.

TABLE 1 Numbers of Claims and Criteria for Hearing Loss Compensation under Federal and State Programs

JURISDICTION	IS OCCUPATIONAL HEARING LOSS COMPENSABLE?	NO. OF CLAIMS PAID—1977 [1]	MAXIMUM BENEFITS—TOTAL LOSS IN BOTH EARS	TIME LIMIT TO FILE CLAIM	APPORTIONMENT (BETWEEN EMPLOYERS)	CHOICE OF PHYSICIAN	HL WAITING PERIOD	HL FORMULA	DEDUCTION FOR AGING	HEARING AID PROVIDED [2]		AGENCY PROVIDING HEARING AID	CREDIT IN AWARD FOR HEARING AID IMPROVEMENT	ACTUAL REHABILITATION [3] PROVIDED	DEDUCTION FOR PREEXISTING LOSS [4,5]
										I	R				
Fed. Emp. Program	YES	1,800	$135,600	D-3 yrs.	N	Employee	N	NIOSH	N	Y	Y	WC	N	P	N
Longshore/ Harbor	YES	500	73,444	D-3 yrs.	N	Employee	N	Und	N	Y	Y	WC	N	Y	N
Alabama	YES	20	20,884	1 yr.	Unk	Carrier	N	ME	N	Y	N	WC	N	P	Y
Alaska	YES	4	28,000	D-2 yrs.	N	Employee	N	ME	N	Y	Y	WC	N	P	N
Arizona	YES	10	32,999	1 yr.	N	Employee	N	'59 AAOO	N	Y	Y	WC	N	Y	Y
Arkansas	YES	3	13,125	2 yrs.	Unk	Carrier	N	ME	N	Y	Y	WC	N	Y	N
California	YES	1,925	21,770	D-1 yr.	Y	Employee	N	'79 AAOO [6]	N[7]	Y	Y	WC	P[8]	P	Y
Colorado	YES	6	11,676	3-5 yrs.	N	Carrier	N	ME	N	Y	N	WC	N	Y	Y
Connecticut	YES	50	22,932	D-1 yr.	Y	Employee	N	'59 AAOO	N	Y	P	WC	N	N	N
Delaware	YES	5	13,125	D-1 yr.	N	Employee	N	ME	N	Y	Y	WC	N	Y	Y
Florida	NO-PPD	0	18,900	D-2 yrs.	N	Carrier	N	ME	N	Y	Y	WC	N	Y	Y
Georgia	YES	11	18,500	1 yr.	N	Carrier	6 mos.	'59 AAOO	N	Y	Y	WC	N	Y	Y
Hawaii	YES	5	37,800	D-1-2 yrs.	Y	Employee	N	'59 AAOO	N	Y	P	WC	N	P	N
Idaho	YES	3	18,576	1 yr.	N	Carrier	N	ME	N	Y	Y	WC	N	Y	Y
Illinois	YES	0	48,232	3 yrs.	N	Employee	N	ME	NR	NR	NR	NR	NR	NR	Und
Indiana	NO-PPD	0	15,000	2-3 yrs.	Unk	Carrier	N	ME	N	Y	N	WC	N	Y	Y
Iowa	YES	10	42,700	2 yrs.	Y	Carrier	N	ME	P	Y	Y	WC	N	Y	Y
Kansas	YES	6	14,197	1 yr.	N	Carrier	N	'47 AMA	N	Y	Y	WC	N	Y	N
Kentucky	YES	2	17,472	1-3 yrs.	N	Employee	6 mos.	'59 AAOO	Y	Y	N	WC	N	N	Y
Louisiana	NO-PPD	0	[9]	D-4 mos.	Unk	Carrier	N	ME	NR	NR	NR	NR	NR	NR	N
Maine	YES	10	46,344	2 yrs.	Unk	Employee	1 mo.	'59 AAOO	N	P	P	WC	N	Y	Y
Maryland	YES	28	17,000	2 yrs.	Unk	Employee	6 mos.	'59 AAOO	Y	Y	Y	WC	N	Y	Y
Massachusetts	NO-PTI	0	12,000	D-1 yr.	N	Employee	N	ME	N	P	P	WC	NA	P	N
Michigan	NO-PPD	0	[10]	D-4 mos.	N	Carrier	N	ME	N	Y	Y	WC	N	Y	Y
Minnesota	YES	50	33,480	D-3 yrs.	N	Employee	N	ME[11]	N	Y	Y	WC	N	Y	N
Mississippi	YES	2	13,650	D-2 yrs.	N	Carrier	N	ME	N	Y	Y	WC	N	Y	Y
Missouri	YES	28	15,120	D-1 yr.	N	Carrier	6 mos.	'59 AAOO	Y	N	N	NA	N	N	Y
Montana	YES	5	19,400	D-30 days	N	Employee	6 mos.	'59 AAOO	Y	Y	Y	WC	N	Y	Y
Nebraska	YES	0	15,500	D-6 mos.	N	Employee	N	'59 AAOO	N	Y	Y	WC	N	N	N
Nevada	NO-PTD	0	4,305	D-90 days	N	Employee	N	'79 AAOO	N	Y	Y	WC	N	P	Y
N. Hampshire	YES	0	38,520	2 yrs.	N	Carrier	6 mos.	'59 AAOO	P	Y	Y	WC	N	Y	N
N. Jersey	YES	3,000	6,000	D-1-2 yrs.	Y	Carrier	N	'47 AMA	P	Y	P	VR	N	N	N
N. Mexico	NO-PTD	0	25,809	1 yr.	Unk	Carrier	7 days	ME	NA	NA	NA	NA	NA	NA	Y
New York	YES	368	15,750	D-90/2 yrs	Y	Panel	6 mos.	'59 AAOO	N	Y	Y	WC	N	P	Y
N. Carolina	YES	17	25,200	0-2 yrs	N	Carrier	6 mos.	'59 AAOO	N	Y	N	WC	N	Y	Y
N. Dakota	YES	5	8,000	1 yr.	N	Employee	N	ME	N	Y	Y	WC	N	Y	N
Ohio	NO-PTD	0	13,500	6 mos.	Y	Employee	N	ME	N	NA	NA	NA	N	Y	Y
Oklahoma	YES	10	18,000	D-3-18 mo	Y	Carrier	N	ME	N	Y	P	WC	N	Y	N
Oregon	YES	48	18,320	D-6 mos.	N	Employee	N	500-4K[12]	N	Y	P	WC	N	Y	[illegible]
Pennsylvania	NO-PTI	0	55,380	120 days	Unk	Carrier	N	ME	N	N	N	NA	N	N	Y
Rhode Island	YES	10	9,000	D-2 yrs.	N	Employee	6 mos.	'59 AAOO	P	Y	Y	WC	N	Y	Y
So. Carolina	YES	1	28,300	D-2 yrs.	N	Carrier	N	ME	P	Y	N	WC	N	Y	Y
So. Dakota	YES	0	23,250	2 yrs.	Unk	Carrier	N	ME	N	Y	Y	WC	Y	Y	Y
Tennessee	YES	6	15,000	1-3 yrs.	N	Panel	N	ME	N	Y	N	WC	N	N	N
Texas	YES	2	13,650	6 mos.	Y	Carrier	N	'59 AAOO	N	Y	Y	WC	N	Y	Y
Utah	YES	0	13,100	D-1 yr.	N	Carrier	6 mos.	ME	Y	Y	N	WC	N	N	Y
Vermont	YES	3	38,915	1 yr.	N	Employee	N	ME	N	Y	Y	WC	N	Y	Y
Virginia	YES	6	10,700	D-2 yrs.	N	Panel	N	'59 AAOO	N	N	N	NA	N	Y	Y
Washington	YES	240	14,400	D-1 yr.	Y	Employee	N	'59 AAOO	N	Y	Y	WC	N	NR	Y
W. Virginia	YES	42	33,480	D-3 yrs.	N	Employee	N	'59 AAOO	N	Y	Y	WC	N	Y	N
Wisconsin	YES	149	21,450	None[13]	Y	Employee	2 mos.	CHABA	Y	Y	Y	WC	N	Y	Y
Wyoming	YES	5	11,282	D-1/3 yrs	N	Employee	N	ME	P	Y	Y	WC	N	Y	N

FOOTNOTES

1 Some state figures are maximums which may include a few traumatic hearing loss claims.

2 States usually require medical proof or prescription for hearing aid.

3 In most cases, provided by Vocational Rehabilitation agency.

4 Where allowed, either pre-employment audiogram or medical evidence required. Where deduction is made, it is determined by subtracting the previous rating from current rating.

