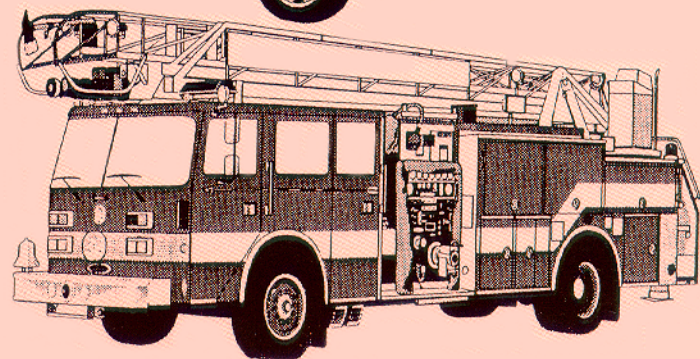
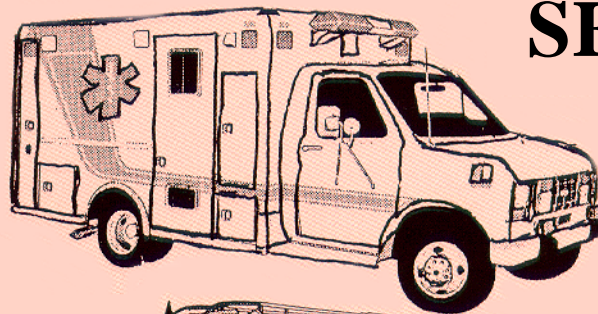


# FIRE & EMERGENCY SERVICE



Hearing Conservation Program Manual



Federal Emergency Management Agency  
United States Fire Administration

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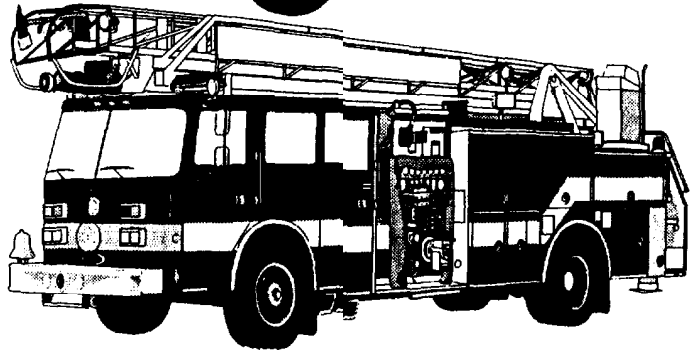
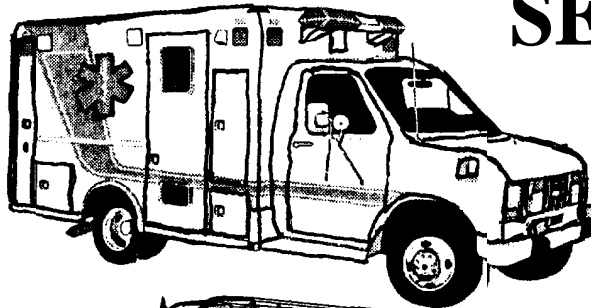
**Federal Emergency Management Agency  
United States Fire Administration**

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Any opinions, findings, conclusions or recommendations expressed in this publication do not necessarily reflect the views of the Federal Emergency Management Agency or the United States Fire Administration.

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# FIRE & EMERGENCY SERVICE



Hearing Conservation Program Manual



Federal Emergency Management Agency  
United States Fire Administration

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Federal Emergency Management Agency  
United States Fire Administration

Emmitsburg, Maryland 21727



September 1992

Dear Colleague:

Since its inception, the United States Fire Administration (USFA) has been committed to enhancing the health and safety of emergency response personnel. Fire, rescue, emergency medical service (EMS), and other emergency response agencies across the country rely on the USFA for state-of-the-art information on critical emergency management issues. Thus, some of our most aggressive initiatives in recent years have focused on the very real and serious occupational health hazards of emergency responders.

Noise is probably the most underrated health hazard affecting fire and EMS personnel. The siren required to warn the public that emergency vehicles are approaching is just one example of the overlooked noise hazard for individuals riding the engine, truck, rescue, ambulance or other emergency vehicle.

The dangers of excessive noise exposure to emergency service personnel is finally being addressed. There have been a number of evaluations of fire departments that have substantiated the fact that firefighters and EMS personnel are being exposed to high noise levels with resultant hearing loss. These studies have also found a substantial increase in high frequency hearing loss related to the amount of time spent in the emergency services.

The cases of hearing loss are irreversible and incurable. They are also preventable! This manual will be an important resource in the development of programs to control the emergency responder's noise exposure problem.

Sincerely,

A handwritten signature in black ink, appearing to read "Olin L. Greene".

Olin L. Greene  
U.S. Fire Administrator

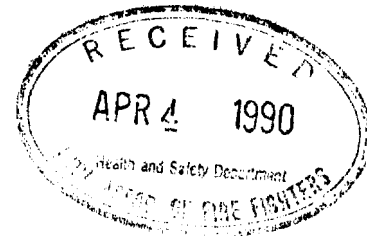


Federal Emergency Management Agency  
United States Fire Administration  
Emmitsburg, Maryland 21727



APR 02 1990

Mr. Richard M. Duffy  
Director  
Department of Occupational  
Safety and Health  
International Association  
of Fire Fighters  
1750 New York Avenue, N.W.  
Washington, D.C. 20006



Dear Mr. Duffy:

I have reviewed An Evaluation of Current Hearing Conservation Programs which the International Association of Fire Fighters (IAFF) performed under contract (EMW-88-R-2896) with the United States Fire Administration. The report content meets the requirements of the contract, and I believe that, based upon a reading of this report, fire departments will be able to recognize the value of a Hearing Conservation Program (HCP) to the members and to the department. I do not believe that any changes, additions, or deletions are necessary, and I look forward to receiving camera ready when they become available.

Sincerely,

A handwritten signature in cursive that reads "Tom Smith".

Tom Smith  
Acting Assistant Administrator  
Office of Firefighter Health  
and Safety  
U.S. Fire Administration

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# ***INTRODUCTION***





Although sight is commonly considered our most valued sense, some people who are totally deaf claim that if they had their choice they would rather be blind. This is because the deaf person has lost an extremely important and basic process of communication for which there are only poor substitutes. Sound can provide a basic source of information and pleasure. However, excessive noise can be a menace.

Of all the hazards faced by workers, noise may be one of the most serious. While noise-induced hearing loss (NIHL) is one of the most common occupational diseases, it has frequently been overlooked or underrated because it is neither visible nor painful. The effects of noise are cumulative and often take a long time to become permanent. Often, the permanent effects of noise are not noticed by an individual until it is too late.

Noise is often defined as sound bearing no information and whose intensity varies over time. Noise is usually unwanted. It frequently interferes with wanted sound and evidence shows that it can be physiologically harmful. However, noise does not have specific characteristics that distinguish it from wanted sound except how it is perceived by the human ear. Harmful noise can be generated in two ways. First, there is continuous noise. This is the type of noise that may be generated by an engine or by equipment such as an exhaust fan or cutting tool. The second type is called intermittent noise, that is noise generated by a siren or the blowing of an air horn.

Noise is one of the few occupational health hazards common to all industries. It not only causes "auditory" effects (hearing loss), but can also be accompanied by "extra-auditory" effects (psycho-logical problems, or long or short term physiological effects). The physiological effects of noise may be enhanced when accompanied by other stressors that are common to the nature of emergency services, such as shift work and trauma related stress. An individual's encounter with high occupational noise levels over time may cause the

degradation of hearing, mask reception of desired sounds, interfere with speech communication, heighten emotions and physiologic activity, disrupt concentration and cause other actions that may hinder job efficiency or induce accidents at the workplace.

The hazards of noise have been known for centuries. In the early 1700's, Ramazzini described the effect of hearing loss on coppersmiths. In the 19th century, blacksmiths were identified as an occupational group that would routinely experience hearing loss. The dawning of the industrial revolution brought on noise as we know it today-a common part of our everyday lives. In every urban and suburban area, the sounds of traffic, pneumatic and electric tools, sirens and horns, and even aircraft flying overhead can be heard.

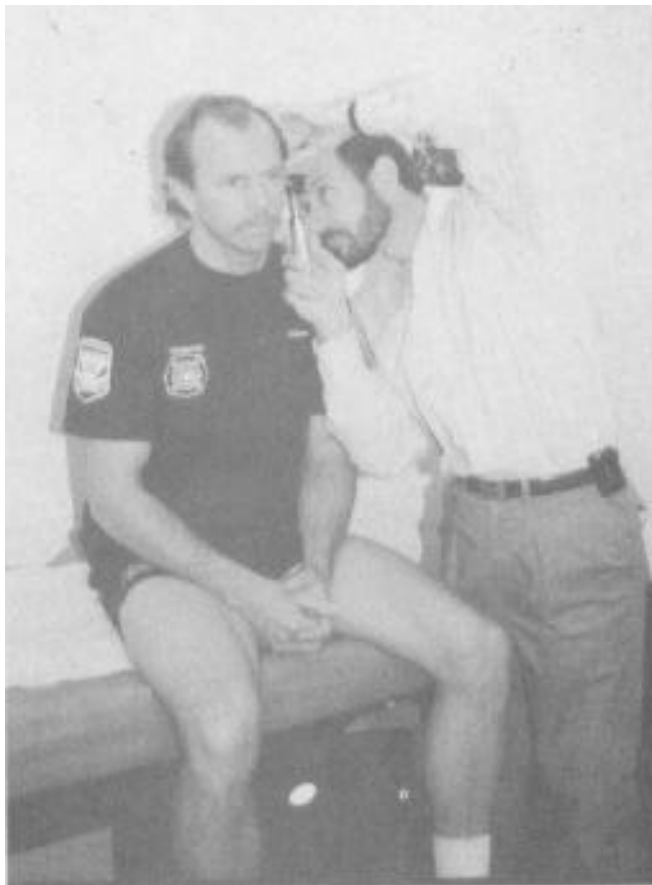
Noise Induced Hearing Loss is recognized as a significant occupational health hazard throughout the fire service. Emergency Medical Service (EMS) personnel face many of the same hazards of excessive noise exposure. Sirens, air horns, motors, power tools, and radio speakers create noise hazards for fire and EMS personnel in emergency apparatus, during emergency operations, and during training evolutions.

To assist fire and EMS departments and emergency response personnel in understanding the hazards of excessive occupational noise exposure, this manual discusses (a) the hearing process, (b) occupational hearing loss, (c) the extra-auditory effects of excessive noise exposure, (d) standards for noise exposure, (e) the measurement of sound, (f) fire fighter noise exposure, (g) noise control practices, (h) workers' compensation and hearing loss, (i) the elements of a hearing conservation program, (j) the evaluations of the Phoenix and Anaheim fire departments' hearing conservation programs, and (k) a step-by-step approach to reduce excessive noise exposure for fire fighters and EMS personnel.





## ***THE HEARING PROCESS***







Although many people think of the ear only as an organ for hearing, it basically serves three functions. The ear provides the function of hearing, the ear also sends impulses to the brain to inform us of our spatial orientation and of our body's movements in the three dimensions of space. The focus of our attention will be the auditory system, since that is the primary function of the ear that can be damaged by excessive long-term occupational noise exposure.

Sound can be defined as a variation in pressure through any elastic medium (gas, solid or liquid) that the human ear can detect. Sound is caused by vibration, which causes air particles to expand and compress against each other (for example, the vibration of your vocal cords when you speak or guitar strings when you pluck them). These movements then spread as "waves" through the air.

The auditory system of the ear has three basic components:

- 1 the outer ear directs sound into the ear;
- 1 the middle ear mechanically transmits  
1 the sound waves from the air to the  
1 fluid-filled inner ear; and
- 1 the inner ear changes sound waves from  
1 mechanical to neural energy.

In the hearing process, the outer ear flap or pinna collects sound waves and channels them into the auditory canal to the eardrum. In humans, this outer ear flap is immobile, however, many animals (e.g., dogs and cats) can direct their ears to face the direction of the sound. (See Figure 1)

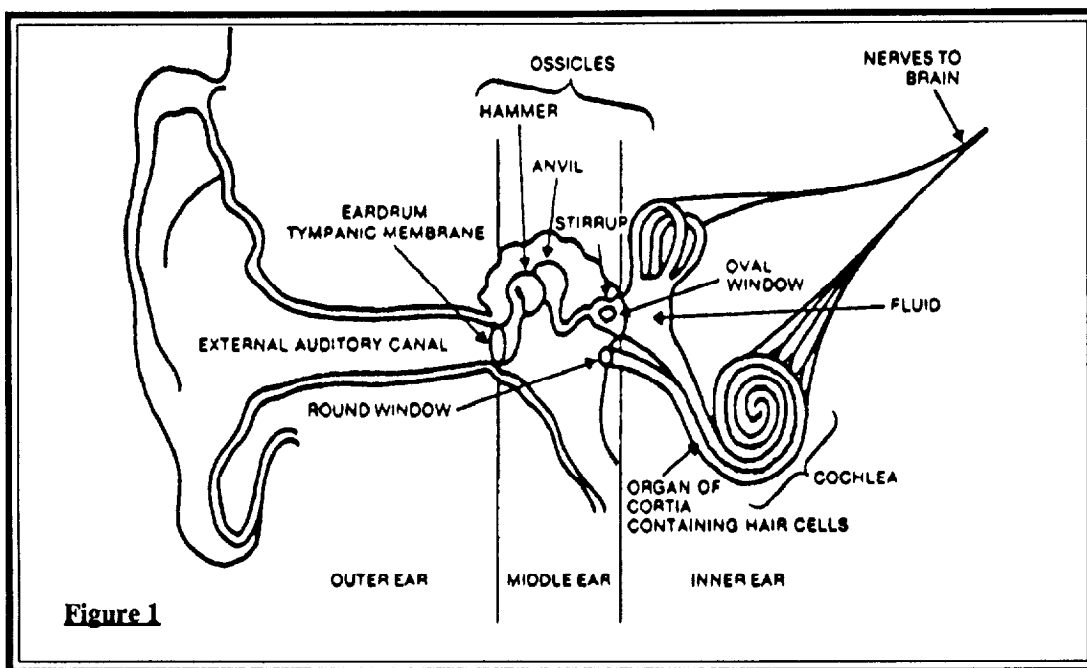
The eardrum or tympanic membrane, which separates the outer and middle ear sections, vibrates in a manner similar to that of the original sound sources. These vibrations are passed onto the ossicles, three tiny bones in the middle ear (the hammer, anvil and the stirrup). The distal end of the ossicles attach at the tympanic membrane. The ossicles act as a series

of levers to transfer the sound waves into mechanical movements. They do this by reacting to the inward and outward movements of the tympanic membrane caused by sound waves.

The proximal end of the ossicles attach to the oval window of the inner ear. The sound waves travel through the fluid contained in the cochlea. The cochlea is a snail-shaped organ in the inner ear and contains thousands of microscopic hairs, collectively called cilia, that are connected to the auditory nerves. Each hair has its own nerve attached to it. These tiny hair cells along with their supporting cells comprise the auditory sense organ known as the Organ of Corti. The fluid in the cochlea vibrates in time with the eardrum which causes the cilia to move back and forth in rhythm with the wave motion of the fluid. This action results in the stimulation of the attached nerve sending impulses to the brain for interpretation.

There are several theories that attempt to explain what happens to the inner ear when it is exposed to intense levels of noise. One belief is that the vigorous stimulation of the hair cell structures by high levels of noise subjects them to shearing forces or other types of mechanical stresses that cause the hair break or be damaged in some other way. Another theory states that when the hair cells are exposed to constant intense sound stimulation it causes the metabolic processes essential for cellular life to become exhausted or poisoned which in turn leads to the death of the hair cells.

According to a report by the Environmental Protection Agency, industrial chemicals may play a role in increasing the effect of high noise levels in the ear. For example, carbon monoxide, carbon disulfide and trichloroethylene are known to damage the nervous system and the inner ear. It has been suggested that further research may reveal other chemicals, particularly solvents, that may have a similar damaging effect on the ear.



**Figure 1**



## ***OCCUPATIONAL HEARING LOSS***





The primary factors that determine if noise can inflict hearing loss are intensity, frequency, exposure pattern and duration. The risk of damage to the ear increases with greater intensity and exposures of longer duration. Noise levels in the frequencies above 1000 Hz are also more damaging than those in the frequencies below 1000 Hz.

In addition to these noise exposure factors, there are other components that could contribute to hearing loss:

- Individual susceptibility
- Age
- Diseases of the ear
- Type of surrounding in which the noise exposure occur
- Distance from source of noise
- Type of noise (impact, continuous)

It is estimated that 25% of the newly employed adult population already experience some degree of hearing loss caused by physical blockage of the auditory canals, trauma, disease, hereditary, prenatal damage or drug-induced damage. While the outer and middle parts of the ear are usually not damaged by exposure to high levels of noise, explosive sounds or blasts can rupture the eardrum. This type of damage can impair or prevent the normal passage of sound from the outer to the inner ear. However, the most common form of damage is of the neural type whereby the hair cells are worn out or damaged.

It is estimated that 20% of all workers between the ages of 50 and 59 years will develop hearing loss regardless of any occupational exposure to noise. When hearing loss develops as a natural occurrence of age (presbycusis), it will not normally cause significant impairment unless the individual lives to be very old. However, when occupational noise-induced hearing loss is added to presbycusis, then substantial hearing impairment does occur.

