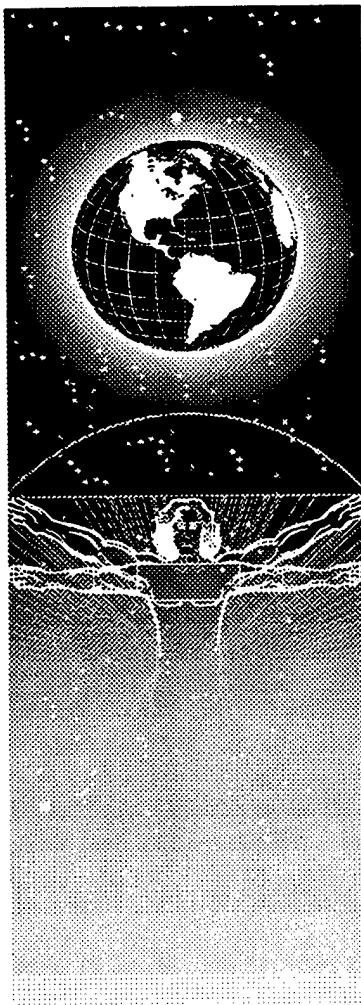




UNITED STATES AIR FORCE RESEARCH LABORATORY

A Glimpse of History: The Origin of Hearing Conservation Was in the Military?

Charles W. Nixon

January 1998

Interim Report for the Period June 1995 to June 1997

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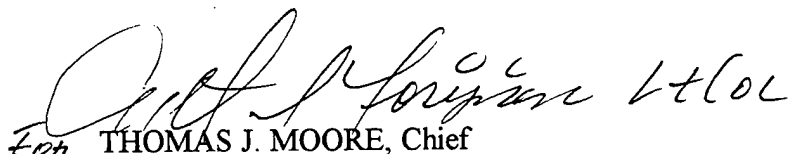
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FOR THE COMMANDER


THOMAS J. MOORE, Chief
Crew Survivability and Logistics Division
Air Force Research Laboratory

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PREFACE

This work was accomplished in the Noise and Vibration Branch, Crew Survivability and Logistics Division, Human Effectiveness Directorate, Air Force Research Laboratory, Wright-Patterson AFB, OH. The report related to the early and ongoing work accomplished, in part, by civilian and military personnel in this laboratory. It archives the emergence and growth of hearing conservation programs in the military and notable pioneering efforts initiated and maintained by the Air Force, including the first hearing conservation program.

The effort was done under Project 7184, Biomechanics of Air Force Operation, Task 718441, Biocommunications, Work Unit 71844104, Bioacoustics and Biocommunications Research. The Task Manager for this effort was Richard L. McKinley, AFRL/HESN.

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HEARING CONSERVATION

During and following World War II (1941 - 1945), and later the Korean War (1950 - 1953), there were no hearing conservation programs in the military, or elsewhere in the nation. Professional areas such as audiology, otology, otolaryngology, and psychoacoustics were focused on high priority problems that degraded performance and increased the vulnerability of U.S. personnel in combat. Among the most important problem areas identified at that time were audition, voice communications, and operator performance. General knowledge was well advanced in these areas; however, very little experience had been acquired with these problems under combat conditions. The government dealt with these situations by mobilizing efforts to accelerate their resolution to the extent required to increase human performance and to provide advantages to U.S. military personnel over their foes.

Intensive research programs to support the military were initiated by the government in universities, government laboratories, and in some industries. Among these programs was one instituted at Harvard University in 1940 that consisted of a special group of experts who focused on "increased understanding to enhance communications and performance" for military purposes. This group created solutions to emerging problems as well as to those that continued to threaten military personnel. The Harvard Psycho-Acoustics Laboratory (PAL) research included articulation testing, hearing aids, hearing protection devices, perception, and many other areas of psychoacoustics. Timely and outstanding work was successfully accomplished by this Who's Who group of scientific experts. They were highly motivated, responsive to a wide variety of issues, and instrumental in completing tasks that were critical to the successful war effort. Most of the key scientists left the group and moved to other positions at different times following the close of the war. In 1962, the name of the laboratory was changed to the Psycho-Physics Laboratory. It was closed in 1973.

Similar research was also underway in numerous universities and in government laboratories, such as the Navy research laboratories at Pensacola, San Diego, and New London, and the Army Research Laboratory at Ft Knox. Most of these laboratories were directed and operated by key professional personnel from academia working in cooperation with the staff at the local government facility. Personnel in these laboratories tackled problems and issues that also originated within wartime operations and were being pursued at the PAL and at numerous universities.

