Are Georgetown Firefighters at Risk for Noise Induced Hearing Loss?

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Abstract

The problem is the Georgetown Fire Department may be putting their fire fighters at risk for noise induced hearing loss. Research was needed to determine if the decibel levels Georgetown fire fighters are exposed to were at or above the levels which can cause hearing loss. The purpose of this research project was to determine if Georgetown fire fighters are at risk of noise induced hearing loss. The researcher utilized the evaluative research method as the primary method for determining the research questions. The research questions used in this project were: 1) What is noise induced hearing loss and how does it occur?, 2) What are the decibel levels that Georgetown firefighters are exposed to during a shift of work?, 3) What current hearing protection practices are in place within the Georgetown Fire Department? The procedures utilized for this applied research project included obtaining decibel readings when fire fighters were performing apparatus checks, equipment checks and while riding with crew during varies driving situations. The results concluded that the Georgetown fire department was compliant with some NFPA and OSHA standards, but fire personnel were being exposed to noise levels which could cause hearing loss. Recommendations included the issuance of foam hearing protection to all Georgetown fire fighters, continuing current audiogram testing during annual physicals, issuance of a standard operating guideline as it pertains to hearing loss awareness and the prevention of hearing loss and providing hearing protection in all fire apparatus.

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Introduction

Good hearing is critical for firefighters. Firefighters are constantly exposed to noise which may cause hearing damage. The problem is that the Georgetown Fire Department may be putting their firefighters at risk for noise induced hearing loss. The purpose of this research project is to determine if Georgetown firefighters are at risk of noise induced hearing loss. An evaluative research method was used in this research project. The research questions used in this project were: 1) What is noise induced hearing loss and how does it occur?, 2) What are the decibel levels that Georgetown firefighters are exposed to during a shift of work?, 3) What current hearing protection practices are in place within the Georgetown Fire Department?

Background and Significance

Prior to 1994 the Georgetown Fire Department (GFD) did not use hearing protection while their fire apparatus was operational. Since 1994, the GFD has provided hearing protection for fire personnel who are riding on first response, class "A" fire apparatus. However, there are no standard operating procedures in place addressing the use of hearing protection in the GFD. The fire department currently does not provide personnel hearing protection in the form of earmuffs or ear plugs for firefighters. Georgetown firefighters do not use hearing protection while in training or performing operational checks on power equipment. Those firefighters who expose themselves to excessive noise during shift may be at risk for noise induced hearing loss. If GFD firefighters suffer from noise induced hearing loss, then the GFD will not support the United State Fire Administration's strategic goal of improving the fire and emergency services' capability for response to the recovery from all hazards. This theory is based on the premise that GFD will be placing their personnel in danger of hearing damage. If a firefighter suffers from hearing damage, their ability may be hampered as it relates to hearing a victim cry for help, locating an activated pass device on a down firefighter and hearing a low air alarm on their self-contained breathing apparatus.

Literature Review

A literature review was conducted to gain information in four areas of research. The first area of research is to define the problem of hearing loss. The second area of research is to establish perimeters of what is considered a safe noise level and a noise level with potential to cause hearing loss. The third area is to determine how noise induced hearing loss can occur. The final area of the literature review will investigate ways to protect fire personnel from noise induced hearing loss.

Define the Problem of Hearing Loss

In *Safety Engineering*, Marshall identifies what sound is. Sound can be looked at as a pressure wave moving through the air. As the pressure wave enters the ear, it vibrates the membrane that separates the inner ear from the middle ear cavity. This sound wave is expressed in decibels (dB) (Marshall, 1982/1994). Marshall states "Our response at a frequency of 1000 Hz is often taking at a reference. On either side of this reference frequency, our hearing ability is diminished; that is it takes greater or louder sound intensity to be heard as an equally loud sound" (p. 94).

The National Safety Council indentifies two types of effects that noise has on a person. The first type of effect is psychological. "Noise can startle, annoy, and disrupt concentration, sleep or relaxation. Interference with verbal communication, and as a consequence, interference with job performance and safety" (p. 104). The second type of effect that noise has on a person is physiological. "Noise induced hearing loss, aural pain, and even nausea (when exposure is severe) and some research links long term overexposure to noise to circulatory and heart problems" (Laing, 1997, p. 104).

Greenberg defines noise induce hearing loss, as indentified by The American Occupational Medicine Association, "as a slowly developing hearing loss over a long time period (several years) as the result of exposure to continuous or intermittent loud noise" (Greenberg, 2011 p. 227).

Benjamin defines noise induce hearing loss as "hearing loss which is caused by prolong exposure to intense noise gradually damages the cochlear hair cells of the inner ear resulting in a permanent threshold shift across multiple frequencies" (Benjamin, 1971/2002, p. 64). Dr. Benjamin addresses the causes of noise induced hearing loss as sound levels in excess of 60-80 dB, sound having energy frequencies of 50Hz-2,000Hz and shorter and less frequent between theses sounds with no rest period (Benjamin, 1971/2002).

Noise Perimeters

Marshall addresses that no one knows how loud a sound needs to be to cause hearing loss, he refers to the OSHA standard of any sound over 90 dB for more than an eight hour period will result in some type of hearing loss (Marshall, 1982/1994).

Greenberg identifies those signs and symptoms that describe noise induce hearing loss. There are summarized as affecting the hair cells in the inner ear, bilateral hearing loss, notching in the audiogram at 3,000 Hz, 4,000 Hz, or 6,000 Hz and recovery at 8,000 Hz. Greenberg is quick to point out the noise exposure alone usually does not produce hearing loss over 75dB in high frequencies or 40db in low frequencies .

OSHA CFR 1910.95 indicates that an 8-hour time weighted average for noise will be 85dB. Table 1 shows a chart which are the permissible noise exposures limits noted by OSHA.

