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Update

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GET LOUD! Crowd Noise Measurements at Football Games

By: Andrew R. Barnard, Ph.D., INCE Bd. Cert.

Sound levels at sporting events are often anecdotally referenced in the main-stream sports media, and by sports fans, coaches, and players. For example, the main subheading on the Seattle Seahawks *12th Man* website is "The Loud & Proud" followed by an article titled "Loud, Louder, the Loudest" (www.seahawks.com/12th-Man/). Particularly in American football, both collegiate and professional, crowd noise is considered a vital part of the game, and can affect the game by causing communication failures among the opposition. These communication failures can result in penalties, broken plays, or forcing the opponent to use a timeout.

Although crowd noise is good for the game, it has been widely ignored by the scientific community. It is rarely measured inside of a stadium. When it is measured, it's most often done in a manner that is unscientific and misleading to the general public. The exception is when a community noise complaint arises around a stadium. In this case detailed measurements are reported, but typically at locations outside of the stadium. Finally, player and fan noise induced hearing loss (NIHL) has not been explored in detail. Although the exposure time may only be 3-4 hours per week, the sound pressure levels (SPL) are sufficiently high to warrant an investigation into NIHL.

The failing with typical media-driven crowd noise measurements is that their singular goal is to register the highest SPL on record. To do this, peak SPL is recorded at a single location in the stadium, which normally is on the sidelines, in the nearfield of a small portion of the crowd. This type of peak SPL measurement is neither a good representation of the actual sustained sound power of the entire crowd nor is it representative of the ability of the crowd to effectively mask opponents' communication. Finally when these peak levels are reported, they are commonly compared to things like "aircraft carrier flight deck (140 dB)" or "jet takeoff at 100 m (130 dB)", which are time-integrated SPLs. This is a classic "apples-to-oranges" comparison.

In an attempt to apply better science to crowd noise measurement, we conducted several measurements at Penn State's Beaver Stadium, the second largest football stadium in the US, in 2007-2012. Measurements were made around the entire field simultaneously and throughout the entire game. For the most part, 10 second averaged equivalent A-weighted sound pressure levels, L_{Aeq}, were measured at 8 locations evenly distributed around the field. Table 1 shows measurement results from the first halves of the Penn State vs. Iowa and the Penn State vs. Ohio State games in 2009. These measurements were recorded on the 10 yard line in front of the student section at Beaver Stadium, locating the sound level meter as far away from the crowd as possible without interfering with play on the field. Measurements were obtained simultaneously at other locations around the field, but are omitted here, for brevity.

Metric	PSU vs. OSU	PSU vs. Iowa
L_{max} (Slow, Fast, Impulse) [dBA]	107, 110, 110	109, 110, 111
L_{max} (Slow, Fast, Impulse) [dB]	107, 110, 112	110, 111, 112
Peak SPL, L_{peak} [dBA]	121	125
Equivalent SPL, L_{eq} [dBA]	94	95
Equivalent SPL, L_{eq} [dB]	95	97
Exposure Level, L_E [dBA]	134	134
Exposure Level, L_E [dB]	135	136
Statistical Exceedance Levels, L_N, (N=1%, 5%, 10%, 50%, 90%, 95%, 99%) [dBA]	104, 101, 98, 87, 81, 79, 77	104, 102, 100, 89, 82, 81, 78

Table 1. Overall, integrated SPLs measured at two Penn State football games in 2009 (first halves only).

You can see that there is very little difference between the levels measured at these two games. In particular, the statistical exceedance levels of the overall crowd noise vary by less than 2 dB. This shows that the overall nature of the noise in a particular stadium at a particular location may be repeatable from game-to-game. The measured peak levels are 25-30 dB higher than the equivalent SPL, and 10-15 dB

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Update

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Message from the Chair: Noise Induced Hearing Loss in New Hires

By:Bruce Kirchner, MD MPH CPS/A

In my discussions with other "Occ Docs" and Occupational Health Nurses, they are all reporting an increased number of noise induced hearing loss patterns on baseline audiograms in younger new hires. Through an informal survey, I have found that my company's manufacturing site occupational health nurses are seeing marginal noise notches in young new hires. This really was no surprise to me—you could see this coming! I'd like to refer you back to the *Winter/Spring CAOHC Update, 2007*. In an article entitled "Portable Music Players and the Potential Risk of Hearing Loss," Dr. Brian Fligor pointed out the ubiquitous use of portable listening systems and the risk of auditory damage, depending on preferred listening level and type of earphone used. It was clear that no matter which brand of MP3 player was tested, it was possible to deliver sound levels up to **100 dBA**!!! As in-the-ear devices are more efficient in funneling sound into the ear canal, Dr. Fligor proposed that earbuds were riskier than supra-aural earphones. In fact, if your child is cranking these devices up to 100% volume, they really should be exposed to these high intensities for only a few minutes. Now that very large storage is available on personal listening devices and cellphones, there is an opportunity to listen to music for even longer periods of time!

The World Health Organization (February, 2015) came out with a report and indicated that about 1.1 billion teenagers and young adults are at risk of noise induced hearing loss. According to the CDC, an estimated 12.5% of children and adolescents aged 6–19 years (approximately 5.2 million) have suffered permanent damage to their hearing from excessive exposure to noise. Among teenagers and young adults between 12-35 years-old, nearly 50% are exposed to unsafe levels of sound from the use of personal audio devices, and approximately 40% are exposed to potentially damaging sound-intensity levels at entertainment venues. In a study conducted by Siemens, 46% of teens admitted that they had symptoms of tinnitus. Furthermore, a survey demonstrated that 88% of teenagers know that their chosen listening level is too loud, but choose to do little about it.

As I said previously, we could see this coming! Now, we are beginning to see this young population joining the workforce. So, if they are exposed to noise at work, and continue their over-exposure habits when not at work, I think we will see what's coming next, don't we?

Because most new younger employees have their baseline audiogram conducted before they are exposed to hazardous work noise, you may see an early notch present on the audiogram in the high frequencies. **A teaching moment has arrived!!** This is the time to talk about their work and recreational noise exposures. Although other noise sources such as equipment, weapons, clubs and concerts will come up as part of the discussion, undoubtedly, the subject of personal listening devices will too! Please make your new worker aware of the 60/60 rule: try to keep the volume under 60 percent and only listen to music devices with ear buds for a maximum of 60 minutes per day. That may be a little conservative, but it should be protective, if they decide to listen beyond 60 minutes. To lower the volume, they need to go to "Settings" on their device menu and select "Volume Limit." Also, encourage workers not to fall asleep with their earbuds in, and urge them to take breaks (quiet time) to help their inner-ear cochlea hair cells recover. Be assertive, and tell them to "**turn it to the left**"!!!!