AURAL REHABILITATION

The Army and Navy Surgeons General anticipated a large number of aural casualties due to combat who would need rehabilitation before returning to civilian life. Aural rehabilitation centers were established at Walter Reed Hospital, Washington, DC in 1943 and the U.S. Naval Hospital, Philadelphia, PA in 1944. However, the first waves of patients were not casualties returning from combat, but individuals accepted for military service with undetected partial deafness. It was not anticipated that such a large number of those who entered the Army and Navy would be handicapped with impaired hearing. The earliest aural rehabilitation was provided to these inductees with existing partial hearing losses instead of to those returning from combat with aural problems.

Although audiometers were available at that time, audiometric testing rooms were not constructed at the large number of induction centers required to process incoming personnel. The conversational speech test was used to evaluate the hearing ability of inductees. The Army used 20/20 and the Navy 15/15 as normal hearing. The denominator was the distance in feet at which conversational speech was understood by normal hearing persons, and the numerator indicated the distance at which the individual inductee actually understood the speech. There were no firm guidelines or quality controls for ensuring consistency with administration of the speech test, and many men with impaired hearing were mistakenly inducted as normal hearing. Some of these men were accepted because the tests for identifying hearing loss were inadequate and others were able to fool those who evaluated their hearing upon entering the military. Many individuals intent on fighting for their country developed strategies that defeated the speech test. Consequently, audiometric tests of these individuals at the time of their discharge from the military showed the presence of hearing loss. Since there was no evidence of hearing loss in the tests administered prior to entering the service, many of these individuals received life-long compensation for hearing loss from the government.

Most of the hearing losses that were not identified during induction were revealed later in training and these men could have been discharged. However, the military urgently needed manpower and the aural rehabilitation centers provided training that enabled the partially deaf to successfully perform special duty assignments with their impaired hearing capabilities.

Active-duty military personnel who could no longer perform their duties under combat conditions because of medical and/or psychological reasons began returning to the military medical centers. The patient loads at medical treatment centers grew to maximum capacity. The level of effort focused on recovery and rehabilitation was increased to accommodate this growing population of veterans. Some existing research programs in other areas were redirected to accommodate the swell of those requiring aural rehabilitation. The center at Walter Reed was moved to Deshon General Hospital in Butler, PA, and two other Army aural rehabilitation treatment centers were established at Hoff General Hospital in Santa Barbara, CA and Borden General Hospital in Chickasha, OK. The U.S. Naval Hospital in Philadelphia remained the only Navy aural rehabilitation center. The Army established a Surgeon General's Branch to oversee the operation of their centers. The three Army aural rehabilitation centers were consolidated and returned to Walter Reed Army Medical Center in 1946 at what was then known as the Army Audiology and Speech Correction Center. The Walter Reed aural rehabilitation center was staffed by civilians for the next 20 years. Dr. Aram Glorig, the first recipient of the National Hearing Conservation Association (NHCA) Award for Outstanding Contributions to the Field of Hearing Conservation, was one of the first directors of the Army Audiology and Speech Correction Center. He has been an outstanding consultant and strong supporter of military audiology and hearing conservation during his entire career. During this period, the Army held the first conference on "Rehabilitation for the Hard of Hearing Soldier" and began providing V-51R earplugs to artillery personnel.

The population of military personnel requiring rehabilitation grew even larger after the close of WW II in 1945. An arrangement between the Navy Department and the Veterans Administration (VA) enabled veterans to be admitted as VA patients beginning in the fall of

1946. The VA, established in 1930 by combining the Veterans Bureau, the Bureau of Pensions, and the National Home for the Disabled Volunteer Soldier, was reorganized under the Soldiers Readjustment Act of 1944. Although the development of hearing conservation programs was of interest, it was of relatively low priority compared to aural rehabilitation during the post-war recovery period. Many universities with speech, hearing, and audiology outpatient clinics provided government-sponsored aural rehabilitation services for veterans. A partial chronology of events that directly and indirectly influenced the evolution of hearing conservation programs in the military services is tabulated in Appendix A.

A very significant event took place in 1947. The U.S. Air Force was established as a branch of the military separate from the Army Air Corps. The importance of air power to the conduct of war was acknowledged.

JET AIRCRAFT NOISE

One of the most important occurrences to the subsequent development of hearing conservation programs was the introduction of jet engine aircraft into the military in the late 1940s and early 1950s. The unprecedented increase in the intensity of the noise from jet aircraft was viewed with alarm; no sound of that magnitude and duration had ever been routinely experienced in military operations or by civilians. Initial observations revealed that jet engine noise, with and without afterburner, was substantially more powerful than the noisiest propeller aircraft. Jet engine noise was described as an increasingly serious hazard that will cause permanent hearing loss in a short time, make voice communications impossible, and impose physiological effects. The cited effects included, (a) skull and teeth may vibrate as well as the soft tissues of the throat and nose, (b) body and chest and muscles of the arms and legs may vibrate, (c) blurring of vision, and (d) a feeling of fear. Aftermath effects were described to include earache, headache, excessive fatigue, and irritability.