5 For states not deducting, pre existing loss is usually covered under second injury fund.

6 California formula in effect since 1963; basis for 1979 AAOO formula.

7 Compensation is generally decreased for ages below 39 and increased for ages above 39; also adjusted for type of employment.

8 Award usually made on uncorrected audiogram since correction would also commit employer to lifetime purchase and maintenance of hearing aid

9 No fixed maximum; based on individual case.

10 No maximum; all permanent disability benefits based on lifetime replacement of wage loss.

11 No formula; courts have allowed speech discrimination scores, in addition to audiometric tests.

12 Average of frequencies 500-4K with 25 decibel low fence.

13 In 1975, Wisconsin eliminated the Statute of Limitations for occupational diseases. Disease claims barred by the time limit for injuries are paid from a special state fund.

SOURCE NOTE

Data from telephone survey of federal and state compensation agencies and state statistical reports. In a few cases, other published sources were used (Barth, Fox, National Commission on State Workmen's Compensation Laws, and U.S. Chamber of Commerce.) New Jersey, California, and Washington figures are close estimates from available raw data. Figures updated to October 1978 or later.

Abbreviations

D = Discovery Rule (time limit begins when worker becomes aware of disability; otherwise, usually starts with date of injury)
I = Initial Hearing Aid
ME = Medical Evaluation (impairment percent determined by physician; decision on degree of hearing impairment left to individual medical opinion, which usually means the AAOO formula)
N = No
NA = Not Applicable
NR = No Response
P = Possible
PPD = Permanent Partial Disability
PTI = Permanent Total Impairment
PTD = Permanent Total Disability
R = Replacement Hearing Aid
Und = Undecided
Unk = Unknown
VR = Vocational Rehabilitation
WC = Worker's Compensation
Y = Yes

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Among the nine States compensating more than a token number of claims, New Jersey and California lead the way with 3,000 and 1,925 claims respectively. This is not surprising because as will be discussed in Chapter III, both States compensate high frequency hearing loss and have no waiting periods or serious restrictions on claims. The total for all nine high claim States is 5,870 claims. If we add a maximum of 225 claims from the remaining States which pay few or no claims, the total for all States is 6,095. It is striking to note that 41 out of the 50 States have paid few or no claims.

Total State benefits for hearing impairment of $13 million in 1977 was ***less than 3 tenths of 1 percent of the $6 billion total U.S. worker's compensation*** **bill.** Thus, even the rapidly rising dollar volume for occupational hearing loss claims is still a minute factor in total worker's compensation costs.

Figure 1 is a map comparing States by claims activity and compensability of hearing loss. As shown, only the Pacific Coast States, and Wisconsin, Minnesota, New York, Connecticut and New Jersey compensate more than a few claims. Thirty-two States comprising the Plains and Mountain States and most of the South have few or zero claims even where they allow hearing loss compensation. Finally, nine States make occupational hearing loss virtually noncompensable by special requirements to be discussed in Chapter III.

Table 2

Total State Benefits Paid, 1977

	Number of Claims	Average Benefits	Total Benefits[5]
New Jersey	3,000	1,500[1]	4,500,000
California	1,925	3,000[2]	5,775,000
New York	366	2,485[3]	910,000
Washington	240	2,300[4]	552,000
Wisconsin	149	2,300[3]	342,700
All Other	415	2,300[4]	931,500
	—	—	—
Totals	6,095		$13,011,200

Source Notes: From Table 1

[1]Average of nine claim sample from attorney files plus agency estimate.
[2]State estimate.
[3]Actual figures.
[4]Using Wisconsin average since some State claim figures unavailable.
[5]Calculated from claims number and average benefits.

Table 3
State and Federal Worker's Compensation Rules Affecting Occupational Hearing Loss-Positive and Negative Impact on Claims

	JURISDICTION	NO. OF CLAIMS PAID—1977	COMPENSABLE □ yes ■ no	MAXIMUM BENEFITS—1 TOTAL LOSS IN BOTH EARS □ over $21,700 ■ under $21,700	TIME LIMIT TO FILE CLAIM □ discovery rule ■ no discovery rule	APPORTIONMENT (BETWEEN EMPLOYERS) □ no ■ yes	CHOICE OF PHYSICIAN □ worker choice ■ insurer or employer choice or panel	HL WAITING PERIOD □ no ■ yes	HL FORMULA □ inc. freq. above 2,000 Hz ■ no freq. above 2,000 Hz	DEDUCTION FOR AGING □ no ■ yes	DEDUCTION FOR PRE-EXISTING LOSS □ no ■ yes
HIGH CLAIM STATES	Fed. Emp. Program	□	□	□	□	□	□	□	□	□	□
	Longshore & Harbor	□	□	□	□	□	□	□	2	□	□
	California	□	□	□	□	■	□	□	□	□	■
	Connecticut	□	□	□	□	■	□	□	■	□	□
	Minnesota	□	□	□	□	□	□	□	□	□	□
	New Jersey	□	□	■	□	■	■	□	□	■	□
	New York	□	□	■	□	■	■	■	■	□	■
	Oregon	□	□	■	□	□	□	□	□	□	■
	Washington	□	□	■	□	■	□	□	■	□	■
	West Virginia	□	□	3	□	□	□	□	■	□	□
	Wisconsin	□	□	■	□	■	□	■	□	■	■
COMPENSABLE—FEW OR NO CLAIMS	Alabama	■	□	■	■	■	■	□	■	□	■
	Alaska	■	□	□	□	□	□	□	■	□	□
	Arizona	■	□	□	■	□	□	□	■	□	■
	Arkansas	■	□	■	■	■	■	□	■	□	□
	Colorado	■	□	■	■	□	■	□	■	□	■
	Delaware	■	□	■	□	□	□	□	■	□	■
	Georgia	■	□	■	■	□	■	■	■	□	■
	Hawaii	■	□	□	□	■	□	□	■	□	□
	Idaho	■	□	■	■	□	■	□	■	□	■
	Illinois	■	□	□	■	□	□	□	■	2	2
	Iowa	■	□	□	■	■	■	□	■	■	■
	Kansas	■	□	■	■	□	■	□	□	□	□
	Kentucky	■	□	■	■	□	□	■	■	■	■
	Maine	■	□	□	■	■	□	■	■	□	■
	Maryland	■	□	■	■	■	□	■	■	■	■
	Mississippi	■	□	■	□	□	■	□	■	□	■
	Missouri	■	□	■	□	□	■	■	■	■	■
	Montana	■	□	■	□	□	□	■	■	■	■
	Nebraska	■	□	■	□	□	□	□	■	□	□
	N. Hampshire	■	□	□	■	□	■	■	■	■	□
	N. Carolina	■	□	□	■	□	■	■	■	□	■
	N. Dakota	■	□	■	■	□	□	□	■	□	□
	Oklahoma	■	□	■	□	■	■	□	■	□	□
	Rhode Island	■	□	■	□	□	□	■	■	■	■
	So. Carolina	■	□	□	□	□	■	□	■	■	■
	So. Dakota	■	□	□	■	■	■	□	■	□	■
	Tennessee	■	□	■	■	□	■	□	■	□	□
	Texas	■	□	■	■	■	■	□	■	□	■
	Utah	■	□	■	□	□	■	■	■	■	■
	Vermont	■	□	□	■	□	□	□	■	□	■
	Virginia	■	□	■	□	□	■	□	■	□	■
	Wyoming	■	□	■	□	□	□	□	■	■	□
NON COMPENSABLE	Florida	■	■	■	□	□	■	□	■	□	■
	Indiana	■	■	■	■	■	■	□	■	□	■
	Louisiana	■	■	3	□	■	■	□	■	2	□
	Mass.	■	■	■	□	□	□	□	■	□	□
	Michigan	■	■	3	□	□	■	□	■	□	■
	Nevada	■	■	■	□	□	□	□	□	□	■
	New Mexico	■	■	□	■	■	■	■	■	2	■
	Ohio	■	■	■	■	■	□	□	■	□	■
	Pennsylvania	■	■	□	■	■	■	□	■	□	■