The chart indicates as the decibels levels of the noise/sound rises, the duration per day, in hours that a person may be exposed to decreases. (OSHA, 2008).

Duration per Day, in hours	Sound level in decibels
1/4 or less	115
1/2 or less	110
1	105
1 to 1/2	102
2	100
3	97
4	95
6	92
8	90

Table 1

Occurrence of Hearing Loss

Author Robert Winston, of *Fire Chief Magazine*, identifies that a major cause of hearing loss with fire firefighters comes from operating power tools inside of an enclosed structure were noise cannot dissipate or be absorbed. While on scene of an emergency noise that result from high radio volumes, the striking of forcible entry tools and a pass alarm sounding are sources which can cause noise induced hearing loss (Winston. R, 2010).

Greenberg (2011) states "the rate of hearing loss due to chronic noise exposure is greatest during the first 15-20 years of exposure and decreases as the hearing threshold increases"(p. 227). Greenberg identifies that constant exposure to occupational noise will damage the hairs cells in the ear, leading to sensory hearing loss. Routine or daily exposure to industrial noise will not cause damage to the inner or outer ear. (Greenberg, 2011)

In an article from *Occupational health and Safety*, Carmen notes that hearing loss is most common at high frequencies. Carmen points out that the same noise which may damage hearing in one person, may not affect the next person in the same manner. Carmen address that hearing loss from noise depends on its intensity, the amount of time one is exposed to the noise and to a lesser extent the frequency of the noise (Carmen, 1999).

Protection of Hearing Loss

In an article in *Fire Chiefs Magazine*, Winston advised that hearing protection is required for firefighters who are subjected to noise levels in excess of 90 decibels per NFPA 1500. Winston also addresses how NFPA 1500 requires fire departments to establish a hearing conservation program that identifies noise sources, annual hearing tests, noise reduction control devices, noise reduction techniques and hearing protection devices (Winston. R, 2010). The International Fire Service Training Association (IFSTA) reinforces what Winston writes. In IFSTA's *Fire Department Occupational Safety* book it is written that "anytime firefighters are exposed to noise levels exceeding 90 decibels (for any duration of time), they must be provided with hearing protection" (Fire Department, 1991/1997, p.174)

As addressed in NFPA 1500 (Teele. B, 1992/2007), an audiometer test should be administered during the firefighter's annual physical. This test is referred to as an audiogram. "The audiogram must be of pure air conduction hearing threshold examination with test frequencies including, as a minimum, 500 Hz, 1000Hz, 2000 Hz, 3000 Hz 4000 Hz and 6000 Hz. Each ear must be tested separately" (P. 325). NFPA 1500 identifies that each firefighter should receive a baseline audiogram. Within one year of the base line audiogram and routinely each year after, the firefighter should be given an audiogram again. Results from each audiogram are compared to the base line audiogram. If a threshold shift has occurred, an audiologist can identify the shift. These test results must be kept for the duration of the firefighter's employment (Teele. B, 1992/2007).

The International Association of Firefighters in conjunction with the National Institute for Occupational Health (NIOSH) produced a brochure addressing hearing conservation programs. It notes that every fire department should have a hearing conservation program that indentifies areas and equipment that may be hazardous to the hearing of firefighters. Each fire fighter should have an annual physical that includes hearing test (IAFF, & NIOSH, 2004).

NFPA 1500 address the use of hearing protection through earplugs. Earplugs are listed in three classifications: formable, custom molded and pre-molded. Earplugs are considered as an inexpensive means to protect hearing. Formable and pre-molded earplugs can be purchased over the counter. The down fall of these types of earplugs is that the service life is extremely limited. Custom molded ear plugs can be obtain through a physician. This type of ear plug is more expensive that the previous two, but will last longer and provide a better fit for the user (Teele. B, 1992/2007). NFPA 1500 states "that hearing protection shall be provided and use by all members exposed to noise in excess of 90 decibels" (p. 89) and "the use of earplugs or ear muffs can assist in reducing exposure to noise. It is an effective protective device will act as barrier between the noise and the inner ear" (p. 326).

Marshall (1982/1994) identifies that there are only two ways to stop sound pressure waves from entering the ear canal. The first way is to plug the ear canal. The second way is to cover the whole ear with an ear muff. Marshall states that "there is no satisfactory way to prevent sound from being transmitted via the bone structure of the body. Therefore, only part of the sound that reaches the inner ear can really be stopped or reduced" (p. 95). Marshall indicates that by wearing earplugs decibel levels can be reduced by 30 to 40 dB and by wearing earmuffs, noise can be reduced by 25dB. Total noise cannot be eliminated since the bone structure of the body transmits sound up to 25 dB through the ear canal (Marshall 1982/1994).

The National Safety Council addresses hearing protection in the *Supervisors' Safety Manual*. The Safety Council urges that excessive noise should be reduced by noise reduction techniques and that hearing protection should be only used as a last resort (Laing, 1997).

IFSTA identifies that once a noise problem has been identified there are three components to reducing exposure. They are the noise source, path of travel and the receiver. At the noise source, the most desirable method to control the problem would be to reduce the noise level. With the path of travel, the best way to control the problem is to increase the distance between the source and the receiver. With the receiver, the best way to control the problem is to reduce the noise at the receiver by a barrier, such as earplugs or earmuffs (Fire Department, 1991/1997).

In an article from *Firehouse Magazine*, Dr. Randy Tubbs states "Hearing loss from occupational noise is a completely preventable disease. The premise is based on the simple fact: if we are able to stop excessive noise from entering the ear, no loss of hearing can result" (p. 92). The article address that noise induce hearing loss can be minimized by the use of hearing protection while fire fighters are riding in apparatus who are subjected noise over 90dB (Winston R.M, 2003).

Procedures

A digital decibel meter was purchased from Radio Shack. The meter was model 33-2055. The meter was used to gain knowledge of the average and peak decibel levels during power equipment checks, apparatus operational checks, training evolutions and during driving evolutions.

