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EVALUATION AND COMPENSATION OF OCCUPATIONAL HEARING LOSS IN THE--ETC(U)
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The legal system of the United States deals with occupational hearing loss in two ways: first prevention of hearing loss through noise exposure regulations and second through laws providing for compensation for occupationally induced hearing loss. The various ways in which Federal and state laws cover both aspects will be discussed. There is a difference in philosophy in evaluating hearing loss for purposes of prevention as opposed to compensation. A certain amount of hearing loss is allowed to occur before a loss is considered handicapping and therefore compensable. However, modern approaches to hearing

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conservation and the establishment of protective standards dictate that any hearing loss should be prevented, so far as possible. Occupational hearing impairment is now compensable in all 50 states. Early compensation laws covered only acoustic trauma resulting from accident or injury as it related to lost time or wages. Nowadays, noiseinduced permanent threshold shift is considered compensable in most states. There is, however, wide variation among the states as to the rules for filing claims, the maximum amount of compensation awarded and the method by which hearing impairment is determined.



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Evaluation and compensation of occupational hearing loss in the United States

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History

Legislative concern for occupational health in this country took the form of workmen's compensation, long before preventive regulations were developed. Likewise, occupational safety took precedence over health in the early years, even as it does to some extent today. The first U. S. workmen's compensation laws enacted in 1908, covered civilian employees of the Federal government¹. By 1949 all of the individual States has passed workmen's compensation legislation. The early laws dealt only with occupational accidents, and in order to win a claim, a worker had to establish disability, or lost wages as a result of occupational injury. In more recent years occupational diseases have become compensable, and loss of

hearing has been recognized by most states as an occupational disease. Even today, there are some state laws that consider gradual hearing impairment as a series of traumas or accidents, and therefore treat it as a safety rather than a health problem.

Special legislation to cover hearing loss began to be enacted by the States during the 1950's and 1960's. This process began in 1948 when the New York Court of Appeals decided that it was not necessary to show lost time and wages in order to be compensated for a work related hearing loss¹. Similar decisions followed in Wisconsin in 1950 and Missouri in 1959. At the present time nearly all states have provisions for compensating hearing loss but the statutes vary considerably. While a few states compensate fairly liberally, some states

require "total" loss of hearing in one or both ears, and others still require proof of disability and lost wages.

Added concern for the diagnosis and treatment of hearing impairment came during and after World War II. At this time the military established aural rehabilitation centers, where returning soldiers and veterans were given hearing tests, hearing aids and training in lipreading. During this same period the Veterans Administration was examining hearing impaired veterans and giving them "ratings" for compensation according to the severity of their hearing losses. For some years after the war the V.A. compensated on the basis of "whisper" and watch-tick tests of hearing. It is not surprising that the more exact audiometric testing methods eventually took precedence, since the V.A. must have spent considerable amounts of unnecessary or unwarranted funds because of these crude testing procedures. Even today, the V.A. compensates fairly generously since any hearing problem incurred during military service, whether or not it is noise-induced, is considered "service connected". These impairments are treated if possible, hearing aids and remedial therapy are given, and for any untreated component of the loss the veteran is given monetary compensation. Compensation is calculated on the basis of the hearing loss without benefit of a hearing aid.

The fact that excessive noise causes hearing loss has been well known for many years. However, quantitative criteria to predict the effects of noise on hearing has developed rather slowly over the past few decades. One of the first major efforts was the monograph published in 1950 by Karl Kryter entitled "The Effects of Noise on Man"². The concept of "damage-risk criteria" was introduced by Horace Parrack of Wright-Patterson Air Force Base around 1951, and this concept was pursued by a number of researchers over the next few years, including Rosenblith and Stevens, Rosenwinkle and Stewart, Rudmose, Yaffe and Jones and Kryter. Various criteria were proposed as safe, or at least as appropriate for occupational noise exposure, although there was disagreement over the amount of hearing loss to be allowed, and the percentage of the exposed population to be protected.