1 Above and below average benefits, based on fifty-state mean.
2 Undecided or unknown.
3 No fixed benefit levels; see Table 1.

LEGEND ■ Limits Claims
□ Encourages/Does Not Discourage Rightful Claims

Table 4
Hearing Loss Formulas Used in U.S., State and Federal Workers's Compensation Programs

Formula	Audiometric Frequencies Used (Hz)	Method of Calculation	Low Fence (ANSI-1969)	High Fence	Percent Per Decibel Loss	Better Ear Correction	States That Use Formula
AMA - 1947	500, 1,000, 2,000 4,000	weighted average	20 dB	105 dB	varies	7/1	KS, NJ
AAOO - 1959	500, 1,000, 2,000	average	25 dB	92 dB	1.5	5/1	AZ, CT, GA, HI, KY, MD, ME, MO, MT, NE, NH, NY, NC, RI, TX, VA, WA, WV
AAOO - 1979[1]	Same as California	average	25 dB	92 dB	1.5	5/1	CA
NIOSH Recommendation	1,000, 2,000, 3,000	average	25 dB	92 dB	1.5	5/1	FEC
CHABA Recommendation	1,000, 2,000, 3,000	average	35 dB	92 dB	1.75	4/1	WI
California Formula (Now 1979 AAOO)	500, 1,000, 2,000 3,000	average	25 dB	92 dB	1.5	5/1	CA
Oregon Formula	500, 1,000, 2,000 4,000, 6,000	average	25 dB	92 dB	1.5	5/1	OR
Berney Formula	500, 1,000, 2,000 4,000	average	25 dB	92 dB	1.5	5/1	NJ

Note: Data are from Table 1.

1. States with no formula listed leave decision to examining physician (medical evaluation), who will probably now use the 1979 AAOO.

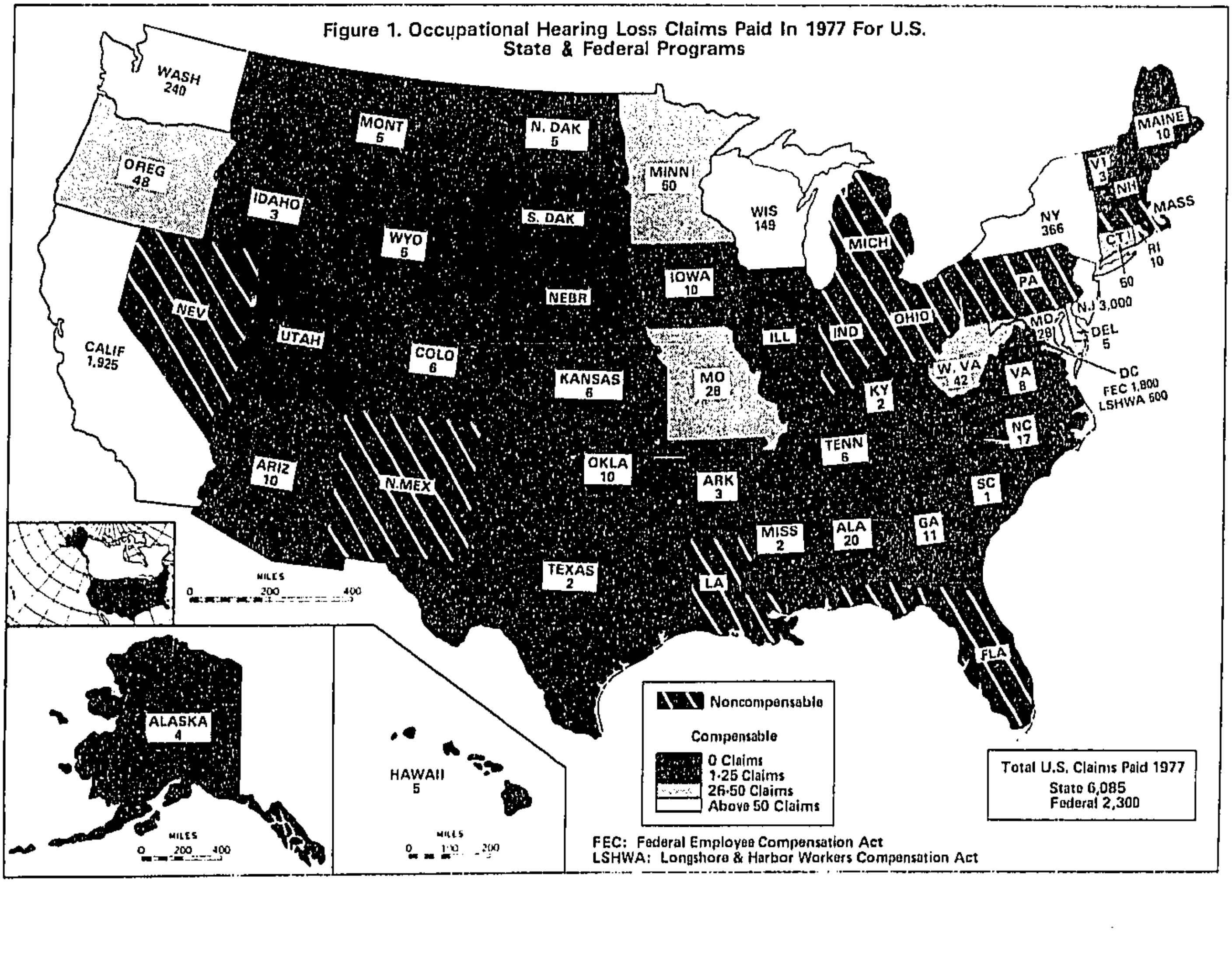

Figure 1. Occupational Hearing Loss Claims Paid In 1977 For U.S. State & Federal Programs

RULES
PERTAINING TO CLAIMS FOR OCCUPATIONAL LOSS OF HEARING UNDER THE WORKERS COMPENSATION LAW PARTICULARLY WITH RESPECT TO DAMAGE RISK CRITERIA AND THE MEASUREMENT AND DETERMINATION OF THE LOSS OF HEARING

The Guide for the evaluation of hearing handicap has required periodic revision as new information becomes available.