Power Equipment Checks

The decibel level check during power equipment operations occurred during scheduled weekly operations on Mondays. Power equipment checks included activities were fire personnel started and ran, for varies periods of time, the following equipment: chain saws, hydraulic power pumps, generators, and "K" saws. Decibel reading location where taken at the work out area in the bay area of each station and a second reading was taking at the same station on another Monday. During the second reading, the decibel meter was with the fire fighter performing the operational check. Decibel readings for this phase of testing where taking at the following locations: Station 1, located at 300 Industrial Ave; Station 2, located at 215 Central Drive; Station 3, located at 5 Texas Drive; Station 4, located at 4200 Airport Road. During each of the readings, it was noted who had on ear protection and who did not have on ear protection. The duration of exposure was also recorded during this test period. The maximum decibel exposure recorded by the meter was documented. These results were recorded on an Excel Spread Sheet and can be found as appendix A.

Apparatus Operational Checks

Decibel level readings were taken at all stations throughout the research period, during apparatus operational checks. These checks included starting the apparatus, idling of the apparatus, operation of the PTO pump, if equipped, and operations of the apparatuses pump. The decibel meter was with the fire fighter performing the apparatus operational check. During each of the readings, the name of the firefighter performing the activity was recorded. It was noted which firefighter had on ear protection and which did not have on ear protection. The duration of exposure was also recorded during this test period. The maximum decibel exposure and average decibel exposure recorded by the meter was documented. All times were rounded to the nearest whole number. All results were recorded on an Excel Spread Sheet and can be found as appendix A.

Driving Evolutions

The researcher and/or assigned designee rode with the crews from Engine 1, Engine 2, Quint 3, Engine 4, Rescue 3, BC1, BC7, Truck 1 and the reserve quint. Decibels levels were recorded during non-emergency driving with windows up, non-emergency driving with windows down, emergency responses with windows up and emergency responses with windows down. It should be noted, unless specified in appendix B that all personnel riding in a fire apparatus had on ear protection. The duration of exposure with maximum decibel readings and average decibel readings was also recorded during this test period. All results were recorded on an Excel spread sheet and can be found as appendix B.

Training Evolutions

A decibel level check during training evolutions occurred during forcible entry training on November 10, 2011. The tools used during the training evolution were the flathead axe, a halagon bar and the enforcer, forcible entry door. Firefighters were instructed to place the forks of the halagon bar into the jamb of the enforcer. The firefighter was then to strike the blunt end of a flathead axe against the flat end of the halagon bar until the locking mechanism separated from the door jamb and the door opened. The first decibel reading was taking with the meter next to the firefighter performing the activity, at head level. The second reading was taken 15 foot away from the forcible entry prop with the meter at waist level. This area was the staging area for firefighters waiting to perform the training evolution. A decibel level check during training evolutions occurred during forcible entry training on November 10, 2011. Firefighters using a "K" saw were instructed to cut hinges off of a commercial grade door. The enforcer training prop was the training aid used to hold the commercial grade hinges in place during the training evolution. The decibel reading was taken next to the firefighter performing the training evolution and a second reading was taken 15 foot away from the forcible entry prop. All results were recorded on an Excel Spread Sheet and can be found as appendix C.

A decibel level check during ventilation cutting evolutions was performed on December 21, 2011. Three fire personnel were directed to cut one four foot by four foot ventilation hole through OSB sheathing using a chain saw. The decibel meter was held next to the fire fighter cutting the ventilation hole at waist level. All results were recorded on an Excel Spread Sheet and can be found as appendix C.

A decibel level check during training evolutions occurred during relay pumping training on January 24, 2012. The training evolution consisted of Engine 4 relay pumping to the reserve quint, while the reserve quint was supporting a single master stream from the tower. The decibel reading was taken next to the pump panel of Engine 4, next to the pump panel on the reserve quint. During each of the readings, it was noted who had on ear protection and who did not have on ear protection. The maximum decibel level and average decibel level exposure was recorded. The duration of exposure was also recorded during this test period. All results were recorded on an Excel Spread Sheet and can be found as appendix C.

A decibel level check during training evolutions occurred during relay pumping training on January 25, 2012. The training evolution consisted of Engine 2 relay pumping to Quint 3, while the Quint 3 was supporting a single master stream from the tower. The decibel reading was taken next to the pump panel of Engine 2, next to the pump panel on the Quint. During each of the readings, it was noted who had on ear protection and who did not have on ear protection. The maximum decibel level and average decibel level exposure was recorded. The duration of exposure was also recorded during this test period. All results were recorded on an Excel Spread Sheet and can be found as appendix C.

The limitations of this research project are that only one decibel monitor was utilized. Results of decibel levels could not be check between monitors during the research. The decibel reading may have been incorrect or off a percent if the device was out of calibration. Additionally, the decibel reading taken only showed a snap shot of what Georgetown Firefighters may be exposed to. To gain a more in depth understanding on what dB levels a Georgetown firefighter is exposed to over their shift, a meter would need to be placed with each crew for a giving time frame, so decibel readings could be recorded constantly over a long time frame.

Results

The results for research question one, what is noise induced hearing loss and how does it occur? Noise induced hearing loss is hearing loss which is the result of long term, repeated exposure to excessive to loud noises. Firefighters who use power equipment, forcible entry tools and operate fire apparatus are exposed to this type of noise while conducting their duties. The cochlear hair cells of the inner ear receive the damage of the continuous exposure to the loud noise and as a result, high frequencies sounds are often diminished in a person's ability to hear. This type of hearing damage is non-reversible. Hearing loss, such as noise induced hearing loss, affects each individual at different levels. What may cause extensive hearing loss in one individual, may not affect the next persons hearing ability.

