PERSONNEL NOISE EXPOSURE DUE TO FIRE APPARATUS BACKUP ALARMS: EUGENE FIRE AND EMS

Executive Development

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Abstract

One of the most common causes of hearing loss is noise in the workplace. This applied research project examined the issues regarding noise exposure to fire fighters due to electronic backup alarms installed on fire apparatus. The problem was that fire fighters were being exposed to high noise levels caused by fire apparatus in combination with backup alarm activation. The purpose of the research was to analyze relevant issues regarding occupational hearing loss, applicable codes and standards , how others addressed the problem, and then to determine what measures were appropriate to reduce noise emissions. This analysis was then applied to the current data available for Eugene Fire and Emergency medical Services (EMS) backup alarm noise levels.

The project employed action research to answer four questions: What are the critical issues regarding hearing loss for fire fighters? What codes and standards apply to fire fighter occupational noise exposure? What are the factors regarding fire apparatus backup alarms which affect fire fighter hearing loss? What measures are appropriate to mitigate noise exposure due to fire apparatus backup alarm operation?

The major findings of this study were: 1) Eugene fire fighters are exposed to excess noise levels generated by apparatus backup alarms. 2) Codes and

standards do apply to the noise levels encountered, and mitigation is required. 3) There are a number of factors in the fire fighters' environment which increase the exposure due to backup alarms.

Recommendations resulting from this study include: 1) A comprehensive assessment of work site noise levels should be initiated to establish a baseline for a hearing conservation action plan. 2) An annual employee audiometric testing program should be established. 3. A training and education plan should be established. 4) Appropriate hearing protection should be provided to mitigate backup alarm exposure, and employees should be required to wear the protection. 5) A variance or code change should be pursued in order to eliminate the requirement for backup alarms when a fire fighter is present backing up the apparatus.

A safe work environment includes an active and progressive program to identify and eliminate or mitigate noise emissions. This research is only a part of that safety effort, and much remains to be done to ensure hearing protection in the workplace.

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Introduction

Noise is everywhere in our daily lives. Fire departments across the country are challenged to identify and correct noise exposures whenever and wherever there is a safety or health issue. Noise exposure to fire fighters caused by fire apparatus electronic backup alarms can be part of those challenges.

This research analyzed relevant issues regarding occupational hearing loss, codes and standards that apply to this occupational health issue, and how fire apparatus backup alarms affect noise emissions. Analysis of relative data from the Eugene, Oregon Fire and EMS Department was then done to determine commonalities and differences as compared to research findings.

Based on this research, areas for improvement could be identified and recommendations made for significant deficiencies found. The study used an action research methodology to apply research findings to identified noise exposure issues created by fire apparatus backup alarm operation. This was accomplished by addressing the following research questions:

1. What are the critical issues regarding hearing loss for fire fighters?
2. What codes and standards apply to fire fighter occupational noise exposure?
3. What are the factors regarding fire apparatus backup alarms which

affect fire fighter hearing loss?

4. What measures are appropriate to mitigate noise exposure due to fire apparatus backup alarm operation?

Background and Significance

Hearing loss in the workplace is a significant threat to worker safety and health in today's world. According to the National Institute on Deafness and other Communication Disorders (NIDCD) (1990), "... more than 20 million Americans are exposed to hazardous sound levels on a regular basis" (p. 2). Additionally, "Of the 28 million Americans who have some degree of hearing loss, about one-third have been affected, at least in part, by noise". (p. 2).

Hearing loss concerns in the workplace are echoed by the U.S. Occupational Safety and Health Administration (OSHA). OSHA (1998) notes that "Occupationally induced hearing loss continues to be one of the leading occupational illnesses in the United States" (p. 1). Plog, Niland, and Quinlan (1996) note that, in addition, "... noise levels in the workplace, particularly those maintained in mechanized industries, are likely to be more intense and sustained than any noise levels experienced outside the workplace" (p.197).

Fire fighters are also subject to this unhealthy noise exposure. Studies show

increased hearing loss in the general population, and Reischl, Bair, and Reischl (1979) assert that, “The audiometric data nevertheless shows that, on the average, firefighters, regardless of age and years of service, have poor hearing” (p. 48).