In 1969 there was an amendment to the Walsh-Healey Public Contracts Act of 1935 to limit the amount of permissible noise exposure. The Act covered employees of all companies with Federal contracts of \$10,000 or more. According to the Department of Labor, the time-weighted exposure level of 90 dBA was "considered to be the upper limit of a daily dose which will not produce disabling loss of hearing in more than 20% of the exposed population"³. Disabling loss of hearing was defined as "a loss which makes it difficult to understand speech in sentence form" and by audiometry a pure tone average in excess of 25 dB average (ISO 1964) in the audiometric frequencies 500, 1000 and 2000 Hz⁴.

The Occupational Safety and Health Act of 1970 incorporated existing standards, such as the Walsh-Healey noise standard, and required the formation of new regulations to protect workers against toxic chemicals and harmful physical agents. A new noise exposure standard has been proposed and public hearings are planned for the end of this month (June 1975). Although the current time-weighted exposure level of 90 dBA has been repropoed, there is some disagreement as to the effect of this exposure level on hearing. There is even greater disagreement on the amounts of hearing loss that should be prevented and the percent of the population to be protected according to the dictates of the Occupational Safety and Health Act.

Methods for assessing hearing handicap

With the development of pure tone and speech audiometry came the need for a simple method of describing an individual's hearing ability for medicolegal purposes. Evidently the medical profession decided early on that pure tone audiometric thresholds should be used because of difficulties involved in standardizing speech audiometry⁵. The earliest of these methods was developed by Harvey Fletcher of the Bell Telephone Laboratories. His rule was not intended to be a measure of handicap, but rather to provide an overall index of a patient's hearing capacity, in the form of a single number⁶. Since the early audiometers had a range of approximately 120 dB, Fletcher's rule divided the entire range of

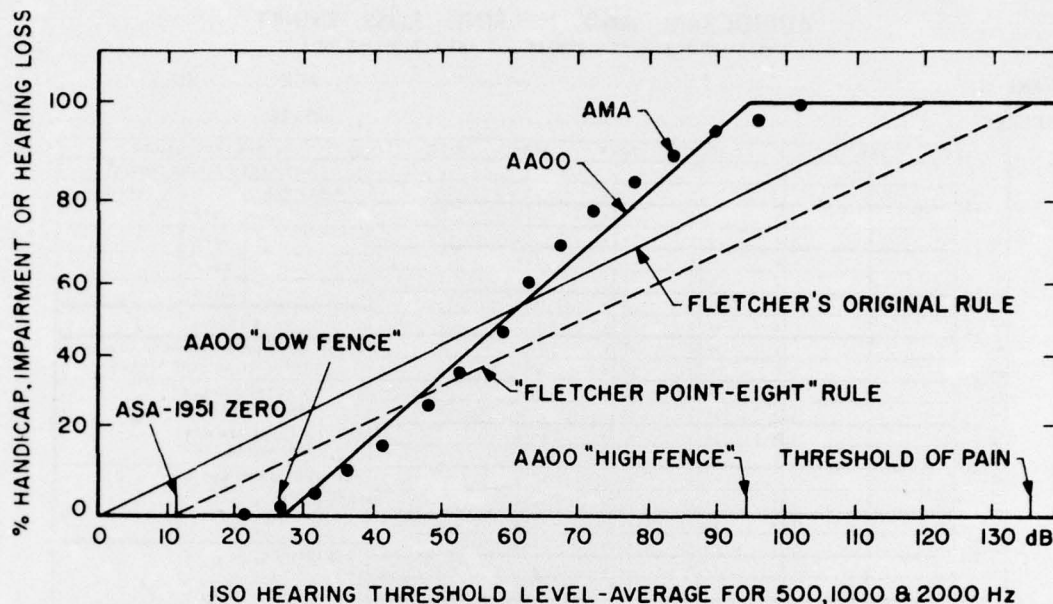


Fig. 1. — The relation of percentage impairment (or handicap or hearing loss - see text) to the average of ISO hearing levels at 500, 1000 and 2000 Hz according to four different rules. (From H. Davis, Ref. #6).
 Note: The above relationship between the AMA and the AAOO rules only holds for flat hearing losses.

audibility for the averaged frequencies 512, 1024 and 2048 Hz into degrees of hearing loss. Minus 10 dB (ASA) was the point of 0% hearing loss and the line extended to 110 dB (ASA) with a slope of 0.833% hearing loss per dB. Later (1929) the rule was modified so that 0% hearing loss occurred at 0 dB (ASA) with the 100% point above 120 dB (ASA), and the slope was changed to 0.8% per dB, hence the name "Fletcher point-eight rule" (Figure 1 translates these values into ISO 1964 threshold levels).