D. Bruce Kirchner, MD, MPH CPS/A; Occupational Physician. Dr. Kirchner is the Global Medical Leader for Procter & Gamble's Household Care business, with responsibilities in assuring the occupational health of 30,000 employees in manufacturing and research. Additionally, he is the system owner for hearing conservation across the company. He retired from the U.S. Army in 1995 after 21 years of service in which he was involved in hearing conservation in field units, as well as industrial operations. Dr. Kirchner has a B.A. in English from the Virginia Military Institute, an M.D. from the University Of Pittsburgh School Of Medicine, and an MPH from the University Of Pittsburgh School Of Public Health. He is board certified in Internal Medicine, Occupational Medicine, and Preventive Medicine & Public Health. Dr. Kirchner is a Member Delegate to the National Hearing Conservation Association Executive Council. He is also a Fellow of the American College of Occupational and Environmental Medicine and was recently appointed to the Council for Accreditation in Occupational Hearing Conservation as a Council Member representing ACOEM. You can contact Bruce Kirchner at: kirchner.db@pg.com

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higher than the maximum slow, fast, or impulse integrated levels. A histogram of the measured 100 ms L_{Aeq} for the entire Penn State vs. Ohio State 2009 game is shown in Figure 1. It shows the total amount of measurement time recorded over 1 dB bin sizes. These data clearly show that measurements of peak SPLs do not represent the overall noise distribution over the course of a game.

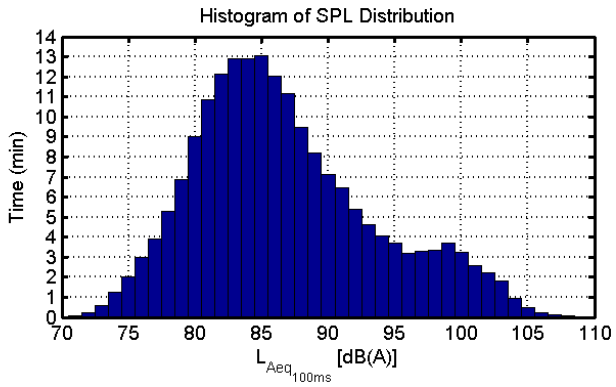

Figure 1. PSU vs. OSU 2009 histogram of 100ms SPL data.

Secondly, a method was needed to quantify the effects of the crowd noise on players, as communication interuption is the desired outcome of loud crowds. Two metrics were evaluated, subjective loudness (sones) and preferred speech interference level (PSIL). PSIL can be related directly to communication distance based on the level of the talker's voice (shout, normal, whisper, etc…). Subjective loudness was calculated and evaluated at points in time when each teams' quarterback was calling plays. When the home team was calling plays the subjective loudness was in the range of 30 to 40 sones. In contrast, when the visiting team's quartback was trying to communicate, the subjective loudness was in the range of 90-110 sones. That is roughly a factor of 3 increase in subjective loudness, making it much harder for the opposing quarterback to communicate with his teammates. The PSIL showed that the effective communication distance for an opposing quarterback at maximum vocal effort was 0-1 meters; whereas, it was 1-4 meters for the home team's quarterback. This is a huge advantage for the home team when efficient communication with offensive lineman is critical.

Finally, NIHL exposure metrics were explored for the measured crowd noise levels on the sidelines. Cumulative noise dose was calculated using both OSHA and NIOSH criteria. An example is shown in Figure 2 for a single game. The OSHA daily noise dose is not exceeded (37%) but the NIOSH daily noise dose is exceeded after the first 1.2 hours of exposure. The cumulative NIOSH daily noise dose on the sidelines for this game was 243%. The A-weighted exposure level was also calculated at 133 dBA for the entire game. These data indicate that, at the very least, more exploration into NIHL at sporting events is justified.

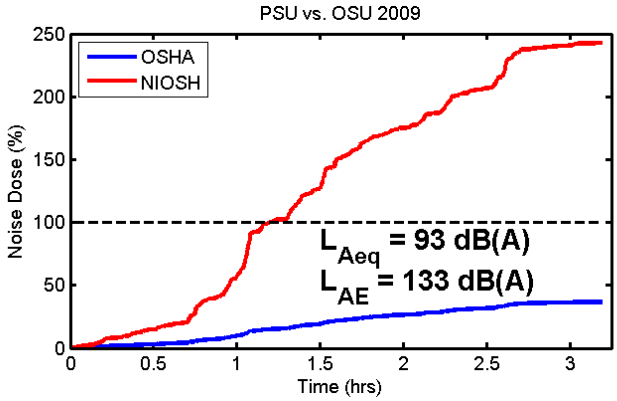

Figure 2. PSU vs. OSU 2009 cumulative daily noise dose on the sidelines.

The question remains as to what are the correct measurement techniques and metrics to use when assessing crowd noise. An effort must be made to make measurements as close to the field as possible, avoiding nearfield measurements of a small subset of the crowd. Also a set of spatially distributed measurements should be averaged over time and location. Since peak levels do not represent the human ear response, some type of time averaging or statistical exceedance level should be used to compare "loud" crowds. A maximum SPL using an impulse integration constant (35 ms) or a 1% exceedance level (L_1), may be better choices than peak levels for comparison purposes. Even better would be the use of time averaged metrics over the entire course of the game, such as L_{eq} or L_E. The best comparative metrics are ones that relate directly to communication effectiveness, such as subjective loudness (sones) or PSIL. These loudness metrics are best evaluated at points in time when the opposing team is trying to communicate, as interfering with this communication is the intended purpose of crowd noise.

Andrew Barnard is an Assistant Professor of Mechanical Engineering Engineering Mechanics at Michigan Technological University. He teaches undergraduate and graduate courses in the design and dynamic systems area. His education and research interests lie in the field of acoustics, vibration, and noise control engineering.


Mr. Charles Jokel, MCHB-IP-MHC


LTC Martin Robinette, AuD, CCC-A, PhD

Will TCAPS Encourage More Soldiers to Protect Their Hearing?

By Mr. Charles Jokel, Noise Control Engineer and LTC Martin Robinette, Program Manager, Army Hearing Program

The Problem

There has been a long-standing assumption amongst Warfighters that losing their hearing is part of the price they pay for doing their job. This assumption has, in fact, worked its way into the Warfighter culture. Hearing protectors aimed at dispelling this belief have been around for many years, but the belief remains.

The Initial Solution

We have all seen movies about WWII showing aircrew with communication headsets. These happened to also protect hearing. Headsets have continued to evolve into today's flight helmets, which do an excellent job in minimizing hearing loss. Today's Aircrew don't think twice about wearing their protection because they have to communicate to do their job, and the hearing protection comes along almost as a side benefit enabling them to maintain the good hearing they need to maintain their flight status. Earplugs became available to augment the protection around the 1970 timeframe, in time to parallel the development of noisier aircraft. Aircrew seem to keep them in good maintenance, especially because the products are individually issued. Tankers also were issued communication headsets starting in the 1980s. Unfortunately, these were vehicle issued, so they were not as well maintained and not always properly sized to provide optimum hearing protection. Nonetheless, all these products have reduced the incidence of hearing loss in the user population.

Different results were obtained for the ground Soldier. In the immediate period after WWII, Soldiers were offered and encouraged to use the first hearing protectors: commercial single-flange earplugs called the V51R. Product choice gradually expanded to a number of devices, each with the potential to adequately protect hearing; but, Soldiers, particularly Infantrymen, have been very reluctant to use any of them.