This research looks at an important health issue in the workplace: noise levels in the fire fighter’s environment. It is important because it examines current trends, general health issues, and potential solutions to a specific issue: apparatus backup alarm noise emissions. Without an ongoing examination of workplace noise, serious health implications can result.

This work was is also important to Eugene Fire and EMS because of the implications to fire fighter safety and health. Any recommendations derived could assist with the long term hearing conservation of the employees, as well as assist the department management in addressing those concerns.

Literature Review

Although minimal literature was found specific to fire fighter noise exposure due to apparatus backup alarms, a large number of studies and research have been done concerning occupational noise exposure. Numerous

studies of noise exposure in the fire service due to emergency response were found. A review of related occupational safety and health information, studies of firefighter noise exposure, applicable codes and ordinances, as well as current trends in noise mitigation was incorporated into this study. Eugene Fire and EMS policies and procedures were also reviewed to compare research information to the department's current practices. In order to simplify and organize pertinent literature review, the information was divided into five main topic areas that followed the research questions previously established.

What are the critical issues regarding hearing loss for firefighters?

To understand and address this critical health and safety issue, it is important to review the significant factors relative to noise induced hearing loss, and how those factors affect fire fighters. Plog et al. (1996) identify the four most important noise exposure factors: "Factors include: intensity, type of noise, period of exposure each day, and total work duration" (p. 207). Intensity (or loudness) refers to sound intensity and is measured in decibels (dBA). Type of noise (or frequency) is also known as pitch; the higher the pitch, the more likely there will be damage.

Plog et al. (1996), observe that additional factors that are relevant to exposure include the character of the surroundings in which the noise is

produced, and the distance from the source (p. 207). Casano (1998) notes that, "The closer you are to the sound of intense noise, the more damaging it is" (p. 3). Noise exposure for firefighters would include these important variables in assessing total or specific impacts, including the effects of fire apparatus backup alarms.

It is also clear that hearing loss is cumulative. Plog et al. (1996) found that, "If the ear is subjected to high levels of noise for a sufficient period of time some loss of hearing will occur" (p. 207). Myers (1994) found that, "People exposed to noise for long periods of time can develop noise-induced hearing loss. This is a permanent, untreatable condition. It usually worsens over time, compounded by the effects of aging" (p. 22).

It is important to understand how noise is measured. Plog et al. (1996) observe that, "The physical characteristics of a sound as measured by an instrument and 'noisiness' of a sound as a subjective characteristic may bear little relationship to one another" (p. 205). Noise exposure can be measured by a sound level meter. This instrument provides an estimate of the intensity of noise. These sound levels, measured in dBA or decibels are the most prevalent and often used instruments in noise measurement and analysis (p. 26).

Casano (1998) notes that the decibel scale runs from the faintest sound

the human ear can detect, which is labeled 0 dBA, to more than 180 dBA, the noise at a rocket pad during a launch. Decibels are measured logarithmically. A comparative chart illustrating examples of decibel levels and corresponding noise emissions is shown in Appendix A.

Fire fighters are not exempt from this cumulative damage. The National Institute for Occupational Safety and Health (NIOSH) Health Hazard Evaluation Report: Memphis Fire Department (1990) found that "...the fire fighter will accrue hearing loss at any station where he or she is assigned under current practices of the MFD" (p. 11). In a similar earlier NIOSH report on fire fighter noise exposure for the Newburgh Fire Department, NY (1982), the data showed that fire fighters were being exposed to high noise levels, and results of audiometric testing indicated significant hearing loss in the population studied.

Nelson (1989) reported significant data based on audiometric testing of Baltimore County, MD. fire fighters. Nelson found that a test of one-third of the fire fighter population (197 personnel) found 15 fire fighters with compensable noise-induced hearing loss, and 42% of those surveyed had suffered high frequency hearing loss (p. 17). Likewise, 13 studies reviewed in the Federal Emergency Management Administration (FEMA) Hearing Conservation Manual (1992) clearly showed that hearing loss was cumulative and prevalent in a large

population of fire fighters across the country (pp. 33-40). Tubbs (1991) found that the noise exposure data taken in his NIOSH study indicates "a statistical relationship between occupational noise exposures and hearing loss for fire fighters" (p. 372).