The American Medical Association recommends that the criterion for hearing impairment is when the average hearing loss across the frequencies of 500, 1000, 2000 and 3000 Hz exceeds 25 dB. NIOSH uses a similar criterion, except they eliminate 500 Hz. When hearing loss is noise related, the audiogram will show a dip at approximately 4000 Hz. A 4000 Hz frequency hearing loss is not normally noticeable to the individual, The hearing loss will become apparent as it spreads into the speech range (500-2000 Hz). Certain frequencies above 2000 Hz are also extremely important for speech discrimination. Hearing losses in this range can cause functional impairments, particularly for understanding conversation in a noisy environment.

When fire fighters are exposed to high levels of noise, a temporary and/or permanent hearing loss can be expected. Table I shows significant scientific evidence collected by various organizations which indicates that exposure to noise levels above 90 dBA over an extended period of time will cause hearing loss.

There are two types of hearing loss that may result from exposure to intense levels of noise: temporary threshold shift (TTS) and permanent threshold shift (PTS). A temporary decrease in hearing ability is known as 'ITS. TTS is based on the individual's threshold of hearing. The degree of TTS or PTS may be dependent upon the susceptibility of an individual's ears. However, such susceptibility may vary according to the frequency of the noise.

The degree of 'ITS depends upon the intensity and duration of the noise exposure. The greatest amount of temporary hearing loss usually takes place within the first few hours of the exposure. After a short period of time, a person may feel that they have gotten use to the noise. This occurs because the cilia in the cochlea have become fatigued and cannot perform their function in the required manner. Generally, sound levels

**TABLE I**

**ESTIMATE OF POPULATION AT RISK OF EXPERIENCING HEARING**

<i>Organization</i>	<i>Noise Exposure (dBA)</i>	<i>Population at Risk</i>
International Organization for Standardization	90 85 80	21 % 10 % n/a
Environmental Protection Agency	90 85 80	22 % 12 % 5 %
National Institute for Occupational Safety and Health	90 85 80	29 % 15 % 3 %

must exceed at least 80 dBA before the average person will experience TX. The greater the intensity above the 80 dBA level, the greater the potential for TTS to occur.

As might be expected, the louder the noise and/or the longer the exposure, the more time it will take for temporary hearing loss to subside. The length of time it takes TTS to disappear will vary from a few minutes to possibly weeks. Hearing loss of a temporary nature is usually restored in about 24 hours with the majority of recovery in the first few hours.

It should also be remembered that many of us live in areas where highway and aircraft noise as well as noise from nearby industrial plants are prevalent. Thus, some individuals may be exposed to noise close to 24 hours per day without adequate opportunity to recover either physiologically or psychologically. Although it is sometimes difficult to differentiate between noise from non-work and occupational exposures, studies have shown that industrial noises are generally much louder than those encountered in our non-work lives.

Any person who regularly experiences a temporary threshold shift (TTS) will eventually suffer permanent hearing loss. TTS indicates that an individual has been affected by noise. If that individual continues to be exposed to these same noise levels, the end result will be a noise-induced permanent threshold shift (PTS). Studies have suggested that after approximately ten years of noise exposure, temporary hearing loss tends to become permanent. Table II provides some of the common warning signs of hearing loss.

Permanent hearing loss occurs when excessive noise expo-

sure causes the hair cells in the cochlea to become damaged. Hearing loss due to damage of the cochlea or of the auditory nerve is called sensory-neural hearing loss. This type of damage can affect the perception of sound intensity. Thus, even if sounds are amplified, they will still seem indistinguishable from each other. Sensory-neural hearing loss usually occurs first and is most severe for the 4000 Hz frequency (sounds like those from the letter 'S'). If exposure to high noise levels continue, then the hearing loss will expand across the 2000 or 3000 through 6000 Hz band.

Sensory-neural hearing loss is irreversible. Although hearing aids assist in amplifying sound, they can not make it clearer or less distorted. There are no ways to correct sensor-neural hearing loss.

Persons experiencing noise-induced high-frequency hearing loss will usually have difficulty hearing consonant sounds and will have difficulty understanding speech. These people may feel that they are at a loss when attempting to communicate in a group or on a noisy street.

Another result of occupational noise exposure is a complication known as tinnitus. It is often associated with hearing loss at specific frequencies. This ringing in the ears can become so loud as to disturb one's ability to sleep. Persons experiencing tinnitus are often more relaxed at work because the noise of the work environment will drown out the tinnitus. Tinnitus may be remedied by a simple procedure like removing excess wax from the ear although usually it can not be cured. Aspirin, quinine and alcohol may also cause or contribute to tinnitus.

**TABLE II**

*Warning Signs of Hearing Loss*

- You must shout in order to be heard by someone working near you
- Your hearing is dulled immediately after your work shift
- After your shift you experience noises in your head or ringing in your ears
- You, family members or friends notice that your hearing is getting worse
- You have difficulty hearing people when others are talking around you
- You regularly experience headaches during or after your work shift

# ***THE EXTRA AUDITORY EFFECTS OF NOISE***





Excessive noise exposure may result in adverse health effects other than hearing loss. These extra-auditory effects of noise are complex and difficult to document. However, there is increasing evidence that noise may have adverse effects on physiological and psychological aspects of a person's general health. Studies have found noise to be a causative factor in stress related illnesses such as hypertension, ulcers, allergies and neurological disorders. Excessive noise exposure may also have psychological effects. Noise has been shown to cause nervousness, fear and psychosomatic illnesses as well as disturb sleep. Evidence to date shows that noise does effect the visual sense. Noise will cause slight impairment of the ability to detect lights in the periphery. Noise will also create elevated thresholds of flicker fusion and slow adaptation to darkness.

One theory indicates that noise, like other stressors, triggers a startle response which induces a widespread change in the bodies activities. These changes may include a rise in blood pressure, a rise in pressure inside the head and increased sweating. Normally, these physiological changes are brought about by intense sounds of sudden onset, much as if a fire fighter would experience going from a relaxed state in the fire station to an alarm response.

The startle response starts with the brain sending out nerve impulses to other parts of the body. Then the various glands that produce hormones such as adrenaline are stimulated. When the body receives constant levels of excessive noise, it causes the body to "tense up" and release adrenaline. When the body is in danger this "alert" reaction may be lifesaving. However, when the body must remain in this state of "alertness" for a long period of time, it begins to fatigue and deteriorate. Blood vessels may constrict forcing the heart to work harder to pump the same amount of blood through the body. This can lead to hypertension (increased blood pressure levels).

These physiological effects of excessive noise exposure have been found in both animal and human studies. In one study, the exposure of guinea pigs to a siren-like noise for fairly long periods of time eventually caused the onset of endocrine and metabolic deficits that decreased their ability to deal with the noise stress. These deficits will reduce the ability to respond to another "startle response" situation. Additional siren exposure to the guinea pigs brought about gastrointestinal ailments, cardiovascular disease and even tissue damage in the kidney and liver. Although the results of this and other similar studies with animals have been criticized, they do demonstrate the existence of extra-auditory effects.

Studies of fire fighters' reaction to the alarm signal indicate that the onset of both physiological and psychological stress induces measurable biological effects. Although the physical activity necessary to get into a truck following an alarm signal should not increase the heart rate to more than around 100 beats

per minute; studies have found that heart beats, particularly among younger fire fighters, increased to as much as 130- 150 beats per minute. Several studies have shown increases in pulse rate after the alarm signals from between 47-61 beats per minute. It has been theorized that such excited responses to the alarm signal could cause an excessive discharge of catecholamines, which have been shown to disrupt the integrity of the arteries' endothelial lining in animals. A disruption in the integrity of the endothelial lining is believed to cause premature atherosclerosis and could be a contributory factor in the higher incidence of cardiovascular disease among fire fighters.

A study performed in Germany found that steelworkers in noisy jobs had a higher incidence of circulatory and neurologic irregularities than their coworkers in less noisy areas of the plant. In Italy, neurological examination of weavers exposed daily to intense noise levels found them to have hyperactive reflexes. In Russian studies, there is a finding that workers in noisy ball-bearing and steel plants have a relatively greater incidence of cardiovascular irregularities. Several of these studies also mentioned that workers complained of fatigue, irritability and conflicts in social settings.

Further evidence is found in the United States through a NIOSH-sponsored study conducted by the Raytheon Service Company. In this study, the medical records of factory workers routinely exposed to noise levels at or above 95 dBA were compared to those of a population exposed to noise levels at or below 80 dBA. The findings showed statistically significant increases in the number of cardiovascular and circulatory disorders as well as other complaints among the factory workers exposed at the higher levels. This study concluded that exposure to high levels of noise over a prolonged period of time did seem to result in increased incidence of various medical, accident and attendance problems.



Deafness has social implications as well as medical effects. Hearing is a vital instrument for learning, communications, safety and pleasure. Obviously, a loss of hearing will have an impact on the effected person's life. Other people will talk around him and he will miss out on the conversation. He may answer questions incorrectly. He may be accused of not listening. Social relationships may begin to be marked by depression and suspicion. A person experiencing hearing loss may withdraw to avoid embarrassment.

In addition, hearing loss could have adverse implications at work leading to injury or even death if a tire fighter can not hear their fellow fire fighters' warning or distress cry or other signals indicating danger. High noise levels may also increase stress making fire fighters more irritable. When combined with other stress factors associated with the job, such as shift work, noise may result in damage to both physical and mental health.



# STANDARDS FOR NOISE EXPOSURE

<b>CODE OF FEDERAL REGULATIONS</b>
29 CFR 1910.95
<i>Occupational Noise Exposure</i>
UNITED STATES DEPARTMENT OF LABOR Occupational Safety And Health Administration


NFPA 1500
Fire Department
Occupational
Safety And Health
Program
1992 Edition

<small>National Fire Protection Association • P.O. Box 9141 • Quincy, MA 02269-9141</small>



## The OSHA Standard

Federal regulations pertaining to the control of noise began with the Walsh-Healey Public Contracts Act. However, these regulations were only enforceable to those contracts issued under the Walsh-Healey Public Contracts Act and the McNamara-O'Hara Service Contracts Act. With the passage of the Occupational Safety and Health Act of 1970 new progress was made in developing occupational noise exposure standards.

The original standard (29 CFR 1910.95) under the newly adopted law was promulgated in 1971 and duplicated the standard established under the Walsh-Healey Public Contracts Act. As the primary research agency under the OSHA, the National Institute for Occupational Safety and Health (NIOSH-I) issued recommendations for a revised noise standard in 1972 with the document, *Criteria for a Recommended Standard: Occupational Exposure to Noise*. NIOSH passed these recommendations onto the rule making and enforcement arm of the Department of Labor (DOL), the Occupational Safety and Health Administration (OSHA). The NIOSH recommendation was for an 85 dB limit instead of the standard's 90 dB permissible limit.

The controversy surrounding the permissible limit of noise exposure has continued. Modifications to the OSHA standard to date were made in 1981, 1982 and 1983 when final amendments were promulgated which set forth new requirements for a hearing conservation program. In 1984, the amendment was stayed in its entirety by the Fourth Circuit US. Court of Appeals. However, the full court reversed this decision the following year. The original standard required a hearing conservation program. However, it did not specify what constituted such a program. These amendments were an outgrowth of a proposed revision to the standard that was released in 1974.

The current OSHA noise standard specifies a maximum permissible noise exposure level (PEL) of 90 dBA for an 8 hour duration, with higher levels allowed for shorter durations. This level is known as a time weighted average sound level, abbreviated TWA. Typically, for an increase of five dBA the permissible exposure time is halved. This permissible noise level is contained in 29 CFR 1910.95, Table G-16 (Table III). It is based on what was believed to be the upper

limit of a daily dose of noise that will not produce a disabling loss of hearing of more than 20% after a working lifetime of 35 years.

When one is exposed to different types of noise exposures, such as fire fighters, the TWA must be calculated. This combined effect is the sum of the fractions, at all levels, of the actual time (hours) divided by the permissible time. The sum of these fractions must be equal to or less than 1.0 for a permitted daily noise dose. For example, if an individual was exposed to 100 dBA for 1 hour, 65 dBA for 5 hours, and 92 dBA for 2 hours during an 8-hour workday, the times of exposure are  $C_1 = 1$  hour;  $C_2 = 5$  hours; and  $C_3 = 2$  hours. The corresponding OSHA limits from 29 CFR 1910.95, Table G-16 are  $T_1 = 2$ ;  $T_2 = \text{infinity}$ ; and  $T_3 = 6$ . The combined exposure dose for this individual would be  $C_1/T_1 + C_2/T_2 + C_3/T_3$  or  $1/2 + 5/\text{infinity} + 2/6 = 5/6$ , which is below the specified limit of 1.0.

When workers are exposed to sound levels that exceed the OSHA permissible exposure limit, feasible engineering or administrative controls, or combinations of both, must be implemented to reduce levels to permissible limits.

The OSHA maximum permissible noise TWA level is 90 dBA. Hearing conservation program implementation is required by employers for employees who are exposed to a TWA of 85 dB or greater. This is called the Action Level (AL). The program must include exposure monitoring, audiometric testing, and training for employees on effects of noise and attenuation practices.

The hearing conservation program allows employers to select the method best suited for their individual situation to monitor all levels of noise exposure between TWA's of 80 dB to 130 dB. Area monitoring is difficult with workers who are mobile or are exposed to fluctuating noise, such as when fire fighters respond to an emergency. Personal noise dosimetry is a more appropriate method to measure this kind of exposure. Area monitoring in the fire station would be allowed under the OSHA standard. Each employee must be notified of monitoring results when exposed at or above a TWA of 85 dBA. The method of informing the employee is left to the discretion of the employer. Employees or their representatives are entitled to observe monitoring procedures.

Audiograms must be pure tone air conduction hearing threshold examinations with test frequencies including as a minimum 500Hz, 1000Hz, 2000Hz, 3000Hz, 4000Hz, and 6000Hz. Tests shall be taken separately for each ear. The employee must not have been exposed to workplace noise for at least 14 hours prior to the audiogram. The audiometric testing program includes baseline audiograms and annual audiograms. Audiometric testing must be made available, at no cost, to all employees who have average exposure levels of 85 dB and above. Exposure is determined by the measurement of the noise environment with out hearing protection.

A professional (audiologist, otolaryngologist or physician) must be in charge of the program. The professional

**TABLE III**

<i>Duration</i>	<i>Sound Level dBA</i>
8.00	90
8.00	92
4.00	95
3.00	97
2.00	100
1.50	102
1.00	105
0.50	110
0.25	115

does not have to be present if a qualified technician is assigned to perform the actual tests. The professional must be responsible for overseeing the testing and the work of the technicians, reviewing problem audiograms and determining whether referral is necessary. Baseline audiograms are what future audiograms will be compared with to determine if noise induced hearing loss (NIHL) exists. Base line audiograms must be conducted within six months of an employee's first exposure at or above a TWA of 85 dB. If mobile vans are used to obtain audiograms, then baselines do not have to be completed for one year provided that hearing protectors are provided and used after six months. Baseline audiograms which were taken before the effective date of the hearing conservation amendments are acceptable if the professional supervisor determines that the audiogram is valid. The baseline audiometric tests required by OSHA were to be completed by March 1, 1984. The annual audiogram must be conducted within one year of the baseline. Annual audiograms must be routinely compared to baseline audiograms to determine whether an employee has lost any hearing ability. The employer may retest the employee within 30 days if the audiogram shows the employee has suffered a standard threshold shift. The retest is considered to be the annual audiogram. Hearing protectors may be worn prior to audiometric testing.

OSHA uses the term standard threshold shift instead of significant threshold shift. OSHA defines a standard threshold shift (STS) as an average shift in either ear of 10 dB or more at 2000, 3000 and 4000 Hz. When a STS is identified the employee must be fitted or refitted with adequate hearing protectors, he must be trained in how to use them and informed that he is required to wear them. Employees must be notified within 21 days when a determination has been made that a STS occurred. When a professional determines that the test results are questionable or if he/she believes that the employee has an ear problem that is caused or aggravated by wearing hearing protection, then the employee can be referred for further tests. When subsequent audiometric tests show that the STS on previous audiograms is not persistent, then employees who are exposed to a TWA of less than 90 dB have the option of wearing hearing protection.

Employers are required to provide, at their cost, hearing protection to all workers exposed to a TWA of 85 dB. This hearing protection must be capable of reducing noise levels to at least a TWA of 90 dB for everyone and 85 dB for employees who have experienced a STS. Employees are allowed to decide, with the help of a person who is trained in fitting hearing protectors, which size and type is most suitable for their working environment. Employers are responsible for ensuring that employees wear hearing protectors correctly.

Employees exposed to a TWA of 85 dB must be trained at least annually on the effects of noise, the purpose of personal hearing protective devices (PHPDs), advantages and disadvantages of different PHPDs and noise attenuation characteristics of various types of hearing protectors. The selection, fitting and care of protectors and the purpose and procedures

of audiometric testing must be addressed in the training as a minimum. The training may be structured in any format at the discretion of the employer. Noise exposure measurement records must be kept for two years and audiometric test results for the duration of a worker's employment. Audiometric test records must include the name and job classification of the employee, the date and time, the examiner's name, the date of acoustic or exhaustive calibration measurements of the background sound pressure levels in audiometric test rooms, the serial number of the audiometer, and the employee's most recent noise exposure measurement. All records shall be provided by the employer at the request of the employee, former employee, or representative designated by the employee.