In 1953 a Committee of Consultants on Occupational Loss of Hearing issued a report to the Chairman, setting forth their recommendations as to how occupational loss of hearing should be evaluated.

In 1960 a similar Committee was appointed to review the rules adopted by the Board pursuant to the 1953 recommendations. This Committee suggested certain changes in measuring of hearing loss and the criteria which were subsequently adopted.

In 1979 the Chairman appointed a Committee to review the rules and statute pertaining to the present rules in effect. It made recommendations taking into consideration the two previous reports

On the basis of all the reports, the following rules are hereby adopted:

RULE 1. Frequencies to be used in measuring industrial hearing loss.

In evaluating pure tone audiometric results, the method of determining the percentage of impairment for hearing speech is to use the average of the pure tone air conduction and audiometric readings at 1000, 2000, and 3000 Hz.

RULE 2. The point below which there is no hearing disability and the point above which the inability to hear should be deemed total.

The audiometric reading below which there is no hearing impairment shall be specified as 25 decibels (A.N..S.I. - 1969) using the average of the hearing levels at the three speech frequencies of 1000, 2000, and 3000 HZ. In other words, if the hearing level of an individual in these three frequencies averages 25 decibels or less, no hearing impairment shall be considered.

The point at which the inability to hear should be deemed total shall be specified as 92 decibels re: A.N.S.I. - 1969, using the average of the hearing levels at the three speech frequencies of 1000, 2000, and 3000 Hz.

RULE 3. Method of Computing Percentage of Impairment.

For every decibel that the average hearing level of an ear exceeds 25 dB, allow 1 1/2% up to a maximum of 100%. That maximum is reached at 92 decibels.

RULE 4. Method of computing Binaural percentage loss of hearing.

In computing the percentage of hearing impairment, the binaural method of evaluation should be used. The percentage of impairment in the better ear should be multiplied by five (5). The resulting figure is added to the percentage of impairment in the poorer ear and the result divided by six (6). The final percentage represents the binaural evaluation of hearing impairment.

RULE 5. Proper deductions for presbycusis and other non-industrial causes of hearing impairment.

With respect to presbycusis, no allowance should be made for the possible effect of age on the hearing level. With respect to the possible effect of non-industrial causes of an individual's hearing impairment other than presbycusis, determination of the amount of the loss due to such other causes should be made by the examining Otologist. The opinion of the examining Otologist as to the etiological factors responsible for the patient's hearing loss, and the extent to which each contributed to such loss, together with all other pertinent data, should be taken into consideration in fixing the amount of the award to be paid.

RULE 6. The number of examinations needed to evaluate industrial hearing loss and the fairest method of determining the loss from the results of successive examinations.

Examinations as to the extent of hearing impairment should be performed by qualified professionals, Board certified otolaryngologists or licensed audiologists using audiometers meeting standards as specified in ANSI S3.6 - 1969 "Specifications for Audiometers". However, the nature of such impairment shall be evaluated by a Board certified otolaryngologist.

The test environment should meet or exceed those detailed in ANSI S3.1 - 1960 "Criteria for Background Noise in Audiometer Rooms". Internal test consistency and professional judgment should determine whether a second or third test battery or other more extensive forms of testing may be necessary. Pure tone audiometry (air conduction and bone conduction), impedance measurements, speech thresholds and speech discrimination measures shall be considered to establish the nature and extent of the hearing impairment.

Examinations shall be made after the date of separation from harmful exposure to noise in accordance with the provisions of Section 49 bb of the Workmen's Compensation Law.

RULE 7. Tinnitus.

Tinnitus should not be considered in determining impairment.

RULE 8. Ability to understand speech - Hearing aids.

No consideration should be given to the question of whether or not the ability of a claimant to understand speech is improved by use of a hearing aid.

RULE 9. Acceptance of Substantial Compliance with Criteria and Standards.

Notwithstanding the provisions above, when in a particular case there is not exact compliance with the criteria and standards herein set forth, the Board, nevertheless, in its discretion, for good cause shown, and in the interest of justice, may accept substantial compliance with the criteria and standards set forth in above, as full compliance therewith.

SERVICE DELIVERY MODELS

NOTES

ACADEMIC TRAINING

NOTES

MARKETING

Session

HOW TO MARKET YOUR SERVICES

- Advertising – Trade Journals
  Mailings
- Exhibits – Trade Meetings – Safety, Engineer, Nursing, etc.
- Direct Selling – Sales Force: To Whom
  Hard Copy
  Audiovisual
- Why You: Quality? Price? What Else?

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Reprinted from the ASHA Private Practice
Workshop manual

PROMOTING YOUR SERVICES

Promoting your professional services is an essential element in conducting a successful practice. It is the means by which you will generate client flow into your practice setting. Generally, professionals have little, if any, experience or formal training in marketing/promotion. The typical mistake professionals make with this aspect of practice conduct is engaging in various forms of promotion with no real thought given to what they are trying to accomplish. As a result, very often the promotion is less than effective and a poor use of hard earned revenue. A systematic approach to the promotional aspect of your practice can assure you receive the most benefit from the dollars spent. Therefore, the intent of this section is to give you a basic structuoe that will enable you to build a marketing campaign for your practice.

I. Market vs. Product Analysis

One method to systematically approach marketing/promotion begins with a market vs. product analysis. This method is a rather simple procedure and does not require any special skill. It will only require your time and thought. Once completed, the analysis will provide you with a structure from which you will be able to develop promotional strategies. These strategies will then create a bridge between your product(s) and market(s) or, in other words, stimulate patient-client flow.

A. The first step in developing the analysis requires that you construct an exhaustive list of products you offer. Products include all services to be offered, such as basic audiometric tests; hearing aids and assessories; hearing aid adjustment and repair; speech-language evaluation and treatment; teacher consultation; etc. In the course of developing this list, you should pair products/services with market age groups such as services for: prenatal, neonatal, child, young adult, middle-aged adult, aged adult.

Sample:	Product	Market
	1 - Prenatal Counselling re: development of speech, language, and/or hearing behaviors in newborn	1 - Young first-time parents

The primary reason for grouping according to age is to assist you in locating geographically your target markets, i.e., consumers. By doing this, you eliminate the shotgun approach by focusing in on a specific target market or geographic locale.

B. The second phase of the analysis, once you have completed the product vs. market analysis by age, requires you to locate your projected markets. In other words, where are they located geographically or are there certain settings where potential consumers gather? One example could be the local hospitals that offer prenatal classes for families expecting their first child. Rather than try and run down each family expecting their first child, this setting attracts young, first-time parents in groups. Think about contracting your services to the hospital as part of their prenatal package. In future days or years, the parent will recall your presentation when and if a hearing problem occurs. This process creates future consumers of your services through awareness. This is only one example, but the same approach can apply to each age group. Age groups generally have several target geographic locations. Be sure to list all probable locations.

During this phase of the analysis, determine the potential size of your market in your locale. One excellent way to get a handle on this is through your local county recorder and census tract data. Later on you can compare your office flow to the potential market and determine your market share.

Sample:

Product	Market	Location
Prenatal Counselling re: development of speech, language and/or hearing in newborn	Young first-time parents	Community hospitals offering prenatal classes

C. The third phase of the analysis requires you to formulate a geographic area which you intend to serve with your practice. There is no set area size; however, a good rule of thumb is a 25-mile radius from your front door. Get yourself a well-detailed map and mark your boundaries and your office location. Next, using your office as the center point, take a compass and draw circles concentrically to scale each about five miles from each other. Each one of the concentric rings will represent priority marketing areas -- the closest to the center point having the greatest priority. Using your analysis, plot on your map the locations for your targets, such as hospitals, senior centers, nursing homes, referring physicians, etc. Once your map is completed you will have a good feel for your focal points for promotion. This will also delineate groupings of potential markets and will assist in developing specific market strategies.