The results of research question two, what are the decibel levels that Georgetown firefighters are exposed to during a shift of work, will be shown in three categories. The first category will be the results listed by station showing the results gathered during equipment and apparatus checks. The second category will be listed by apparatus showing the results gathered during driving in emergency and non-emergency situations. The third category will be listed by training activity showing the peak decibel levels gathered during the training evolution.

Station 1

Test found the during power equipment checks, inside the bay, the decibel levels in the work out area peaked out with a decibel reading of 109dB for a thirty second duration during vent saw check. The average reading in the workout area was 97dB for a maximum duration of three minutes. When a firefighter was followed while performing power equipment checks, outside of the bay, the highest decibel reading was 105dB for a time frame of thirty seconds during vent saw check. The average decibel exposure was 98dB for a maximum duration of five minutes.

When a firefighter was followed while the apparatus operational check was conducted the maximum decibel reading was 105 dB for a time frame of two seconds during the siren check. The average decibel exposure was 93dB for a maximum duration of ten minutes.

Station 2

Test found during power equipment checks the decibel levels in the work out area peaked with a decibel reading of 100dB for a one minute duration during both the vent saw check and PPV fan check. The average reading in the workout area was 93dB for a maximum duration of three minutes. When apparatus operational check, inside the bay was conducted, the maximum decibel reading was 105 dB for a time frame of two seconds during the siren check. The average decibel exposure was 90dB for a maximum duration of five minutes. This reading was from the workout area. When a firefighter was followed while the apparatus operational check, outside of the bay, was conducted the maximum decibel reading was 106 dB for a time frame of four seconds during the siren check. The average decibel exposure was 92dB for a maximum duration of five minutes.

Station 3

Test found the during power equipment checks the decibel levels in the work out area peaked out with a decibel reading of 91dB for a twenty second duration during vent saw check. The average reading in the workout area was 81dB for a maximum duration of five minutes. When a firefighter was followed while performing power equipment checks, outside of the bay, the highest decibel reading was 102 dB for a time frame of one minute during the "K" saw check. The average decibel exposure was 93dB for a maximum duration of three minutes. When a firefighter was followed while the apparatus operational check was conducted, outside of the bay, the maximum decibel reading was 106dB for a time frame of two seconds during the siren check. The average decibel exposure was 94dB for duration of three minutes.

Station 4

Test found the during power equipment checks the decibel levels in the work out area peaked out with a decibel reading of 93dB for a four minute duration. The average reading in the workout area was 86dB for a maximum duration of four minutes. When a firefighter was followed while the apparatus operational check was conducted the maximum decibel reading was 103 dB for a time frame of three seconds during the siren check. The average decibel exposure was 87dB for duration of ten minutes.

BC1

During a code 3 response though commercial and highway streets with windows in the open position, the peak decibel level reached was 93dB for a period of one minute. The peak decibel level reach during a six minute code three response with windows in the closed position was 87 dB for duration of three minutes. During a code one response the peak decibel levels reach inside the vehicle with windows down was 80dB for duration of two minutes. During a code one response the peak decibel level reached inside the vehicle with the windows in the closed position was 77db for duration of four minutes.

BC7

While responding code one through residential streets with the windows in the up position the peak decibel level was 65dB for duration of fifteen minutes. While responding code one at high way speeds with the windows in the open position a peak decibel level of 72 dB was recorded. This response lasted ten minutes. While responding code three with windows in the closed position a peak reading of 80 dB was recorded. While responding code three with windows in the open position a peak decibel reading of 96dB was recorded at duration of four minutes.

Engine 1

The decibel readings on Engine 1 where taken over a two shift period when driving the apparatus through light commercial and residential districts. When responding code one in Engine 1, the decibel reading with windows in the open or in the down position the average decibel reading was 74dB and the peak decibel reading was 86dB. When responding code one with windows up or in the closed position, the average decibel reading was 65dB and the peak decibel reading was 75dB. When responding code three, with windows in the down or open position, the average decibel reading was 86dB and the peak decibel reading was 99 dB. When responding code three with windows up or in the closed position, the average decibel reading was 77dB and the peak decibel reading was 88dB.

Engine 2

The decibel readings on Engine 2 where taken over a two shift period when driving the apparatus through light commercial and residential districts. When responding code one in Engine 2, the decibel reading with windows in the open or in the down position the average decibel reading was 73dB and the peak decibel reading was 78dB. When responding code one with windows up or in the closed position, the average decibel reading was 70dB and the peak decibel reading was 74dB. When responding code three the average decibel readings with windows in the down or open position the average decibel reading was 83dB and the peak decibel reading was 89 dB. When responding code three with windows up or in the closed position, the average decibel reading was 80dB and the peak decibel reading was 89dB.

Engine4

The decibel readings on Engine 4 where taken over a three shift period when driving the apparatus through light commercial and residential districts. When responding code one in Engine 4 the decibel reading with windows in the open or down position the average decibel reading was 70dB and the peak decibel reading was 80dB. When responding code one with windows up or in the closed position, the average decibel reading was 75dB and the peak decibel reading was 84dB. When responding code three the average decibel readings with windows in the down or open position the average decibel reading was 82dB and the peak decibel reading was 94 dB. When responding code three with windows up or in the closed position, the average decibel reading was 77dB and the peak decibel reading was 88dB.

Truck 1

The decibel readings on Truck 1 where taken within a single shift period when driving the apparatus through heavy commercial and residential districts. When responding code one in

Truck 1, the decibel reading with windows in the open or down position the average decibel reading was 74dB and the peak decibel reading was 79dB. When responding code one with windows up or in the closed position, the average decibel reading was 74dB and the peak decibel reading was 78dB. When responding code three, with windows in the down or open position, the average decibel reading was 80dB and the peak decibel reading was 83 dB. When responding code three with windows up or in the closed position, the average decibel reading was 79dB and the peak decibel reading was 81dB.