### **NFPA 1500**

The National Fire Protection Association (NFPA) revised a voluntary consensus standard entitled NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, in August, 1992. This comprehensive standard, which sets minimum requirements for fire service related occupational safety and health programs, includes hearing protection requirements.

To comply with the requirements of NFPA 1500, a fire department must provide hearing protection for all fire fighters riding on apparatus who are subjected to noise levels above 90 dBA. NFPA 1500 considers the use of hearing protection as an interim measure only until engineering controls can be instituted to reduce the noise levels produced by vehicles, warning devices and radios. Purchasing or retrofitting apparatus to a maximum limit of 85 dBA without audible warning devices and 90 dBA with warning devices in operation is recommended by NFPA as the permanent measure for riding on apparatus without the use of hearing protection. When hearing protective devices are utilized as an interim measure, protective ear muffs are recommended since ear plugs can be difficult to fit and insert. For those fire fighters that must listen to the radio, NFPA 1500 recommends the use of ear muffs with built-in speakers and volume controls for radio and intercom communications.

Hearing protection is required by NFPA 1500. Fire fighters are often exposed to noise levels above 90 dBA while using power tools or equipment. NFPA 1500 requires the use of hearing protection in these environments except when such hearing protection could create an additional hazard to the user. NFPA 1500 recognizes that ear muffs may not adequately interface with helmets and foam plastic ear plugs could melt in the fire environment. However, NFPA 1500 recommends that hearing protection be utilized whenever possible, such as during non-emergency operations. Furthermore, fire departments are urged to seek alternative procedures to reduce noise exposure in emergency situations that make the use of available hearing protection impractical or hazardous.

Finally, NFPA 1500 requires a fire department to establish a hearing conservation program that identifies potential sources of harmful noise and seeks to reduce or eliminate them. NFPA recommends that the requirements set forth in the OSHA standard be used as a basic minimum approach for establishing a hearing conservation program. A hearing conservation program should address as a minimum, monitoring noise sources, audiometric testing (to be administered in the annual physical and included in the data base as described in the standard), noise reduction engineering controls, noise reduction techniques and hearing protection devices.





# ***THE MEASUREMENT OF SOUND***





There are three major factors that need to be considered when evaluating sound. They are intensity, frequency, and duration (sound exposure over time).

**Intensity**

Intensity is the loudness or softness of noise and is expressed in decibels (dB). While we frequently talk about noise readings in decibels, actually what we are referring to with respect to hearing protection programs is decibels on the A weighted scale (dBA). This is a scale that weights the noise level to duplicate how the human ear perceives the noise. The weakest sound that can be heard by a person in an extremely quiet location is assigned a value of 0 dBA. A person’s threshold of pain is reached around 140 dBA. Table IV provides examples of common noise sources and their corresponding loudness levels. The decibel scale was selected

Source	dBA
Saturn Rocket	194
Ram Jet	160
Turbo Jet	150
Threshold of Pain	140
Pipe Organ	130
Propeller Plane, Auto Horn	120
Pneumatic Drills	110
Siren	105
Passing Truck	100
Subway, Machine Shop	90
Noisy Restaurant	80
Inside Car w/Closed Windows	70
Office	60
Average Home	50
Quiet Office	40
Recording Studio	30
Whisper	20
Rustling Leaves	10
Threshold of Hearing	0

because of the unique problems associated with sound. Sound pressures have a tremendous range that must be accounted for in the measurement of them. For this reason the decibel is used to measure them because they progress linearly through a logarithmic scale rather than exponentially as sound pressure levels do. That is, we can measure a wide range of sound using only a small range of numbers. Thus, the range of sound from 0 to 140 dBA covers a sound intensity range of 1 to 100,000,000

N/m<sup>2</sup> (Pascal). Obviously a small change in decibel value can mean a tremendous difference in the intensity of the sound. Apparently small declines in decibel level will result in significant reduction in sound pressure levels.

Table V shows that an increase of 20 dBA means that noise intensity is increased 10 times. This rule generally applies for any increase of 20 dBA. Thus, the noise intensity at 62 dBA is 10 times as great as that at 42 dBA. It should also be noted that each increase of 20 dBA means that the sound intensity

<i>Sound Pressure (Pascals)</i>	<i>Sound Level in dBA</i>
100000000	140
10000000	120
1000000	100
100000	80
10000	60
1000	40
100	20
10	1

becomes 10 times as great. Thus, an increase from 10 dBA to 50 dBA or a total change of 40 dB A would mean that the sound intensity would be 100 times greater (10 x 10). Likewise a reduction of 20 dBA would mean that the noise intensity is 10 times less.

Another general rule about noise intensity is that an increase of 6 dBA will double the intensity of the sound. Thus, 66 dBA is twice as intense as 60 dBA.

Hearing damage is related to noise intensity, not the loudness of sound. An increase or decrease of 3 dBA could be significant in protecting the ear from noise related damage even though the human ear may not be able to “tell the difference.” Therefore, it is important to pay more attention to the decibel readings than how loud the noise sounds to the ear.

**Frequency**

The frequency of sound is related to the pitch or tone of the sound. It is expressed in cycles per second (cps) or Hertz (Hz). The higher the Hz value, the higher the frequency, and the higher the pitch.

The human ear is more sensitive to middle frequencies than the very low or very high ones. The lowest audible frequency level is usually about 20 Hz. For a young adult, the normal upper limit is usually between 16,000 and 20,000 Hz. Hearing loss caused by exposure to excessive noise is usually first

detected in the middle frequencies, especially above 3000 Hz. It is important to remember that as a person ages, they will normally lose hearing sensitivity in the higher frequency levels. This aging effect is called presbycusis.

### **Duration**

The length of time a sound is heard can vary from microseconds to hours. Occupational noise exposure is categorized as either continuous, fluctuating, intermittent or impulsive. Continuous noise is one that remains relatively constant for a long period of time. Fluctuating noise 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. Impulse noise is distinguished by a sharp rise in sound pressure level to a high peak followed by rapid decay. These peaks must occur less than one per second, otherwise the noise is considered continuous.

### **Sound Measuring Instruments**

There are various instruments that can measure the intensity and frequency of sound. When noise is being measured to determine compliance with a standard, the different frequency measurements are automatically lumped together by the instrumentation to obtain one average reading. Several different scales have been devised to do this averaging and are labeled “A,” “B” and “C”.

The A-weighting network is the scale most frequently utilized in the measurement of industrial and environmental noise. The “A-weighted” network discriminates against low frequency sound. It is used primarily because low frequency sounds are not readily perceived by the human ear. As a result, the A-weighting network is believed to be an adequate predictor of human response to noise. The least common measuring scale is the B-weighting network. The B-weighting scale discriminates against low frequency sounds to a lesser extent than the A scale. The C-weighting network is another measuring scale used primarily to attenuate the noise level. The C scale reflects sound as it actually occurs in the environment without a bias for human response. This scale can be useful in measuring the effectiveness of hearing protectors because it does not discriminate against the presence of low frequency sounds.

The noise level (sound intensity) can be measured using a sound level meter. Sound level meters register the level of noise that occurs at a particular instant. It is a useful instrument for measuring the noise level of a given industrial process or piece of equipment. This method uses a microphone to pick up on sound pressure waves. The sound waves are converted into electrical signals that are enlarged by an amplifier and transmitted to an analog display (e.g., a meter). The sound level meter then displays the amount of noise measured in decibels. Sound level meters usually contain both the “A” and “C” scale

options. One limitation of a sound level meter is that it can not distinguish between a pleasant sound and an unpleasant noise. It can only measure the sound pressure level. However, the perceived loudness of a sound is not judged solely on its sound pressure level. A sound at a constant pressure can appear to be quieter or louder depending upon the frequency of the sound.

A sound level meter can provide a rough estimate of the intensity of noise. Often, more specific information is required. To perform this analysis of exactly where the noise lies in the frequency spectrum, an octave-band analyzer is usually attached to the sound level meter. The frequency spectrum can be divided into octave bands that are identified by its center frequency (e.g., 125, 250, 500, 1000, 2000, 4000 and 8000 Hz). This type of analysis is particularly useful for planning engineering controls, since industrial noise is usually made up of various frequencies at various intensities. It is also useful for selecting a room to perform audiometric tests. By completing an octave band analysis, engineering controls may be employed to reduce the intensity of problem frequencies and reduce the overall intensity of the noise environment by attenuating the problem frequencies.

Another & vice, the dosimeter is utilized to measure the amount of noise exposure received by an individual worker. Dosimeters measure noise dose by integrating various sound levels over an entire work shift. Fluctuating, intermittent and impulse noises can be most easily measured using a dosimeter. This device and microphone can be attached to an article of clothing and worn throughout the work shift. The microphone picks up sound energy and converts it to electrical energy. This energy is sent to a storage cell where it is measured to determine the amount of noise energy the worker has been exposed to. The results of the monitoring are then given in terms of a percentage of allowable exposure concerning a specific regulation or standard.

The audiometer is an instrument utilized to test hearing. Audiometers produce pure tones at specific frequencies (e.g., 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz) and specific intensity levels. The ability of individuals to hear pure tones is directly related to their ability to hear speech. OSHA requires that employees’ hearing be tested between 500 and 600 Hz. This range is most vital for understanding speech and determining the extent of the hearing loss.

An audiometric test is designed to measure the amount of hearing loss an individual has accrued. This simple test procedure requires the individual to sit in a soundproof room while wearing headphones. Each ear is tested separately by delivering a series of faint-sounding beeps or tones at several different frequencies to the individual being tested. The individuals are instructed to respond that they have heard the sound by pressing a button or raising a hand. The intensity level between the point where the person last responded and where they didn’t hear the sound is labeled the threshold level. This procedure is repeated two or three times at each frequency to insure that the person is reporting his true threshold level. It is extremely difficult to falsify an audiometric test because of

the fact that different tones are repeated and an individual's response can hardly be the same if they really cannot hear the particular frequency.

The record of an individual's results from the audiometer is known as an audiogram. (See Figure 2). An audiogram graphically illustrates the hearing threshold level measured in decibels as a function of frequency in Hertz. The audiogram visually shows how loud a sound must be before it is heard by allowing the audiologist to evaluate the status of an individual's hearing. The audiogram is an important component in identifying the early stages of NIHL (Noise Induced Hearing Loss). When hearing loss is related to noise exposure, a dip will appear on the graph at about 4000 Hz. The bigger the dip, the more severe the hearing loss. If results are worse than 20 dB, especially between 3000 and 4000 Hz, there is reason for concern (see audiogram). Further medical attention and/or preventive measures may be mandated.

Audiometric testing using beeps or tones has been criticized because it does not equate to the reality of hearing. Speech is heard against background noise and not in the sanitized soundproof setting of the audiometric booth. To counter these criticisms, another test known as speech audiometry has been developed. This test is similar to the one described previously, except that actual words instead of pure tones are presented at different levels of loudness. The degree of hearing loss is determined on the basis of the number of words that the subject can not understand. This method appears to be a more realistic test. An individual with hearing damage in the 3000 to 4000 Hz range may be able to hear the

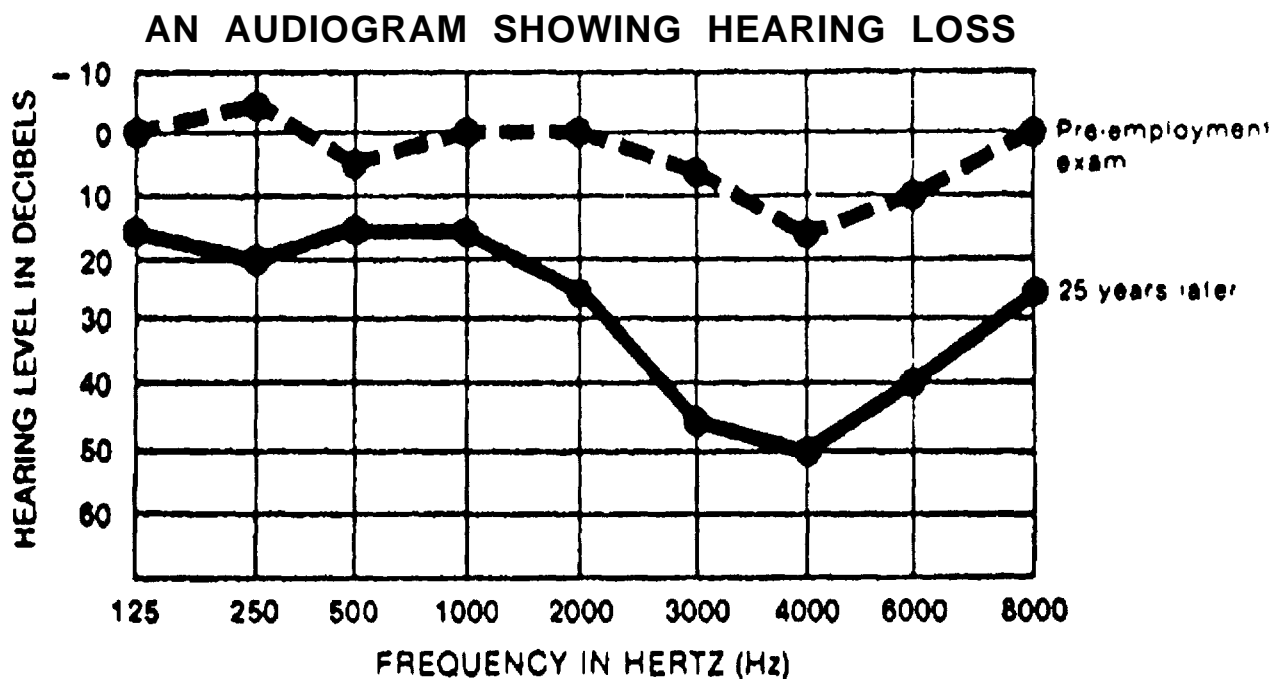
pure tone sound, yet may not be able to understand speech or words.

Hearing threshold levels are measured in decibels when recorded by an audiometer. However, audiometric zero is not always the same as 0 dB sound pressure level. Audiometric zero represents the median hearing threshold level for a young person with normal hearing. Similar to eyesight, some people have exceptionally good hearing sensitivity (as acute as -10 dB) while others may have hearing thresholds at 10 or 15 dB and still be considered to have hearing in the normal range. Thus, audiometric zero represents normal baseline hearing. The American National Standards Institute's specification for audiometers S3.6-1969 outlines the standard for audiometric zero in the US. population.

Before performing audiometric testing, there are several important considerations that should be addressed:

- The data should be obtained by a qualified and objective individual to avoid potential for bias.
- The instruments and measurements procedures utilized should conform fully with applicable American National Standards and/or Occupational Safety and Health Administration regulations.
- Such instruments should be calibrated before and after each significant set of readings. If the calibration is out of tolerance all readings back to the previous calibration must be repeated.

**Figure 2**





***NOISE CONTROL PRACTICES***







There are three primary noise control strategies: administrative, engineering and personal protection. The most effective and desirable of the noise control strategies is engineering controls. Engineering controls address the problem at its source rather than trying to rely on the cooperation and participation of people. The control of noise is best obtained by getting as close to the source as possible, since once the sound is airborne, it becomes more and more difficult to control. However, there may be times when engineering controls are not feasible because of economic or technical reasons. In such cases, it may be necessary to utilize other noise control mechanisms and devices to achieve the required level of noise reduction.

Engineering controls are most effective when they are applied at the design stage of equipment development. While technology is readily available to reduce equipment noise levels, it has not been applied to its full advantage because of the lack of demand for such controls in products. Even on older, noisier equipment, the use of noise-absorbing materials, enclosures or barriers, vibration absorbing materials, and mufflers to reduce specific noise sources can be extremely successful in reducing noise exposures.

As might be expected, riding on a fire apparatus is one of the major sources of occupational noise exposure for the fire fighter. The primary source of noise on a truck is the engine. Other major sources of truck noise are from the warning devices (sirens and horns), exhaust system, the engine cooling fan and tire noise. The noise from each of these sources can be reduced through engineering controls. For example, the en-

gine noise can be controlled through the installation of specially treated oil pans, valve covers and air intake manifolds to isolate these parts from the vibrating engine. The placement of warning devices on the front bumper or running board as well as the use of broader band, lower frequency devices *can reduce* both the degrees and type of noise exposures experienced by fire lighters. The exhaust noise problem can usually be solved by installing the correct muffler. Fan noise can be reduced through the installation of a thermostatically controlled or modulated fan drive, which will limit the amount of operating time for the fan. Tire noise can be solved by selecting tires with a tread design that minimizes noise while supplying the best possible traction and wear resistance. For example, urban response vehicles typically do not need rough terrain treads on their tires. Proper maintenance and replacement is another critical factor in eliminating vehicle noise.

Administrative controls in industrial settings are commonly aimed at reducing the amount of time workers are exposed to excessive noise levels. This means arranging work schedules to avoid continuous noise exposure at levels exceeding the OSHA permissible exposure limit (PEL). Administrative controls for fire fighters have limited use since their occupational noise exposure is uncertain and intermittent and based upon when an emergency response occurs.