Hearing loss affects more than just the individual's ability to hear. Myers (1994) found that high levels of noise can interfere with job performance, especially when the task is complex or requires a certain amount of concentration. Burkell (1984) cites a study conducted in the late 1970's by the University of Kansas. The study concluded that fire fighters who were exposed to high noise levels from an unmuffled engine made more decisions than did fire fighters exposed to the lower level of noise of a muffled engine. However, the fire fighters exposed to the lower level of noise made proportionally fewer incorrect decisions. Burkell (1984) also notes that fire ground noise is an environmental stressor, and exposure to high noise levels can result in fatigue and adverse cardiovascular effects.

Smith (1997) discusses the by-products of noise in the workplace. He cites four impacts of noise in addition to hearing loss: miscommunication, worker isolation, productivity impacts, and health issues (elevated stress and blood pressure levels). With the fire fighter's critical job functions in emergency

management and operations, these consequences of noise exposure may have a significant negative effect on personnel performance. Smith also states that, "High levels of noise can interfere with job performance, especially when the task is complex or requires a certain amount of concentration" (p. 79). This also reinforces the concern regarding performance during critical situations.

Hearing loss could have adverse implications at work leading to injury or even death if a fire fighter cannot hear their fellow fire fighters' warning, distress cry, or other signals indicating danger. High noise levels may also increase stress, making fire fighters more irritable.

Statistics on noise measurement for fire service operations invariably focus on apparatus operation and other high-noise situations. Burkell (1984) reported that in a NIOSH study of the Newburgh (NY) Fire department, the environmental testing of apparatus produced noise level ranges from 99 decibels (dBA) to 116 dBA in cab areas. This sampling utilized a sound level meter. In comparison, individually worn sound dosimeters (an instrument designed to measure noise levels over time) showed that time-weighted average noise exposures ranged from 62.3 dBA to 85.3 dBA for the sampled fire fighters. Clearly there is a difference between the average sound levels for a full work period and levels such as those measured for a specific short-duration

event.

Most fire fighter studies have found that time-weighted average noise exposures are not in the health hazard range. Plog et al. (1996) found that, "The critical range where hearing can be damaged painlessly is between 85 and 125 dBA" (p. 253). Unfortunately, studies consistently show noise levels well into the 100-110 decibel range for shorter-term activities that are common to the fire service.

What codes and standards apply to fire fighter occupational noise exposure?

The Occupational Safety and Health Act of 1970 made the Department of Labor responsible for enacting regulations governing noise exposure of industrial workers. In 1971, OSHA issued the first noise standard (29 CFR 1910.95), which limited occupational noise exposure to a time-weighted average (TWA) of 90 dBA. In 1981 OSHA issued an amendment to the standard, outlining requirements for a hearing conservation program to be instituted by employers and extending the standard to take into account exposure to noise levels below 90 dBA. Under the amended standard (OSHA/EX, 1998), employees who are subject to a TWA of 85 dBA or more must be provided with hearing protectors. Employers must ensure that protectors are worn by employees whose TWA noise exposure exceeds 90 dBA (pp. 1-2).

FEMA'S Hearing Conservation Manual (1992) summarizes the current OSHA standard noise exposure limits: "a permissible noise exposure level (PEL) of 90 dBA for an 8-hour duration, with higher levels allowed for shorter durations" (p. 19). The following table (OSHA/EX, 1998) is contained in 29 CFR 1910.95, Table G-16 (Table III). It is based on what was believed to be the 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 (p. 19).

DURATION:	SOUND LEVEL dBA:
8.00	90
6.00	92
4.00	95
3.00	97
2.00	100
1.50	102
1.00	105
0.50	110
0.25	115

When workers are exposed to sound levels that exceed the OSHA permissible limit, feasible engineering or administrative controls, or combinations of both must be implemented to reduce levels to permissible limits. Clearly, this OSHA standard is central to the question of fire department occupational noise exposure and backup alarm noise exposure issues.