Quint 3

The decibel readings on Quint 3 where taken within a single shift period when driving the apparatus through light commercial and residential districts. When responding code one in Quint 3, the decibel reading with windows in the open or down position the average decibel reading was 79dB and the peak decibel reading was 89dB. When responding code one with windows up or in the closed position, the average decibel reading was 76dB and the peak decibel reading was 86dB. When responding code three, with windows in the down or open position, the average decibel reading was 79dB and the peak decibel reading was 91 dB. When responding code three with windows up or in the closed position, the average decibel reading was 83dB and the peak decibel reading was 86dB.

Reserve Quint

The decibel readings on the reserve Quint where taken within a single shift period when driving the apparatus through light commercial and residential districts. When responding code one in the reserve Quint, the decibel reading with windows in the open or in the down position the average decibel reading was 76dB and the peak decibel reading was 80dB. When responding code one with windows up or in the closed position, the average decibel reading was 72dB and the peak decibel reading was 83dB. When responding code three, with windows in the down or open position, the average decibel reading was 88dB and the peak decibel reading was 94 dB. When responding code three with windows up or in the closed position, the average decibel reading was 85dB and the peak decibel reading was 91dB.

Rescue 3

The decibel readings on Rescue 3 where taken within a single shift period when driving the apparatus through a residential district. When responding code one in the Rescue 3, the decibel reading with windows in the open or in the down position the average decibel reading was 82dB and the peak decibel reading was 86dB. When responding code one with windows up or in the closed position, the average decibel reading was 80dB and the peak decibel reading was 86dB. When responding code three the average decibel readings with windows in the down or open position the average decibel reading was 94dB and the peak decibel reading was 99dB. When responding code three with windows up or in the closed position, the average decibel reading was 84dB and the peak decibel reading was 89dB.

Training evolution: Forcible Entry

The peak decibel reading obtained when firefighters were striking a flathead axe against a halagon bar to force a commercial grade door open was 93dB. The average decibel reading during this evolution was 87db. The average time to complete the evolution was two minutes.

The peak decibel reading obtained when firefighters were using a "K" saw to cut hinges from a commercial grade door was120dB. The average reading during this training evolution was 114dB. The evolution lasted two minutes per firefighter.

The peak decibel reading obtained when firefighters were using a chain saw to cut a four foot by four foot hole through a sheet of OSB was 115dB. The average reading during this training evolution was 90dB. The evolution lasted four minutes.

The peak decibel reading obtained during the relay pumping training evolution between Engine 4 and the reserve Quint was 96. The average decibel reading was 86. The duration of the training evolution was ten minutes.

The peak decibel reading obtained during the relay pumping training evolution between Engine 2 and Quint 3 was 94. The average decibel reading was 83. The duration of the training evolution was eight minutes.

The results of research question three, what current hearing protection practices are in place within the Georgetown Fire Department? The question can be addressed in three folds.

The first part of question three results will be addressed towards hearing protection in fire apparatus. The GFD does meet NFPA 1500 by providing fire personnel with a communication type headset on each type 1 fire apparatus. Those apparatus include Engine 1, Engine 2, Engine 4, Quint 3, Truck 1, and the Reserve Quint. This headset incorporates an ear muff type hearing protection with an internal microphone. This allows the firefighter to communication with members of his crew without removing the earmuffs, while riding in the fire apparatus. However, on the Battalion Commanders response vehicles (BC1& BC7) and on Rescue 3, no hearing protection is provided by the GFD. No hearing protection is provided for any of the unstaffed apparatus that are type 3, type 4 or type 6 fire apparatus. Those apparatus include Tender 1, Attack 1, Attack 3, Engine 462 and Squad 4.

The second part of question three results will be addressed toward hearing protection while training and while operating power tools. Currently there is not standard operating procedure with the City of Georgetown or with the Georgetown Fire Department which mandates the use of hearing protection during any training evolution. Fire Station 1 was the only fire station that had a large box of foam type ear plugs in which fire personnel could take and use at their discretion.

During apparatus checks no fire personnel were noted as wearing any type of hearing protection. During power equipment checks no fire personnel were noted as wearing any type of hearing protection. During forcible entry training one out of eight firefighters were wearing hearing protection. During ventilation cutting evolutions no fire personnel were noted as wearing hearing protection. During relay pumping operations no fire personnel were noted as wearing of any type of hearing protection.

During all equipment checks, apparatus checks, training evolutions and vehicle responses OSHA's 8-hour time weighted average for noise were not exceeded. However, decibels readings in excess of 60dB were present in all activities. Many activities reached and surpassed 90dB at some point during their monitoring. As outlined in NFPA 1500, fire personnel shall be provided ear protection when they are exposed to noise levels over 90dB. As a result, the Georgetown fire department is not compliant to the NFPA recommendation.

The third and final part of question three's results will be addressed as it relates to a fire department hearing conservation program. The GFD does have members participate in a medical physical on an annual basis. As part of that physical, a hearing test is conducted. Each test is compared with the firefighter's base line audiogram. The audiogram is given in accordance with OSHA 1910.95. The GFD does not have an engineering controls or administrative controls in place. No SOG's over the use of hearing protecting exist. There have been no training classes over hearing protection or the causes of hearing loss in the fire service. Therefore, the GFD is not fully compliant with OSHA 1910.95 or NFPA 1500, as each address the needs for these programs.

Discussion/Implications

The American Occupational Medicine Association defines noise induce hearing loss "as a slowly developing hearing loss over a long time period (several years) as the result of exposure to continuous or intermittent loud noise" (Greenberg, 2011 p. 227). While the results of this research project only showed a decibel exposure snap shot. Each activities recorded continues on a weekly basis and every firefighter will be exposed to intermittent decibel levels over 90dB thousands of times over a twenty plus year career. Without personnel hearing protection, as recommended by NFPA 1500, Georgetown fire personnel are endangering themselves to the slow hearing loss process which Greenberg has addressed. "The rate of hearing loss due to chronic noise exposure is greatest during the first 15-20 years of exposure and decreases as the hearing threshold increases" (Greenberg, 2011 p. 227).

