

used to bridge this gap in information. It seems certain that eventually there will be standardization in this area, and it is probable that a method relating compensation to the lack of ability to understand everyday speech will be agreed upon.

R. THE SEVERITY OF A NOISE EXPOSURE

The severity of a noise exposure depends upon a number of factors. In assessing any noise exposure, each of these factors should be evaluated as carefully as possible.

The *intensity level* of the noise is probably the most important single factor in determining the severity of the exposure, but by itself can never be used as a criterion for safety or as evidence of a causal relationship between a noise and a person's hearing impairment. For instance, peak sound pressures up to 0.03 bar (a pure tone with a level of 160 db would have the same peak pressure) can be tolerated without permanent damage to the hearing apparatus under circumstances such as short exposures to artillery fire and heavy explosions.²¹

The *duration of a noise exposure* is a tremendously important factor. The longer the exposure to intense noise, the greater and more permanent can be the resulting impairment. An exposure that continues for eight hours a day throughout a working lifetime is many times more serious than one of similar intensity that occurs only once and lasts for a few minutes.

The *temporal pattern* of the noise must be taken into consideration. Exposure to a noise for one hour out of eight per day may have a completely different effect than exposure to the same noise for one minute out of every eight throughout the day. Impact noises, such as those produced by drop hammers, are momentarily of very high intensity, yet the average intensity may be relatively low. Present data give us almost no information that allows comparison of the effects of these intermittent noises with the somewhat better-known effects of continuous noise.

The *frequency distribution* of the noise must be examined because damage to the hair cells is not uniformly probable nor is it equally significant throughout the audible frequency range. Hearing loss occurs at other frequencies than those present in the stimulating noise. In fact, no matter what the spectrum of the noise, the irreversible part of the hearing loss is usually most severe in the 3000 to 6000 c.p.s. range. However, when the energy of the stimulating noise is primarily in the mid-frequency range, there is likely to be more hearing loss below 3000 c.p.s. than when the energy of the stimulating noise is primarily in the high-frequency range. Since hearing loss at high frequencies has little effect on the ability to understand everyday speech, noise concentrated in the mid-frequency range is a more important hazard than a noise of similar intensity at high frequencies.

Hearing loss is relatively less probable when the stimulating noise is concentrated at low frequencies. Thus the mid-frequency range (300 to 2400 c.p.s.) is of

chronic importance in noise control for the conservation of hearing. In fact, present data²⁰ indicate that the 300 to 600 c.p.s. octave band should be weighted most heavily in estimating the effects of noise on the hearing loss for speech.

The band width of the noise should be known, at least approximately. Narrow-band and pure-tone sounds appear to be somewhat more damaging than wide-band noises of the same intensity.

The *susceptibility to noise* of exposed persons may vary over a wide range. Some fail to develop a significant hearing loss after long exposure to intense noise, whereas others may develop a severe impairment. The unusually susceptible individual can be tentatively identified only through repeated audiograms taken of the exposed group. He will suffer significantly greater changes in hearing sensitivity than his co-workers in the same noise exposure. Also, upon leaving the noise he is less likely to show rapid improvement in his hearing.

S. HOW MUCH NOISE EXPOSURE CAUSES HEARING DISABILITY?

The variations in individual susceptibility make the task of answering the question "How much noise is too much?" extremely difficult. A small percentage of any group of people will incur hearing loss from age and other causes no matter what their noise environment. Some will incur presbycusis (the natural loss of hearing as a result of aging) before middle age, while others may have normal hearing well into old age. The symptoms of these hearing losses will be, in some cases, indistinguishable from the symptoms of hearing loss caused by noise. Therefore, no matter how quiet the environment, a certain percentage of the employees will appear to have a noise-induced impairment. As indicated above, these impairments may actually result from diseases of the central nervous system, certain other illnesses, hereditary causes, head injuries, explosions, nonoccupational noise exposures, and, above all, presbycusis.

Although these factors influence only a very small percentage of the group, their presence makes an accurate definition of the "maximum nonhazardous noise exposure" almost impossible. That is, when the number of people in the group who incur hearing disability following repeated noise exposure is about the same as the number who may be expected to incur similar disability during the same period of time as the result of some other cause, it becomes statistically impractical to measure reliably the effect of noise. In such a situation, the uncertainty in the determination of whether or not noise has actually produced damage to hearing requires that an unreasonably quiet condition would have to be established to preclude the possibility of hearing impairment to the most susceptible member of the group. The cost of noise control to this end would, in most cases, be enormous. In addition, because of the statistical difficulties discussed above, noise control may actually be sufficient in many cases. It seems impractical, therefore, to attempt complete elimination of all industrial noise exposures. A more reasonable approach is the reduction of any noise that impairs the hearing of a statistically significant percentage of the people exposed.

²¹ BENOX Report, An exploratory study of the biological effects of noise, ONR Report NR 144079, 1953, p. 32.