The National Fire Protection Agency (NFPA) addressed fire fighter safety and backup alarm issues in the standards 1901 and 1500. Noise levels in the work place have been demonstrated to be a health hazard. The NFPA has addressed firefighter safety issues related to backup alarms in NFPA 1500 (1997) by requiring that

> Hearing protection shall be provided for and used by all members when exposed to noise in excess of 90 dBA caused by power tools or equipment, other than in situations where the use of such protective equipment could create an additional hazard to the user (5-11.1).

This standard applies to non-emergency activities as well as emergency response.

The NFPA also addressed backup alarms as a required safety device on fire apparatus in NFPA 1901, the Standard for Automotive Fire Apparatus (1996). This national standard requires that, "An electric or electronic backup

alarm shall be provided that meets the Type D (87 dba) requirements..." (9-12). The NFPA 1500 safety standard reinforces this requirement by requiring that, "All new apparatus...shall be specified and ordered to meet the applicable requirements of NFPA 1901, Standard for Automotive fire Apparatus" (4-1.2).

NFPA standards are not legal mandates. However, recognized national standards are clear directives which will be important in litigation and help to provide solutions to existing hazards. These standards make it clear that apparatus backup alarms are required, and that hearing protection must be worn when the noise levels caused by backing apparatus are above 90 dBA. These requirements also echo the OSHA standard for industrial noise exposure. In combination, they identify clear parameters for fire departments regarding noise exposure due to fire apparatus and backup alarms.

What are the factors regarding fire apparatus backup alarms which impact fire fighter hearing loss?

Hearing loss usually occurs over time. Cumulative hearing loss is affected by many noise sources. The average fire fighter is away from the workplace approximately one-third of his or her working life. Noise exposure during off-duty time is a factor in fire fighter hearing loss. It is important to remember the cumulative nature of hearing loss. Backup alarms are but one of many noise

exposures that the fire fighter may experience during a typical work period.

Noise levels generated by fire apparatus responding code 3 have been well documented. Numerous studies have found noise levels well over 100 dBA during these activities. For example, Reischl et al.(1979) noted that in the 170 code-3 responses that their study monitored, sound pressure levels in excess of 115 dBA were found. These results are characteristic of studies conducted over the years. Any survey of fire fighter's duties and tasks will indicate that the highest noise exposure on a regular basis occurs during code-3 vehicle operations.

Occupational noise sources are everywhere in the fire service. Koerner (1997) noted numerous sources for noise exposure in his review of the Eau Claire Fire Department hearing loss exposures. Koerner found that:

> Engine noise, siren and airhorn noise, back-up alarms, and air brake release noise contribute to vehicle noises. Chain saws, K-12 saws, Hurst tools, generators and positive pressure ventilation fans (PPV) contribute to equipment noises. Station noises such as vacuum cleaners, lawn mowers, snow blowers, exhaust fans, air compressors, and cascade systems all contribute to firefighter hearing loss (p. 19).

This large list of noise generating tools and apparatus confirms the fact that fire

service equipment, and particularly fire apparatus are major emitters of harmful noise.

Electronic backup alarms are a common component of modern fire apparatus. While documentation regarding noise levels generated by backup alarms is not easily found, some data is available. Backup alarms are a fairly recent addition to apparatus safety equipment, and many fire departments around the country still have few (and sometimes no) apparatus equipped with this component. Increasingly, apparatus are being furnished from the manufacturer with the alarms installed due to NFPA and OSHA requirements.

Many fire agencies are becoming more aware of the apparatus noise problem and are initiating actions to protect their personnel. The Tucson, AZ. Fire Department considers the diesel engine the primary source of noise, and the department has experimented with engine design to reduce noise levels (Burkell, 1984). Measurement of back-up alarm noise levels in the work environment are a combination of the noise emitted from the apparatus as it backs up and the alarm itself. This combination of engine noise and the piercing sound of the backup alarm generate very high noise levels and has an impact on firefighter hearing.