This research project has showed that the Georgetown Fire Department complies with OSHA's permissible noise exposures limits. No Georgetown firefighter is exposed to more than 90dB for more than an eight hour time frame within a twenty-four hour period. Even at the results highest decibel reading of 120dB the exposure time was only two minutes and did not reach the fifteen minute limit as addressed by OSHA. Continuous exposure to constant decibel levels is not an issue within the Georgetown Fire Department. However, short term intermittent exposure to high noise levels, which occurs each shift, is a concern over a firefighter's career is a concern.

Fire House Magazine, Dr. Randy Tubbs states "Hearing loss from occupational noise is a completely preventable disease. Marshall (1982/1994) identifies that there are only two ways to stop sound pressure waves from entering the ear canal. The first way is to plug the ear canal. The second way is to cover the whole ear with an ear muff. If the Georgetown fire department concurs with these two individuals, ear plugs should be provided to all fire personnel to be used during those activities which produce a noise level over 90dB. This would be an inexpensive way to reduce the intensity of the noise entering the ear.

Robert Winston, of *Fire Chief Magazine*, identifies that a major cause of hearing loss with fire firefighters comes from operating power tools inside of an enclosed structure were noise cannot dissipate or be absorbed. The results of this study identified that some of the highest decibels levels that Georgetown fire personnel were exposed to occurred during equipment operational checks with in the bays of the stations and during forcible entry training.

If Georgetown fire personnel do not start protecting themselves from intense load noise, hearing loss may be inevitable. Dr. Benjamin states that "hearing loss which is caused by prolong exposure to intense noise gradually damages the cochlear hair cells of the inner ear resulting in a permanent threshold shift across multiple frequencies" (Benjamin, 1971/2002, p. 64). Georgetown fire fighters were observed during this research project being subjected to intense decibels levels of 90dB and greater, repeatedly over short durations.

Recommendations

It is the recommendation based of this study that Georgetown fire fighters be provided with foam hearing protection to use during apparatus and equipment checks, since many activities during these check reached decibels levels of 90dB or greater. Continue to following NFPA 1500 by providing an audiogram during the annual physicals. The GFD should develop and issue a standard operating guideline addressing the causes of hearing loss in the fire service and preventive measures which fire fighters should take to reduce the effects of hearing loss.

This will initiate administrative controls as outlined by OSHA. The final recommendation would be to make all fire apparatus comply with NFPA 1500 by equipping all apparatus with the headset type hearing protection.

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Appendix A

dB Levels During Apparatus and Operational Checks

Test Date: 10/04/2011

Activity: E4 Apparatus check Performed by FF Jolly no hearing protection
Special considerations: All bays doors opened Location of Meter: Work out area
Location: Inside bay of sta.4

Actions	Duration	Max. Decibel Exposure
Starting apparatus	1 second	73dB
Engage pump and operate	5 minutes	78dB
Siren test	3 seconds	100dB
Idling apparatus	5 minutes	70dB

Test Date: 10/05/2011

Activity: E4 Apparatus check Performed by: A/O Owen no hearing protection
Special considerations: none Location of Meter: With person performing check
Location: Exterior of truck bay

Actions	Duration	Max. Decibel Exposure
Starting apparatus	1 second	78dB
Horn	1 second	97dB
Siren test	3 seconds	103dB
Prime pump	2 seconds	87dB
Engage pump and operate	4 minutes	82dB
Idling apparatus	10 minutes	75dB

Test Date: 10/10/2011

Activity: E4 Power Tool checks Performed by: Fryer & DeLaCruz no hearing protection
Special considerations: Location of Meter: Work out area
Location: Station 4 outside of bay

Actions:	Duration	Max. Decibel Exposure
Utility saw	3 minutes	90dB
Vent saw	3 minutes	93dB
Chain saw with PPV fan	4 minutes	93dB
Port o power unit	4 minutes	68dB
Tones dropped on bay speaker	10 seconds	105dB
Voice after tones	10 seconds	90dB

Test Date: 10/12/2011

Activity: E2 Apparatus Check — Performed by Traxler no hearing protection
Special considerations: — Location of Meter: with person performing check
Location: Sta 2 outside of bay

Actions:	**Duration**	**Max. Decibel Exposure**
Starting apparatus	1 second	83dB
Engaging pump	1 second	83dB
Siren test	4 seconds	106dB
Air horn test	2 seconds	97dB
Operate pump	5 minutes	90 dB
Internal generator check	5 minutes	86 dB
Prime pump	2 seconds	101dB

Test Date: 10/13/2011

Activity: E2 Apparatus Check — Performed by Beyers no hearing protection
Special considerations: bay door open in front and rear of apparatus
Location of Meter: workout area
Location: apparatus check conducted inside bay

Actions:	**Duration**	**Max. Decibel Exposure**
Starting apparatus	1 second	83dB
Engaging pump	1 second	83dB
Siren test	2 second	105dB
Air horn test	2 seconds	105dB
Operate pump	3 minutes	92dB
Internal generator check	4 minutes	82dB
Idling apparatus	5 minutes	82dB

Test Date: 10/17/2011

Activity: E2 Power Tools Check — Performed by Bizzell, Inmann and Traxler / no hearing protection in place
Special considerations: all bay doors open
Location: power tools checks conducted outside
Location of Meter: Work out area

Actions:	**Duration**	**Max. Decibel Exposure**
Utility & Vent Saw Check simultaneously	1 minute	100dB
K-saw check	1 minute	96dB
PPV fan check	1 minute	100dB
Idling tools	3 minutes	75dB