A malaise-type illness with accompanying headaches, called "ultrasonic sickness," spread throughout the jet engine maintenance community. It was attributed to very high, ultrasonic frequency energy in jet noise spectra that was not present in the spectra of propeller aircraft engine noise. A medical study conducted in various operational aircraft units subsequently revealed that the symptoms and the illnesses that were being reported were real. The study also reported that there were no direct cause-and-effect relationships of the sickness with the ultrasound. It was concluded that the ill effects were due to the very high levels of the audible frequencies and not from exposure to ultrasound. Ultrasonic sickness in the workplace was associated with subjective reactions to the dramatic changes in environments from the propeller aircraft to the jet aircraft engine noises. The symptoms of the ultrasonic sickness gradually disappeared, without treatment, as personnel became more familiar with the new, high-level noise environments.

The Navy expressed special concern for aircraft carrier operations with the jet engine aircraft because crew members were required to be very close to the aircraft during flight deck operations and during maintenance. A special investigation of the effects of the jet aircraft engine noise on personnel aboard the aircraft carrier USS Coral Sea was accomplished and reported in 1952. This shipboard study verified the negative impact of the jet noise on the

aircraft carrier personnel and on operations. The report was interpreted to conclude that the scope and seriousness of the high-intensity noise problem was much greater than commonly believed.

NATIONAL ACADEMY OF SCIENCES - NATIONAL RESEARCH COUNCIL

Exposures of personnel to high-intensity noises from jet aircraft immediately became a major priority of the Navy. The Navy petitioned the National Academy of Sciences - National Research Council (NAS-NRC) Committee on Hearing for assistance with this new noise phenomenon that was a major threat to jet aircraft operations and to the safety and health of both crew members and support personnel. During this period the Psycho-Acoustics Laboratory at Harvard conducted a survey of facilities and personnel capable of defining the nature of the high-intensity noise problem. A recommendation from the survey was to conduct a special study, involving recognized personnel and facilities, of the nature of the intense noise produced by military aircraft. This recommendation was approved by the NAS Committee on Hearing.

COMMITTEE ON HEARING AND BIOACOUSTICS

The NAS-NRC, in response to the Navy request, also established a special committee to respond to questions and issues dealing with the new intense noise. The committee was called the NAS-NRC Armed Services Committee on Hearing and Bioacoustics (CHABA). It was jointly organized by the three services in December 1952. CHABA was to consider problems in the areas of (a) effects and control of noise, (b) auditory discrimination, (c) speech communications, (d) fundamental mechanisms of hearing, and (e) auditory standards. The committee consisted of about an equal number of representatives appointed by the three services and civilians appointed by the NAS-NRC. The first committee of CHABA was comprised of five individuals: Hallowell Davis, Edwin Newman, Horace Parrack, Clifford Phoebus, and Aram Glorig. Don Eldredge was the Executive Secretary.

NO EXPERTS IN THE HOUSE

A major dilemma with the jet engine noise problem existed at that time; virtually no experts on the effects of high-intensity noise on people were available to the NAS-NRC. The jet noise phenomenon appeared somewhat suddenly, and there had been little opportunity for scientists to access this noise source and to study its characteristics and effects. The precise effects of high-intensity noise on man were largely unknown. Scientific studies of these effects could not be accomplished until the very high levels of the sound sources could be controlled enough to ensure safe human experimentation. The high levels of jet engine noise were new to human experience. It was clear that the nation was not equipped to immediately deal with this high-intensity noise problem.

BIOLOGICAL EFFECTS

The major concern of the military services was the anticipated biological and non-auditory effects of the high-intensity noise, as well as its effects on the auditory system. The threat that this high-level noise caused disorientation, tissue discomfort and pain, interference

with the primary senses of touch, vision and the like, disruption of performance of skilled tasks, fatigue, loss of sleep, and long-term cumulative impairment of the brain took precedence over hearing and voice communications. The Navy request for a quick study of these risks was the first scientific problem approved by CHABA.