The NFPA 1901 Standard for Automotive Fire Apparatus (1996) requires

that a backup alarm installed on all new fire apparatus generate at least 87 dBA (9-12). Today's apparatus are generally delivered equipped with an alarm. A review of numerous fire service noise surveys and studies found that the information rarely included data regarding these required backup alarms.

Koerner (1997) did a comprehensive study identifying noise exposures for the Eau Claire, WI. Fire Department. As in numerous other studies, Koerner found apparatus noise measurements during emergency response as high as 106 dBA (p. 12). Of particular interest were Koerner's audiometric results for apparatus backup alarms. Koerner reported an average backup alarm noise emission of 90 dBA for the 12 apparatus tested, with the highest reading registering 103 dBA. These measurements were taken 15 feet to the rear where a person guiding the apparatus would be positioned.

The noise generated by a backing apparatus with backup alarm will most certainly impact the firefighter guiding the apparatus. As the apparatus enters an enclosed space (apparatus bay, etc), the noise level will increase based on the size of the space and echo tendencies of the enclosed area. Plog et al. (1996) noted that, "Noise produced by a source travels outward in all directions. If all of the walls, the floor, and the ceiling are hard, reflecting surfaces, all the sound is reflected again and again" (p. 217). Aside from health issues, this

environmental factor is important because backup alarm noise exposures in confined spaces will be unavoidable unless preventative measures are undertaken by fire department staff to control or abate the hazard.

What measures are appropriate to mitigate noise exposure due to fire apparatus backup alarm operation?

When an employer identifies significant occupational noise in the workplace, the recognized mitigation measures include a hearing conservation program. Caple (1989) states that an effective program should address the following elements:

- Assessment of noise areas and employee duties;
- An annual employee audiometric testing program;
- An employee education program;
- A noise reduction/personal protection program;
- Clearly established management goals (p. 48).

The NFPA 1500 Firefighter Safety Standard (1997) addresses measures to mitigate noise exposure. There is a clear directive to engage in a hearing conservation program to "identify and reduce or eliminate potentially harmful sources of noise in the work environment" (5-11.3). When testing indicates, the fire department must take steps to control potentially harmful noise exposure to

its personnel.

Employee complaints and violations of occupational noise standards and regulations often initiate a fire department's move to mitigate noise exposure in the workplace. A preliminary noise survey may uncover obvious and hidden noise sources which endanger the employees hearing. Often, a preliminary noise survey may trigger solutions to identified problems.

The preliminary noise survey does not completely identify a given exposure problem. Plog et al. (1996) observed that, "The preliminary noise survey normally does not define the noise environment in depth and therefore should not be used to determine employee exposure time and other details. The preliminary survey simply supplies sufficient data to determine whether a potential noise problem exists and, if so, to indicate how serious it is" (p. 216). Based on a preliminary noise assessment, additional measurements and appropriate action can be taken.

The easiest solution to the problem of noise exposure from backup alarms is to eliminate the alarm (noise source) itself. Unfortunately, this measure would create a safety hazard when backing apparatus. According to the National Highway and Traffic Safety Administration (1998), "In 1994, approximately 15,400 turning and backing accidents across the country resulted in injury or death.

The potential of preventing back-up accidents is better than 90 percent with a backup alert system". (808.016). Clearly, more effective solutions are available.

Due to the fact that backup alarm noise levels can be difficult to remedy without expensive construction or equipment changes, employers often opt for hearing protection devices (HPD) to reduce decibel levels. Caple (1989) states that "...more than 95 percent of occupational hearing loss can be prevented by the proper and timely use of hearing protectors" (p. 4). The most effective HPD has been proved to be earmuffs. Plog et al. (1996) notes that, "Well-fitting earplugs can reduce sound by between 15 and 30 decibels" (p. 228). This illustrates the fact that HPD can have a significant impact on hearing loss in the workplace.

The NIOSH Health Hazard Evaluation Report, Memphis Fire Department (1990) found that the use of hearing protection devices should be mandated for fire fighting operations (including equipment usage) that exceed 90 dBA. This finding was repeated in the NIOSH report for Newburgh Fire Department, NY (1982). Koerner (1997) recommended that all personnel be provided with two separate means of hearing protection, allowing an option for the user. Hearing protection was the predominant mitigation measure in the surveys reviewed. Additional measures as outlined in OSHA and NFPA guidelines and regulations

were also adopted.