Test Date: 10/17/2011

Activity: E1 Power Tool Check Performed by Vaughn / no hearing protection in place
Location: Inside truck bay Location of Meter: with person conducting check
Special considerations: all bay doors open & Brush truck power tool checks going on doing evaluation 30 ft away from test area

Actions:	**Duration**	**Max. Decibel Exposure**
Vent Saw Check	30 seconds	105dB
K saw Check	30 seconds	102dB
Utility saw check	30 seconds	103dB
Generator check	3 minutes	80dB
Background noise	5 minutes	98dB

Test Date: 10/19/2011

Activity: Truck 1 operational check Performed by Bourland no hearing protection
Special considerations: no ear protection in place Location of Meter: with person conducting the check
Location: Station 1 exterior of bay

Actions:	**Duration**	**Max. Decibel Exposure**
Starting apparatus	1 second	85dB
Pump check	3 minutes	88dB
Siren test	2 seconds	98dB
Air horn test	2 seconds	105dB
Outrigger alert	2 minutes	95dB
Idling apparatus	10 minutes	89db average 80dB
Ladder extention PTO engage	3 minutes	90dB

Test Date: 10/31/2011

Activity: Power tool and Q3 operational check Location: Sta 3 exterior of bay
Special considerations: 2 out of 3 bay doors open Location of Meter: Workout area
Performed by A/O Cullar, FF Mattern and FF Armatta no hearing protection

Actions:	**Duration**	**Max. Decibel Exposure**
Starting apparatus in bay	2 seconds	88dB
Vent saw check	20 seconds	91dB

PPV fan check	3 minutes	81dB
Hydraulic power unit check	3 minutes	67dB
K saw chck	30 seconds	87dB
Pump check	2 minutes	85dB
Horn	1 second	80dB
Siren test	3 seconds	84dB
All power equipment idling	5 minutes	80dB average
Aerial/PTO operational check	3 minutes	62dB

Test Date: 11/7/2011

Activity: Power tool and Q3 operational check Performed by Westerfeld no hearing protection

Location: Exterior bay Sta 3
Location of Meter: Meter was with Westerfeld while he conducted the checks

Actions:

Idle of Q3 during checks	**Duration**	**Max. Decibel Exposure**
Siren check	10 minutes	85 constant
Pump operational check	2 seconds	106dB
PTO/Aerial check	3 minutes	92 dB
PPV check	3 minutes	90 max dB - 87dB average
K saw check	1 minute	94dB
Utility saw check	1 minute	102dB max - 85dB idle constant level
Hydraulic power unit check	1 minute	102dB max - 85dB idle constant level
Generator check	3 minutes	85dB
	3 minutes	87dB

Appendix B

dB Levels During Driving Conditions

Test Date: 10/17/2011

Activity: Riding with BC1

Performed by Boatright no hearing protection

Special considerations: response through commercial district and on open highway

Location of Meter: Cab of excursion / passenger side front seat

Location: Response Code 3

Actions:	Duration	Max. Decibel Exposure
Windows up in commercial area	3 minutes / top speed 45 mph	87dB @ code 3 driving
Windows up on Interstate 35	3 minutes / top speed 80 mph	84dB @ code 3 driving
Windows down on Interstate 35	1 minutes / top speed 80 mph	92dB @ code 3 driving
Windows down on hwy 195	2 minutes / top speed 50 mph	80dB @ code1 driving
Windows up from hwy 195/shell rd	5 minutes / top speed 55 mph	76dB @ code 1 driving
Windows up from shell rd to sta 2	4 minutes / top speed 50 mph	77dB @ code 1 driving

Test Date: 11/7/2011

Performed by Cummings

Location: In cab of BC7

Location of Meter: In cab (front seat) of BC7

Activity: BC7 ride along

Special considerations: no hearing protection in place

Actions:	Duration	Max. Decibel Exposure
Code 1 through residential 35 mph	15 minutes	62dB average with 64dB max.
Code 1 at highway speeds	10 minutes	72dB average with 75dB max.

Test Date: 1/18/2012

Activity: E4 ride outs	Performed by : Cummings	Location: back seat of E4
Special considerations:		Location of Meter: in lap of FF

Actions	**Duration**	**Decibel Exposure**
Code 1 windows up	4 minutes	Max. 80 Ave. 70
Code 1 windows down	6 minutes	Max. 84 Ave. 75
Code 3 window up	3 minutes	Max. 88 Ave. 77
Code 3 Window down	1 minute	Max. 94 Ave: 84

Test Date: 1/19/2012

Activity: E4 ride outs	Performed by : Cummings	Location: back seat of E4
Special considerations:		Location of Meter: in lap of FF

Actions	**Duration**	**Max. Decibel Exposure**
Code 1 windows up	2 minutes	Max. 75 Ave. 72
Code 1 windows down	3 minutes	Max. 77 Ave. 75
Code 3 window up	2 minutes	Max. 88 Ave 77
Code 3 Window down	3 minutes	Max. 94 Ave. 80

Test Date: 1/20/2012

Activity: E4 ride outs	Performed by: Coker	Location: back seat of E4
Special considerations:		Location of Meter: in lap of FF

Actions	**Duration**	**Max. Decibel Exposure**
Code 1 windows up	5 minutes	Max. 80 Ave. 72
Code 1 windows down	2 minutes	Max. 78 Ave. 74
Code 3 window up	2 minutes	Max. 87 Ave. 77
Code 3 Window down	2 minutes	Max. 93 Ave. 84

Test Date: 1/20/2012

Activity: E1 ride outs	Performed by: Laurich	Location: back seat of E1
Special considerations:		Location of Meter: in lap of FF

Actions	**Duration**	**Max. Decibel Exposure**
Code 1 windows up	5 minutes	Max. 73 Ave. 67
Code 1 windows down	5 minutes	Max. 84 Ave 73
Code 3 window up	2 minutes	Max. 86 Ave. 77
Code 3 Window down	2 minutes	Max. 98 Ave 85