The use of personal hearing protective devices (PHPD) such as earplugs or earmuffs, can assist in reducing exposure to noise. Table VI compares various features of earplugs and earmuffs. An effective PHPD will act as a barrier between the

**Table VI**

COMPARISON OF EAR PLUGS AND EAR MUFFS

<i>Feature</i>	<i>Earplugs</i>	<i>Earmuffs</i>
Noise Protection	Varies	Greater, less variable
cost	Less Expensive	More Expensive
Size	Small, convenient	Not easily carried or stored
Fit	May be difficult	One size fits most
Monitoring Use	Can't be seen	Easily seen
In Hot Environment	Comfortable	Uncomfortable
Head Movement	No restriction	Restrictive in close quarters
Wearability	Only in healthy ear	Can be worn even with minor ear infection. Can interfere with glasses, head gear and hair.

noise and the inner ear. However, it must be remembered that ear protection does not remove the noise hazard. Such protection has many limitations when used in place of engineering controls on a permanent basis. A person wearing a PHPD can still be exposed to excessive noise levels as sound can pass through the bone and tissues, bypassing the PHPD and reaching the inner ear. This can occur if the sound causes the protector to vibrate, if there are leaks in the protector or if there are leaks around the protector. Ear protection does not keep out all the noise. A properly fitted earplug can produce up to 40 decibels of attenuation at higher frequencies (4000 Hz).

Earplugs or inserts are generally inexpensive, however, the service life is limited. They are made from materials that are soft and pliable, thus there is little danger of injury if the plug is pushed against the tender lining of the ear canal. An examination by a qualified medical physician should be performed prior to the earplugs being fitted because the shape of some people's ear canals may limit the use and type of PHPD that may be used. In addition, some ears may be allergic to certain types of materials. There are three general classifications of earplugs: formable, custom-molded and premolded.

Formable protective devices can provide good noise attenuation and fit for all ears. Generally, these disposable plugs (most are designed for one-time use only) are made from fine glass fiber (Swedish wool), wax-impregnated cotton and expandable plastic. They are generally rolled into a conical shape before insertion into the ear. All employees must be trained on insertion of this type of PHPD. Special care must be taken when inserting these types of PHPD into the ear canal as not to insert them so far that they will not be easily removed. In addition, the employee must be made aware of the importance of having clean hands when inserting these devices. Dirty hands may transfer dirt, grease, or other foreign material into the ear canal and possibly lead to an infection within the ear canal.

Custom-molded protective devices are exactly that, they are specifically molded for the individual ear. Generally, two or more separately packaged materials are mixed together to form a compound that resembles soft rubber. To apply, the material is carefully placed in the outer ear with some portion placed in the inner canal according to the manufacturer's instructions. The material takes on the shape of the external ear canal as it sets.

Premolded protective devices come in two different versions. The universal fit type is a plug that is designed to fit a wide variety of ear canal shapes and sizes. The other type comes in a variety of sizes to assure a good fit. These devices are usually made of a soft silicone or rubber. This type of hearing protection should be regularly cleaned with soap and water to maintain its service life and to avoid infection. Most manufacturers also provide storing cases that will keep them clean and free of contamination. There are many limitations to this type of protection. Since many ear canals have irregular

shapes, even between the left and right canals on an individual, the incorrect plug size may be chosen. A good fit can be obtained by proper insertion and fitting. Fitting of pre molded devices should be performed by properly trained personnel. This type of plug must fit tightly into the ear canal to form a seal between the plug and ear canal. Because many people have irregular ear canal shapes, the wrong size plug may be chosen for reasons of comfort and will not provide a proper seal. Some types of premolded plugs may become hard and possibly shrink over time. This is caused by the build up of ear wax on the plug. The personal hygiene of the user and the proper maintenance of the plug, i.e. proper and regular cleaning, will help to extend the life of the device as well as allow the device to provide the maximum level of attenuation over that lifetime. Finally, wearers of earplugs must be made aware that earplugs have a tendency to work themselves loose over time. It is important to pay close attention to the placement of the plug and regular fit checks may be necessary.

Ear muffs consist of two cup or dome-shaped devices that fit over the entire external ear, including the lobe. The muffs seal against the head with a suitable cushion or pad. Generally, the cups are made of a molded rigid plastic and then lined with an open cell foam material. The shape, size and degree of attenuation of earmuffs will vary from one manufacturer to another.

Typically, ear plugs are preferred for low frequency exposures and ear muffs are preferred for high frequency exposures. All noise attenuating devices (PHPDs) are given a noise reduction rating (NRR) by their manufacturer. This number represents an average attenuation across the frequency range of 125 Hz to 8,000 Hz. Ear muffs will provide a NRR of 23 to 30. Different types of ear plugs offer different ranges of NRRs. Some representative values for NRRs follow: for moldable foam ear plugs the NRRs typically fall between 29 and 37: for single flange type the values range from 23 to 33: for triple flange type the values range from 26 to 37. For custom molded devices the NRR range is between 20 and 26. Again, it is important to remember that the amount of protection offered by an ear plug is solely dependent upon the insertion into the ear canal. Training is required for all types of PHPDs.

Personal protective devices for healthy workers will affect speech communication in a relatively quiet environment. However, when noise levels exceed 90 dB PHPDs will not hinder speech communication and may actually improve speech intelligibility. This is a difficult concept to comprehend and many workers feel that they should not use PHPDs because of anticipated problems in communication. This is especially true when the worker tries on the personal protective device in a quiet environment. Workers with a preexisting hearing loss will have poorer speech communication when wearing personal protective devices.

# ***FIRE FIGHTER NOISE EXPOSURE***





There have been several noise exposure studies specifically involving fire fighters. Probably the most significant of these studies was conducted by the National Institute for Occupational Safety and Health (NIOSH) following requests made by the International Association of Fire Fighters (IAFF) Department of Occupational Health and Safety.

NIOSH's investigation of noise levels and the associated losses of hearing among fire fighters in Newburgh, New York was initiated after a private audiologist found significant high frequency hearing losses in 45% of the fire fighters tested. Based on this information, the audiologist recommended that an extensive noise survey be conducted to examine vehicle noise and auxiliary power equipment exposure.

After a thorough examination of the private audiologist's report, NIOSH found deficiencies in the manner in which the evaluation was conducted. This led NIOSH to carry out its own comprehensive tests that included a vehicle/equipment noise survey, dosimeter noise exposure sampling for selected fire fighters and hearing examinations for all fire fighters in the Newburgh Fire Department.

The apparatus noise survey, conducted at 30-second sampling periods during simulated response runs, found that fire fighters are exposed to high noise intensity levels for each piece of apparatus at each position. The noise levels at the various riding positions on the apparatus are depicted in Table VII. Exposures ranging from 99 dBA to 116 dBA in the vehicle's cab, 105 dBA to 112 dBA in the jumpseat, 106 dBA to 108 dBA on the back riding step, and 91 dBA to 101 dBA at the vehicle's pump panel were found. NIOSH's survey of fire fighting equipment also discovered noise levels in the range from 93 dBA to 110 dBA.

NIOSH's survey utilizing a dosimeter on nine selected fire fighters found that the 8-hr time weighted average (TWA) noise exposure ranged from 62.8 dBA to 85.3 dBA. All the readings were below the maximum OSHA standard of 90 dBA for an 8-hour TWA exposure and only one fire fighter exceeded the NIOSH criteria of 85 dBA for an 8-hour TWA. In addition, NIOSH found that only one of the simulated runs exceeded the OSHA ceiling exposure value of 115 dBA.

The hearing examinations conducted by NIOSH of 54 fire fighters involved a group with an average age of 37.7 years with an average length of fire department service of 13.2 years. Based on a statistical analysis of the data, NIOSH concluded that the fire fighters surveyed all began their careers at nearly the same age and have not left the fire service. Because hearing loss is cumulative over time, NIOSH placed the 54 fire fighters into groups based on age. The groupings were as follows:

- less than 30 years
- 30-34 years
- 35-39 years
- 40-44 years
- 45-49 years
- 50 years and older.

<b>TABLE VII</b>	
NIOSH VEHICLE/EQUIPMENT NOISE SURVEY	
	<i>Average dBA</i>
<b>1977 Mack MB Pumper</b>	
Back-Step	<b>108</b>
Pump Position	91
<b>1974 Mack MB Pumper</b>	
Jumpseat	112
Pump Position	<b>97</b>
Cab	110
<b>1975 Mack Aerial Ladder</b>	
Jumpseat	105
Cab	100
<b>1977 Pontiac</b>	
Windows Up-Yelp	101
Windows Up-Siren	99
Windows Down-Yelp	102
Windows Down-Siren	104
<b>1963 American LaFrance Ladder</b>	
Cab	108
Jumpseat	107
Back-Step	106
Cab, Left	116
Pump Position	101
<b>1955 American LaFrance Pumper</b>	
Cab	107
<b>Auxiliary Power Equipment</b>	
Gas-Powered Cutting Tool	110
Portable Power Generator	<b>93</b>
Portable Floating Pump	<b>103</b>
Air Compressor	106

NIOSH found that the group 50 years and older exceeded both the American Medical Association (1979) and the NIOSH 25 dBA criteria for hearing impairment. NIOSH then compared their data with a 1960- 1962 National Health Survey (NHS) and found that while the fire fighters had better hearing than the national norm in the early age grouping, they were consistently poorer at the oldest age grouping.

While NIOSH found definite high frequency hearing loss, the results of the noise survey did not show enough noise exposure to account for the observed hearing losses. Based on an average of 9 to 10 responses per week for each squad in the Newburgh Fire Department, NIOSH estimated that fire fighters were exposed to noise exposures ranging from 99 to 116

dBa for only 1.5 hours out of a 40 hour work week. However, NIOSH pointed out that the trends found in the audiograms did point to noise overexposure among the fire fighters. NIOSH concluded that fire fighters must “assume that the noise associated with these response runs could be damaging and should be reduced as much as possible.”

NIOSH did offer some possible explanations for the apparently contradictory findings. One possible explanation proposed for the occurrence of hearing loss may be due to the interaction of noise with other agents confronted by fire fighters in the environment. In other words, exposures to toxic materials may act to change the physiology of the ear such that it may not be able to tolerate as much noise exposure as a normal ear. The disruption of auditory function by asphyxiation has been shown repeatedly. Recent studies of rats conducted by the Johns Hopkins School of Public Health and Hygiene found that exposure to carbon monoxide preceding and concurrent with exposure to a 110 dBA broad-band noise level produced high-frequency threshold shifts of greater magnitude than those produced by exposure to the noise source alone.

Since there were no fires during the study, NIOSH also left open the possibility that the noise exposure levels may be intense enough at the fire scene to have an impact on fire fighters’ hearing. This explanation still needs to be documented.

Finally, NIOSH indicated that the type of noise to which fire fighters are exposed may be leading to the hearing loss. Citing the Committee on Hearing, Bioacoustics and Biomechanics (CHABA) recommendation of a maximum exposure to pure tones or narrow band noises of 105 dBA for 15 minutes, NIOSH did find a narrow band component to the noise created by the siren and air horn. However, further investigation would need to be conducted to determine if the narrow component is distinct enough to yield the observed hearing loss.

Despite the lack of a definite explanation for the observed hearing loss experienced by fire fighters in the NIOSH study, similar findings were found in an earlier study conducted by the University of California at Irvine and the California Department of Forestry. The study evaluated eight fire fighter positions on board three types of emergency vehicles during emergency responses. Emergency responses were chosen because they represented the highest level of noise exposure that a fire fighter may experience on a regular basis, that is, riding on a vehicle at relatively high speeds accompanied by a siren and air-horn.

Like the NIOSH study, this investigation involved three distinct segments. In the first segment, an analysis of overall vehicle noise and individual components during simulated runs was undertaken. The vehicles surveyed included four 28,000 lb. fire engines, two 51-foot fire trucks and a 310 Chevrolet paramedic Fire-Rescue van. The fire engines and fire trucks all contained 350 hp 567.5 cubic inch 8V71 Detroit Diesel engines with manual transmissions.

The analysis of the individual components during simulated emergency runs (Table VIII) found that the primary contributors to the noise problem are the motor, radio speaker, air-horn and siren, Unlike the other components, which con-

<i>Vehicle/Component Part</i>	<i>Average dBA</i>
Engine	
4	109
22	113
26	113
26M	109
Truck	
4	112
21	105
Component Part	
Siren	106
Air-Horn	105
Radio	107
Motor	104

tribute equally to the sound pressure level though in different frequency distribution. the motor contributes peak sound pressures at much lower frequencies.

The second segment involved noise dosimeters being placed on eight fire fighters. The Fire Fighters were given instructions to turn the dosimeter on before boarding the emergency vehicle for an emergency run and to turn the dosimeter off when they arrived at the emergency scene or when the emergency operation ended. The results of these measurements (Table IX) found that the captain position on both the fire engine and the truck experienced the highest level of noise exposure. The reading from the dosimeters also showed that the truck tiller man and the paramedics received the least amount of noise exposure. Based on the readings, the researchers believed that the captain and engineers would probably be exposed to noise levels in excess of 115 dBA during a typical emergency response.

During the third stage, audiograms were given to 134 fire fighters in eight separate fire stations located in Orange County, California. This was an attempt to correlate hearing loss with length of employment in the fire service. After screening the fire fighters and eliminating those taking medication or those who had previous high level noise exposure prior to fire service employment, 89 audiograms remained to be analyzed. The data compiled from these 89 audiograms

**TABLE IX**

**NOISE DOSIMETRY MEASUREMENTS  
DURING EMERGENCY RESPONSE**

<i>Vehicle Position</i>	<i>Average dBA</i>
Engine Captain	114.5
Engine Engineer	110.4
Engine Fireman (R)	107.4
Engine Fireman Q	111.3
Truck Captain	114.7
Truck Engineer	110.0
Truck Tillerman	103.4
Paramedics	104.2

were broken down into categories according to age and length of fire service.

Based on the analysis of the audiograms, the University of California researchers found that the 89 fire lighters had generally poor hearing regardless of their age or length of service. The researchers suggested that the greatest threshold shift may occur during the first three years of employment. However, they were unable to substantiate this claim because of the lack of preemployment audiograms.

In analyzing their overall results, the researchers examined four categories in terms of sound pressure levels: emergency operations, the fire scene environment, return travel to the station and the station environment. The findings of this study found that the average sound pressure level was approximately 80 dBA at the fire scene: 95 dBA during the return run for the fire engine and truck; 78 dBA during the return run for the paramedic van: and 40 dB A at the fire station. Depending upon vehicle position, the average time weighted average (TWA) for an 8-hour day of noise exposure ranged from 98.4 dBA for the engine captain to 84.6 dBA for the truck tiller man (Table X). Except for the truck tiller man, all noise levels exceeded 90 dBA. The researchers concluded that their data suggests the

**TABLE X**

**8-HOUR TWA CALCULATIONS FOR  
EIGHT FIRE FIGHTER POSITIONS**

<i>Vehicle Position</i>	<i>8 Hour TWA(dBA)</i>
Engine Captain	98.4
Engine Engineer	94.4
Engine Fireman (R)	91.7
Engine Fireman (L)	95.3
Truck Captain	90.6
Truck Tillerman	84.6
Paramedic Captain	91.7

noise exposures in the cabins of the fire engine and tire truck both regularly exceed the OSHA permissible levels.

Both the NIOSH and University of California studies found a substantial growth in fire fighter hearing loss as department service time increased. However, the University of California study found noise intensity levels that could explain the observed hearing loss. The surveying of different vehicle models (open cab vs. closed cab) is the principal reason given to explain the differences found in noise intensity levels between the two studies.

In 1982, following a request by the New York City (New York) Fire Department, NIOSH conducted a noise survey on a representative sample of fire apparatus during simulated runs on the chauffeur's training road course at Randall's Island. The tested apparatus included 31 American LaFrance and Mack Pumpers; 23 Mack, Seagrave, and Sutphen Ladder Trucks; a Mack Rescue vehicle; a Chevrolet Suburban Battalion Chief's car, and the John D.McKean, one of the department's fire boats.

The procedure used to obtain the noise patterns for each vehicle was to have the officer and the chauffeur operating the vehicle while a NIOSH investigator gathered the noise measurements. The siren, air horn and radio were operated as they would be on an actual response run. The NIOSH investigator took measurements from five or six different riding positions, depending on the make and model of the vehicle being tested. Additionally, noise recordings were made at the pump panel during pumping operations for the pumpers and at the ladder turntable for the ladder trucks.

This noise survey found the noise levels emitted by sirens, air horns, radios and fire engines ranged from 18 dBA to 81 dBA during the simulated response runs. There was little difference in the overall dBA values measured for the pumpers and the ladder trucks. All of the riding positions had an average dBA value in the middle 90's with the exception of the "2 Left" riding position on the ladder trucks which consistently recorded noise levels above 100 dBA. This exception is because the "2 Left" position is an open riding position, usually just behind the air horns mounted on the cab's roof. The noise levels found on the fire boat ranged from 81 dBA (pilot house) to 113 dBA(horn). The noise measured in the engine room was quite consistent and more intense. The dBA values for the engine room ranged from 102 dBA to 111 dBA.

NIOSH concluded that this noise survey showed the potential for noise overexposure among New York City fire fighters. The fact that the possibility for intense, impulse-type noise (e.g., explosions, crashing timbers, chopping) exist at the actual fire scene further emphasizes the fact that fire fighters are more likely overexposed to noise.

In 1984, at the request of the General Services Administration, NIOSH evaluated the effect of siren speaker location on noise levels in a Type 1 ambulance having a conventional cab-chassis with modular ambulance body.