The committee established a working group to respond to the Navy request. The working group consisted of Hallowell Davis, William Neff, Walter Rosenblith, and Horace Parrack. In view of the urgency of the problem, the paucity of experience and of information in the literature, and the recommendations of the PAL survey, a contract was executed by the Office of Naval Research with the University of Chicago. The contractor was to conduct a survey of existing information, conduct preliminary experiments, and make recommendations for future actions that would enable people to work effectively and safely in very high levels of noise. A team of scientists and engineers with expertise in areas closely related to the problem were assembled and provided extensive indoctrination on the nature of the problem prior to initiation of the study. The short-term study was conducted in early 1953 and included site visits to an aircraft carrier and other airbases supporting jet engine powered aircraft. The team accomplished its difficult task within the allotted time by moving to locations where access to good laboratory facilities and jet aircraft engine noises was available. Members of the team, and other volunteer subjects, were exposed to incrementally-increasing levels of jet engine noise to establish thresholds and tolerance limits of human systems.

BENOX REPORT

In December 1953, the unprecedented accomplishments of this team were published as the Biological Effects of Noise Exploratory Study (BENOX) report. It contains individual reports of independent and cooperative research in the areas of concern with high-intensity sound exposures. The individual studies, conclusions, and recommendations of the report include the general areas of aural pain, hearing loss and hearing protection, limiting factors for protecting the ear from noise, communication, orientation in space, central nervous system effects, psychological effects, and neuropsychological effects. The report recommends routine audiometric monitoring for the prevention of noise-induced hearing loss as well as the establishment of databases that provide additional knowledge about the effects of both single and repeated noise exposures on hearing. BENOX was, and is, a benchmark report of experiments of biological responses to intense acoustic energy, many of which have never been repeated. The scientists and engineers who performed the research for the BENOX report had relatively little information about military operations, so their results were further interpreted for these applications by the working group and by appropriate military personnel.

SEEDS OF HEARING CONSERVATION PROGRAMS

Shortly after its creation in 1952, CHABA began to sponsor and publish reports of other study efforts focused on the needs of the military. Some of the first reports addressed "High-Intensity Noise and Military Operations" and the "Effects of Blast on Man." The topics were almost immediately expanded to include other reports on testing hearing in the armed services, monitoring audiometry, evaluating audiometers, problems of criteria for noise, and hearing conservation data and procedures. These reports accomplished for the military represent an early

recognition of the existing and potential problems of controlling noise exposure as a preventive measure. The relationship between noise exposure and hearing loss was not well enough understood to generalize about the threat of noise environments. In spite of this lack of information, several prominent scientists developed and proposed limits for noise exposure based on their individual understanding of the function of the human auditory system.

Dr. Aram Glorig, a long-time consultant to the Army in audiometry and otolaryngology, toured 11 Army installations in 1954 after the Korean hostilities ceased in order to form an opinion as to whether the noise problem was serious enough to demand attention. He provided individual recommendations for each of the installations ranging from the distribution of hearing protection devices in some instances to the establishment of hearing conservation programs in others. Dr. Glorig was also a member of the CHABA council and Director of the American Academy of Otology and Otolaryngology (AAOO), Committee on Conservation of Hearing. A Subcommittee on Noise in Industry Research Center was established by the AAOO in 1947 to study the relationships of noise exposure and hearing loss. This Center conducted hearing conservation research and pioneered the distribution of educational and training materials to industry and the public. Dr. Glorig continued to promote hearing conservation by publishing and distributing a series of brief, informative reports on audiology and hearing conservation suitable for public dissemination. The subcommittee became affiliated with the University of Southern California in 1965.

Throughout this period of time, much of the research accomplished under the NAS-NRC in universities, the Harvard PAL, and in many government laboratories was sponsored by the Office of Naval Research (ONR). ONR was the original CHABA agent that accomplished all contractual and administrative actions of the committee between the sponsors and the NAS-NRC until the early 1990s.

Dr. Horace O. Parrack, better known as "Hop" and the Air Force member of the CHABA committee, was a strong advocate of hearing conservation programs even with the dominant emphasis at that time on whole body and non-auditory effects. He initiated efforts to establish a hearing conservation program in the Air Force because he recognized the long-term development of permanent hearing loss and the need to control the exposure of personnel working in noise. In addition to intense individual efforts, he obtained primary guidance from an Ad Hoc Committee on Audiology convened by the Air Force Surgeon General and from the CHABA. Interest in hearing conservation programs began to spread with the recognition that the best solution to noise-induced hearing loss is prevention.