D. Market strategies are the vehicles by which your promotional materials are presented to the public, that is, newspapers, radio, television, presentations, health care events, personal calls on referral resources, open house, etc.

Sample: The predominant market or population with the greatest need for rehabilitation of speech/hearing loss are 55 years of age and over. One strategy to reach this market with ease might be through senior centers where groups of elders gather for various reasons. Another may be senior citizen news releases or local agencies serving the elder. The basic strategy is to reach the most people with the least amount of effort and cost expenditure.

E. <u>Promotional materials</u> are those items linked to the marketing strategy. They include the business card, business announcement, brochures, presentation materials, newspaper ads, yellow pages telephone listing, etc. To date, there is no set format for promotional materials. One should always keep in mind the market that the materials are meant to influence. It is reasonable to assume that materials meant to influence medical referral resources would be more technical than those designed for the lay public. For instance, in an announcement to physicians you may state: <u>Offer (or complete differential speech and language evaluations).</u> In a similar announcement meant for the public you may state: <u>Offer professional hearing testing performed by clinical audiologist (or speech-language evaluation by certified speech-language pathologist.)</u> In short, your promotional materials must be easily understood by the intended market. Not considering this is a common mistake professionals often make. Remember, the demonstration of professionalism is best served when working directly with the patient/client. Promotional materials then serve to educate, inform and identify resources for consumers. Promotional materials should connote professionalism and, at the same time, be understandable to be effective.

1. <u>Basic Promotional Materials</u>

   a. Business card . . . . . Any commercial printer will assist you in preparing your business cards. The cost is minimal and they are generally ordered in quantities of 1000.

   b. Formal business announcement . . . . . Generally the professional printer will assist in the formulation of this as well. These are generally short and list services, address, hours and your name.

c. Brochure describing your services. . . . The brochure should be quality work since it represents you. It describes services and hopefully educates the reader at the same time. Many have found a good brochure to be quite expensive to produce. Check with local colleges and their art departments for cost camera ready design. This can save you $500 or more.

d. Yellow page ad.. . . Your telephone directory service will design this to your specification. Put some thought and survey what others do. Top left placement on the page receives the most attention from yellow page users.

2. Other promotional materials to consider may include the printing of personalized referral pads for physicians to use when referring to your office. These have proven very successful and are well received by physicians. When addressing groups you should have well-prepared materials such as slides, handouts, etc. Remember, always leave something people can take with them.

3. Mass media promotional materials for newspaper and electronic media are generally designed by the media. The cost of these materials as well as air time or column inches is generally prohibitive unless your business setting is nonprofit in organizational design.

   Although typical mass media advertising is generally cost prohibitive, public service announcements or public interest stories are a strategic means of reaching the general public. You should make maximum use of these and generally the only cost involved is your time.

F. Special Considerations: You have probably noticed that this section has addressed promotional management from the view of the independently practicing professional. If in the implementation of your practice you locate with a physician and your arrangement connotes togetherness to onlookers, considerable thought and joint planning must occur between you and the physician regarding marketing and promotion. The two of you must agree on the type(s) of marketing that both can accept. Just a word of caution: many physicians do not support the concept of marketing/promoting health care services; however, this is slowly changing.

Marketing your business is an ongoing process and not a onetime activity. Periodic updating and changing promotional materials is very important.

our ability and skill as a professional should always be complemented by the way you market yourself. Your marketing must also serve to fill a consumer need through education and/or awareness.

G. Measuring the Results: Naturally, measuring the results of your marketing strategies is as important as the design phase. Reviewing the results on a monthly basis gives you feedback on which strategies produced the greatest yield and which didn't. Many find that the easiest way to measure re-results is to ask patients/clients how they selected your service or practice. Keep records of this information and compare the census flow to the original market analysis. Those strategies which are working well you want to keep and probably accelerate. For those that did not meet expectations, reevaluate your strategy and try something else.

If particular markets cannot be stimulated after several tries, you may find there was not as viable a market as you originally projected. This is very useful information, and it will prevent further use of productive time and revenue on a nonproductive endeavor.

You also should be aware that a good marketing strategy may take some time to pay off. Give your strategies a chance. Many find 60 to 90 days or even longer is necessary for an accurate measure of its effect. Also, remember not all marketing can be approached scientifically. There is a certain element of guesstimating and risk taking although you should always try to minimize these as much as possible.

Sources of Data for Making Market Surveys

1. Maps. Maps showing major trading areas of counties and states are available from chambers of commerce, industrial development boards, trade development commissions, and city newspaper offices. Such maps indicate where the major business of the subject area is being done and thus reflect buying habits of the population.

2. Road Maps. A study of the road network of any area gives information on ease of access to a particular site. We have seen that access is an important consideration in determining market area limits.

3. Census Tracts. Population density and distribution are given in easily available census tracts. Almost every county government has such reports. They usually show the number of people living in specific parts of the county. Often-used breakdowns of the area are by precincts, by minor political subdivisions such as water districts, or even by 10-block areas. The exact number of people living in each section is given. Some counties have reports which show the population 10 years ago, five years ago, and currently. These can indicate the population trend.

4. The United States Census. Most students have never seen a copy of the United States census report, which is made every 10 years, with some intermittent supplements. A visit to the nearby library can be an enlightening experience. Much of the desired information about population breakdown statistics will be found in the census reports. Such items as those we have discovered to be important—age, sex, race, religion, educational level, native- versus foreign-born, and occupation—are abundantly available in the census. When only a portion of a town is involved in a market survey, the figures may need to be studied differently.

5. Sales Management Magazine. This highly significant publication is considered indispensable by professional market research people. Once each year it publishes its "survey of buying power" issue, which gives such figures for every county in the country and for every city over 10,000 in

population. Because the United States census is completely done only once in 10 years, this annual magazine report is particularly valuable for years between census dates. It contains information on total population, households, breakdown of retail sales into divisions for different kinds of business firms, and total purchasing dollars represented in each city and county. The households are even divided into income levels.

6. United States Census of Business. This gigantic study includes information on total volume of business done in a particular line. Numbers of firms in each line of business are reported for towns down to 2,500 population. Larger city reports are more detailed. Your own state census of business is also very valuable in this regard.

7. Chambers of Commerce or Business Development Departments. Major cities have these organizations, which have the important job of encouraging the development of new business firms in their communities. They will gladly supply all types of information regarding population studies, income characteristics of the community, trends, payrolls, industrial development, and so on. Such information is usually free for the asking.

8. Bureaus of Business and Economic Research at Universities. These organizations are usually fortified with many studies about local markets. Published reports are available to the public.

9. Market Research and Advertising Firms. Many of these firms offer their professional services in making complete market surveys. They also, however, have reports covering special market areas, which in many instances may be procured.

American Speech-Language-Hearing Association

Issues in Ethics Statement

Public announcements and public statements

December 15, 1980

General principle

Public statements or announcements of services attributable to individuals* should serve to provide accurate and adequate information to aid the consumer public in making informed choices in matters concerning the profession and the services rendered by its practitioners. This principle must be observed as an affirmative ethical obligation of all individuals, whether acting on an independent basis or in representing an institution, agency, or organization.