*Siren* speakers were fixed to the ambulance in either of two

locations: (1) the roof of the driver's cab which is been the traditional location on most ambulances, or (2) near the grille area or front bumper of the ambulance. For each siren location, the tests were conducted with the driver cab windows open and the driver cab windows closed. During each test condition, the siren was operated in the three available modes: wail, yelp and European or Hi-Lo for a period of about 15 seconds. Four locations were monitored during the tests:

- Driver Compartment-driver position, inside the ambulance
- Patient Compartment-patient position, inside the ambulance
- Ten feet from the siren speakers, outside the ambulance
- One hundred feet from the siren speakers, outside the ambulance.

NIOSH found that noise levels are fairly consistent across the S-modes of siren operation (wail, yelp, European). With the ambulance siren speakers mounted on the ambulance cab roof, resultant overall noise levels ranged from 85-109 dBA inside the ambulance and 92 - 122 dBA outside the ambulance. With the ambulance siren speakers mounted in the ambulance grille area, resulting noise levels were substantially reduced in the driver compartment and patient compartment, ranging from 76 - 87 dBA. NIOSH also found that keeping the windows closed in the driver compartment reduced the noise in the driver cab by 7.1-12.8 dBA and up to 7.1 dBA in the patient compartment (Table XI). The noise levels under the best operating conditions (grille siren, driver cab windows

closed) ranged from 76 to 80 dBA.

The Phoenix Fire Department completed noise surveys in 1986 and 1987. The surveys included many different types of apparatus at various speeds and in various modes of operation. The results of the Phoenix surveys concur with the previously discussed studies.

NIOSH has also been involved with two additional fire departments at the request of the IAFF Department of Occupational Health and Safety.

In 1985, the Memphis, Tennessee Fire Department was concerned about the hearing levels of fire fighters assigned to the two international airport fire stations. It was thought that the additional airport and aircraft noises would put an additional burden on the fire fighters' ears.

While a final report has not yet been published, NIOSH has issued several interim reports about the noise exposures and the hearing levels of the Memphis fire personnel. The personal noise dosimetry survey of five different fire stations revealed that the fire fighters were being exposed to 8-hour TWA's of 60 to 80 dBA. This range of TWA values is from a total of 141 full 8-hour shift samples. Thus, again NIOSH found that the full shift noise exposure values were less than both OSHA's permissible exposure level and NIOSH's Recommended Exposure Limit.

The hearing levels of the fire fighters who were assigned to these five Memphis tire stations were also tested and evaluated by NIOSH. A total of 197 tire fighters took part in the audiometric testing. The statistical analyses of this data showed that the average hearing levels at the noise sensitive frequencies of 3,000, 4,000, and 6,000 Hz were significantly

**TABLE XI**

**SOUND LEVEL REDUCTION AS A FUNCTION OF SIREN LOCATION AND OPERATING CONDITIONS**

<i>Location/Condition</i>	<i>Overall dBA</i>		<i>RS-GS</i>
	<i>Roof Siren (RS)</i>	<i>Grille Siren (GS)</i>	
Driver-Windows			
Open (DWO)	109.1	87.1	22.0
Driver-Windows			
Closed (DWC)	96.3	80.0	16.3
<b>DWO-DWC</b>	12.8	7.1	
Patient-Windows			
Open (PWO)	91.2	75.9	15.3
Patient-Windows			
Closed (PWC)	84.3	76.8	7.5
<b>PWO-PWC</b>	6.9	0.9	



reduced as a function of time on the job as a fire fighter. The analyses did not indicate that being assigned to either of the airport fire stations would put a fire fighter at a greater risk of potential hearing loss from noise exposure. Rather, it seems that the fire fighter will accrue a hearing loss regardless of where he has been assigned.

The second fire department surveyed by NIOSH for potential noise exposures was the Olmsted Falls, Ohio Fire Department. This small combination full-time/volunteer department's fire station was located adjacent to a Conrail railroad right of way with three tracks. Approximately 50 trains would use these tracks over each 24 hour period. The station was located such that the trains' movement would have a noise impact on the station house. The trains were required to sound their air horns to signal that they were crossing the roadway in front of the fire station. Additionally, the station was oriented in the final approach and takeoff pattern for aircraft using Cleveland's Hopkins International Airport.

A total of 12 dosimeter samples were collected during the noise survey at the station. The full shift TWA ranged from 60 to 75 dBA. These samples are lower than the OSHA and NIOSH evaluation criteria for noise exposure. Even though the noise exposures were lower than existing criteria, NIOSH determined that the noise exposures were a source of distress to the fire fighters who worked at this station. NIOSH recommended that steps be taken to reduce the noise levels inside the station house.

The Phoenix Fire Department completed personal dosimetry sample surveys in February and March of 1981. These dosimetry samples are of particular importance because they reflect real working environments of fire fighters. The results of these surveys show that fire fighters are exposed to significant levels of noise, particularly noise levels in excess of 115 dB.

Although the studies performed by NIOSH and the University of California are probably the preeminent ones for fire fighters, other investigations have also noted the effect of noise exposure in the fire service.

In 1979, the Medical Services Division of the City of Los Angeles and the Center for Health Sciences at Oakland University collaborated in an assessment of hearing loss among Los Angeles City Fire Department fire fighters. In this study, 750 male fire fighters between 20 and 59 years of age were administered noise exposure questionnaires and audiometric examinations. The results of this study indicated that fire fighters had additional hearing loss at the 3000 Hz, 4000 Hz and 6000 Hz test frequencies. The researchers then compared these results with the general national population. In relation to age, it was found that the hearing loss for fire fighters was in excess of the general population. The researchers also concluded the medical history and life-style data obtained from the noise exposure questionnaire could not account for the observed hearing loss. The results of this study again suggested that the increased hearing loss with age found among fire fighters is due to occupational overexposure to

noise.

In 1984, 192 fire fighters were randomly selected from the Houston, Texas Fire Department for hearing tests. The researchers computed the total number of hours of siren noise exposure for each of the 192 fire fighters. The researchers then compared the duration of siren noise exposure with hearing loss and found a positive correlation. The researchers concluded that the hearing loss could be attributed to job related sources. Based on the data, the study found that the rate of hearing loss over time is increased at one and one half times the rate expected for an age-matched, non-noise-exposed male population. This study reaffirmed other findings which indicate fire fighters experience an additional higher risk of hearing loss than that expected from aging alone. The researchers also set forth the proposition that the hearing loss is directly attributable to the duration of intense siren noise exposure.

A graduate degree dissertation performed by a Howard University student in 1974 reviewed the effects of noise exposure on selected Washington, DC rescue personnel. This study chose ten male rescue personnel ranging in age from 24 to 32 with normal hearing based on their audiometric examinations. Rescue personnel were selected because it was believed they were exposed more often to siren-producing noise than regular fire fighters. Two 1974 Ford Econolines, Model E300 and a 1972 International Harvester Truck Model M1310 with General Electric Power Call sirens were utilized during the study. Audiometric examinations were conducted as soon as possible following exposure to the ambulances' sirens. In the analysis of the data, the researcher concluded that the length of time and the frequency of the noise exposure was more significantly related to hearing loss than the actual amount of noise exposure (the decibel level). For example, the researcher found that the little-used, but loudest warble and wail sirens produced little change in hearing threshold levels. Rescue personnel exposed to the main and warble sirens did show statistically significant differences in their hearing threshold levels.

In another 1974 investigation, the State of Michigan Bureau of Industrial Health found that fire fighters on pumping engines in the Lansing Fire Department had exposures in excess of the OSHA permissible eight hour noise exposure limit of 90 dBA. Since the operating engineer must communicate with a dispatcher, it was recommended by the Bureau of Industrial Health that ear muffs which provided hearing protection as well as radio communication be utilized.

In a mid-1970s study conducted by the University of Kansas, the extra auditory effects of noise exposure on pump operators was explored. This research found that those pump operators exposed to a higher level of noise made proportionally more incorrect decisions than those operators exposed to noise from a muffled pumper. This study on job performance illustrated the far-reaching potential effects of noise. It also demonstrated the need for modifications in vehicle design.



***ELEMENTS OF A  
HEARING CONSERVATION PROGRAM***





Hearing conservation programs have been in place in the United States in many noise hazardous industries for the last 20 years. The elements of a hearing conservation program as delineated in the OSHA's Hearing Conservation Amendment promulgated in 1983 are described in this section.

The reason a fire department should consider a hearing conservation program is to reduce the probability that the department's fire fighters will obtain a permanent noise induced hearing loss as a result of their employment. The program must include ways to identify areas and equipment that are potentially hazardous to hearing and then attenuate the amount of noise emitted by them. It must also include the monitoring of the fire fighter's hearing ability and the use of personnel protective devices that will help to reduce fire fighters' exposure to harmful noise. A training program must be in place to educate fire fighters as to the effects of noise and the handicaps associated with permanent hearing loss; as well as methods needed to protect the fire fighter from noise damage. Finally, a record keeping system must be maintained to track the effectiveness of a department's hearing conservation program.

### **Noise Monitoring**

Periodic monitoring of the noise being generated by different types of fire fighting equipment must be undertaken to evaluate the magnitude of the noise exposures. This monitoring should be done for vehicle noise levels and noise levels emitted by the different tools in use by the department, including power saws, electrical generators, extrication tools, and air compressors.

Monitoring can take the form of area noise sampling or personal monitoring with a noise dosimeter. The kind of sampling conducted depends on what is being evaluated. If a fire fighter's exposure is the designated target of the monitoring, then a personal dosimeter would be recommended. Usually, more mobile workers exposed to variable noises warrant the use of a noise dosimeter. According to the current OSHA regulation, any type of meter or dosimeter may be used to take the noise measurements as long as "all continuous, intermittent and impulsive sound levels from 80 decibels to 130 decibels are integrated into the noise measurements."

If the monitoring is being undertaken to evaluate an area or piece of equipment a sound level meter (SLM) should be used. Depending on the intent of the survey an octave band analyzer may be added to the SLM. Since most commercially available American National Standards Institute (ANSI) Type 1 or Type 2 sound level meters will meet the above specification, it is best to choose an instrument that meets the fire department's personal needs and preferences. A SLM measures "total noise" generated by the entire spectrum of noise frequencies. An Octave Band Analyzer measures the noise generated by a narrow band of frequencies. This type of information may be useful in devising an attenuation strategy. If the bulk of the

noise is generated by lower frequencies as opposed to high frequencies certain types of attenuation materials will be more or less effective. (Do not buy an instrument with so many lights and gadgets that it takes an engineering degree to operate it.) Complexity is not always desirable. There is the alternative of contracting out the monitoring function to a local acoustical consultant firm.

Monitoring should be done on a frequent schedule, possibly as often as once a year. Any changes in procedures or equipment that produce noise should be monitored as soon as possible following the change. Finally, fire fighters' problems with an operation or complaints about a noise source in the department should be addressed as soon as possible.

When noise is monitored at a station house, the on-duty fire lighters should be allowed to watch how the measurements are taken with an explanation regarding what values are actually being recorded. This is a good opportunity to conduct some informal training about noise.

### **Engineering and Administrative Controls**

Once areas of noise have been identified, it is prudent to attempt to attenuate the noise. This can be accomplished either through permanent engineering changes or administrative controls. Administrative controls, which do not change the noise source, but rather change the amount of time a fire fighter would be potentially exposed to noise, are also available. Engineering controls should be used as the primary control measure. Engineering controls are preferred because they address the exposure problem at its source.

Some of the equipment used in fire fighting already has accepted standard noise reduction techniques associated with it. This includes new and more efficient mufflers for electrical generators, chain saws, circular saws, extrication tools, and diesel engines on vehicles. The reduction techniques includes isolation mounts for siren speakers and air horns placed on fire apparatus. Also original equipment manufacturers are beginning to address noise reduction in the design of new replacement equipment and vehicles. Thus, quieter saws, generators and vehicles are now available on the market.

Not all noise reduction in the fire service is standardized. Sometimes the collective imagination of a fire lighter, the chief, and a good mechanic can help to reduce the amount of noise from a piece of equipment. A good rule of thumb in this area of noise control is to keep trying something until it works.

For example, when one goes about the task of relocating warning devices on a vehicle, clamp the sirens and air horns down with C-clamps and or vise grips in different areas. This can be tried until the best combinations and locations are found that reduce noise exposure to the fire fighter on the vehicle to the greatest extent and provide maximum noise 100 feet down the street. Once the best location has been found, the placement can then become permanent. Experimenting with

the length of the air horn's trumpet and the cone of a siren speaker has been found to be beneficial in noise reduction. Packing noise absorbing materials into vehicle doors, compartment walls, and engine enclosures has also been found to be helpful in reducing the noise exposure to fire fighters. But remember, not every control will work for every piece of equipment or vehicle. Try the change before it is made permanent or before significant amounts of money has been put into it.

Even though a great deal of fire service activity is spontaneous and not under the direct control of an individual, there are several routine activities that will lend themselves to administrative controls. These include the daily or weekly warm-up of equipment to check its operating efficiency. This activity can take place in an area that is removed from the rest of the personnel in the station. If it is impractical to move the equipment to such a place, then the amount of traffic through the area should be regulated while the noisy activity takes place. Another important option is to rotate the fire fighters who use the equipment if the task takes some appreciable time to complete.

### **Audiometric Testing**

Audiometric testing is the crucial phase of a hearing conservation program which will indicate the effectiveness of the program. The purpose of a hearing conservation program is to reduce the likelihood of employees developing NIHL. Audiometric testing provides a way to check if NIHL is a problem and if it is under control. If NIHL is under control, the hearing conservation program is performing well and should be maintained or improved upon. The purpose of audiometric testing is to visually illustrate damage that has already occurred. This damage may be in the form of a permanent threshold shift or a temporary threshold shift. Further audiograms will make the distinction between the two possible. It is very important that accurate and reliable data are collected from this part of the Program.

Audiometric testing can be performed in-house by the fire department or by an outside contractor. The list of outside contractors may include local health departments or the city's contracted medical group. Of course, the list should also include independent organizations who provide the needed services.

One main consideration in determining whether to test in-house or hire an outside organization is cost. The cost of an audiometer and the acoustic enclosure needed for properly testing the hearing of the department's personnel is a minimum of \$4,000 to \$5,000. If the system is to be computerized (computers, software and interfaces), then the cost will be greater. Even though these initial start up costs may seem high, usually maintenance costs for subsequent years of the program are low. Acoustic booths will usually last for a very long time. Audiometers are also low in cost following pur-

chase, requiring only periodic maintenance and calibration checks. The costs of an outside contractor can range up to \$1,500 per day of testing, and these costs continue each year of the program.

The personnel requirement needed to administer this portion of the program must also be considered. OSHA requires that a "licensed or certified audiologist, otolaryngologist (ear specialist), or other physician" (usually occupational) must be responsible for the audiometric testing phase of the hearing conservation program. The person administering the program can do the audiometric testing or they can oversee a responsible and competent audiometric technician who performs the actual testing. Competency in this case refers to certification by the Council of Accreditation in Occupational Hearing Conservation or satisfactory demonstration of testing ability to the person responsible for the program.

The actual hearing test itself should evaluate the fire fighter's ability to hear pure tones of 500,1000,2000,3000,4000,6000, and 8000 Hz separately in both ears. All of the audiometric tests, or audiograms, should meet the minimum requirement set forth in Appendix C of OSHA's hearing conservation amendment. The results of the test should be in a form that are easily understandable, easily filed and easily retrievable. Small pieces of flimsy paper stuck away in a file drawer will become lost very quickly. While not required by regulation, it is recommended that a qualified person make a visual inspection of the ear with an otoscope for obvious changes that might affect the audiometric test.

Each fire fighter in the program must receive a baseline audiogram and a series of annual audiograms. The baseline audiogram for fire fighters already employed will be the first test taken after the inception of the hearing conservation program. The baseline audiogram will be the pre-employment test of individuals hired after the hearing conservation program is put into place. The annual audiograms are compared to this baseline to ascertain if any significant change in hearing is occurring or has occurred in the fire fighter.

Different definitions currently exist on "what constitutes a significant change in hearing". OSHA uses the frequencies of 2000, 3000 and 4000 Hz to define their standard threshold shift (STS). An average shift of 10 dB or more at these three frequencies in either ear is defined as a STS. OSHA requires that certain follow-up procedures be undertaken if a STS is diagnosed. The sensitivity of this definition has been questioned. A more sensitive measure of hearing change appears to be a 15 dBA shift at any frequency on two consecutive annual audiograms. The type of definition used is less important than the ability to detect changes and make corrections in the program to minimize the loss of hearing ability as soon as possible.

The results of the annual audiometric test should be made known to the individual fire fighter. This is the only feedback that he will receive about how well he is doing in the program. If the results are filed away without notifying the fire fighter, then he may quickly lose interest in his own hearing ability and

the hearing conservation program will be destined for failure. The employer is required by law to notify the employee within 21 days if any audiogram indicates a threshold shift.

### **Hearing Protection Devices**

If the recognized engineering and administrative controls necessary for controlling the noise are too costly, too impractical, or are waiting to be installed, then the department should offer personal hearing protection devices (PHPDs) to the fire lighters. However, it must be remembered that these devices are not always worn properly or sometimes may not be worn at all and should be considered only as an interim solution. Always continue to attempt to reduce the noise being generated by the equipment through engineering controls.

The same type of problems associated with the use of PHPD's in industry will be encountered by fire fighters. PHPD's are sometimes uncomfortable, may interfere with one's perception of speech from other employees, and are frequently lost or misplaced. The fire service has the added impracticality of the PHPD's being needed during emergency responses when time is of the essence. A fire fighter does not have the luxury of spending a great deal of time properly inserting an ear plug prior to boarding the vehicle.