The Secondary Problem Surfaces

Dismounted Soldiers became keenly aware of a problem with the hearing protector that providers were reluctant to acknowledge. That is, although hearing protectors lowered the overall level of what was heard, there were side-effects that made it hard to make sense of the sound that got through the protector. Soldiers know their life could depend on audible environmental cues from their surroundings, and these cues can be lost because of the uneven effects of hearing protectors on the frequency content of the sound, or loss of other cues that are important to binaural hearing. The soldier may lose the ability to quickly identify where an enemy shooter is located and how far away the shooter is. If they are on a foot patrol, they may lose audible cues from the enemy that are part of faint sounds that could warn of impending trouble, including footfall, safeties on weapons being turned off, and the like. All these things are compromised to one degree or another when ears are covered. This is why many Soldiers have deliberately decided to not wear the hearing protection they have been given. This situational awareness is a critical part of Soldier training. When faced with the choice between possibly incurring a hearing handicap when they have to fire their weapon, and balancing that from the possibly lethal effects of an attack, it seems natural that Soldiers are going to opt for first protecting their lives.

The Better Solution

This issue prompted the development of level-dependent earplugs that became routinely issued to the dismounted Soldier replacing the original passive, non-level-dependent, earplugs. The design of the level-dependent earplug allowed quiet sounds to pass into the ear with relatively little change. There have even been generational design changes in the short time these products have been available such that more recent products are more comfortable and easier to use. Still, these earplugs are not the perfect answer, because the changes in the sound that is passed through remain important to the Soldier.

New Problems Surface

Even though these products perform better than older non level-dependent products with regard to perceiving surrounding sounds, the residual effects these new products have on surrounding sound still cause problems. Because they increasingly attenuate sound as frequency increases, it hinders being able to understand a spoken command. Each brand of level-dependent device performs differently in this regard. Again, although things are improved, they are not where we would like to see them.

There is also something called the occlusion effect which causes internally generated sounds, such as those caused by chewing gum or simply by the act of walking, that adversely alters our sense of hearing when our ears are covered.

For these reasons, Soldiers remained reluctant to use the hearing protector. And we have learned that what we need is a device that is basically acoustically completely transparent in order to gain complete Soldier acceptance.

Have We Found the Answer?

There are now new products that come even closer to the ideal. These are the Tactical Communication and Protective System (TCAPS) headsets that are now part of the inventory and are issued to dismounted Soldiers who require radio communication with command and control. TCAPS electronically reproduce the environmental sounds to come as close as we can get to what we would hear without anything covering the ear. Specifically, they do not change the frequency content of the environmental sound. These are not your traditional headsets, in that, the devices more closely resemble earplugs, but with cable attachments to radios. The TCAPS in the inventory come with radio communication capability. The Army is in process of bringing into the inventory a version of the TCAPS that has the same features but without radio communication capability. This product is intended for issue to the remainder of the dismounted Soldier force. Both versions are communication devices. The version with radio communication is

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OHC Spotlight on Justin Adams, RN, COHC

By Antony R. Joseph, Au.D., Ph.D., CPS/A

Justin Adams, RN, COHC

Mr. Justin Adams is a registered nurse who has been practicing for 10 years. He has a special interest in diabetic education and hearing conservation. Since taking the CAOHC OHC course, he finds himself spending more time on taking the medical-occupational history of his patients. The OHC course includes advanced training in how to select, fit, and care for hearing protection devices. Whenever workers mention that they use earplugs, Justin gives them a new set in the clinic, and ensures that they know how to use them properly. He is hoping to add fit-testing capability in the future. I met Justin in an OHC course I taught recently, and I asked him a few questions after the course.

Dr. Joseph, Editor: What motivated you to acquire this certification and perform the duties of an OHC?

Justin: I became motivated to obtain an OHC certification after transitioning into the Occupational Medicine field. Hearing Conservation is a major part of Occupational Health, so it's inherently important. During team meetings, I am focusing on increasing communicating with Environmental Health and Safety, while presenting observations from the clinic that pertain to worker noise exposure. I use the worker's hearing test to identify how they are doing in the field and translate that information into useful reports for safety and company leadership. The CAOHC course was helpful in providing me with a best practice approach to managing my program, which is a plus for the workforce we serve.

Dr. Joseph: Can you tell us about one of your favorite segments of the course and what helped you to enjoy it?

Justin: I especially enjoyed the lectures on hearing loss because it was helpful in my personal life. The practical sessions on earplug fittings and manual audiometric testing were effective, and I liked the interactions during class with other students. These practical exercises assisted with understanding the many technical concepts and with getting a feel for what it's like to be in the patient's shoes. Simple things like, hearing test data and the use of hearing protection can be more clearly explained to the patient after taking the CAOHC training. I feel that patients are less frustrated when we can make simple and clear explanations for them during or after their visit to the clinic.

Dr. Joseph: What do you recommend should be done by a clinical supervisor (e.g., every two years) to determine if an OHC has maintained competency?

Justin: Maybe once a year or two, supervisors should have the OHC administer the entire protocol on them. From top to bottom, the OHC should administer a history, hearing test, interpretation of the data, and identify what information needs to be addressed with the Professional Supervisor. I would primarily be concerned with how OHCs deliver the message to patients? I have to do a complete physical examination, and would expect an OHC to do an otoscopic exam properly and safely, while reporting the results adequately. By watching the OHC conduct an exam on a live patient, I believe that would allow a supervisor to determine their ability to properly execute the primary responsibilities of an OHC. I like to also say that I believe that Continuing Education is important, and OHCs should find opportunities to attend courses on hearing and occupational health to maintain a good knowledge base. I plan to visit the CAOHC website to look for training opportunities, webinars, and information from the Update e-Newsletter.

Dr. Joseph: You are a unique asset to the Hearing Conservation Program because of your auditory disposition. Thank you for allowing us to show our readers your audiogram, and have a few questions for you about your hearing loss: (1) How did you get your hearing loss? (2) What is the most difficult situation for you because of the hearing loss? (3) Have you ever used a hearing aid, and did it help? (4) How do you protect your better ear? (5) Why is it important to you to protect your hearing?

Justin's Current Audiogram

	500	1000	2000	3000	4000	6000	8000 (Hz)
Left ear	15	60	75	70	75	70	90
Right ear	00	00	05	00	10	05	05

Justin: My hearing loss happened suddenly in the 8th grade, 25 years ago. The sound of the tinnitus woke me up from sleep. My mother was at work, and when I put the phone up to my ear to call her, I couldn't hear anything. I eventually went to the hospital, and was examined by an Audiologist. I was sent for a scan where they checked for a brainstem tumor, which was negative. I was never given a cause for the hearing loss. Until taking your CAOHC OHC class, I did not know about the viral attack condition you discussed with us. I was told everything was normal and that the hairs in my inner ear were lying down, but they did not know how to treat it.