Procedures

Background

Audiometric testing for this research was conducted in Eugene, Oregon, a city of approximately 125,000. The Eugene Fire and EMS Department is a career department with 180 employees. The department's nine engine companies, two truck companies, and four ambulance companies are operated out of 11 stations, including an airport station with two airport rescue and fire fighting (ARFF) units. The department responded to approximately 14,000 emergency calls for service in 1997. Noise levels for apparatus were taken from all fire stations and all staffed apparatus.

Eugene Fire and EMS has addressed fire fighter noise exposure over the years. According to Chuck Solin, Environmental Manager for the City of Eugene Health and Human Resources Department, specific noise problems in the fire department have been dealt with as they were identified, or as applicable standards were created. For example, when the NFPA standard changed to include backup alarms as required equipment, the department included that

component in all specifications for new fire apparatus. Solin stated in a February 16, 1998 personal interview that "The city policy is to go beyond the minimum standards or code requirements anytime noise levels exceed 85 DBA even for brief periods."

Eugene Fire and EMS employees have been required by department standard operating procedure (SOP) to provide a backup guide at any time the apparatus is backing up. This requirement was designed to provide safe backing maneuvers, but it also ensures that firefighters will be exposed to backup alarm emissions every time the apparatus is placed in reverse. Due to this fact, recent concerns have been voiced that activation of the backup alarm may create the opposite environment for the firefighter (backup guide) due to noise exposure.

Currently, all fire and EMS apparatus have backup alarms provided. This includes the nine engines, two ladder trucks, and four ambulances that are staffed on a 24 hour basis. New apparatus are specified and purchased according to NFPA Standard 1901, and backup alarms are provided on every new piece of equipment by the manufacturer.

The department safety committee has been struggling with the noise issue created by backup alarms in the past year (1997). To date, no final action

has been taken other than an assessment of relative noise levels due to apparatus and emergency response. Results of this noise survey are set forth in Appendix B.

Personnel exposure

A review of Eugene Fire and EMS apparatus activity revealed information regarding how often backup alarm noise exposure occurs to personnel over time. In 1997, Eugene Fire and EMS responded to just under 15,000 emergency calls for service. Many of these calls required multiple unit response. A review of the January, 1998 fire unit call report (Appendix C) showed a total of 2,307 emergency calls for 36 apparatus which were equipped with backup alarms. Backup alarms activate every time fire equipment is backed into the station after calls for service, as well as returning from normal routine assignments.

In order to find general numbers of times backup alarms sounded (exposing fire fighters to alarm noise), a calculation using information in Appendix C was done. The number of alarms for each apparatus for the average month (taking into account the three shift staffing system), provided each firefighter (assigned to guide the apparatus back) with the potential for 21 exposures due to returns from emergency calls for that month. Busy stations would certainly have much higher exposures than the average.

No data exists for the average number of times department apparatus back into the apparatus room in a typical 24 hour period, but this value would increase the total number of exposures significantly. While it is difficult to derive a total average number of backup alarm exposures, it is clear that apparatus backup alarms are activated frequently during daily emergency and normal operations.

Testing processes

Initial audiometric testing to identify noise emissions from Eugene Fire and EMS fire apparatus was conducted in the fall of 1997. A Quest Model 2115 dBA sound pressure meter was used. Additional measurements were taken on February 20, 1998 to obtain specific data regarding noise levels from backup alarms when apparatus backed into stations.

The data was gathered using a variety of normal backing situations to determine exposure. Backup alarm readings were taken at the rear of the vehicle approximately 5 to 10 feet behind the apparatus, in the position a backup guide would normally be standing. Apparatus in two-company stations may return simultaneously, so readings were also taken with both apparatus backing together. Results were then compiled and issued by Solin to the fire department safety committee in early 1998.