TENTATIVE NOISE EXPOSURE AND HEARING LOSS RELATIONSHIP

The AAOO published a pamphlet titled "Guide for Conservation of Hearing" in 1953; the Navy published a Bureau of Medicine and Surgery Instruction called "Hearing Conservation Program" in 1955; the Army published Technical Bulletin Medical 251 "Noise and Conservation of Hearing" in 1956 (revised in 1967 and again in 1972); and CHABA published a Memorandum No. 2 on "Hearing Conservation Data and Procedures" also in 1956. These documents described components of hearing conservation programs and provided a range of recommendations for their implementation. The CHABA memorandum included data on the levels of noise produced

by specific machines and on work areas that included these machines. The Navy instruction assigned responsibilities and requirements for implementing the elements of their instruction. However, none of these documents included requirements such as noise exposure criteria, limits on exposures, or other means of determining when personnel were overexposed to noise to a degree that threatened hearing. The AAOO, in their revised guide published in 1957, stated that "At the present time our knowledge of the relations of noise-exposure to hearing loss is much too limited for us to propose safe amounts of noise exposure." This quote reflects the period of time extending through the 1960s during which the relationships between noise exposure and hearing loss were not well enough defined to convince most agencies and organizations to establish general noise exposure criteria.

FIRST HEARING CONSERVATION REGULATION

The Air Force published the first hearing conservation regulation in October 1948, soon after its creation as a separate military service, and revised it in 1949. This Medical Services regulation, AFR 160-3 "Precautionary Measures Against Noise Hazards," established requirements for prevention of illness and injury from the operation and testing of jet and rocket engines where hazardous levels of noise existed. This early regulation assigned program responsibility to surgeons at AF installations. Dangers were reported that a 20 dB hearing loss in the frequency range of 500 to 3400 Hz would be acquired from 8 to 16 minute exposures to a level of 130 dB, cumulative loss would be acquired with repeated exposures (without sufficient rest), and transient physiological effects of vertigo, nausea, visual difficulties, fatigue, and irritability would be experienced. Limiting noise exposures were defined in terms of overall sound levels in the audio spectrum. Overall exposures should never exceed 95 dB and should be kept below 85 dB. Overall exposures in areas with transient occupancy should never exceed 100 dB. Standard ear defenders, cotton wads moistened with paraffin, or custom-molded dental acrylic earplugs were effective only against minimal exposures. Individuals exposed to sound fields over 130 dB for longer than five minutes during any 24-hour period were required to have weekly audiograms, and if the loss was over 20 dB the individual was temporarily reassigned to noise-free duties until hearing recovered. Pre-employment audiograms were mandatory.

The Army published TB MED 195 in 1947. This bulletin on "The Army's Audiology and Speech Correction Program for the Deafened" was based on the comprehensive aural rehabilitation programs that were provided to the veterans of WW II. It was not a hearing conservation document.

FIRST COMPREHENSIVE HEARING CONSERVATION PROGRAM

The Air Force objective to establish a comprehensive hearing conservation program was achieved on 31 October 1956. Air Force Regulation 160-3, "Hazardous Noise Exposure," became the first recognized "complete" hearing conservation program either within or outside the military. Some of the unique features of that early document were:

- 1) Responsibilities for implementing and sustaining the program were assigned to commanders, surgeons, and other functional units such as operations, safety, and ground maintenance

- 2) Identification of hazardous noise environments required measurements and labeling, and data were retained as permanent records
- 3) Use of a hearing conservation data card that also included noise exposure and hearing protection information
- 4) Establishment of an audiogram data bank: one copy of the hearing conservation data card was sent to the central repository at the USAF School of Aviation Medicine, Randolph Air Force Base, TX. The repository was moved to Brooks AFB in 1959.
- 5) Integration of individual exposures during the work day into an 8-hour daily exposure
- 6) Limiting noise exposures were defined in terms of the sound levels in the four octave bands from 300 Hz to 4800 Hz
- 7) A nomogram for quickly determining the limiting noise exposure by inspection
- 8) Information on noise levels measured at specific machines and in the work areas around the machines was provided in tabular form
- 9) Provisions for adjusting allowable noise exposures when pure tones were present in the noise (reduce allowable exposure level by 10 dB)
- 10) Hearing classifications established as A, B, and C depending on amount of hearing loss
- 11) Flow charts providing guidance for the disposition of personnel based on amount of hearing loss

This 1956 Air Force Regulation, and its revised version in 1973, were model comprehensive programs after which those in many organizations within and outside the government were fashioned. Some of the major appeals of this program, other than the novelty, were its comprehensive nature and the inclusion of noise exposure standards and criteria. All elements were included that are considered important to an effective hearing conservation program by today's standards. All current military hearing conservation programs are fully comprehensive in their structure and operation.