Presently, I seem to have the most difficulty following conversations in learning environments, because ambient noise is a problem. In conversational situations, professional or social environments, I have to tell people I have a hearing loss, proactively. I usually just say, "I'm hard of hearing in my left ear." If not, people talk on the left and think I'm ignoring them or being rude. This leads to frustration, more so for

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clearly a communication device, but because it aids in face-to-face verbal communications, the non-radio version is also a communication device. Both types come with built-in electronics that sense the environmental sounds with an external microphone and rebroadcast them into the ear, recreating what the wearer would hear if their ears were not covered. They can even amplify the surrounding sound electronically, extending the sense of hearing to even quieter sounds.

Sound too good to be true? Drawbacks remain.

These are not your simple ten dollar earplugs. Both versions cost hundreds more, which is obviously a provisioning issue. But, their high cost is also an issue to the user community. Every Soldier signs for their issued equipment and is expected to keep it in good repair and not lose it. Early versions of the devices were not particularly robust, and Soldiers soon found that out during training. For example, the cables snagged and broke the ear insert. This makes life more difficult for the Soldier when the device breaks, even if it does so through no fault of the Soldier. Fearing the cost of replacement is going to come out of pocket, the Soldier may be reluctant wear it, bringing us back to square one. The TCAPS vendors have sincemade the product more robust. Whether it is sufficiently robust to allay the Soldiers fear remains to be seen. Maybe eventually we will have wireless devices, so they will not snag.

TCAPS appear to give us the best chance we have ever had to reverse the long-held belief that to be a Soldier meant sacrificing hearing.

The views expressed in this article are those of the author(s) and do not necessarily reflect the official policy of the Department of Defense, Department of the Army, U.S. Army Medical Department or the U.S.

Mr. Charles Jokel is a Noise Control Engineer for the Army Hearing Program in the Public Health Command at The Aberdeen Proving Ground, Edgewood, Maryland Campus. He is the Subject Matter Expert on noise issues for the Army Health Hazard Assessment Program that examines all new weapons and materiel brought into the Army inventory, and is a consultant on noise measurement and control issues within the Army. Before employment with the Military, Mr. Jokel was an acoustic consultant in industry. He has written extensively on techniques used in the discipline, and was the principal author of the NIOSH Industrial Noise Control Manual.

Dr Robinette is an audiologist serving in the U.S. Army. A native of North Salt Lake, Utah, he received a B.S. in Speech and Hearing Science from the University of Utah (1994), an M.S. in Audiology from Vanderbilt University (1996), an Au.D. in Audiology from Central Michigan University (2008), and a Ph.D. in Industrial and Systems Engineering at Virginia Polytechnic Institute and State University (2013).

Dr Robinette first joined the military in 1985 where he served as an Aircraft Structural Mechanic and an Aeroscout Observer in the Utah Army National Guard. Dr Robinette has served in the Active Army since 1996 as an Audiologist/Preventive Medicine Officer in the Medical Service Corps. He joined the Public Health Command in August 2013 as the Program Manager of the Army Hearing Program.

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others, and it frustrates me too. I frequently have to apologize to people in these circumstances. But overall, one of my biggest challenges is in professional settings – as a nurse, I want to ensure that I hear adequately when using my stethoscope, so I use a cardiology stethoscope with good quality sound. I don't need to use an amplified stethoscope.

I have never used a hearing aid. Why? I think it's because my impaired ear is very sensitive to sound vibration. Just the thought of putting amplified sound in my left ear is uncomfortable.

Sound is always muffled in that ear. The constant tinnitus in my left ear sounds like a high pitched hum. My tinnitus is not masked by ambient sound, so I mentally focus on other things and try not to pay attention to it. Once in a while, the sound gets louder, which raises concern, but I have figured out how to mentally block out the tinnitus.

I prefer using foam earplugs when exposed to noise at work or recreationally. It's important to protect my hearing because of the magnitude of hearing loss my left ear. I actually took American Sign Language (ASL) in college because of a concern of losing more hearing. I protect my hearing to allow me to continue to appreciate music and musical instruments. I want to enjoy life- I play the banjo and harmonica, and enjoy attending live music events. I am acutely aware of noise standards and am very interested in hearing loss prevention as a result of my hearing loss, the training from your course, and my CAOHC certification.

Dr. Joseph: Thanks so much for taking the time to answer these questions, Justin. I think you are going to always be able to relate to your patients and workers much better than those of us who do not have a hearing loss, and this makes you a special asset in the program. Good luck, and **continue to protect your hearing too!**

A native of London, England, Dr. Joseph completed doctorates at Central Michigan University (AuD), and Michigan State University (PhD), emphasizing Experimental Audiology and Epidemiology, and is the first audiologist in the world to achieve the AuD-PhD status. As a retired US Naval Officer, he held numerous leadership positions, including Director of Public Health (Okinawa), large-outpatient Clinic Director (Florida), and certified Lean Six Sigma Black Belt. His professional activities have included: Chair, Board of Governors, American Board of Audiology (ABA); Council Member, CAOHC; and Board of Directors, American Academy of Audiology. Dr. Joseph holds Board Certification from the ABA, Certificate of Clinical Competence in Audiology (CCC-A), and is a CAOHC Certified Professional Supervisor of the Audiometric Monitoring Program and Course Director. He is an Assistant Professor in Communication Sciences and Disorders at Illinois State University, and has been the Editor for the CAOHC Update e-Newsletter since 2011.

Changes to MILSTD 1474, Noise Design Limits

By Charles Jokel, Noise Control Engineer, Army Hearing Program

The Department of Defense (DoD) has a standard entitled "noise limits." It is MILSTD 1474, Version D, which was published in 1997, and was the best available guidance at the time. It was intended for Acquisition organizations and Product Developers to use in setting design goals having to do with steady-state or impulsive noise, in terms of health effects, impact on communities surrounding military facilities, and aural detectability. The design standard limits for exposure to steady-state and impulsive noise were later adopted as medical criteria by the Army when DA Pam 40-501 was published in 1998. Over the years we have come to recognize that the MILSTD document was difficult to use and the described limits, specifically the described impulsive noise limits, were inaccurate. The impulsive noise limits were found to be too loose for small arms weapon fire and too tight for large caliber weapon systems and this affected weapon user survivability and mission effectiveness. Furthermore, the manner for dealing with hearing protection was over-simplified.

A working group was organized by Army proponents three years ago to update MILSTD 1474 and before long, the working group was reconstituted to include representatives from the other Service branches. Due to the complexity of the topic, it has taken all this time to prepare a new standard, Version E, which has just been published (April 2015). The new standard reorganizes and simplifies the document. It consolidates elements that apply to all the requirements into one place, making it easier to find advice on how to make noise measurements and on what measurements are needed. Detailed sections follow that apply to impulsive noise, to steady-state noise, and to special considerations needed for ship and aircraft development and acquisition programs. The working group should be proud of the job they have done in putting together this complex and ground-breaking standard.

This article focusses on the requirements dealing with impulsive noise. Due to limitations on research that could be conducted using human subjects, only a limited amount of data useful for developing methodologies are available for assessing risk. Scientists involved with risk analysis for impulsive noise have different opinions about the options for dealing with this limitation. Thus, while ongoing research is being undertaken to resolve outstanding issues, the different Service branches have agreed to include more than one approach for dealing with impulsive noise in the new standard. However, the Army requires that one method be used, even though the other branches are free to choose either method according to their own policy decisions. For the new standard, data must be obtained that is sufficient to enable either method to be applied.