Limitations:

There was one major limitation on this research work: time. Given the six month period available for research, there are some undeniable omissions in data and research based on the time restriction. Due to the fact that fire apparatus backup alarms are a somewhat recent addition to motorized fire equipment, minimal data was found for comparison to Eugene Fire and EMS test results.

Results

Data from audiometric testing of Eugene Fire and EMS vehicles, conducted in late 1997 and early 1998, is detailed in Appendix B. This data showed a number of issues relative to noise exposure from backup alarms.

This data demonstrated that Eugene fire fighters were exposed to excess noise levels generated by apparatus backing procedures, particularly when apparatus are backing into enclosed spaces. The study also demonstrated that appropriate action is indicated to address the present situation.

The measurements of apparatus backup alarm noise levels revealed significant noise levels in a variety of situations. One apparatus (Engine 6) had

an inoperative backup alarm, and still registered 82 dBA due to engine noise. These measurements showed noise emissions over the threshold value for noise exposure (85 dBA) for all of the apparatus tested.

A review of the average noise levels for different backing situations gave an indication of the overall problem. Computations for all backing situations (backing into the station and parked outside) with backup alarm sounding showed a total average noise emission of 84.57 dBA.

Specific environments also impact emissions. The average noise level for a backup alarm sounding outside the station was 89.45 dBA for 11 apparatus tested. The average noise level for a solitary apparatus backing into a fire station was 94 dBA. This increase in noise level of 5 dBA demonstrates the fact that enclosed apparatus bays increase the noise level in relation to emission levels measured outside.

When two apparatus were backed into the apparatus floor at the same time, the audiometric values observed increased. The average noise level for apparatus (engine and ambulance or engine and ladder truck) backing into the apparatus floor together jumped to 100.33 dBA. Clearly, noise levels increased as apparatus backed into the station, and when two pieces of equipment backed in together, a significant increase was shown over readings

for a single vehicle.

Another interesting discovery from the test process was that noise levels from six of the test vehicles equipped with self-adjusting alarms (backup alarms which adjust from 87-112 dBA depending on surrounding noise levels) actually increased noise levels as the backup alarms operated. As the alarm sensed surrounding noise, the alarm dBA emission increased. Two vehicles backing together (and equipped with the self-adjusting backup alarms), showed the highest noise measurement recorded (100 dBA) as each apparatus backup alarm caused a volume increase in the adjacent apparatus' alarm.

Discussion

Solid data regarding noise exposure is critical to addressing the noise problem in the workplace. It is clear from the research that Eugene fire fighters are being exposed to excessive noise levels every time they step from the apparatus and guide it back. It is also easy to surmise that fire fighters across the country have similar exposures when fire apparatus are equipped with electronic backup alarms.

A review of information regarding the issues related to hearing loss in the workplace, and specifically hearing loss for firefighters, indicates this is a serious health problem for all Americans. This byproduct of our industrialized world must be continually addressed as new machinery and processes are introduced into the work environment. It has also been shown that fire fighters are regularly subjected to unhealthy or damaging noise levels on the job.

The safety issues with noise and hearing loss can cause a major impact to employers and employees alike. The evidence of altered performance and decision making when employees are exposed to high noise levels must not be ignored, particularly in the fire service, where emergency situations demand only the highest levels of attention and technical skill.

The cumulative effects of noise exposure make identification of specific

hearing loss causes difficult. Audiometric testing of the work site and employees on a regular basis can help isolate those noise sources and hearing problems which are generated in the workplace. The individual worker, with proper education and hearing protection, can be trained to recognize and prevent exposure to high noise levels occurring at the job site as well as in his or her personal life.

The review of codes and standards reveals comprehensive guidelines and requirements for high noise level detection and mitigation in the workplace. OSHA's standard of making hearing protection available for noise levels above a TWA of 85 dBA establishes a benchmark for action. For the purposes of our study, the 85 dBA standard also provides a point at which we can begin to identify and act on fire fighter noise exposure.

The literature review also disclosed the harmful effects of short term exposure to high levels of noise. These are issues which regularly do not meet the OSHA time-weighted values requirement. These short term exposures are central to our issue regarding fire fighter hearing and backup alarms. These exposures do not normally meet the minimum one-quarter hour dBA allowance, and yet the frequency and noise levels measured (up to 107 dBA for Eugene Fire/EMS exposures) indicate a potential for hearing loss over time.