General guidelines

I. Announcement of Services

A. Generally individuals may use as a guide the type of announcement customarily used by other professionals in their local communities. Individuals are encouraged, however, to include a simple listing of such of the following items as they consider appropriate:

1. *Identification*, using appropriate titles. "Speech-Language Pathologist" and "Audiologist" are the official titles of professionals in the field of Speech-Language Pathology/Audiology.
2. *Fees*, listing fixed prices or a stated range of prices for specified professional services. When additional charges may be incurred for an integral part of the overall service it shall be so stated.
3. *Qualifications*, including certification; licensure; educational, experiential, and biographical data.
4. *Services*, including specialties or restrictions.
5. *Location, hours*, and *telephone number*.
6. *Staff* or *associates'* names and qualifications.

B. In making information available to the consumer public, individuals have the responsibility of fairly and accurately representing their services and the profession so that the public is not misled that competence exists in areas in which it does not. It is thus appropriate to list such items as certification, licensure, honorary awards, and accreditation at a service facility or training program by the Professional Services Board or the Education and Training Board, but not to describe any particular expertise which supposedly results from any of those matters. Additionally, individuals should:

1. Avoid misrepresentations of the nature or extent of services provided.
2. Ensure that when fees and services are listed they are listed in a manner which is not misleading. For example, one level of service (diagnostic) may not be offered at a specified fee when in fact a lower level of service (screening) is provided for that fee.
3. Not use laudatory comments or testimonials by implication or quotation of persons served professionally..
4. Not state or imply claims of unusual professional skills.
5. Not use comparisons of abilities with those of other individuals.
6. Describe services, qualifications, facilities, staff, products dispensed, etc., in a factual nonevaluative manner.
7. Use appropriate and accurate terminology, such as Speech-Language Pathologist, Audiologist, Professional/Clinical Services, Clinical Management, and Diagnosis and Treatment.
8. Avoid "blind" listings in the classified section of newspapers or other periodicals. "Blind" listings are announcements which omit the name of the individual or agency offering services.

II. Promotional activities

A. In representing their services or professional products to the general public, individuals accept the obligation of presenting information objectively and accurately, avoiding misleading the public by misrepresentation through implication, deception, exaggeration, half truths, or superficiality.

B. Individuals offering free speech and/or hearing screening should provide those who need further services with a choice of referral sources. Individuals should avoid participation in any activities recommending to the general public the use of any single source product or service.

C. Individuals shall not use their affiliation with the American Speech-Language-Hearing Association to endorse the marketing and promotion of products, whether related or unrelated to the profession.

*"Individuals" refers to all Members of the American Speech-Language-Hearing Association and nonmembers who hold Certificates of Clinical Competence from this Association

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III. Other constraints on advertising

A. The rules set out in this statement are offered only as general guidelines for application of the Code of Ethics of the Association with regard to public statements and announcements. In addition, individuals may be subject to various state laws such as licensure laws. Individuals may be subject also to the regulations of the Federal Trade Commission governing the use of endorsements and testimonials in advertising. Individuals must be aware therefore that there are other restraints in the area of professional advertising and indeed they may be greater than those set forth in this statement. If ASHA guidelines should prove less restrictive in any respect, individuals must adhere to any higher standards that might be applicable. This statement does not purport to give legal advice in this regard.

Definitions

"*Public Statement.*" Any direct or indirect statement, suggestion or implication, including but not limited to one that is made orally, in writing, pictorially, or by any other audio or visual means, or by any combination thereof.

"*Announcement of Services.*" Any written or oral statement, illustrations, sign, notice or depiction which is designed to inform the public about professional services or products related to the field.

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A SURVEY OF HEARING CONSERVATION PROGRAMS OF AREA MANUFACTURERS

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The deleterious effects of exposure to loud noise are well documented (Burns, 1973; Henderson et al., 1976; Lipscomb, 1978). In an effort to protect persons during working hours from the emotional and physical sequelae brought on by prolonged noise exposure, the U.S. government has established specific guidelines for the duration and intensity of noise to which workers may be exposed. These guidelines are mandated under the Occupational Safety and Health Act of 1970. The purpose of the present study is to review briefly the OSHA guidelines for industrial noise exposure and to examine the status of industrial hearing conservation programs in a large metropolitan area.

REVIEW OF OSHA GUIDELINES

The original Occupational Safety and Health Act was passed in 1970. Three new entities were evolved from the act. The first is the Occupational Safety and Health Administration (OSHA). It is the branch within the Department of Labor that is responsible for administration and enforcement. The second, the National Institute for Occupational Safety and Health (NIOSH) has research and manpower development as its major concern and also functions in an advisory capacity to OSHA. NIOSH is an organization developed from the Department of Health, Education and Welfare. Third, is the Occupational Safety and Health Review Commission. This commission is independent of the HEW and Labor Departments. It makes decisions regarding appeals from employers who feel they have been cited for unjust reasons.

Present OSHA guidelines state that every company must have a program of hearing conservation and each employee must wear ear protectors whenever a 90 dBA noise level exists. This program includes regular audiometric testing (at least every two years). Audiometric testing should take place after fourteen hours of non-exposure to noise levels exceeding 80 dBA (ear protectors may be worn during this period if they attenuate below 80 dBA). A baseline audiogram should be taken at the time of initial exposure to the work situation. The audiometric test required by OSHA examines hearing thresholds in octave intervals for the frequencies .5 through 6000 Hertz (Hz). OSHA is requiring the testing of 8000 Hz as of March 1, 1982.

Audiograms should be analyzed for threshold shifts using the initial

baseline audiogram as the control. Significant threshold shifts are thought to be the difference of 15 dB between an individual's hearing threshold at any two frequencies tested. If a shift exists, the individual must be re-tested within one month. If a permanent shift is positively identified by the re-test, the employer must see that the employee is given proper notification regarding his change in hearing. The employee must also be counseled regarding medical intervention or treatment.

All audiometers used in hearing conservation programs should be calibrated according to the guidelines set forth by the Department of Labor. Each instrument used in a hearing conservation program must maintain accuracy through biological, periodic, and exhaustive calibration. A biological calibration consists of comparing the threshold scores of an individual known to have a normal or stable audiogram (not exceeding a hearing level of 25 dB at any frequency) with that same person's thresholds on the day of calibration. The periodic calibration is defined as measuring output of the audiometer using an artificial ear coupler. Also, both earphones are measured for linearity in 10 dB steps between 10 dB and 70 dB at 1000 Hz. This procedure should be performed yearly, or as indicated by the biological calibration. An exhaustive calibration technique should be employed every five years. It includes testing for accuracy of intensity, frequency linearity and harmonic distortion.

Specifications regarding the use of personal ear protectors are part of the standards utilized by the State of Kentucky. It is stated that protectors will be supplied by the employer whenever his employees are exposed to excessive noise levels (90 dBA) during their work period. The policies regarding distribution, requirement of use, and maintenance are left up to each employer.

Audiometric data for employees must be maintained in an accurate file so as to be available to State and Federal agencies (i.e., State Commissioner of Labor, or U.S. Secretary of H.E.W.) upon request. The individual employee has the right to obtain such audiometric data for himself or his physician upon written request. Also, each employee must be informed of any hazards surrounding his exposure to excessive noise levels. The employee must be counseled on proper precautions as well.

METHODOLOGY

In an effort to determine the status of hearing conservation programs in one community, several area manufacturers were contacted by telephone and polled regarding their hearing conservation programs. Since most manufacturers have some safety requirements, questions were directed toward the safety director or someone within the company who functioned in that capacity. Questions applicable to the local industrial population were adapted from the Health, Education and Welfare publication entitled, "Survey of Hearing Conservation Programs in Industry". The questionnaire used in the present investigation is presented in The Appendix.