Establishment of design limits does not necessarily mean the same limits would apply for medical considerations. Specifically, the medical community demands more assurance about the applicability of the design limits. The medical community will wait until the outstanding research provides us with better answers as to what criteria should be applied to medical risk assessment. The Army has determined that in the interim, a medical criterion for impulsive noise will be used that is an extension of the D version limits, with modifications that have already been scientifically validated to apply to specific kinds of weapons systems. The engineering and acquisition community finds that it can accommodate the changes made in version E immediately, and thus for an indeterminate period of time we will have different design and medical noise standards to consider.

What are the new impulsive noise criteria in MILSTD 1474E? The first one, which is the criterion that must be used for Army programs, is a limit of 200 or 500 Auditory Risk Units (ARU) as calculated by the Auditory Hearing Assessment Algorithm for Humans (AHAAH) program. The two ARU limits apply to occupationally- or occasionally-exposed individuals respectively. To use the program, one has to assign a default category of the hearing protection will be worn (as defined in the Standard according to how the materiel will be used), and then process a digitized sample waveform of the noise made by the materiel through the software. AHAAH outputs either a warned or unwarned number of ARU for the waveform. The warned/unwarned choice is a selection the assessor uses depending on whether the exposed individuals will know the impulse is about to happen immediately or not. According to the AHAAH model, a warned condition will cause a contraction of small muscles in the middle ear, and that contraction will lessen the transmission of noise to the inner ear. The number of ARU per impulse is multiplied by the number of impulses to determine how many rounds per day is safe.

This is a completely new way of assessing risk; before, it depended on peak level and duration of the impulse. As alluded to above, questions involving the concept of a warned vs. unwarned exposure, and the bio-mechanical responses of the ear that are assumed in the software, are all the subject of ongoing research. But the net effect of the new method does address the original objections to MILSTD 1474D described above.

For additional information on the AHAAH criterion see http://www.arl.army.mil/ahaah

The other criterion is an offshoot of the A-weighted equivalent level, the A-duration adjusted A-weighted Leq. Although Leq is commonly used with steady-state noise, its application to impulse noise is new. Here, the measured decibel value of the noise gets corrected according to the A-duration of the impulse (which is a measure of the duration of the main impulse, exclusive of reflections). The corrected A-weighted Leq for an 8-hour time period should not exceed 85 dBA when using hearing protection. The longer the A-duration, the less risky the exposure, up to a limit. This method is somewhat simpler to use than AHAAH, makes sense according to how we think our ears respond to noise insults, and also addresses the original objections to the MILSTD 1474D. However, as a novel metric, the technique has not undergone any validation testing; it is presumed valid based on observations about less hazard associated with impulsive sounds with greater low-frequency content.

The bottom line is that from an engineering prospective, we now have a design limit for noise that is more realistic than the standard being replaced, and we have a standard that is better organized and easier to use.

The views expressed in this article are those of the author(s) and do not necessarily reflect the official policy of the Department of Defense, Department of the Army, U.S. Army Medical Department or the U.S.

Trends in Worker Hearing Loss within the Manufacturing Sector, 1981-2010

By: Elizabeth A. Masterson, PhD, CPH, COHC

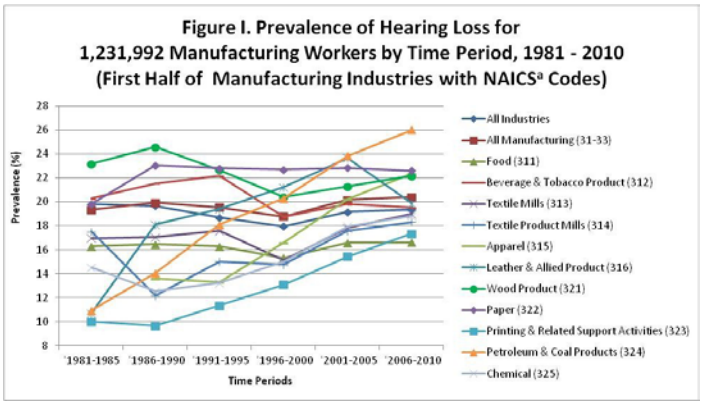
Occupational hearing loss (OHL) occurs with exposure on the job to loud noise or chemicals that can damage hearing, called ototoxic chemicals. Approximately 17% of workers in the United States are exposed to noise loud enough to be hazardous to their hearing (Tak, Davis & Calvert, 2009). Manufacturing workers make up the largest group of these noise-exposed workers.

The National Institute for Occupational Safety and Health (NIOSH) recently published information on the trends in hearing loss over a thirty-year time period for noise-exposed workers. "Trends in Hearing Loss by Industry Sector, 1981-2010" explored the trends in each industry sector and provided information for the Manufacturing sector as a whole (Masterson et al., 2015). We feel it is also important to report the trends for each industry within the Manufacturing sector. The methodology is detailed in the original paper (Masterson et al., 2015).

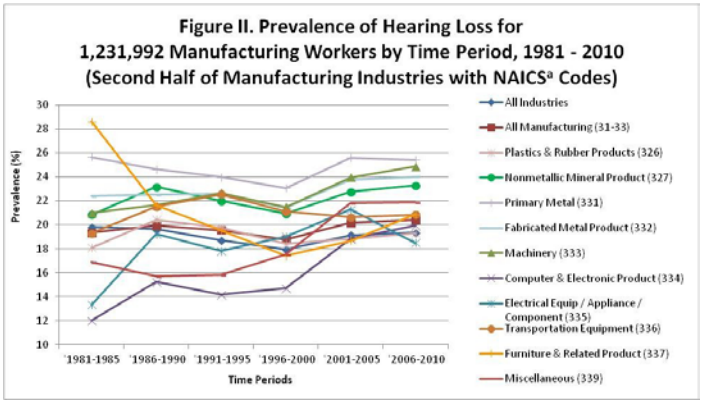
Briefly, we examined worker audiometric data collected by the NIOSH OHL Surveillance Project. The Project commenced in 2009 to develop a national surveillance system for OHL. As part of the Project, audiometric service providers, occupational health clinics and others, hereafter referred to as providers, shared de-identified audiometric tests with NIOSH, which were previously conducted for regulatory reasons for workers exposed to high noise (≥85 dBA). NIOSH assigned arbitrary employee IDs to the audiograms. We included audiograms for male and female Manufacturing workers ages 18 to 75 years during the years 1981-2010 and meeting study quality standards. We chose this time period because there were insufficient numbers of audiograms prior to 1981 and 2010 was the latest year of data available. We then analyzed the data in 5-year blocks to increase the sample size in industry groups and the power to detect trends over time.