According to Davis⁵, Fletcher's rule was not suitable for medicolegal compensation since individuals whose hearing was within the normal range could claim disability. Also, the rule contained no provision for a threshold of handicap, or for that matter a ceiling, since the 100% point would almost never be reached. In 1942 the Council on Physical Medicine of the American Medical Association recommended a formula called the Fowler-Sabine scale, or the AMA rule. This rule was modified in 1947 and although it was not very popular because of its complexity⁵, it was used for many years, and is incorporated into the statutes of two States today. It introduced the concept

of a threshold and a ceiling of handicap, the former occurring at 10 dB (ASA, or 20 db ISO) and the latter at 95 dB (ASA, or 105 dB ISO). It also introduced a binaural weighting factor for hearing losses that are unequal in the two ears, with the better ear given five times more weight than the poorer ear. In order to calculate an individual's percentage of handicap, a special audiogram or chart was needed, which showed the relative weightings for four different audiometric frequencies, (Fig. 2). The frequencies were weighted as follows:

- 512 Hz = 15%
- 1024 Hz = 30%
- 2048 Hz = 40%
- 4096 Hz = 15%

The Fowler - Sabine scale was unique in terms of the formula that preceded and followed it because of its inclusion of 4000 Hz and the relative importance given to 2000 Hz over the other frequencies, presumably because of its contribution to the intelligibility of speech.

In an effort to develop a simpler and more useable rule, the subcommittee on Conservation of Hearing of the American Academy of Ophthalmology and Otolaryngo-

AUDIOGRAM AND HEARING LOSS CHART

(PREPARED BY EDMUND P. FOWLER, M. D. AND P. E. SABINE, PH. D.)

NAME..... AGE..... NO.....
 ADDRESS..... DATE.....

HEARING LOSS IN DECIBELS	OCTAVE FREQUENCIES						PER CENT HEARING LOSSES		
	128	256	512	1024	2048	4096	8192	RIGHT EAR	LEFT EAR
	0								
10			2		4		1		
20			5	9	13		17		
30			11	21	29		39		
40			14	27	37		47		
50			18	36	48		60		
60			24	48	63		78		
70			32	63	83		103		
80			42	84	109		135		
90			54	108	141		176		
100			70	140	182		227		

COMPUTATION OF PER CENT LOSS OF CAPACITY TO HEAR SPEECH	
(A) 7 X TOTAL PER CENT LOSS, BETTER EAR	
(B) 1 X TOTAL PER CENT LOSS, WORSE EAR	
(C) SUM (A) + (B) =	
(D) C ÷ 8,	%
RECORDED BY	
1946 COPYRIGHT, AMERICAN MEDICAL ASS'N	

INSTRUCTIONS: Plot the hearing losses by air conduction for each ear at the four frequencies shown, and connect contiguous points by straight lines. (solid for right—broken for left) The per cent loss assigned to each interval is the figure immediately above the horizontal line. Set down these figures in the four spaces under right and left ear, in the columns to the right of the chart. Add each column and compute the binaural per cent loss of capacity to hear speech, as indicated.

Fig. 2. — Audiogram and Hearing Loss Chart prepared in 1946 for the American Medical Association by Drs. E. P. Fowler and Paul A. Sabine. (From H. Davis, Ref. #6).

logy (AAOO), developed a simplified version of the Fowler-Sabine scale. The AAOO formula was first proposed in 1959, around the same time that the first state formula was developed in the state of Wisconsin. The similarity between the AAOO and Wisconsin formulas is not surprising in view of the timing.