SUBJECTS

Participating manufacturers were selected for use by applying a table of random numbers to the Directory of Manufacturers, located in the local OSHA office. The criteria for selection were that the manufacturer must have at least thirty employees. No constraints on the type of production were employed. In general, cooperation of the participants was judged to be good, since only two of the thirty manufacturers sampled would not take part in the survey.

For the purpose of this study the following characteristics were considered as indicators of the existence of a "hearing conservation program": 1) the company must conduct periodic noise measurements, 2) ear protectors must be available to employees, and 3) there must be periodic hearing evaluations.

RESULTS

Initially, the size of the workforce was compared with the existence or non-existence of a hearing conservation program. This was done due to the fact that large production operations necessitate a greater workforce and quite often require more equipment than the smaller manufacturing company. Table 1 gives the results of this tabulation. Of the 18 manufacturers employing between 30-99 workers, only six (33.3%) had active hearing conservation programs, while 10 (55.6%) had no such program, and two (11.1%) in this group refused to participate. Of the manufacturers employing 100-199 individuals, six (85.7%) had hearing conservation programs, and one (14.3%) did not. Two manufacturers employing 200-299 workers were divided evenly; one (50%) had an active hearing conservation program while the other (50%) did not. The manufacturers employing 300-500 individuals and above were grouped together since there were only three falling into this category. All three (100%) had a hearing conservation program. These results would imply that as the workforce increases, so too does the utilization of hearing conservation programs.

Table 1

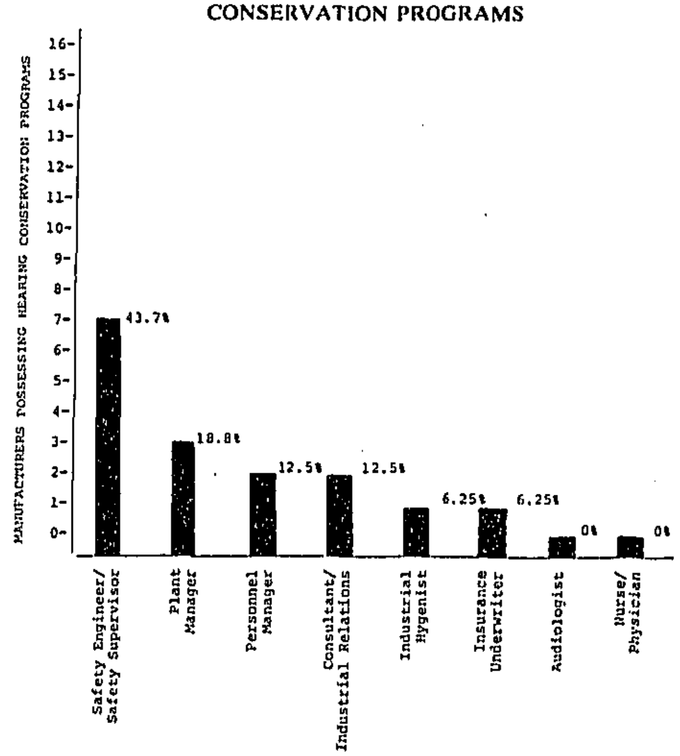
NUMBER OF EMPLOYEES VERSUS HEARING CONSERVATION PROGRAMS

Number of Employees	Total Number in Sample	Hearing Conservation Program				Refused to Participate
		YES		NO		
		Number	Percent	Number	Percent	
33-99	18	6	33.3%	10	56.6%	2 (11.1%)
100-199	7	6	85.7%	1	14.3%	0
200-299	2	1	50.0%	1	50.0%	0
300-500	3	3	100.0%	0	.0%	0
TOTALS	30	16		12		2

As shown in Table 1, 16 manufacturers from the total sample of 30 have hearing conservation programs. Figure 1 presents the date regarding who directs and supervises these hearing conservation programs. Of these 16 manufacturers, seven (43.7%) are directed by the safety engineer or safety supervisor. The industrial hygenist and insurance underwriter head one program each for a total of 12.5%. Consultants or industrial relations personnel, as well as personnel managers direct a total of four programs (25%). Three programs are supervised by the plant manager (18.8%). No programs are supervised by a physician, nurse or audiologist.

Figure 1

PERSONNEL DIRECTING HEARING CONSERVATION PROGRAMS



Noise levels often compare positively with the type of production being used and the product being manufactured. For comparison purposes, the sample has been divided into subgroups according to their type of production. These five subgroups are as follows: 1) food, 2) metal fabrication, 3) plastic and paper works, 4) lithographic printing or engraving, and 5) home/lawn/garden products. Results shown in Table 2 reveal that the most stringent hearing conservation programs are in the food industry, where three of the total four employed hearing conservation programs. Production involving metal fabrication, however, made up the largest subdivision of the sample. Five (62.5%) of the total eight in this category employed conservation programs. The lithographic printing and engraving category showed three (42.8%) of the total seven utilizing hearing conservation programs, and gave the majority of negative responses to questions regarding hearing conservation. The overall breakdown of results shown in Table 2 revealed that 16 companies employed hearing conservation programs with each administering periodic audiograms, periodic noise level measurement, and providing ear protectors to employees. Of these 16 companies, nine also administer pre-employment audiometric evaluations, with eight administering them for all employees, and one administering them for only employees exposed to 90 dBA or above.

Table 2

SUMMARY OF MANUFACTURER TYPE AND COMPARATIVE HEARING CONSERVATION EFFORTS

Type of Manuf.	No. In Sample	HEARING CONSERVATION EFFORTS: Administer Periodic Audiograms		Periodic Noise Efforts		Ear Protector Usage*	Administer Pre-Employment Audiograms	
		YES	NO	YES	NO	REQUIRE	YES	NO
Food	4	3	1	3	1	3	2	1
Metal Fabrication	8	5	3	5	3	5	3	2
Plastic & Paper Prod.	4	2	2	2	2	1	2	0
Lithographic Printing/ Engraving	7	3	4	3	4	0	1	2
Home/Lawn & Garden Prod.	5	3	2	3	2	2	1	2
TOTALS	28**	16	12	16	12	11	9	7

*-All manufacturers in each group provided ear protectors, therefore, only figures for those REQUIRING employees to wear them were reported.

**-2 Companies refused to participate, bring total to 30.

Additional data revealed through analysis of these 16 hearing conservation programs indicates that periodic audiograms are performed by a nurse or physician in two programs, an audiologist in one program, and an outside agency in 13 programs.

For two companies the testing environment consisted of a quiet room, while only one used a sound treated room. Eight companies employed a mobile unit for testing and five sent their employees to an outside testing facility.

Periodic noise measures occurred for one company monthly, for one company biennially, for two companies semi-annually, for five companies annually, and for two companies quarterly. Also, noise measures were conducted by five companies upon modification of production techniques or whenever deemed necessary by spot checks.

One company distributed earmuffs only, eight companies distributed earplugs, and seven were found to distribute both types of ear protectors.

DISCUSSION

Reactions to the survey indicated that many companies were concerned with OSHA involvement in their production techniques. It is felt that this concern is often due to cost factors that would be involved in changing production to reduce noise levels. Many companies treat information on this subject as strictly confidential.

Results imply that as the workforce increases, so too does the need for and utilization of hearing conservation programs. This is probably due in part to the larger company generating more income that can be applied to such a program. Also, the larger company would have more administrative staff available to supervise and maintain such a program. A national survey of similar methodology polled 2074 companies and revealed that 23.5% of the overall industrial population had programs involving hearing conservation. The results of the present study indicate that of the 30 companies polled, 16 (53%) had hearing conservation programs, representing a high percentage than discovered nationally. However, when comparing these results, one must consider the variation in population size of the two studies.