We defined hearing loss using the NIOSH definition of material hearing impairment: a pure-tone average threshold across frequencies 1,000, 2,000, 3,000 and 4,000 Hz of 25 dB or more in either ear (NIOSH, 1998). The industries within the Manufacturing sector were identified using North American Industry Classification System (NAICS) codes (U.S. Census Bureau, 2011; U.S. Department of Commerce and The Kraus Organization Limited, 2007). NAICS codes range from two-digit to six-digit numbers and industry specificity increases with each digit. Our analyses were conducted at the 3-digit level of specificity.

We generated estimates of hearing loss prevalence for five-year time periods from 1981-2010, estimates of hearing loss incidence, and risk of incident hearing loss as compared with a reference time period for five-year time periods from 1986-2010. The prevalence is the percentage of workers currently suffering from hearing loss and represents the burden of the illness. Audiograms for 1,231,992 Manufacturing workers were included in the prevalence analyses. The incidence is the percentage of new cases of hearing loss. As such, every worker in the incidence analysis had to have at least two audiograms, so that to be considered a new case, the worker had to have a prior audiogram without hearing loss. Audiograms for 560,320 Manufacturing workers were included in the incidence analyses.



[a] *North American Industry Occupation Classification System*



[a] *North American Industry Occupation Classification System*

The risk estimates (probability ratios [PRs]) are not stand-alone estimates of risk, but depict the comparison of the risk for incident hearing loss in an industry in a time period, to the risk in that same industry in the reference time period (1986-1990). These estimates were adjusted for gender, age group, geographical region and provider. We assumed that workers in our reference time period would be at higher risk than workers in later time periods due to the timing of the 1983 OSHA Noise Standard amendment (29 CFR 1910.95). The regulation had only been effect for a short time and there is some evidence that regulations are protective (Verbeek et al. 2009). Audiograms for 560,320 Manufacturing workers were included in the analyses of risk.

The trends in prevalence are depicted in Figures I and II. As reported in the original article (Masterson et al., 2015), the prevalence in the Manufacturing sector as a whole remained steady over time, decreasing from 20% during 1981-1985 to 19% during 2006-2010. While the prevalence increased in many of the industries within Manufacturing,

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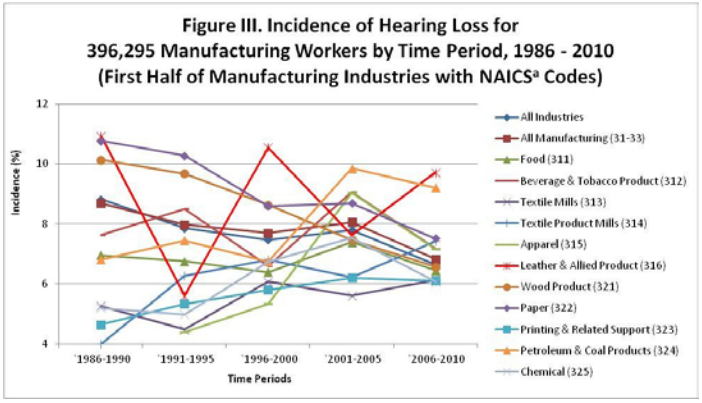

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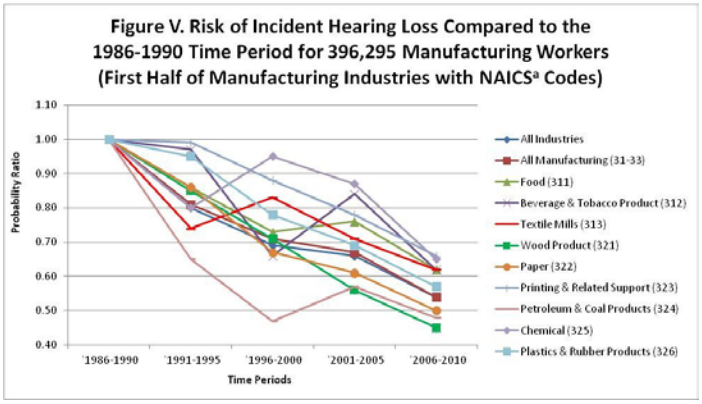

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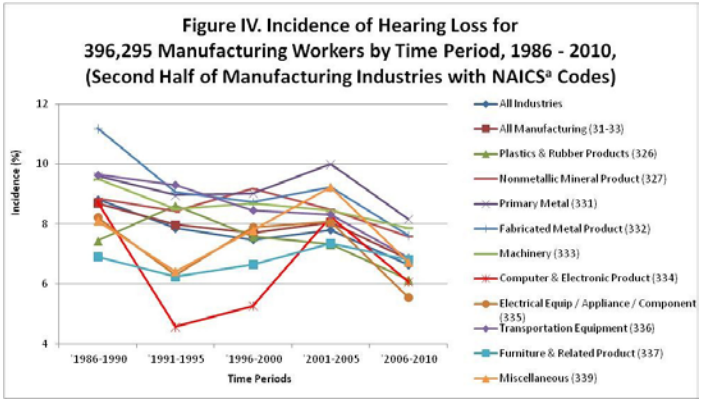
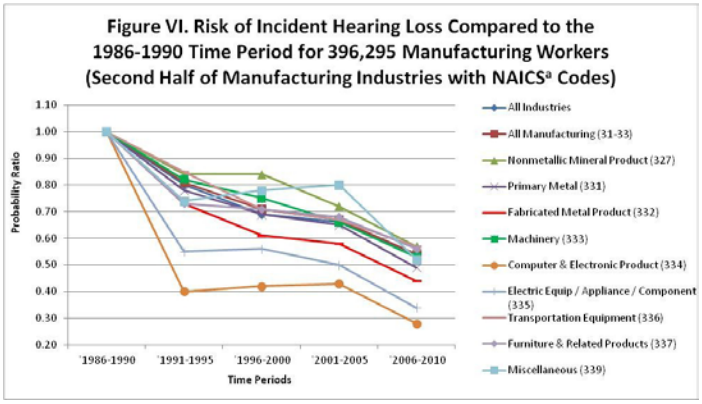


[a] *North American Industry Occupation Classification System*



[a] *North American Industry Occupation Classification System*

the increase was dramatic in Petroleum & Coal Products (from 11% to 26%), Leather and Allied Product (from 11% to 20%), and Apparel (from 14% to 22%). The prevalence decreased in only 4 of the 21 Manufacturing industries; in 3 of these by 1% or less. There was a substantial reduction in the prevalence of hearing loss within Furniture and Related Product (from 29% to 21%), although it increased in the last time period. The Manufacturing industries with the highest prevalence during 2006-2010 were Petroleum & Coal Products (26%), Primary Metal (25%) and Machinery (25%). The Manufacturing industries with the lowest prevalence were Food (17%) and Printing and Related Support Activities (17%), although the latter had a substantial increase over time.

Figures III and IV display the trends in hearing loss incidence. The overall incidence for the Manufacturing sector decreased from 9% to 7% over 25 years. The figures depict the widely fluctuating nature of the incidence trends for some industries, particularly Leather and Allied Product, Computer & Electronic Product, and Petroleum & Coal Products. All but six of the industries had a reduction in incidence over time. The two Manufacturing industries with notable increases in incidence were Textile Product Mills (from 4% to 7%) and Apparel (from 4% to 7%). Industries with appreciable reductions in incidence included Paper (from 11% to 8%), Fabricated Metal Product (from 11% to 8%), and Wood Product (from 10% to 7%). The Manufacturing industries with the highest incidence during 2006-2010 were Leather and Allied Product (10%), and Petroleum & Coal Products (9%). Seven Manufacturing industries tied at the lowest incidence of 6% during 2006-2010.