NOISE EXPOSURE CRITERIA

Dr. Henning Von Gierke, the fourth recipient of the NHCA Award for Outstanding Contributions to the Field of Hearing Conservation, was instrumental in the early development of numerous noise exposure criteria including the "Criteria for Short Time Exposures to High Intensity Jet Aircraft Noise" in 1955 and "Criteria for Work Spaces, Living Spaces, and Other Airbase Areas" in 1957. Other early information on the relationship of noise exposure to hearing loss was available in the BENOX study (Kryter (1950), Davis (1950), Strasberg (1952), and Tonndorf (1953)). In 1965, the CHABA published the first national criteria on "Hazardous Exposure to Intermittent and Steady State Noise." The CHABA "Proposed Damage-Risk Criteria for Impulse Noise (Gunfire)" was developed with extensive input from Army personnel and published in 1968.

Interest in hearing conservation was growing both in the military and in industry. Research efforts continued to improve databases of the noise exposure/hearing loss relationship. The number of new and improved hearing protection devices was increasing. The Navy increased its civilian staffing for hearing conservation in 1960, acquiring its first (10) military audiologists in 1979. The Army established requirements for and acquired its first (11) military

audiologists in 1966. They were required to know how to develop hearing conservation programs.

Starting with the original 11, individual Army audiologists made significant contributions to the advancement of the profession both within and outside the military. Army audiologists organized the first annual Army Audiology Meeting in 1967 (audiologists from the other services participated) and established the Military Audiology and Speech Pathology Society (MASPS) in 1968. MASPS annual workshops sustain interservice interactions and ensure that state-of-the-art science and technology (often initiated by the military) are fully utilized by military audiologists and hearing conservationists. The first Army training course on military audiology was also conducted in 1968, one year before the first training course in the Navy.

During this period several organizations developed and recommended guidelines and requirements on hearing conservation in hazardous noise environments. Among them were the International Standards Organization (ISO), the "Intersociety Committee," the American Conference of Governmental Industrial Hygienists (ACGIH), and the National Academy of Science Committee on Hearing, Bioacoustics and Biomechanics. The two CHABA criteria documents addressed intermittent and steady-state noise and impulse noise (gunfire).

NATIONAL INTERVENTION

The 1969 amendment to the Walsh Healy Public Contracts Act of 1935, by the Department of Labor, Safety and Health Standards Department, was the next significant hearing conservation historical event because it established hearing conservation requirements at the national level. The amendment required that protection against the effects of noise be provided when sound levels exceeded an equivalent 8-hour exposure of 90 dBA (with a 5 dB trading relationship). Individual exposures during a work day (8 hours) were summed. Impulsive/impact exposures could not exceed 140 dB peak pressure level. If engineering controls did not work, hearing protection was required. In 1971, this noise standard was incorporated in the Occupational Safety and Health Act of 1970, after which a revision process began that produced the OSHA Hearing Conservation Amendment of 1983.

The Navy also adopted this noise standard of an equivalent 8-hour daily exposure at 90 dBA (5 dB trading relationship) in March 1970 (BUMEDINST 6260.6B) in their full hearing conservation program. Hearing conservation programs were mandatory when noise levels exceeded 90 dBA. The greatest boost to the Navy hearing conservation program occurred in 1979, when responsibility was transferred from the Bureau of Medicine to the Chief, Naval Operations. This ensured that all Navy personnel would be included in the program. In 1972, the Army adopted a criterion of an equivalent 8-hour daily exposure of 85 dBA, retaining the 5 dB trading relationship (TB MED 251). However, the Army "Noise and Conservation of Hearing" bulletins did not include requirements, but only guidelines and recommendations for implementation. In 1971, the Army initiated a pilot study that eventually led to the establishment of its hearing data repository.

In the early 1970s, the Environmental Protection Agency, Office of Noise Abatement and Control (ONAC) was created and the Noise Control Act was enacted. Several criterion

documents were produced, including "Public Health and Welfare Criteria for Noise" and "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety." These were called the "criteria" and "levels" documents. ONAC initiated and sponsored important research that significantly increased the understanding of noise effects and advanced the science of noise and man. The Office of Noise Abatement and Control was abruptly and unexpectedly shut down in the early 1980s. The most pervasive impact was the disappearance of an aggressive and productive national noise research program that has never recovered or been restored.

COMPREHENSIVE HEARING CONSERVATION PROGRAMS IN DOD SERVICES

In 1978, the first Department of Defense Instruction (DoDI) was published and contained guidance and requirements that were intended to make hearing conservation programs uniform across services. The individual branches of the service responded by implementing or modifying their programs to be in compliance with the DoDI. The Navy (OP NAV INST 6260.2) updated their hearing conservation program in 1978, the Army implemented their program (TB MED 501) in 1980, and the Air Force revised the 1956 AFR 160-3 regulation to create the new AFR 160-3, "Hazardous Noise Exposure" in 1973. Major changes introduced in the new Air Force regulation included limiting noise exposures in terms of the A-weighted level of the noise (dBA); adoption of a noise criterion of an equivalent 8-hour daily exposure of 84 dBA with a 4 dB trading relationship; detailed criteria for various types of impulsive noise exposures; noise exposure limits for infrasound (20 Hz and below) and for ultrasound (12,500 to 40,000 Hz); whole body effects criteria; and music exposure criteria. In addition, criteria were added for effective voice communications in activities ranging from noisy work places to rest and relaxation areas. Mean sound attenuation values and five categories of C-A attenuation values were provided for 21 hearing protector, helmet, and headset systems that were standardized for use in the Air Force.