It is of interest that none of the companies surveyed employed an audiologist as supervisor of the hearing conservation program. It seems that the audiologist's place within the manufacturing industry would be many-fold. First, the audiologist could act as hearing conservation consultants. By using their expertise in the areas of noise, vibration, hearing conservation guidelines, as well as the clinical aspects of audiology, the audiologist could make recommendations on various methods of quieting production. Second, they could serve in an advisory capacity as hearing health care educators for all personnel. Third, the audiologist could perform the pre-employment or periodic audiometric testing and noise level measurements required by OSHA. In order to provide these services, audiologists must actively seek out the opportunity to use their expertise in the industrial setting. Therefore, the audiologist should become familiar with OSHA guidelines for the locality in which they work, thereby expanding both their knowledge and professional opportunities.

SUMMARY

The present study demonstrated that the following general trends exist concerning hearing conservation programs of the sample population. First, it was shown that an increase in the size of the work-force promoted better hearing conservation programs. Second, safety engineers or safety supervisors rather than audiologists were found to direct the majority of existing hearing conservation programs in this sample. Third, it was shown that the food industry provided somewhat more stringent regulations for hearing conservation as compared to other subgroups.

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Schmidek, M.E.; Layne, M.A.; Lempert, B.L.; Fleming, R.M. **Survey of Hearing Conservation Programs in Industry,** U.S. Department of Health, Education and Welfare, National Institute for Occupational Safety and Health, Publication No. (NIOSH) 75-178, U.S. Government Printing Office, Washington, D.C. 20402, June 1975.

Standards Interpretation Directive No. 24, Kentucky Department of Labor, Occupational Safety and Health Program, Frankfort, Ky. 40601.

APPENDIX

Number of employees: __________

Type of Product Produced: ______________________________

HEARING CONSERVATION SURVEY QUESTIONNAIRE

Title of Person Answering Survey: ______________________

1. Do you have a program concerned with hearing conservation?

   ______ yes

   ______ no

   IF YES, Who is developing and organizing (or currently supervising) this program?

   a. ______Industrial Hygenist
   b. ______Safety Engineer/ Safety Supervisor
   c. ______Physician/Nurse
   d. ______Audiologist
   e. ______Consultant/Industrial Relations
   f. ______Personnel Manager
   g. ______Plant Manager
   h. ______Insurance Underwriter

2. Do you give periodic hearing tests to your employees at least once in two years?

   ______ yes

   ______ no

   IF YES, Who performs the hearing test?

   a. ______Physician/Nurse
   b. ______Audiologist
   c. ______Outside Service

   IF YES, What type of test environment is used for hearing testing?

   a. ______Quiet office
   b. ______Sound treated room
   c. ______Private hearing clinic
   d. ______Mobile Unit

l. Are the noise levels in work areas measured periodically during the year?
a. ______yes
b. ______no
IF YES, How often are these measures taken?

a. ______monthly
b. ______semi-annually
c. ______annually
d. ______quarterly
e. ______bi-annually
f. ______upon modification of production techniques or whenever deemed necessary by spot checks

l. Are personal ear protectors supplies to your employees?
a. ______yes, to all employees
b. ______yes, to employees working in noisy areas (90dBA or above)
c. ______yes, employees are REQUIRED to wear ear protectors
d. ______no
IF YES, What type of ear protectors are made available?
a. ______muffs
b. ______plugs
c. ______muffs and plugs

i. Are pre-employment audiometric tests performed?
a. ______yes, for all employees
b. ______yes, for employees working in noisy areas (90dBA or above)
c. ______no

ADDITIONAL INFORMATION

HEARING CONSERVATION

EDUCATIONAL TRAINING MATERIALS

1. PAMPHLETS

(1) Hearing Loss Can Be Permanent

Tracor, Inc.
6500 Tracor Lane
Austin, TX 78721

(2) Industrial Noise and Hearing Loss

Maico Hearing Instruments
7375 Bush Lake Road
Minneapolis, MN 55435

(3) Multi-Media Education Program and Motivation Kit

Bilsom International, Inc.
11800 Sunrise Valley Drive
Reston, VA 22091

(4) Noise and You

1. Channing L. Bete Co., Inc.
200 State Road
South Deerfield, MA 01373
Telephone: - 413-665-7611

*2. David Clark Co., Inc.
360 Franklin Street
Worcester, MA 01604

* less expensive

(5) Now Hear This

Safety Health Services
Employers Materials of Wausau
Wausau, Wisconsin 54401

1. PAMPHLETS (continued)

(6) Protect Your Hearing

Liberty Mutual Loss Prevention Service
(available to companies which are Liberty Mutual policy holders)

(7) Sound and Noise and Hearing Protection

Willson Products Division
P.O. Box 622
Reading, Pennsylvania 19603

(8) The Sound Facts of Hearing

AudioTone
P.O. Box 2905
Phoenix, AZ 85062

2. FILMS

(1) Can You Hear Me?

Bureau of National Affairs Communications, Inc.
9401 Decoverley Hall Road
Rockville, MD 20850

(2) Contraphon

Bilsom International, Inc.
11800 Sunrise Valley Drive
Reston, VA 22091

2. FILMS (continued)

(3) The Ear and Hearing

Encyclopedia Britannica
Educational Department
425 North Michigan Avenue
Chicago, IL 60611

(4) For Good Sound Reasons

Willson Products Division
2nd & Washington Streets
P.O. Box 622
Reading, PA 19603
(215) 376-6161

(5) Hearing the Forgotten Sense

Price Filmakers
3491 Cahvenga Boulevard
Hollywood, CA 90028

(6) Hear What You Want to Hear

1. Modern Talking Picture Service, Inc.
   5000 Park Street N
   St. Petersburg, FL 33709
   813-541-6661

2. National Safety Council
   425 North Michigan Avenue
   Chicago, IL 60611

(7) It Takes Two

Price Filmakers
3491 Cahvenga Boulevard
Hollywood, CA 90028

2. FILMS (continued)

(8) It's Up To You

E.A.R. Corporation
7911 Zionsville Road
Indianapolis, IN 46268
317-293-1111

(9) Nice To Hear

Bilsom International, Inc.
11800 Sunrise Valley Drive
Reston, VA 22091

(10) Protect Your Hearing

1. Bray Studios, Inc.
   630 Ninth Avenue
   New York, NY 10036

2. David Clark Company, Inc.
   360 Franklin Street
   Worcester, MA 01604

(11) SOS

Bilsom International, Inc.
11800 Sunrise Valley Drive
Reston, VA 22091

(12) The Sound of Sound

American Optical Corporation
Safety Products Division
Southbridge, MA 01550

(13) Sound Off

Pyramid Film Producers
P.O. Box 1048
Santa Monica, CA 90406

(14) Stick It In Your Ear

Colorado Hearing and Speech Center
4280 Hale Parkway
Denver, CO 80220
Toll Free (800) 525-1393

(15) To Conserve and Protect

Modern Talking Picture Service, Inc.
5000 Park Street N
St. Petersburg, FL 33709
813-541-6661

3. SLIDE/TAPE PROGRAMS

(1) Sound Advice

Industrial Training Systems Corporation
311 New Albany Road
Moorestown, NJ 08057

(2) Supervisor and Employee Education Program

Oto-Data, Inc.
842 N. Highland Avenue, NE
Atlanta, GA 30306

(3) You People Live In a Noisy World

Health Education Resources
Suite 525
3545 Olentangy River Road
Columbus, OH 43214

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