This does not mean, however, that PHPD's have no place in the fire service. It is practical to use PHPD's during noisy routine maintenance operations, such as vehicle and equipment checks performed at the station. Also, some departments have begun to issue earmuffs to fire fighters to wear instead of or in conjunction with their fire fighting helmets during travel to and from emergency scenes.

New technology is now beginning to emerge in fire service equipment. There exists on the market radio devices that are manufactured to be worn in noisy environments. Radio speakers are placed inside noise attenuating ear muffs and voice-activated microphones with noise blankers are taking the place of conventional vehicle and portable radios. These new communication devices not only help to block noise from existing fire fighting operations, they also make communications easier so that radio transmission levels can be reduced in intensity.

### **Training**

The training necessary in a hearing conservation program is for both the education of the fire fighter and the education of management. The training should inform both groups about the potentially harmful effects of noise exposure and the requirements of an effective program to reduce or eliminate these effects. The person or persons responsible for this training must show all that they are committed to the program and are truly concerned about the program's outcome.

The training program should be geared towards the fire department in which it is to be administered. When discussing the effects of noise all data should pertain to the fire service. The kinds of available noise controls should be directly relevant to the fire fighter. There is no need to discuss irrelevant information about noise controls for heavy industrial operations.

This training should be viewed as a continuing process. A one-time meeting to discuss noise will not create an effective program, no matter how professionally produced the program might be. The message of reducing hearing loss must be stressed periodically. Questions about the program or about noise effects in general must be answered quickly and clearly. If a fire fighter has to wait several months to receive an answer or if the answer is so complicated that he cannot understand it, then he will rapidly lose interest in the program.

Finally, an effective training program should attempt to get some fire fighters involved who have already begun to experience the effects of their occupational noise exposures. It will generally have more impact on a fire fighter who has not experienced the handicap of a hearing loss to learn about it from a member of his own peer group.

### **Conclusions**

When the five parts of the program discussed above are implemented, it has the beginnings of an effective hearing conservation program. However, just securing the pieces does not guarantee success. The program must have certain characteristics about it.

For any program to work well, it must be consistently and fairly enforced. There is nothing more undermining to a program than for the supervisor to come out in the noisy workplace and ignore all warnings concerning the noise. If the chief visits a station during a noisy operation, then he must either remove himself from the noise or wear hearing protection just like everyone else. The officer in charge must make abiding by the rules of the hearing conservation program just as important as the safety rules enforced on the fire ground. A fire fighter who fails to wear PHPD's during an appropriate time must be reprimanded.

A competent individual should be made responsible for the entire hearing conservation program. This does not mean that one person has to do all of the work. Rather, if one key person is responsible and accountable for all components of the program, then small items will have less of a tendency to fall through the cracks which might be perceived by the fire fighters as a shoddy program. This person's enthusiasm toward the program will have a tendency to rub off on the fire fighters and generate positive attitudes toward hearing conservation.

Finally, communication lines must be open at all levels of the department. The private in the fire service with less than five years of service must feel comfortable in discussing

problems about the hearing conservation program with the station captain. Also, the district chief must be able to communicate as easily with the fire department chief about program directives as he is able to reprimand a fire fighter for not wearing his hearing protection during an emergency response. If communication lines are kept active, then un-

founded rumors and misinformation about the program will be kept at a minimum. These open lines will also show the fire fighters that someone does care about their hearing and will help motivate him to maintain an active participation in the Program.



# WORKERS COMPENSATION AND HEARING LOSS

**MEDICAL EXAMINATION TEST RESULTS**  
**AUDIOGRAM RECORD**

LEFT EAR CH. LOSS      RIGHT EAR CH. LOSS

Hz	125	250	500	1000	2000	4000	8000	16000	32000
Unaided HL	20	25	30	35	40	45	50	55	60
Aided HL	15	20	25	30	35	40	45	50	55
Unaided HL	25	30	35	40	45	50	55	60	65
Aided HL	20	25	30	35	40	45	50	55	60

**VISUAL ACUITY**

Distance	Visual Acuity
20 FT	20/20
10 FT	20/20
5 FT	20/20
3 FT	20/20
2 FT	20/20
1 FT	20/20

**HEARING TESTS**

Ear	Frequency	Intensity	Notes
Left	125 Hz	20 dB	
Left	250 Hz	25 dB	
Left	500 Hz	30 dB	
Left	1000 Hz	35 dB	
Left	2000 Hz	40 dB	
Left	4000 Hz	45 dB	
Left	8000 Hz	50 dB	
Left	16000 Hz	55 dB	
Left	32000 Hz	60 dB	
Right	125 Hz	25 dB	
Right	250 Hz	30 dB	
Right	500 Hz	35 dB	
Right	1000 Hz	40 dB	
Right	2000 Hz	45 dB	
Right	4000 Hz	50 dB	
Right	8000 Hz	55 dB	
Right	16000 Hz	60 dB	
Right	32000 Hz	65 dB	

**COMMENTS:** HEARING LOSS IS MILD TO MODERATE BILATERAL.

**DATE:** 10/15/1988

**EXAMINER:** DR. J. W. SMITH

**REFERRING PHYSICIAN:** DR. J. W. SMITH

**TESTING ROOM:** 10101

**TESTER:** J. W. SMITH

**REMARKS:** HEARING LOSS IS MILD TO MODERATE BILATERAL.



Although it is widely acknowledged that noise causes hearing loss, only recently have efforts been made to deal with the problem. The growing interest in the effects of occupational noise exposure is because workers' compensation boards have been extending coverages for hearing loss.

Even though workers' compensation statutes originally failed to cover noise-induced hearing loss, the New York Court of Appeals awarded benefits to a worker despite no lost earnings in 1948 (*Slawinski v. J.H. Williams*). Five years later, the Supreme Court in Wisconsin upheld a similar decision by the Wisconsin Industrial Commission (*Green Bay Drop Forge v. Industrial Commission*). Even though it may be difficult to differentiate between the hearing loss caused by the normal aging process or exposures other than occupational and hearing loss caused by one's occupation, only four states (Indiana, Louisiana, New Mexico, and Virginia) do not provide for some form of compensation for occupational hearing loss.

The recognition of occupational hearing loss by workers' compensation boards has also helped push the development of hearing conservation programs. For example, the Milwaukee (Oregon) Fire Department initiated a hearing conservation program as a result of its findings that 80% of its personnel had some degree of hearing loss. These personnel were then referred for a complete audiometric examination that discovered that 42% of them had significant high frequency hearing loss. These individuals proceeded to file workers' compensation claims, since they failed to meet the hearing sensitivity criteria established by the state. All who filed claims were awarded permanent partial disabilities and damages ranging from \$700 to \$2400. All except one individual has filed an appeal requesting a higher damage award. Because disability benefits can range as high as \$8,000 per person, the Fire Department found that it was far less expensive to initiate a hearing conservation program that included annual audiograms, the installation of noise muffling materials on apparatus, and hearing protection/communication devices on all apparatus for use by officers and engineers.

The amount of allowable compensation varies from state to state. For example, the maximum compensation for one ear in Colorado is approximately \$3000, while the maximum compensation for one ear in Iowa is more than \$26,000. Washington DC. allows a \$63,000 claim for hearing loss in both ears. The same disabilities are worth variable amounts in compensation claims. This clearly demonstrates a need for a uniform and equitable basis for deciding compensation benefits for hearing loss. The present formula for determining if the hearing loss is compensable (recommended by NIOSH) is an average loss of 25 decibels for the frequencies of 1000, 2000, and 3000 Hz. This loss should be retained. To meet the Social Security Administration's guidelines for total disability due to hearing impairment, an individual must have an average threshold of 90 decibels or greater for the better hearing ear, based on both air and bone conduction at 500, 1000, and 2000 Hz. It is estimated that there are almost two million workers in the US. alone between the ages of 50 and 59 have hearing loss that is

compensable. If only 10% of these workers filed claims, then the cost to industry and society could be as much as \$500 million.

While each state's interpretation and handling of workers' compensation claims for job-related hearing loss is different, there are some general principles that should be applied when pursuing such claims.

Generally speaking, a disease is judged to be occupationally related if the following conditions exist:

- The worker's occupational environment (past or present) involved exposure to an agent or agents sufficient to have caused the onset of the disease in question.
- The worker's disease is compatible with the type of agent or agents they were exposed to.
- The weight of the evidence supports that the onset of disease was occupationally related.

To answer these questions, MOSH has developed a criterion of information that needs to be compiled and assembled.

### **Medical History**

- Has the onset of hearing loss been established?
- Has there been any previous illness, injuries or other abnormalities medically associated with non-occupational related hearing loss?

### **Personal History**

- Is the degree of hearing loss correlated with expectation of age and sex?
- Has there been participation in any hobbies or spare time activities that could result in noise exposure?
- Has any ototoxic drugs been used?
- Has any ototoxic chemicals been used in the home?

### **Family History**

- Does the family have any history of progressive hearing loss?

- What is the age, sex and health status of worker's parents, siblings, spouse and children?

### **Occupational History**

- What are the worker's past and present job titles?
- What was the actual work performed by the worker?
- What was the duration of the each type of activity engaged in by the worker?
- What are the dates of employment and the worker's age for each job activity?
- What was the geographic and physical location of employment?
- What type of personal protection clothing and equipment (including hearing protection) was used and how often?
- Was the worker provided with properly fitted hearing protection and instructed in its use?
- What types of agents or substances has the worker been exposed to?
- How often and what was the average duration of each exposure situation?

Do any noise monitoring records exist to demonstrate that excessive noise exposure existed?

### **Clinical Evaluation**

- Is the type of hearing loss found consistent with excessive exposure to noise?
- Have the audiometric tests been performed by a licensed or certified audiologist, otolaryngologist, or other physician, or by a technician who is certified by the Council of Accreditation in Occupational Hearing Conservation or in accordance with the requirements of the OSHA noise standard?
- Have all audiometric records been compared to ensure consistency and to detect possible fluctuation of hearing levels?
- Has a routine medical examination been performed?
- Has a comparison been made between the date of onset of symptoms with the worker's occupational history?

### **Evidence of Exposure**

- Does expert testimony (e.g., industrial hygienist, acoustic engineer, acoustician) exist concerning general environmental conditions, especially if adequate noise monitoring data is not available?

The collection of the above data will assist both fire fighters and fire departments in determining the validity of claims for hearing loss and expedite the handling of claims.

***EVALUATION OF THE  
PHOENIX, ARIZONA &  
ANAHEIM, CALIFORNIA  
FIRE DEPARTMENTS'  
HEARING CONSERVATION PROGRAMS***





Hearing loss has been recognized as an occupational disease in fire fighters. The audiometric testing pattern is characteristic of noise-induced hearing loss; however, noise exposure monitoring does not always reveal that fire fighters have noise exposures of sufficient magnitude to require a hearing conservation program (HCP). The current Hearing Conservation Amendment (HCA) [29 CFR 1910.951 of the Occupational Safety and Health Act (OSHA) requires the establishment of a hearing conservation program when workers are exposed to 85 dB or greater for an eight-hour time weighted average (TWA). The International Association of Fire Fighters evaluated Hearing Conservation Programs at the Phoenix, Arizona Fire Department and the Anaheim, California Fire Department. Site visits were made to both departments to ascertain the structure and implementation of each department's hearing conservation program. Previous noise surveys of equipment and apparatus were reviewed at each department. Personal dosimetry and periodic audiometry was reviewed at Phoenix.

One segment of the evaluation of HCP's is the analysis of the audiometric data base. Audiograms were evaluated from a sample of fifty male Phoenix fire fighters who had periodic audiograms from 1981 through 1988. Hearing threshold levels at 4,000 Hz were 23.1 dB (left) and 19.4 (right) in 1981, much higher than would be expected in the general population. The benefit of the hearing conservation program is evidenced by the trend of the group's change in hearing threshold level from 1981 to 1988 which was less than would be predicted by age. The %BW statistic as described by Royster and Royster ranged from 16% to 73% from 1982 to 1988.

The establishment of a Hearing Conservation Program indicates the commitment each fire department has toward maintaining fire fighter health. This study has shown that the implementation of a hearing conservation program as described in this manual has had a positive effect on the hearing threshold levels of fire fighters. Noise surveys, personal dosimetry, engineering controls, annual audiograms, personal protective devices, education, training and record keeping, are the elements for a model hearing conservation program in the fire service.

### **Evaluation Criteria for a Hearing Conservation Program**

After hearing conservation measures have been instituted, management, employees, and health and safety personnel require a means of assessing the effectiveness of the HCP. In the Hearing Conservation Amendment, OSHA provided guidelines for the review of individual audiograms compared to the worker's baseline audiogram. If the change in hearing threshold met OSHA's criteria as a standard threshold shift (10 dB increase in the average of 2,000, 3,000, and 4,000 Hz from baseline), the individual worker would undergo further medical evaluation. No specific evaluation criteria were specified for interpreting the aggregate hearing level thresholds from the audiograms of the entire population covered by the HCP.

Several measures have been suggested for program evaluation using the audiogram data base accumulated under a HCP. The most commonly studied hearing threshold level is for the frequency 4,000 Hz because it is the one characteristically which commonly has the greatest change from noise exposure. However, the inherent variability in audiometric testing of 5 to 10 dB, does not allow differentiation between the normal variability and early changes of noise induced hearing loss for an individual. In contrast, a change of 5 dB in the mean HTL derived from a group's audiometric data base can provide an indication of noise exposure and the effectiveness of the HCP.

The comparison of the group's average hearing threshold levels to a similar working population is one measure. Several reference populations have been described, but the characteristics of a suitable reference population have not been agreed upon. If the study is cross-sectional, the use of an external reference group is mandatory.

Another evaluation method is the longitudinal study of the population. Royster and Royster have published several different test-retest measures to be applied to a audiometric data base [19,20]. Based on changes in hearing threshold levels compared to either the baseline year or to the previous year, a percentage of individuals showing a change can be computed. They have suggested four different measures:

• **Percent better baseline statistic (%Bb).**

A shift of 15 dB toward better hearing (lower threshold levels) at any frequency in either ear with respect to the initial baseline test (test year 1 to year 2, year 1 to year 3, year 1 to year 4, etc.);

• **Percent worse baseline statistic (% Wb).**

A shift of 15 dB toward worse hearing at any frequency in either ear with respect to the initial baseline test (test 1 to 2, 1 to 3, 1 to 4);

• **Ratio of percent better baseline to percent worse baseline (%Bb/Wb).**

A ratio formed from the % Bb and %Wb values for any selected year of testing;

• **Percent better or worse sequential (%BWs).**

A shift of 15 dB toward either better or worse hearing at any frequency in either ear in a sequential comparison of one test to the preceding test(test1to2, 2to3, 3to4).

The 15 dB significance level for the test-retest statistics was chosen empirically by Royster and Royster and applied to several known audiometric data bases. They believe that it provides the best specificity and sensitivity.

Normal variability may produce shifts of 5 to 10 dB, better or worse, in an individual. Improvements (decreases) in hearing threshold level, due to a learning effect, may result as the population undergoing audiometric testing becomes familiar with the equipment and testing process. Increases in hearing threshold level are due to (1) noise induced temporary threshold shifts, (2) noise induced permanent threshold shifts,

and/or (3) the normal aging process known as presbycusis.

As in any data set, the measured thresholds will exhibit variability about the mean. The %BWs provides an indication of that variability. During the first few years of audiometric testing, an elevated %BWs will reflect the learning effect of the population. After the first four years of testing, the most frequent cause of elevated %BWs is the occurrence of temporary threshold shifts. If the working population is taken from work to have the audiogram done, any workers who were in noise hazardous areas without proper hearing protection may have a temporary threshold shift. Royster and Royster have empirically established 30% as the upper limit of normal for the %BWs test. Another cause of an elevated %BWs is the occurrence of permanent threshold shift from prolonged over-exposure of noise.

**Phoenix, Arizona Hearing Conservation Program**

A site visit was made to the Phoenix Fire Department on June 12,13,and 14,1989. The contact person was Tom Healy, Deputy Chief, PFD. There are approximately 1000 men and women in the Phoenix Fire Department,

All previous surveys of sound level measurements were reviewed. The audiograms of a ten per cent alphabetical sample of a cohort of Phoenix fire fighters with periodic audiograms from 1981 through 1988 were reviewed. The method and results are presented in the next section.

The Phoenix Fire Department formally began hearing conservation in the early 1980's through a city-wide program. Today, the fire department program is consistent with the OSHA and NFPA model as described earlier in this manual. Copies of sound level surveys made in 1986,1987 and 1988 were provided, and they concur with data in published reports. The noise surveys revealed that certain riding positions in the trucks would expose the occupant to levels exceeding 110 dB during Code 3 operations. The PFD had conducted personal noise dosimetry on several fire lighters in 1981. The readings varied from 57 dBA TWA to 85 dBA TWA. Dosimeters were usually worn for eight hour periods.

Since the early 1960's, each member of the fire service had an audiogram performed at the initial physical examination and at each periodic physical examination (not always annual). Prior to 1987, the physical was performed by a contractor. Since 1987, the audiograms were performed in the Phoenix Fire Department Health and Fitness Center. The model of audiometer prior to 1987 is not known. The present instrument is a Maico MA 728 in an Industrial Acoustics Company model mini series 250 booth. The audiometer and booth are calibrated annually to OSHA/ANSI standards. The Health and Fitness Center has produced its own educational video tape on hearing conservation.