COMPLIANCE WITH NATIONAL PROGRAM REQUIREMENTS

In 1980, all three branches of the DoD uniformed services had implemented comprehensive hearing conservation programs that included responsibility, standards, criteria, and the other elements that were missing from earlier instructions and bulletins. The DoD mandated that the uniformed services would comply with the laws of the land, which in this case was OSHA. From the beginning of this mandate, the standards and criteria of the military programs have been more stringent and more protective of exposed personnel than those of OSHA. Initially, the threshold for implementing military programs was 85 dB instead of 90 dB. Subsequently, the trading relationship was changed from 5 dB to 4 dB per halving or doubling of the A-weighted level of the noise. Today, the Army and the Air Force have adopted the 3 dB trading relationship for better control of the very high levels of noise experienced by military personnel.

AFTER A GLIMPSE OF HISTORY

The original members of CHABA were the Army, Navy, and Air Force. The interest in the effects of high levels of noise on biological systems of man and animals and the applications

of the information grew slowly outside the military. However, during the late 1970s and 1980s, when environmental issues became popular, occupational and community noises become national concerns. Federal agencies came to CHABA seeking assistance on the problems peculiar to their charters. During the 1970s and 1980s the makeup of the CHABA membership changed and the military members were outnumbered. Some of the agencies with membership in CHABA were the FAA, EPA, NIH, NIA, NSF, NINCDS, NIOSH, and AFOSR. Financial support for CHABA dwindled in the late 1980s and early 1990s until it was insufficient to support a standing committee of the National Academy of Sciences. The Symposium on Speech Communications Metrics and Human Performance, held at the National Academy on 3 - 4 June 1993, was the last scientific meeting sponsored by CHABA. The committee ceased to exist in 1994, and bioacoustics and biomechanics work that was covered by the CHABA charter is now included under a new Task Force on Behavioral, Cognitive, and Sensory Sciences.

Our 40-year glimpse of hearing conservation in the military deliberately avoided citing the names of all those individuals (with a few exceptions) who "really made the difference" and pushed programs forward under very difficult conditions. A list of contributors could not have been cited without unintended omissions. The focus on hearing disabilities caused by noise was new, science and technology were very limited, and every action required convincing others to join the attack on the problem. As usual, key individuals, both within and outside the military, were responsible for most of the significant advances. Current progress is also due to key individuals in the Army, Navy, and Air Force who recognize the importance of human centered programs and continue to strive for the best in hearing loss prevention and hearing conservation.

Developments that have taken place since 1980, when all three military services implemented comprehensive hearing conservation programs, are not considered part of our glimpse of history. The uninterrupted progression of the military hearing conservation programs has been facilitated by extensive interservice interactions. The experience with and data from the audiometric data registries provide unique insight into weaknesses in the operations as well as opportunities for improvements. The accelerating growth of data storage and management, as well as automation in the clinics, has been fully exploited in the growth of these programs.

The next significant event in the history of military hearing conservation programs will be the establishment of a new DoD Hearing Conservation Program that will be uniform across the three services. Dr. Doug Ohlin, Chair of the DoD Hearing Conservation Working Group, merits recognition for his outstanding acceleration of the efforts of his group. Consensus has been obtained on diverse issues among the services, and the extensive documentation and marketing required for the proposed program has been produced in record time. The initial phase of the new DoD Hearing Conservation Program is expected to be implemented in 1998.

SUMMARY

This brief story provides highlights in the evolution of hearing conservation programs in the military. Among the primary stimuli for these developments were WW II and the deployment to air bases and carriers of military jet engine powered aircraft. The pioneering efforts to conserve hearing were initiated by the Army, Navy, and Air Force. Although these activities to conserve hearing in noisy environments occurred in the military, invaluable input

and direction were provided by individuals in government, academia, industry, and medicine. The first comprehensive hearing conservation program was established in the Air Force. It was a model program and provided the pattern used in the development of hearing conservation programs in industry for many years. Growth was slow, requiring over three decades to upgrade the first hearing conservation program in 1948 to the comprehensive programs in the three branches of the service in 1980. Military hearing conservation has continued to expand and improve, keeping pace with the new technologies that facilitate administration of a program that can conserve and prevent noise-induced hearing loss. The new Department of Defense hearing conservation program has integrated the positive features of the individual service programs to create more efficient and effective ways to reduce the risks of hearing loss in the military. Initial implementation of this new program is expected during 1998.