The AAOO dropped the 4000 Hz frequency and took the simple average of 500, 1000 and 2000 Hz with the point of beginning handicap or "low fence" at 26 dB ISO and the point of 100% handicap at 92 dB ISO with a slope of 1 1/2% per dB in between these points. According to the "Guide for the Classification and Evaluation of Hearing Handicap", a 26 dB average at the frequencies 500, 1000 and 2000 Hz is the point at which people begin to have difficulty understanding sentences spoken in a quiet environment. According to Kryter⁸, this is the point at which a person could understand 90% of sentences and 50% of monosyllabic words in a quiet environment, spoken at a normal conversational level of

effort by a person one meter away⁸. The value of 26 dB was also based on clinical experience of otologists⁵. In the AAOO formula, no consideration is given to presbycusis (the auditory effects of aging). Presumably, these effects would already be included in the 26 dB "fence", and according to Davis, "advancing presbycusis after retirement will inevitably and predictably increase the handicap⁶". Also, no consideration is given for possible benefits from the use of a hearing aid, which seems equitable since noise-induced hearing loss does not always respond very well to amplification. In addition, no consideration is given to special circumstances such as poor speech discrimination, tinnitus (head noises), and the special importance of hearing to a person's job. Thus, there are some individuals whose degree of handicap will be greatly underestimated by the AAOO formula.

Of particular importance is the fact that the simple average of 500, 1000, and 2000 Hz is a much more satisfactory assessment of

flat hearing losses than of losses that slope or "fall off" in the high frequencies. To quote Dr. Davis, "The assessment of handicap or of everyday hearing ability by rules based on this single measure is very satisfactory for individuals who have reasonably flat audiograms and no special problems of poor discrimination for speech... No single number or simple rule can suffice, however, for the exceptional cases of steep audiograms, or of sense organ or central dysacusis⁵". Since noise-induced hearing losses are almost always characterized by sloping audiograms, the use of the AAOO formula for evaluating these kinds of cases is somewhat questionable. For example, an individual with a noise-induced hearing loss might show thresholds of 10 dB at 500 Hz, 25 dB at 1000 Hz, 40 dB at 2000 Hz and 70 dB at 4000 Hz. Assuming the loss were binaural the individual would be 0% handicapped by the present AAOO formula. However, by the old Fowler - Sabine or AMA formula, the individual would be considered 23% handicapped. The Fowler-Sabine formula continues to rate sloping losses with much higher degrees of handicap than does the AAOO formula throughout the audiometric range until the losses become quite severe, at which point the AAOO formula catches up. Unfortunately for the victim of noise-induced hearing loss, the simpler rule took precedence.

Perhaps because it recognizes the value of good hearing in frequencies higher than 2000 Hz, the Division of Federal Employee Compensation in the U.S. Department of Labor calculates hearing handicap based on the amount of loss exceeding 25 dB in the averaged frequencies 1000, 2000 and 3000 Hz⁹. Thus, individuals with noise-induced hearing loss are considered handicapped earlier, and to a greater degree than by the AAOO formula, which is used by most States. Also the Division of Federal Employee Compensation considers noise levels in excess of 85 dBA as potentially hazardous. In most other areas the procedures resemble those of the AAOO. The statute covers civilian employees of the Federal government.

The formula for compensation used by the Veterans Administration is also somewhat more complex than that of the AAOO. Because the V.A. employs a well standardized battery of tests, as well as skilled professionals to administer them, speech audio-

metry is included in the compensation procedures. The veteran's hearing loss is assessed according to his speech reception threshold, his discrimination scores for monosyllables, and his pure tone thresholds at 250, 500, 1000, 2000 and 4000 Hz. A veteran's hearing is considered within normal limits if his speech reception threshold is less than 18 dB, his discrimination scores for each ear are above 92%, all pure tone thresholds are less than 40 dB and are less than 25 dB for at least three frequencies.

State compensation laws

When first established, the idea of workmen's compensation required certain concessions both on the part of employers and employees¹⁰. The employer had to give up such common-law defenses as assumption of risk, contributory negligence, and negligence of a fellow employee. The employee had to give up the right to civil suits for whatever damages he could collect. Thus, definite rules and limits have been established in nearly all states. As mentioned previously, the original purpose of state workmen's compensation programs was to provide for lost wages and medical costs, in short to compensate for disability. Over the years, however, most states have shifted to the philosophy of compensating for a work incurred handicap, and require no proof of lost time or wages.