**Analysis of Phoenix Audiograms**

The cohort was defined to include male fire fighters who were employed by the Phoenix Fire Department from 1981 through 1988, and had an audiogram in 1981. A pilot project was undertaken on an alphabetical sample of the medical records at the Phoenix Health and Fitness Center. The alphabetical sampling method was chosen because a personnel roster was not available. Every tenth record alphabetically was pulled and if the fire fighter was a member of the cohort, the audiograms were recorded. If the tenth chart was not of a member of the cohort, it was replaced and the tenth chart following was pulled. No attempt was made to obtain an exact 10% sample. The sample was not intended to be a representational sample of the entire cohort, and results may have no meaning applied to the whole cohort. The sample was merely a pilot study (See Table XII).

<b>TABLE XII</b>		
<b>Phoenix Fire Department (1980)</b>		
<i>Department Staffing</i>		<i>Sample Size</i>
Total	792 (100%)	50 (100%)
Anglo Male	668 (84.3%)	42 (84.0%)
Hispanic Male	93 (11.7%)	5 (10.0%)
Black Male	27 (3.4%)	5 (6.0%)
Indian Male	2 (<.01%)	0 (0%)
Asian Male	2 (<.01%)	0 (0%)

The mean age was calculated using December 31,1981, as the reference; the years of exposure was calculated using July 1,1981, as the reference. The average age of the cohort was 32 years (range 20-51) in 1981, and the mean years of exposure was 5 years (range 0-22) in 1981. Because the physical examinations were not annual but periodic, not all subjects had eight consecutive annual audiograms. The “per cent missing” reflects the percentage of the sample with no audiogram for that calendar year.

Average hearing thresholds for 4,000 Hz in the left and right ear are in Table XIII and Figures 3 and 4. The %BWs for each year is shown in Table XIV.

**Anaheim, California Hearing Conservation Program**

A site visit was made to the Anaheim Fire Department on June 14,15, and 16,1989. The contact person was Jeff Irwin, Captain AFD. The Anaheim Fire Department has approximately 220 members.

The Anaheim Fire Department has recently instituted a hearing conservation program. The program had its beginnings in a survey performed in 1985 in which the audiograms



**Table XIII**

**Mean Hearing Thresholds**

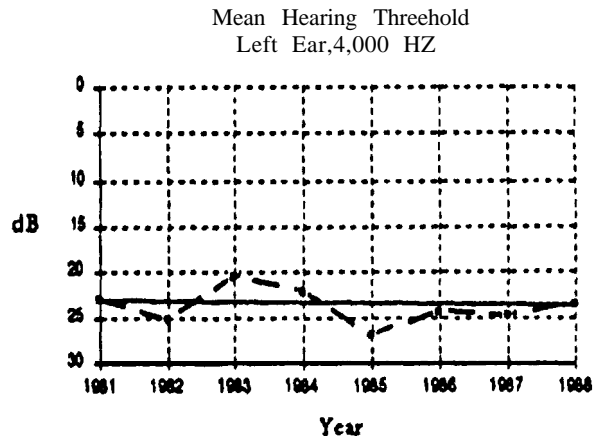
**Average Left Ear Hearing Threshold at 4,000 Hz**

Year	MeanHT	Range dB	% Missing
1981	23.10	0-80	0%
1982	25.33	0-95	8%
1983	20.50	0-85	20%
1984	22.29	0-75	30%
1985	26.97	0-75	34%
1986	24.46	0-75	26%
1987	25.00	0-75	20%
1988	23.75	0-70	20%

**Average Right Ear Hearing Threshold at 4,000 Hz**

Year	Mean HT	Range dB	% Missing
1981	19.40	0-90	0%
1982	21.30	0-60	8%
1983	17.75	0-80	20%
1984	18.71	0-50	30%
1985	22.12	0-80	34%
1986	16.89	0-60	26%
1987	22.38	0-80	20%
1988	20.75	0-55	20%

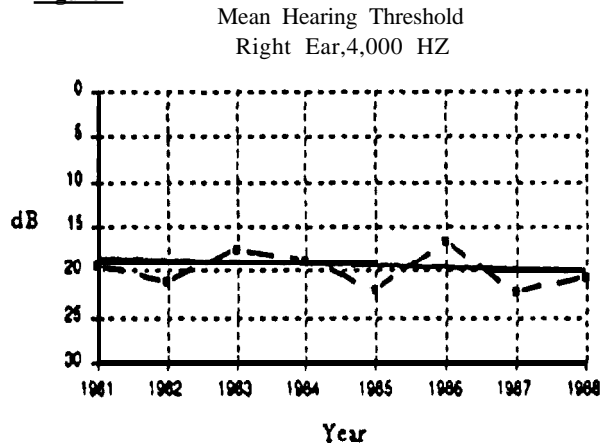
**Figure 3**



Raw Data —

Trend Line - - -

**Figure 4**



**Table XIV**

**Percent BW's for sample 1982-1988**

Year	Number with Shift	Number with Audiograms for Both Years	Percent BWs
81-82	21	46	45.6
82-83	28	38	73.7
83-84	14	30	46.7
84-85	4	24	16.7
85-86	9	25	36.7
86-87	18	31	58.1
87-88	17	30	56.7

of 39 active employees were evaluated for NIHL. Those with no hearing threshold levels greater than 25 dB were categorized as having no impairment. See Table XIV.

<i>Age</i>	<i>No HTL Greater Than 25 dB</i>
29-34	71%
35-36	55%
40-44	22%
45-50	20%

The present HCP was developed by Captain Irwin as a follow-up to the original study done in 1985. Hearing conservation in Anaheim was previously focused on noise level measurements and engineering controls to lower the noise levels. The present program is consistent with the OSHA and NFPA hearing conservation programs.

Sound level surveys of the trucks and equipment have been made over the last several years. Testing done during the site visit demonstrated levels similar to those in the published literature. The highest levels in a rear engine enclosed cab "hush" truck were 85 dB during Code 3 response. An open-cab truck with forward engine (with additional noise insulation on the engine cowling) produced 97 dB during Code 3 response. Code 3 operations produced 103 dB in an open-cab tiller truck which also had additional noise insulation over the engine.

Engineering controls have been attempted on the present fleet of trucks to reduce engine and siren noise. Noise insulation has been applied to engine cowlings. Varying siren and horn placements have been tried to reduce sound levels in the cabs. When ordering new trucks, the fire department has ordered rear-engine trucks in preference to cab-over engine design.

No sequential audiograms are available from Anaheim. The fire fighters will begin having annual audiograms this year.

**Discussion of Results**

Both departments surveyed have an appreciation of the importance of prevention as the most desirable method for maintaining worker health. Through the noise level surveys both departments identified high noise producing equipment and apparatus. The personal sampling done by the Phoenix department provided additional information regarding noise exposures. The engineering controls which could easily be implemented in the placement of sirens or horns were made by both departments.

The most important information revealed by the audiogram analysis of Phoenix fire fighters was that the HTL's of a group of relatively young fire fighters (mean age 31) were high. After applying the age correction from the OSHA Hearing Conservation Amendment, the HTL at 4,000 Hz of the sampled group was 13.1 dB (left) and 9.4 dB (right) greater than expected based on age. This is consistent with the observation that the employee who is likely to experience a hearing loss will not increase his/her HTL linearly but exponentially, rapid at first and slower later [21].

The trend lines for mean hearing threshold at 4,000 Hz for both left and right ear are significant only for the slope which indicates that the HTL increase was less than 3 dB that would be expected for an age related change in hearing threshold levels for the cohort from 1981 to 1988. A least square fit was not calculated because the sample was known to not be representative of the cohort, and a slope derived from a least square fit might have tempted a more detailed comparison than is justified.

Another lesson learned from this study was that without meticulous follow-up, yearly examinations are very difficult to accomplish. The audiograms were done regularly, but not everyone had yearly examinations. From the audiogram review, the 30% "missing" severely hampers the usefulness of an analysis of the HTL. The lack of annual audiograms was the primary reason for not performing an analysis of the entire Phoenix cohort.

The temporal pattern of the mean HTL for 4,000 Hz in either ear over the study period, 1981-1988, was not useful in determining the effectiveness of the HCP. The highly variable mean HTL at 4,000 Hz is most likely due to the small sample of audiograms, but the HTL may also reflect the potential of influence by either the equipment or the technician. The ANSI standard detailing calibration specifies that the sound levels must be within 5% of the defined level. It is possible to have significant changes in a group mean from year to year if the sound levels may vary from -5% to +5% from calibration to calibration.

The %BWs test described by Royster and Royster was higher than the empirically chosen normal of 30%, in all but one year. The test provides an indication of the variability of the HTL for each individual. There are no published studies in the literature using the %BWs by which to compare the Phoenix sample; and therefore, the wide range of the results have little interpretable meaning. Again, applying an indicator of program effectiveness to a non-representational sample itself limits the usefulness of the %BWs.

The noise surveys done by the Anaheim Department were effective in establishing those trucks with the highest exposures and prompting alterations of the trucks. The remainder of the Anaheim program is in the development stage. Audiograms are the most useful data in determining the effectiveness of a HCP, both on an individual level and on a group level. The smaller size of the Anaheim Department also presented a

handicap in not having someone designated to be in charge of the HCP and given the resources to accomplish that job.

## **Conclusion**

Very few plants or industries have evaluated the effectiveness of HCP's. The methods of evaluating HCP's are relatively new, and there is very little practical experience to know those measures which are the most useful. The fire departments studied have designed programs which encompass all the elements of a hearing conservation program as outlined in this manual. The study analyzing Phoenix audiograms provides a rough estimate that hearing conservation is helping to prevent hearing loss because the hearing threshold levels increased at a rate less than would be predicted by aging effects.

Both Phoenix and Anaheim have HCP's with solid foundations, and with continued support and resources, the HCP's will protect the new employee from hearing loss. All fire departments should focus their resources on implementing the HCP. A HCP must include (1) an assessment of noise exposure, (2) an assessment of hearing threshold levels (the audiogram), (3) engineering and administrative controls, (4) education and (5) program evaluation.

## **References**

1. Tubbs RL, Flesch JP. Health Hazard Evaluation Report 81-059-1045, February, 1982, Newburgh Fire Department, Newburgh, New York. Cincinnati: US DHHS CDC NIOSH, 1982.
2. Tubbs RL. Personal communication. July 9, 1987.
3. Pepe PE, Jerger J, Miller RH, Jerger S. Accelerated hearing loss in urban emergency medical services firefighters. *Annals of Emergency Medicine*. 14(5) May 1985, 438-42.
4. Reischl U, Hanks TG, Reischl P. Occupational related fire fighter hearing loss. *American Industrial Hygiene Association Journal*. 42(9)1981. 656-62.
5. Reischl U, Bair HS, Reischl P. Fire fighter noise exposure. *American Industrial Hygiene Association Journal*. 40(6)1979. 482-9.
6. Johnson DW, Hammond RJ, Sherman RE. Hearing in an ambulance paramedic population. *Annals of Emergency Medicine*. 9(11)1980. 557-61.
7. Flesch JP, Tubbs RL. Health Hazard Evaluation Report 84-493-1583, April 1985, General Services Administration, Washington, DC. Cincinnati: US DHHS CDC NIOSH. 1985.
8. Tubbs RL. Health Hazard Evaluation Report, 81-459-1603, July 1985, The City of New York Fire Department, New York, New York. Cincinnati: US DHHS CDC NIOSH.
9. Duffy, Richard M.; Beer, Alan R.; and Tubbs, Randy L. *Fire Fighter Fire Fighter Hearing Conservation Manual*. Washington, D.C. International Association of Fire Fighters/Federal Emergency Management Agency. 1988.
10. Occupational Noise Exposure; Hearing Conservation Amendment; Final Rule (1983). Washington, DC. Occupational Safety and Health Administration, U.S. Department of Labor. *Federal Register*, 48 FR 9738, March 8, 1983. [29CFR1910.95].
11. Miller MH, Silverman CA. *Occupational Hearing Conservation*. Englewood Cliffs, New Jersey: Prentice Hall. 1984.
12. Sataloff RT, Sataloff J. *Occupational Hearing Loss*. New York: Marcel Dekker. 1987.
13. Sataloff J, Paul M. *Hearing Conservation*. Springfield, Illinois: Charles C. Thomas. 1973
14. Berger EH, Ward WD, Morrill JC, Royster LH (eds). *Noise and Hearing Conservation Manual*, 4th ed. Akron, Ohio: American Industrial Hygiene Association. 1986.
15. NFPA 1500, Standard on Fire Department Occupational Safety and Health Program. Quincy, MA, National Fire Protection Association. 1992.
16. Mets JT. Reliability of industrial audiometry as a screening method for incipient noise-induced hearing loss. *South African Medical Journal*. 71;1987. 35-9.
17. Melnick W. Evaluation of industrial hearing conservation programs: a review and analysis. *American Industrial Hygiene Association Journal*. 45(7)1984. 459-67.
18. Thomas WG. Judging effectiveness of hearing conservation programs. In *Hearing Conservation in Industry*. Feldman AS, Grimes CT, eds. Baltimore: William and Wilkins. 1985. 178-201.
19. Royster JD, Royster LH. Using audiometric data base analysis. *Journal of Occupational Medicine*. 28(10)1986. 1055-68.
20. Royster JD, Royster LH. Audiometric data base analysis. In *Noise and Hearing Conservation Manual*, 4th ed. Berger EH, Ward WD, Morrill JC, Royster LH, eds. Akron, Ohio: American Industrial Hygiene Association. 1986. 293-318.
21. Ward WD. Auditory effects of noise. In *Noise and Hearing Conservation Manual*, 4th ed. Berger EH, Ward WD, Morrill JC, Royster LH, eds. Akron, Ohio: American Industrial Hygiene Association. 1986. 197-216.



# ***A STEP-BY-STEP APPROACH TO HEARING CONSERVATION***





The following is a step-by-step approach to confront and reduce occupational noise exposure in the fire service based primarily on the recommendations of NIOSH and reiterated by other researchers.

**Implement a hearing conservation program for fire fighters that includes preemployment, baseline audiograms and annual audiograms.**

Such audiograms should be conducted in accordance with ANSI standards. This program should include periodic monitoring of the apparatus and equipment to ensure that the intensity of the noise does not increase with wear and tear. Educational programs to inform fire fighters of the hazards of noise should be conducted. Fire fighters should also be encouraged to report and document incidents of tinnitus (ringing in the ears) following a call response. Reduction of off-the-job noise exposures should also be emphasized.

The selection of attenuation devices, ear plugs and muffs, is a critical part of the hearing conservation program. When determining the attenuation provided by protection devices the noise reduction rating (NRR) factor is used. The NRR is used to inform the user of the degree of attenuation the device provides. This number is subtracted from the SLM reading dBA. This number should not be used at face value. OSHA requires that the following formula be used when using the NRR to assess hearing protection adequacy:

- Obtain the employees A weighted TWA
- Subtract seven from the NRR
- Subtract the remainder from the TWA to obtain the estimated A weighted TWA under the ear protector.

It has been suggested that when using ear plugs that in addition to subtracting seven from the NRR, the remainder be divided by two. This is because earplugs, often times, are not properly fitted or inserted due to the time and training required to properly select and insert them. This also adds an extra factor of safety to the attenuation device. An example is as follows.

In an environment where an employee has a TWA of 105 decibels, the amount of protection required to attenuate the exposure to compliance would be 15 or if the individual has experienced a threshold shift the needed amount of protection would be 20.

To have an attenuation factor of 15, the required NRR for ear plugs would be 37.

$$(37 - 7) + 2 = 15$$

For ear muffs the required NRR would be 22,

$$22 - 7 = 15$$

**Limit the use of warning devices as much as legally and practically possible. Reduce the intensity of existing warning devices to the lowest level at which they are still effective at alerting traffic.**

Since people are more perceptually aware of changes in their environment, intermittent taps of an air horn should also be more effective in moving traffic than a horn sounding constantly. Remember that louder is not always better.

**Remove and isolate warning devices from the fire personnel on the vehicle.**

Sirens mounted above the rear view mirror on the windshield of an open-cab vehicle should be removed or located elsewhere. In these positions they expose the fire fighter to the total intensity of the siren noise. The front bumper or running board where the vehicle itself can act as a shield from the siren noise is recommended for mounting locations. The Engineering and Specification Division of GSA is responsible for providing the Federal Specification for ambulances (KKK-A-1822). This specification is extensively used by state, county and local governments as well as by the Federal government. NIOSH's recommendation to locate ambulance siren speakers in the grille or bumper area, rather than in the traditional location of on the cab roof, has been included in GSA's revised Federal Specification, which was effective June 1, 1985.

**Replace existing narrow band, high frequency warning devices, particularly mechanical sirens, with broader band, lower frequency devices.**

Narrow band, high frequency devices are more damaging to the fire fighter's hearing. Such devices are also less effective as a warning signal because high frequency sounds will be reflected off vehicles instead of penetrating them. Lower frequency sounds have much less reflection. Also, two-toned devices have the advantage of being perceptually more arousing to people.

**Ensure the use of ear muffs, as a personal protective device on an interim basis until the noise levels of the vehicle are reduced.**

Ear plugs are not advisable for fire fighters in Code 3 operations since their effectiveness is highly dependent on proper fit and proper insertion. Since fire fighters must respond to a call within limited time, the chances of properly inserting ear plugs is remote. The use of ear muffs with communication capability is strongly recommended for all fire fighters who must hear communication during the response and for those fire fighters responsible for operating and monitoring the pump panel at the fire scene. Each set of muffs should have its own volume control similar to the kind found

on stereo headphones. Hearing protection devices should be used during all routine noisy operations such as saw usage or maintenance, vehicle checks, and portable generator checks.