While the NFPA standards that address noise exposure are not binding requirements, the fact that the national standards state that hearing protection is required for any noise level over 90 dBA is a strong motivator for any responsible fire agency. The NFPA and OSHA have also created an inherent conflict with these regulations and standards. Both require installation of backup alarms which, coupled with engine noise, are the immediate causes of unhealthy noise exposure for personnel charged with backing up fire apparatus.

The appropriate measures necessary to mitigate excess noise exposure are well documented. It is incumbent on the employer to initiate a hearing conservation program when OSHA minimums are exceeded. However, due to the issues with cumulative hearing loss, and the nature of fire fighter exposure to short-term excess noise levels, it makes sense that employers and fire managers initiate corrective measures any time noise becomes a concern. This pro-active approach will produce long-term benefit without the punitive action often generated by failure to meet codes and standards. Regular testing of the work site as well as employee hearing coupled with training and personal protection would provide positive results and avoid enforcement issues.-

Fire department management must take the lead in a pro-active program to eliminate or mitigate noise in the workplace. Goals and objectives

must be established and pursued to completion. Employee involvement would create ownership and awareness. As role models, managers can impact and educate workers on a daily basis. Without management dedication and action, a hearing conservation program will not work.

The Eugene Fire and EMS data listed in Appendix B and the results observed are significant in that they identify a specific problem which has not been extensively investigated and documented by others in existing literature. Additionally, this study helps to quantify the problems with backup alarm noise emissions at Eugene Fire and EMS. This study and the results will assist in determining directions and remedies for the problem.

Overall, this review demonstrates that noise exposures from Eugene apparatus backing up with backup alarms sounding are well over the 85 dBA threshold. Another significant result of the study is the fact that exposures inside the station apparatus floor are above the 90 dBA threshold for hearing protection requirements according to current NFPA 1500 firefighter safety standards. The results also indicate that mitigation may be required in order to meet OSHA or NFPA standards or requirements.

Recommendations

The recognition and mitigation of hazardous or unsafe situations where noise levels are impacting the health and safety of fire department personnel has long been established as a duty of the employer. Attitudes and awareness play an important part in the individual's and the organization's willingness to deal with hazardous noise levels in the workplace. Without a commitment by the employer, measures to detect, mitigate, and prevent unhealthy noise in the workplace will be an ineffective effort at best.

Based on this fundamental concept, it is recommended that Eugene Fire and EMS management authorize a comprehensive assessment of work site noise levels and employee duties to establish a baseline for a hearing conservation action plan. This survey may identify additional problem areas which have not been addressed to date.

Additionally, it is recommended that an annual employee audiometric testing program be established. This data would identify hearing loss in individuals, help with determining the status of employee group hearing loss overall, and provide direction regarding implementation and revision of the hearing conservation plan.

A training and education plan should be established, and employee

training initiated to help employees understand and prevent workplace noise exposure. Employees should be specifically trained on preventative methods to avoid exposures while backing apparatus.

Appropriate hearing protection devices should be supplied in all areas where noise exposure over 85 dBA is identified. It is also recommended that all employees be required to carry hearing protection devices (ear plugs) and be required to use them in high-noise situations. Ear-muff type hearing protection should be provided at the entrance to all apparatus bays to mitigate backup alarm exposure. Additional hearing protection devices should be available for use by personnel when more than one apparatus is backing into the station at the same time.

All employees should be required by the employer to wear ear protection in identified high-noise areas and situations as determined by the work site noise analysis. As demonstrated by this research, any time a Eugene Fire and EMS apparatus is in reverse and being guided by a fire fighter, that employee should have hearing protection in place until the alarm stops sounding and the engine is shut off. Finally, we have established the fact that the best solution to noise exposure is to eliminate the hazard itself. To that end, it is recommended that a variance or code change be pursued by fire department management to

eliminate the requirement for backup alarms when a firefighter is present backing up the apparatus.

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