Test Date: 1/20/2012

Activity: RQ ride outs | Performed by: Armatta | Location: back seat of RQ
Special considerations: | | Location of Meter: in lap of FF

Actions	Duration	Max. Decibel Exposure
Code 1 windows up	6 minutes	Max. 83 Ave. 72
Code 1 windows down	3 minutes	Max. 80 Ave. 76
Code 3 window up	2 minutes	Max. 91 Ave 85
Code 3 Window down	2 minutes	Max. 94 Ave 88

Test Date: 2/1/2012

Activity: R3 ride outs | Performed by: Cullar | Location: Front seat of R3
Special considerations: 2 person cab w/ no hearing protection in place | Location of Meter: in lap of FF

Code 1 windows up	4 minutes	Max. 86 Ave 80
Code 1 windows down	4 minutes	Max. 86 Ave 82
Code 3 window up	2 minutes	Max. 89 Ave 84
Code 3 Window down	3 minutes	Max. 99 Ave 94

Test Date: 2/2/2012

Activity: Q3 ride outs | Performed by:Ratliff | Location: Back seat of Q3
Special considerations: | | Location of Meter: in lap of FF

Code 1 windows up	3 minutes	Max. 86 Ave 76
Code 1 windows down	5 minutes	Max. 89 Ave 79
Code 3 window up	3 minutes	Max. 86 Ave 83
Code 3 Window down	2 minutes	Max. 91 Ave 79

Test Date: 2/2/2012

Activity: E1 ride outs | Performed by: Cummings | Location: Back Seat of E1
Special considerations: | | Location of Meter: in lap of FF

Actions	Duration	Max. Decibel Exposure
Code 1 windows up	2 minutes	Max. 75 Ave. 64
Code 1 windows down	3 minutes	Max. 86 Ave 74
Code 3 window up	4 minutes	Max. 89 Ave. 77
Code 3 Window down	1 minutes	Max. 99 Ave 87

Test Date: 2/2/2012

	Performed by:	
Activity: E2 ride outs	Cummings	Location: back seat of E2
Special considerations:		Location of Meter: in lap of FF

Actions	**Duration**	**Max. Decibel Exposure**
Code 1 windows up	4 minutes	Max. 74 Ave 71
Code 1 windows down	2 minutes	Max. 77 Ave. 74
Code 3 window up	3 minutes	Max. 81 Ave 78
Code 3 Window down	1 minute	Max. 88 Ave 83

Test Date: 2/6/2012

	Performed by:	
Activity: E2 ride outs	Cummings	Location: back seat of E2
Special considerations:		Location of Meter: in lap of FF

Actions	**Duration**	**Max. Decibel Exposure**
Code 1 windows up	4 minutes	Max 70 Ave 68
Code 1 windows down	2 minutes	Max 78 Ave 72
Code 3 window up	3 minutes	Max. 86 Ave 83
Code 3 Window down	1 minute	Max. 89 Ave 84

Test Date: 2/13/2012

	Performed by:	
Activity: T1 ride outs	Jackson	Location: back seat of T1
Special considerations:		Location of Meter: in lap of FF

Actions	**Duration**	**Max. Decibel Exposure**
Code 1 windows up	5 minutes	Max 79 Ave 74
Code 1 windows down	3 minutes	Max 78 Ave 74
Code 3 window up	3 minutes	Max. 81 Ave 79
Code 3 Window down	2 minute	Max. 84 Ave 80

Appendix C

dB Levels During Training Evolutions

Test Date: 11/10/2011

Performed by Cummings

Location: Station 1 truck bay

Location of Meter: next to fire fighter performing task

Activity: using K saw to hinge on inforcer prop

Special considerations: 1 out of 8 FF's wearing hearing protection

Shields, Vaughn, Coker, Cinton, Mezger and Azua performing task

Actions:	**Duration**	**Max. Decibel Exposure**
K saw used to cut metal hinges from the inforcer prop cut performed 8 times	average cut time 2 minutes per evolution	120dB max reading and 114dB the average reading during the task

Test Date: 11/10/2011

Performed by Cummings

Location: Station 1

Activity: breaching the inforcer training prop

Location of Meter: next to fire fighter performing task

Special considerations: 1 out of 8 FF's wearing hearing protection

Shields, Vaughn, Coker, Cinton, Mezger and Azua performing task

Actions:	**Duration**	**Max. Decibel Exposure**
Flathead axe and haligan bar used to perform force entry into a commercial door this task was performed 8 times	average force entry time was 2 minutes	93dB was the max reading and 87dB was the ave. reading while FF's were performing the task

Test Date: 12/21/2011

Activity: Ventilation Training
Performed by: England, Armatta and Humphres
Special considerations: performed outside. No ear protections

Location of Meter: With FF perfoming the cut
Location: Station 4

Actions	Duration	Max. Decibel Exposure
Cutting OSB with chain saw X 3	4 minutes average cut evolution	115 dB with a average of 90dB during the 4 minute evolution

Test Date: 1/24/2012

Activity: Relay pumping between E4 and RQ
Special considerations: no ear protection used by any personnel
Performed by: Cummings

Location: San Gabriel Park
Location of Meter: At pump panel of E4

Actions	Duration	Max. Decibel Exposure
E4 relay pumping to RQ RQ had aireal device flowing water	10 minutes evolution	Max. 96 Ave. 86

Test Date: 1/25/2012

Activity: Relay pumping between E2 and Q3
Special considerations: no ear protection used by any personnel
Performed by: Cummings

Location: San Gabriel Park
Location of Meter: At pump panel of E2

Actions	Duration	Max. Decibel Exposure
E2 relay pumping to R3 Q3 had aireal device flowing water	8 minutes evolution	Max. 94 Ave. 83