**Add sound absorption material to existing fire apparatus.**

When sound-absorbing material is packed into the wall of a rescue vehicle’s cab, the noise intensity inside the cab is reduced 3 dBA. One of the most successful methods of reducing noise exposure is having the fire fighters ride in cabs that are insulated and air conditioned so that the windows can remain closed and sealed during response NM. A similar application of sound-absorbing around the engine compartment will reduce the noise exposure for fire fighters riding in the jumpseat. In addition, sirens and air horns mounted on the top of vehicles should use insulation mounting devices rather than the rubber or plastic washers that are now commonly used.

**Ensure that specifications for new apparatus take into consideration both the frequencies and intensities of the noise that the vehicle emits.**

The use of a qualified acoustical engineer as a consultant could be very beneficial when apparatus is being designed and ordered. Many manufacturers of apparatus are now considering noise reduction in the design of new vehicles.

**Ensure that specifications for new power tools and portable equipment (such as fans, generators, saws, etc.) take into consideration both the frequencies and intensities of the noise that the tool and portable equipment emit. Users must ensure that noise arresters are utilized and maintained in accordance with the manufacturer’s recommendation.**

Many manufacturers of power tools and portable equipment are now considering noise reduction in the design of their equipment. The state of the art technology for such devices has been rapidly expanding and should be specified when avail-

able. As a rule, electric powered tools and equipment will be less noisy than those driven by gas engines. However, the use of electric power may not always be feasible.

**Ensure that the alarm signal inside the fire station does not cause a physiological alarm reaction.**

The alarm should be used as a mode of information, such as differentiating who is being called out on the response run. A European (Hi-Lo) electronic signal or more soothing alarm could awaken or notify fire fighters without causing undue stress. It is not necessary to have a bed hall alarm in excess of 85 decibels.

The use of joint labor/management safety and health committees and/or the collective bargaining process are mechanisms that can be utilized to implement the recommendations previously described. It should also be remembered that although federal OSHA has no direct enforcement authority to ensure compliance with health and safety standards for public employees, the OSHA law does permit other methods to be used to maximize the protection of public employees’ health and safety.

A state can choose to implement their own enforcement program providing federal OSHA has approved their state safety and health plan. Under such plans, a state must establish and maintain an effective and comprehensive occupational safety and health program for all public employees. In addition, federal OSHA has issued a set of rules and regulations that would allow for the development of a state plan applicable and enforceable solely for the public employees in those states without approved plans wishing to receive federal financial support for their public employee safety and health programs. Finally, executive order 12196 mandates the protection of the federal fire fighters under federal OSHA safety and health standards.

This means that all state, county or municipal fire departments in any of the states or territories where such OSHA State Plan agreements (Table XVI) are in effect as well as federal fire fighters have the protection of the minimally acceptable health and safety standards promulgated by federal OSHA. Thus, these public sector fire fighters must be provided the minimum protection under the OSHA noise standard.

<b>TABLE XVI</b>			
<b>OSHA APPROVED STATE PLANS</b>			
Alaska	Kentucky	North Carolina	Virginia
Arizona	Maryland	Oregon	Virgin Islands
California*	Michigan	Puerto Rico	Washington
Connecticut	Minnesota	South Carolina	Wyoming
Hawaii	Nevada	Tennessee	
Indiana	New Mexico	Utah	
Iowa	New York*	Vermont	

\*For state and local government employees only.



# ***GLOSSARY***



**Administrative Control - Any procedure** which will change a worker's noise exposure without changing the noise emission levels. Examples of administrative controls are job rotation, work assignment, time periods away from the hazard and the use of personal protective equipment.

**Attenuate** - To reduce in amount.

**Attenuation** - The reduction of noise intensity at a first location as compared with the intensity at a second location which is farther from the source.

**Audiogram** - A record, usually graphic, showing an individual's hearing threshold as a function of frequency, upon which hearing loss may be determined.

**Baseline Audiogram** - The audiogram, usually given at employment or upon the implementation of a hearing conservation program, against which future audiograms are compared.

**Decibel (dB)** - The unit of measurement used to express sound levels.

**Engineering Control - Any procedure** other than an administrative control that reduces exposures by modifying the source or reducing the amount of noise that reaches the operator's zone. Examples of engineering controls include isolation, containment and the use of sound absorbing materials.

**Hearing Conservation Program** - A program that prevents or minimizes noise induced deafness through the use of hearing protection devices, the control of noise through engineering methods, annual audiometric tests and employee training.

**Hertz** - Unit of measurement used to express frequency, numerically equal to cycles per second.

**Noise** - Unwanted sound that at high levels may be damaging to hearing.

**Nosocausis** - Hearing loss caused by medical abnormalities, i.e., hereditary progressive deafness, diseases such as mumps, rubella, Meniere's disease; ototoxic drugs and chemicals; and blows to the head.

**Ototoxins** - Any chemical agent that may cause damage to or cause a decrease in hearing ability.

**Presbycusis** - Natural hearing loss associated with aging.

**Sociocausis** - Hearing loss associated with everyday noises, i.e., lawn mowers, loud music, traffic, etc.

**Sound** - The auditory sensation evoked by oscillations in pressure in a medium with elasticity and viscosity. Sound is also the sensation produced through the organs of hearing, usually by vibrations transmitted through air.



# ***BIBLIOGRAPHY***



**BNA Case for Hearing Protection** (1983), Richard Bailey, The International Fire Chief, April 1983.

**Accelerated Hearing Loss in Urban Emergency Medical Service Firefighters** (1985), Paul Pepe, James Berger, Robert Miller, Susan Jerger, *Annals of Emergency Medicine*, May 1985.

**An Evaluation of Current Hearing Conservation Programs: A look at HCPs in Anaheim, California and Phoenix, Arizona (1990).** International Association of Fire Fighters, Department of Occupational Health and Safety, 1750 New York Avenue, N.W., Washington, D.C 20006.

**Carbon Monoxide Exposure Potentiates High Frequency Auditory Threshold Shifts Induced By Noise (1987).** John Young, Margaret Upchurch, Marc Kaufman and Lawrence Fechter, *Hearing Research*, Volume 26.

**Effects of Carbon Monoxide on Cochlear Electrophysiology and Blood Flow** (1987), Laurance Fechter, Peter Thorne and Alfred Nuttall, *Hearing Research*, Volume 26.

**Fighting Noise on the Job** (1980). Boilermakers Local 802, 301 East Third Street, P.O. Box 618. Chester, Pennsylvania 19016.

**Fire Fighter Noise Exposure** (1981). Uwe Reischl, Herbert Bair and Peter Reischl, *American Industrial Hygiene Journal*, Volume 42.

**Fire Fighters' Reaction to Alarm, an ECG and Heart Rate Study** (1981), Ilkka Kuorinka and Olli Korhonen, *Journal of Occupational Medicine*, Volume 23, Number 11 (November).

**Fundamentals of Industrial Hygiene** (1988), Julian Olishifski, editor National Safety Council, 444 North Michigan Avenue, Chicago, Illinois 60611.

**Guidelines for Developing an Effective Hearing Conservation Program** (1982), L. H. Royster, J.D. Royster and E.H. Berger, *Sound and Vibration*, Volume 23, Number 5.

**Health Hazard Evaluation Report 81-059-1045: Newbergh Fire Department** (1982). Randy Tubbs and Jerome Flesch, National Institute for Occupational Safety and Health, Center for Disease Control, Public Health Service, U.S. Department of Health and Human Services.

**Health Hazard Evaluation Report 81-459-1603: The City of New York Fire Department** (1985). Randy Tubbs, National Institute for Occupational Safety and Health, Center for Disease Control, Public Health Service, U.S. Department of Health and Human Services.

**Health Hazard Evaluation Report 84-493-1583: General Services Administration** (1985), Randy Tubbs and Jerome Flesch, National Institute for Occupational Safety and Health, Center for Disease Control, Public Health Service, U.S. Department of Health and Human Services.

**Hearing Loss in Fire Fighters (1979).** Herbert and Jeanette Kean, 220 South 16th Street .Philadelphia, Pennsylvania 19102.

**Industrial Noise Control Manual** (1975), National Institute for Occupational Safety and Health, Center for Disease Control, Public Health Service, U.S. Department of Health and Human Services, I-II-IS Publication No. (NIOSI-I) 75-183.

**Noise** (1975), David Dempsey, *New York Times Magazine*, November 23.1975.

**Noise and Hearing Conservation Manual**, E.H. Berger, W.D. Ward, J.C. Morrill, L.H. Royster, editors American Industrial Hygiene Association, 475 Wolf Ledges Parkway, Akron, Ohio 4431 1-1087.

**Noise Control** (1978), UAW Social Security Department, 8000 Jefferson Avenue, Detroit, Michigan 48214.

**Noise: The Environmental Problem, A Guide to OSHA Standards** (1972). Occupational Safety and Health Administration, U.S. Department of Labor, OSHA 2067.

**NIOSH: Publications on Noise and Hearing** (July, 1991), U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health, Center for Disease Control, Public Health Service.

**Occupational Exposure to Noise** (1972) National Institute for Occupational Safety and Health, Center for Disease Control, Public Health Service, U.S. Department of Health and Human Services.

**Occupational Noise Exposure; Hearing Conservation Amendment; Final Rule** (1981). Occupational Safety and Health Administration, U.S. Department of Labor, Federal Register, 46 FR 4078, January 16,1981.

**Occupational Exposure; Hearing Conservation Amendment; Partial Lifting of Administrative Stay (198 1), Occupational Safety and Health Administration, U.S. Department of Labor, Federal Register, 48 FR 9738, March 8, 1983.**

**Occupational Noise Exposure; Hearing Conservation Amendment; Final Rule** (1983), Occupational Safety and Health Administration, U.S. Department of Labor, Federal Register, 48 FR 9738, March 8 1983.

**Occupation Related Fire Fighter Hearing Loss**(1981),Uwe Reischl, Thrift Hanks and Peter Reischl, American Industrial Hygiene Journal, September 1981.

**Patty's Industrial Hygiene and Toxicology, Volume 1**(1978). G.D. and F.E. Clayton, editors, John Wiley and Sons, New York, New York.

**Recommended Criteria for Evaluation the Effectiveness of HCPs** (1980), L.H. Royster, D.T. Lilley and G.T. Thomas, American Industrial Hygiene Association Journal, Volume4 1.

**Some Effects of Noise Exposure on Hearing Threshold Levels of Selected Ambulance Drivers in the District of Columbia Fire Department** (1974). Deborah Yvonne Beale, Howard University Graduate School, Washington D.C.

**The Heart Needs Warmup Time** (1973). R. James Bernard, Proceedings from the Second Symposium on the Health and Hazards of the Fire Service, John P. Redmond Foundation, International Association of Fire Fighters.

**The Noise Controversy** (1975). Job Safety and Health, Occupational Safety and Health Administration, U.S. Department of Labor.

**29 CFR 1910.95** (1991), Office of the Federal Register National Archives and Records Administration, U. S. Government Printing Office, Washington D.C.



# ***APPENDIX A***



# FIRE FIGHTER'S SERVICE QUESTIONNAIRE

1. Name: \_\_\_\_\_

2. Address: \_\_\_\_\_  
(Street)

\_\_\_\_\_  
(City) (State) (Zip Code)

3. Age: \_\_\_\_\_ Date of Birth: - -  
(Years) (Month) (Day) (Year)

4. How long have you been a Fire Fighter?: \_\_\_\_\_

## ***CURRENT ASSIGNMENT***

5. Station Assignment: \_\_\_\_\_ 6. How Long: \_\_\_\_\_

7. Job Classification: \_\_\_\_\_

## ***OTHER FIRE DEPARTMENT ASSIGNMENTS***

8. Station Assignment: \_\_\_\_\_ 9. How Long: \_\_\_\_\_

10. Job Classification: \_\_\_\_\_

11. Station Assignment: \_\_\_\_\_ 12. How Long: \_\_\_\_\_

13. Job Classification: \_\_\_\_\_

14. Station Assignment: \_\_\_\_\_ 15. How Long: \_\_\_\_\_

16. Job Classification: \_\_\_\_\_

Note: If you have had additional assignments, please list them on the back of this page

## ***OTHER JOBS: PAST OR CURRENT***

17. Company Name: \_\_\_\_\_ 18. How Long? \_\_\_\_\_

19. Job Classification: \_\_\_\_\_

20. Company Name: \_\_\_\_\_ 21. How Long? \_\_\_\_\_

22. Job Classification: \_\_\_\_\_

Note: If you have had additional assignments, please list them on the back of this page

## ***MILITARY EXPERIENCE***

23. Years and Months of Active Duty: \_\_\_\_\_  
(Years) (Months)

24. Branch of Service: \_\_\_\_\_ 25. Time in Combat: \_\_\_\_\_

26. Military Jobs, Assignments, and Duties: \_\_\_\_\_ Time Spent at Each: \_\_\_\_\_

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_

27. Did you fire weapons for more than 100 days? \_\_\_\_\_ (Yes) \_\_\_\_\_ (no)

If no, then how long? \_\_\_\_\_

***HOBBIES AND ACTIVITIES***

28. Do you engage in any of the following?

**Number of times engaged per.....**

Activity	Yes	No	Day	Week	Month	Year
a. Hunting	_____	_____	_____	_____	_____	_____
b. Shooting	_____	_____	_____	_____	_____	_____
c. Motorcycling	_____	_____	_____	_____	_____	_____
d. Drag Race	_____	_____	_____	_____	_____	_____
e. Chain Saw	_____	_____	_____	_____	_____	_____
f. Farm Tractor	_____	_____	_____	_____	_____	_____
g. Woodworking	_____	_____	_____	_____	_____	_____
h. Loud Music	_____	_____	_____	_____	_____	_____
i. Other	_____	_____	_____	_____	_____	_____

***MEDICAL HISTORY***

29. Have you ever had trouble with your ears? \_\_\_\_\_ (Yes) \_\_\_\_\_ (No)

If Yes, explain: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

31. Have you ever been seen by a physician concerning your ears? \_\_\_\_\_ (Yes) \_\_\_\_\_ (No)

If Yes, explain: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

31. Have you ever noticed any changes in your hearing?

\_\_\_\_\_  
(Yes)

\_\_\_\_\_  
(No)

If Yes, explain: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

32. Have you ever had the following?

	Yes	No	Hearing Change
a. Mumps			_____
b. Measles			_____
c. Allergies			_____
d. High Blood Pressure			_____
e. Mycin Drugs (Antibiotics)			_____
f. Quinine			_____
g. Severe Blow to Head			_____
h. Tinnitus			_____
i. Excessive Ear Wax			_____

If Yes to c, please list allergies: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

If Yes to g, please describe below: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

If Yes to h, how often: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



# Audiological Examinations

Name:	Date of Birth:	Occupation:	Shift:	I.D. Number	
Occupational <b>History</b> (Begin with last position, working back to first job. Use back if necessary.)				Department:	
Employer	City	Duties	Length of Service	Noise Exposure	Ear Protection
1				Yes No	Yes No
2				Yes No	Yes No
3				Yes No	Yes No
4				Yes No	Yes No
Military Service	Time Served	Branch		Exposure to Gun Fire and Noise	
		Army	Navy	Air Force	Marines
				Yes	NO Type: _____
<b>Medical History</b>					
Check If You Have Had Any Of The Following:					
Allergy ____	Dizziness _	Headaches _	Frequent Colds _	Influenza _	Measles _
Mumps ____	Ringing Ears _	Running Ears _	Whooping Cough -	other _____	
<b>Serious Medical Ailments</b>	Surgeries		Industrial Injuries or Illness		
<b>Head Injuries</b>	Hearing Impairment in Family		Workers Evaluation of Hearing Status: Excellent - Good - Fair - Poor - Very Poor		
<b>Education</b>	Previous Hearing Test (Date and Company)		Date Last Worked		
<b>Reviewed By</b>	Title		Date		
<b>Comments</b>					





# Sound Survey For Fire Apparatus

Station: \_\_\_\_\_

Date: \_\_\_\_\_ - \_\_\_\_\_ - \_\_\_\_\_  
 (Month) (Day) (Year)

## VEHICLE

Type: \_\_\_\_\_

Manufacturer \_\_\_\_\_

Date: \_\_\_\_\_ - \_\_\_\_\_ - \_\_\_\_\_  
 (Month) (Day) (Year)

Warning Devices:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Description of survey conditions:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

POSITION WEIGHTING

OCTAVE BANDS

	A	B	C	Flat	31.5	63	125	250	500	1000	2000	4000	8000	16000

COMMENTS:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



Name: \_\_\_\_\_

Soc. Sec. No. \_\_\_\_\_

Test Location: \_\_\_\_\_

Test By: \_\_\_\_\_ Date: \_\_\_\_ - \_\_\_\_ - \_\_\_\_ Certification Number: \_\_\_\_\_ Inst. Ser. No.: \_\_\_\_\_ Cal Date: \_\_\_\_ - \_\_\_\_ - \_\_\_\_

Retest By: \_\_\_\_\_ Date: \_\_\_\_ - \_\_\_\_ - \_\_\_\_ Certification Number: \_\_\_\_\_ Inst. Ser. No.: \_\_\_\_\_ Cal Date: \_\_\_\_ - \_\_\_\_ - \_\_\_\_