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Appendix A

PARTIAL CHRONOLOGY OF EVENTS DURING EVOLUTION OF HEARING CONSERVATION PROGRAMS IN THE MILITARY SERVICES

1940	Army	Research Laboratory at Ft Knox
	Navy	Research Laboratories at San Diego, Pensacola, and New London
1941	Army	Research Facility at Ft Knox
1942	Army	Industrial Hygiene Agency at John Hopkins
	ONR	Harvard Psycho-Acoustics Laboratory
1943	Army	Aural Rehabilitation Center at Walter Reed Hospital
	Army	Aural Rehabilitation Center at Deshon General Hospital
	Army	Aural Rehabilitation Center at Borden General Hospital
	Army	Aural Rehabilitation Center at Hoff General Hospital
1944	Navy	US Navy Hospital at Philadelphia
	Army	Conference on Rehabilitation of Hard of Hearing
	Army	Obtained V-51R earplugs for artillery men
1946	Army	Three aural rehabilitation hospitals consolidated at Walter Reed
	Army	Established Audiology and Speech Correction Center at Walter Reed
1947	Air Force	Air Force established as the third military service
	Army	TB MED 195 - Aural rehabilitation for the deafened, not hearing conservation program
1948	Air Force	First hearing conservation regulation, "Precautionary Measures Against Noise Hazards," AFR 160-3
	Air Force	Revision of AFR 160-3
1950	DoD	Introduction of jet engine aircraft
1952	Navy	NAS-NRC shipboard study on USS Coral Sea aircraft carrier
	CHABA	Organized by military under the NAS - Key members were military and consultants
1953	CHABA	ONR - U. Of Chicago - BENOX Report
1954	Army	Dr. Glorig inspection of 11 Army installations - Recommendations for hearing conservation measures to all University research - Researchers on Navy sites
1955	ONR	BU MED 6260.6 Hearing Conservation Implementation Guide - No requirements
	Navy	
	Air Force	"Criteria for Short Time Exposures to High Intensity Jet Aircraft Noise"
1956	Air Force	First comprehensive hearing conservation program in Air Force; AFR 160-3 upgrade - renamed "Hazardous Noise Exposure"; initiated audiogram repository
	AAOO	"Hearing Conservation Program Guidelines" (today is named American Council of Otolaryngology)

**PARTIAL CHRONOLOGY OF EVENTS DURING EVOLUTION OF
HEARING CONSERVATION PROGRAMS IN THE MILITARY SERVICES (cont.)**

1956-72 1957	Army Air Force	Army TB MED 251 - No Army audiologist input "Criteria for Work Spaces, Living Spaces, and Other Airbase Areas"
1960 1965	CHABA CHABA	"The Problems of Criteria for Noise Exposure" "Criteria for Hazardous Exposure to Intermittent and Steady-State Noise"
1966	Army Army	MOS CODE 3360 - established Army audiologists Audiologists must know how to develop hearing conservation programs
1967	Army CHABA	First Annual Army Audiology Meeting "Feasibility of Intra-Service Standardization of Audiometric Tests and Testing Procedures"
1968	CHABA Army DoD	"(Recommended) Criteria for Impulse Noise (Gunfire)" First military audiology course First established Military Audiology and Speech Pathology Society (MASPS)
1969	Walsh-Healy Army	Public Contracts Noise Standard - First national criteria Established Bioacoustics Division - Operational noise and hearing conservation programs
1970	Navy OSHA	First comprehensive hearing conservation program in Navy Walsh-Healy noise standard incorporated into the OSHA Act - Maintain hearing conservation programs when levels and durations are exceeded
1971	Navy Navy Army CHABA	Buildup of Navy Research Laboratory at Pensacola First classes on hearing conservation Pilot study to establish hearing repository "Hearing Conservation for Submariners"
1972	EPA	Established EPA ONAC under Noise Control Act
1973	Air Force	Upgrade of hazardous noise regulation to AFR 161-35
1978	DoD	First DoDI on hearing conservation programs
1979	Navy Army Navy	First military audiologists in Navy Noise limits for Army materiel OP NAV INST 6260.2 - Hearing Conservation Program Guidelines
	Navy	Hearing conservation programs move from BU MED to Chief of Naval Operations
1980	Army	First comprehensive hearing conservation program in Army; TB MED 501 - Compliance with DoDI
1980		First time that all three branches of the service had comprehensive hearing conservation programs