The following summary of state compensation laws is based largely on a survey conducted by the otologist, Dr. Meyer Fox, in 1972¹¹. Since that time some of the state laws have been revised, the trend being to broaden the coverage and raise the ceiling for dollar amounts of compensation. As of 1972, nearly all of the states have recognized noise induced hearing loss as an occupational disease, instead of an accident or a series of accidents. Approximately five states still require total loss of hearing (93 dB) in one or both ears in order to be compensable. Interestingly, in Pennsylvania, there have been two recent civil suits where workers have collected fairly large sums of money, since the workmen's compensation law did not provide for partial loss of hearing.

Approximately 17 states specify a hazard level, above which it is considered possible

to develop a compensable hearing loss, and below which the employee is supposedly safe. This level is usually 90 dBA, in conformity with the Walsh-Healey Amendment, although the Division of Federal Employment Compensation in the Department of Labor specifies a level of 85 dBA.

In most states, hearing loss is related to number of weeks of wages that the employee receives as compensation. The employee's percentage of hearing handicap is applied to a maximum number of weeks, depending on whether or not the hearing loss is in one ear or both ears, and then the employee receives a certain percentage of his wages for those weeks. In 1972, the median number of weeks for hearing handicap in one ear was 50 to 55 weeks, and for both ears, 220 weeks. The median award for one ear was between \$2,500 and \$3,000 and for both ears was between \$8,500 and \$9,000. As of January 1974¹², maximum benefits for hearing handicap in one ear were \$11,000 in the State of Arizona and \$27,000 for Federal employees. Maximum benefits for both ears were \$42,000 in the District of Columbia and \$103,846 for Federal employees. These amounts are not typical of all the states, where the average maximum value for both ears is around \$12,000.

Approximately half of the states evaluate hearing handicap according to the AMA (AAOO) formula, and half on "medical evidence" alone, which can vary widely. Two states, New Jersey and Kansas, use the old AMA or Fowler-Sabine Formula, and California uses a variation of the AAOO formula where 3000 Hz is included in the averaging. Although the AMA encourages the use of its weighting scheme where the good ear is given five times the value of the poor ear, some states use the ratio of 1-to-1 or 1-to-1.25. Some states penalize the worker by subtracting values for presbycusis. Four of these states deduct ½ dB for each year after the age of 40. According to this rule, people with substantial hearing losses can fail to be compensable if they wait until retirement age to file their claims.

There are other rules that vary considerably from state to state. For instance, 15 states compensate for tinnitus, and surprisingly, 11 states compensate for non-organic or psychogenic hearing loss. Some states deduct for improvement with a hearing aid, while most states do not. Many states have

clauses whereby an employer must provide the claimant with a hearing aid if it is medically indicated. At least one state, North Carolina, prohibits compensation to employees who have been provided, but have not worn hearing protective devices. North Carolina's statute has been amended recently to strike out a presbycusis clause where ½ dB per year over the age of 38 was deducted before determining impairment. Despite the fact that this law has been considered a "model" by some¹⁰, it has so many restrictive clauses that only one claim has been filed to date, and evidently, that one was settled out of court.

Preventive criteria

Since criteria for the prevention of noise-induced hearing loss have been following along after the enactment of compensation laws, it is not very surprising that the idea of compensable hearing impairment should become enmeshed in damage-risk criteria. In 1957, Rudmose suggested damage-risk criteria based on an American Standards Association committee recommendation¹³. He used a definition of hearing impairment currently developed by the Advisory Medical Committee in Wisconsin, that he called "speech average loss". He estimated that his criteria would protect 80% of the exposed population from compensable hearing impairment, but suggested that the percentage of the population to be protected would be industry's decision.

The Committee on Hearing and Bioacoustics of the National Academy of Sciences developed criteria in 1965 that have been very widely used since that time¹⁴. They were developed mainly for military purposes. The curves were based on temporary threshold shift data and the committee predicted that median threshold shifts would not exceed 10 dB at 1000 Hz, 15 dB at 2000 Hz and 20 dB at 3000 Hz after 40 years of exposure. When coupled with the effects of presbycusis, these hearing losses would surpass the compensable level in about half the population.