The trends in adjusted risk are depicted in Figures V and VI. Trends for three industries were not depicted due to insufficient sample size during 1986-1990, precluding us from using that period as the reference time period: Textile Product Mills, Apparel, and Leather and Allied Product. Later time periods were used as references for these industries for risk comparison. Specifically, 1991-1995 was used as the reference time period for Textile Product Mills, and 1996-2000 was used as the reference for both Apparel, and Leather and Allied Product. Nearly all of the PRs for each Manufacturing industry were <1, indicating that the risks were lower in later time periods than in the reference time period.

When comparing the risk in the latest time period to the reference time period, all but four Manufacturing industries had significantly lower risks during 2006-2010. These four industries with risks in the latest time period that were not significantly reduced from the reference time period were 1) Textile Mills, 2) Textile Product Mills, 3) Apparel, and 4) Leather and Allied Product. The risks for Textile Mills are depicted in Figure V. The risk for Textile Product Mills decreased 27% overall from 1991-1995 to 2006-2010, with no improvement in the latest time period. The risk actually increased in Apparel from the 1996-2000 period to the 2001-2005 period, with a modest reduction in the latest

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– continued from page 9: *Trends in Worker Hearing Loss within the Manufacturing Sector, 1981-2010...*

time period (20% overall). The risk in Leather and Allied Product was reduced by 32% overall, with only 2% in the latest time period. The two Manufacturing industries with the highest risks during 2006-2010 as compared with 1986-1990 were 1) Printing and Related Support Activities and 2) Chemical. The two industries with the lowest risks during 2006-2010 as compared with the 1986-1990 timeframe were 1) Computer and Electronic Product and 2) Electrical Equipment, Appliance, and Component Manufacturing.

These results indicate that some progress is being made in preventing worker hearing loss within the Manufacturing Sector. While the prevalence remained constant or increased for most Manufacturing industries, the incidence and adjusted risk of incident hearing loss indicated a clear downward trend for most industries. Over 25 years, there was a 46% reduction in the risk for hearing loss in the sector as a whole. As discussed in the original article, a reduction in occupational exposures or improved hearing conservation efforts are possible explanations or contributors to these improvements. Other factors may also be influencing these results. The overall reduction in smoking in the United States, which is a risk factor for hearing loss (Agrawal et al., 2008), and improved treatment of middle ear disorders, could also be contributing to the reduction in hearing loss incidence and risk.

While the general trend is positive, it is clear that some Manufacturing industries are in need of additional prevention efforts. The Apparel industry had substantial increases in both the prevalence and incidence of hearing loss, and the risk was not significantly improved in the latest time period as compared with the reference period. The incidence increased in the Textile Product Mills industry and the risk did not significantly improve. The prevalence of hearing loss within Petroleum & Coal Products, Primary Metal and Machinery was 25-26%, which was a dramatic increase for Petroleum & Coal Products. Finally, Leather and Allied Product had the highest incidence, a dramatic increase in prevalence, and no significant reduction in risk.

The NIOSH OHL Surveillance Project continues to conduct surveillance and research. Additional OHL surveillance information, documents, data and links are available on the NIOSH Web site at http://www.cdc.gov/niosh/topics/ohl/. There is also a link to sign up for Project email alerts. Thank you for your interest in protecting worker hearing!

Disclaimer

The findings and conclusions in this article have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

Mini-Bio/Affiliation

Elizabeth A. Masterson is an epidemiologist in the Surveillance Branch of the National Institute for Occupational Safety and Health, in Cincinnati, Ohio.

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UPDATE Call for Articles

CAOHC Wants to *HEAR* from you!

CAOHC is currently accepting articles for 2014 *UPDATE*, our publication offered at no charge to the entire hearing conservation community. Each edition is posted on our new website, reaching over 22,000 occupational hearing conservationists. Writing for *UPDATE* is your chance to reach thousands of colleagues within the hearing conservation industry who are committed to occupational Hearing Conservation, just like you!

Articles that will be selected must complement CAOHC's mission and goals, as well as be relevant. We are interested in hearing about innovative hearing loss prevention programs, new innovations in training employees to be hearing conservation compliant, your challenges and your successes.

In addition, *UPDATE* places the "spotlight" on an outstanding Occupational Hearing Conservationist, Course Director, or Professional Supervisor. If you know of someone in your company deserves the "spotlight" for their commitment to hearing conservation, please craft a brief testimonial (approximately 75-100 words or less) and include that person's name, your company name and a recent head-shot photo. Your "spotlight" candidate will be added to our next issue, as well as, posted to the CAOHC website.

Submit your article or your "spotlight" testimonial along with your contact information to Kim Stanton at kstanton@caohc.org, or our *UPDATE* Editor, Dr. Antony Joseph, at earsafety@yahoo.com. Also, please let us know what you would be interested in reading in future issues of *UPDATE*. You may send your comments or questions to the CAOHC Administrative Office at info@caohc.org. Thank you again for your interest in *UPDATE*!

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November 7, 2015
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November 12, 2015
Washington DC

Council Member Updates

Moving On……

Madeleine Kerr, Bruce Kirchner, David Lee (not pictured: Lee Hager)

CAOHC bids a fond farewell and thank you to three great Council members
Representing: ***American Association of Occupational Health Nurses (AAOHN)***

Madeleine Kerr, PhD, RN served on the Council for ten years. During her tenure Madeleine co-authored the chapter on Training and Motivation for the 5th Edition Hearing Conservation Manual, as well as numerous articles for *Update*. Madeleine also served as a leader on the Policy and Bylaws, OHC, and Exam committees and chaired the Nominating committee. In addition Madeleine served as Chair of CAOHC is will be Past Chair until November. Although Dr. Kerr is formally leaving the Council she will remain active as an OHC committee member working on the revision and update to the Anatomy, Physiology and Diseases of the Ear video along with the development of on-line education modules to provide greater access for OHCs regarding CAOHCs offerings

Representing: ***American Society of Safety Engineers (ASSE)***

David Lee, MIS CIH (ret) served on the CAOHC Council for ten years. During his time on the Council David served on the Noise Committee and was an integral part of the development of the Noise Measurement on-line course. In addition David served as a dedicated reviewer for chapters within the 5th Edition Hearing Conservation Manual and provided guidance to the past two Treasurer's as a Finance committee member. David and his wife are in the process of moving their life from Sparks NV to Northern WI.