The incorporation of thresholds for compensation into preventive criteria has been perpetuated into the present-day controversy over acceptable noise exposure limits. For example, as stated earlier, the Department of Labor has claimed that its time-weighted

exposure limit of 90 dBA would protect 80% of the exposed population from "disabling loss of hearing", (emphasis added). It has also found its way into the ISO Recommendation R1999, "Assessment of Occupational Noise Exposure for Hearing Conservation Purposes"¹⁵, and therefore forms the basis for the damage risk criteria of many nations. Nowadays, estimates of the percentage of the population exposed to 90 dBA that will exceed this 25 dB average hearing loss criterion range from 29%¹⁶ to approximately 2%¹⁷. The 2% figure represents the most recent statement by the Department of Labor. What has been too often forgotten is the fact that the compensation formula developed by the AAOO was not meant for purposes of preventive criteria, but rather to provide a formula for assessing hearing handicap. To quote Dr. Davis, again:

"The AAOO rule now enjoys considerable legal prestige by its incorporation into many rules or even State laws relating to compensation for hearing handicap, from whatever the cause. The high fence and the low fence were both adjusted deliberately by the Committee to yield a *simple* rule, namely 1½% handicap per decibel of hearing threshold level above 26 dB HL... In the interest of simplicity, the AAOO rule introduced unreal abrupt transitions at zero and at 100% handicap. From the point of view of the victim, the rule is harsh at the low fence but lenient at the high fence. Perhaps this should be taken into account if we undertake to set arbitrary limits or criteria for habitual noise exposure in order to reduce the risk of developing a hearing handicap."

Certainly it does not seem sensible to establish preventive criteria at the point where hearing *handicap* is allowed to occur in a substantial portion of the population. Perhaps one reason for this predicament has been careless semantics, or the interchangeable use of the words disability, impairment, and handicap. To clarify the situation, the AAOO defined these terms in 1965 as follows⁷:

Disability: actual or presumed inability to remain employed at full wages.

Impairment: a deviation or a change for the worse in either structure or function, usually outside of the range of normal.

Handicap: the disadvantage imposed by an impairment sufficient to affect one's personal efficiency in the activities of daily living.

Clearly, the term handicap is meant to apply to the compensation situation, whereas the term impairment is more appropriate to preventive criteria. The decision of what is an unacceptable amount of impairment is still somewhat in dispute. The Environmental Protection Agency has determined that a 5-dB threshold shift at 4000 Hz after a lifetime's exposure to noise as the maximum allowable impairment is a suitable long range public health goal¹⁸. The yearly 24-hour average of sound energy that has been identified to produce no more impairment than the 5-dB criterion is approximately 70 dB. Although this level is neither economically nor technologically feasible for most production industries at this time, it should be kept in mind as a long range goal in order to eliminate loss of hearing from noise exposure. In the meantime, a criterion for impairment such as a 15 dB average at 500, 1000 and 2000 Hz as suggested by Kryter⁸ might suffice. Or if one examines the amount of threshold shift due to noise alone, apart from the effects of aging, the criterion for impairment could be the Department of Labor's own definition of "significant threshold shift", i.e., an average of 10 dB at the frequencies 2000, 3000 and 4000 Hz¹⁹. This amount of hearing loss, when added to the natural effects of aging, would be fairly consistent with Kryter's suggested 15 dB average at 500, 1000 and 2000 Hz. Certainly it reflects a more appropriate definition of impairment than the concept of handicap, which is erroneously but all too commonly used today.

Summary

The confusion of disability, handicap, and impairment has been traditional in the United States, but these concepts are beginning to be sorted out. The confusion is somewhat natural in that workmen's compensation laws tended to develop earlier and were more explicit than regulations for the prevention of hearing damage. As the emphasis in workmen's compensation has changed from disability to handicap,

so has the emphasis in preventive criteria changed from handicap to impairment. This change is most clearly seen in the Environmental Protection Agency's treatment of the concept of impairment. Although the criteria and identified safe levels purposely do not take economic and technological feasibility into account, they can be considered reasonable public health goals, so that we can strive for the eventual elimination of noise-induced hearing impairment.

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