Representing: ***American Industrial Hygiene Association (AIHA)***

Lee Hager, served on the CAOHC Council for over nine years. An active member of the Council, Lee served on the Executive Council as CAOHC Chair, and as Past Chair. Lee was a major contributor to the Noise Measurement on-line course curriculum, and was actively involved on the Noise Committee and Publications Committee. He volunteered as Guest Editor of the Update Newsletter multiple times, ensuring the quality of that publication. Lee served the CAOHC representative on the American National Standard Institute (ANSI) Bioacoustics Committee S.3, and was an advocate for initiatives such as the Safe-in-Sound Award for hearing loss prevention innovation. Lee's leadership, creativity, and energy will be dearly missed by the CAOHC Council

CAOHC Council Members-Spring 2015 Milwaukee

Top Row from left: Raúl Mirza-ACOEM, Ted Madison-ASHA, Don Garvey-ASSE, Bruce Kirchner-ACOEM, Brent Charlton-ASSE, Bryan Topp-AAOHN, and Antony Joseph-AAA

Middle Row from left: J. Andy Merkley-MAA, Elaine Brown-AAOHN, Charlie Moritz-INCE, David Lee-ASSE, Shanica Sampton-CAOHC, Madeleine Kerr-AAOHN, Chandran Achutan, AIHA, and Chris Whiting-CAOHC,

Seated Row from left: Pam duPont-ASHA, Karin Wetzel-AIHA, Kimberly Riegel-INCE, Kim Stanton-CAOHC (Not pictured: Laurie Wells-AAA, and Jim Crawford-AAO-HNS)

– continued from page 12: *Council Member Updates...*

Moving In....

To fill the void that these individuals are leaving the following individuals have been nominated by their respective associations (CPOs) to serve on the Council

Representing: ***American Association of Occupational Health Nurses (AAOHN)***

Bryan Topp, RN MPH COHN-S COHC

Bryan Topp is a graduate of the University of Minnesota-School of Public Health, he has attained both an MPH and an MS degree. In addition, Bryan is a COHN-S and a COHC. Bryan worked as a public health nurse, emergency department and ICU nurse before starting at 3M five years ago. Bryan worked for several years at a large complex 3M plants, providing occupational health services, managing programs, participating and leading multi-functional teams. In 2013 Bryan joined the corporate team and supports occupational health nurses (OHNs) in two business groups. He is leading the team to identify a process for integrating acquisitions into the 3M medical programs globally. Bryan participates on numerous corporate multifunctional teams to develop and maintain 3M's Global Health Standards. Bryan has hands-on experience managing 3M occupational health and safety programs that potentially impact over 300 3M plants and occupational health professionals globally.

Representing: ***American Industrial Hygiene Association (AIHA)***

Karin E. Wetzel, MSPH, CIH Karin is an Industrial Hygienist who has spent her 19 year career working in R&D and utilities within chemical and pharmaceutical industries. Karin has acted as a guest lecturer on numerous occasions for CAOHC courses and serves on the AIHA Noise committee. In addition to her work with her current employer Eli Lilly as an Industrial Hygiene Consultant for Parenteral Operations, Karin also serves as a Special Government Employee (SGE) for the OSHA Voluntary Protection Program (VPP). Karin received her Master's degree in Public Health, she is a Certified Industrial Hygienist and an AIHA Fellow

Representing: ***American Society of Safety Engineers (ASSE)***

Donald J. Garvey, CIH, CSP, ARM is the construction industrial hygienist with the 3M Personal Safety Division in St. Paul, MN. Prior to 3M, he was the construction industrial hygienist for The St. Paul Companies. Don has a Master's degree in environmental health from the University of Washington, Seattle, WA. He is a past chair of the American Industrial Hygiene Association Construction Committee and is a Fellow of the Association. He has published several articles in *Professional Safety* and is author of the industrial hygiene chapter in the ASSE's recently published *Construction Safety Management and Engineering 2nd Ed.*

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Recognition for one of our own……

CAOHC Course Director, Richard (Dick) Danielson was recently honored with the Silver Snoopy Award

The **Silver Snoopy award** is a special honor awarded to NASA employees and contractors for outstanding achievements related to human flight safety or mission success. The award certificate states that it is "In Appreciation" "For professionalism, dedication and outstanding support that greatly enhanced space flight safety and mission success." The award depicts Snoopy, a character from the *Peanuts* comic strip created by Charles M. Schulz.

The award is given personally by NASA astronauts as it represents the astronauts' own recognition of excellence. It is presented at the workplace of the recipient with the recipient's coworkers present. The Silver Snoopy award is one of several awards overseen by the Space Flight Awareness (SFA) program at NASA.

The award consists of a sterling silver "Silver Snoopy" lapel pin flown during a NASA mission, a commendation letter (stating the mission the Silver Snoopy pin was flown on) and a signed, framed Silver Snoopy certificate.

Congratulations, Dick!

CAOHC is Consolidating Your Numbers

Did you know that if you are a COHC, CD, and a CPS/A within the CAOHC database you could have up to three (3) different identification numbers and two (2) different certificate numbers? If you did not know, CAOHC does, and our database is becoming unwieldy. In an effort to remedy the confusion we are going to consolidate all of your numbers into just one.

At the end of September you will receive a certificate and wallet card with your permanent number. If you are an active CD, COHC and CPS/A your permanent number will be your CD identification number. If you are a COHC with multiple numbers CAOHC staff will determine which number has the most recent activity (i.e., recently recertified or recent information update) and designate that as your permanent number. CAOHC staff may contact you to verify information in the event we find duplicate records for the same person.

The consolidation will allow users to create their own username and password thus providing more security for your demographic and exam information.

The consolidation process should be quick and seamless. If you have any questions or concerns please contact Kim Stanton (kstanton@caohc.org).

Leadership

The CAOHC leadership otherwise known as the Council consists of two representatives from each of the following Component Professional Organizations (CPO).

- **American Association of Occupational Health Nurses (AAOHN)**
  Madeleine J. Kerr, PhD RN
  CAOHC Council Past Chair
  Elaine Brown, RN BS COHN-S/CM COHC
  Bryan Topp, RN, MPH, COHN-S, COHC
- **American Academy of Audiology (AAA)**
  Laurie L. Wells, AuD FAAA CPS/A
  CAOHC Council Vice Chair-Education
  Antony Joseph, AuD PhD CPS/A
- **American Academy of Otolaryngology - Head & Neck Surgery (AAO-HNS)**
  James Crawford, MD MAJ(P) MC USA
  CAOHC Council Vice Chair
- **American College of Occupational and Environmental Medicine (ACOEM)**
  Bruce Kirchner, MD MPH CPS/A
  CAOHC Council Chair
  Raúl Mirza DO, MPH, CSP/A
- **American Industrial Hygiene Association (AIHA)**
  Chandran Achutan, PhD
  Karin Wetzel MSPH, CIH
- **American Speech-Language-Hearing Association (ASHA)**
  Pamela G. duPont, MS CCC-A CPS/A
  Ted K. Madison, MA CCC-A
- **Institute of Noise Control Engineering (INCE)**
  Charles Moritz, MS INCE Bd Cert.
  Kimberly Riegel, PhD
- **Military Audiology Association (MAA)**
  MAJ J. Andy Merkley, AuD CCC-A CPS/A
- **American Society of Safety Engineers (ASSE)**
  Don Garvey, CIH, CSP, ARM
  Brent Charlton CSP, COHC

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555 E. Wells St.
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