T. ENGINEERING CRITERIA FOR NOISE CONTROL

The difficulties enumerated above should explain the rather wide variation that one finds among the various criteria proposed for the prevention of damage to hearing.[22] Each criterion depends quite strongly on the assumptions that are made relative to individual susceptibility, significant hearing loss, and the duration of the exposure.

Engineering criteria for noise control, sometimes called damage-risk (DR) criteria, are extremely useful in spite of the lack of a firm scientific foundation. An example follows of one such set of criteria applied to a noise exposure that is continuous throughout an eight-hour day for five days a week. The noise is wide-band and free from any distinct impulses. The aim is to protect the employees by preventing noticeable hearing loss for everyday speech, while tolerating small changes in hearing acuity. Because of the difficulties enumerated in the previous section, no attempt will be made to protect all of them by noise control. Instead, audiometric examinations given to each employee periodically will aid in identifying unusually susceptible individuals. Those so identified can be transferred to a quieter job. If the number who incur noticeable hearing loss exceeds a significant fraction of the entire group, this procedure becomes impractical. Therefore, the criteria for noise control should be set so that no more than a significant fraction of the group are likely to incur noticeable hearing loss even after exposure for a score of years.

Under these circumstances, and with the given noise exposure, sound pressure levels should be below 95 db in the octave bands important to the conservation of hearing for speech.[20] These octave bands are the 300 to 600, 600 to 1200, and 1200 to 2400 c.p.s. bands with the greatest importance attached to the 300 to 600 band. Clearly, sufficiently intense levels outside of this frequency range will cause hearing loss for speech, but for typical noise spectra we may consider the extremely high and low frequencies of secondary importance.

If it were necessary to reduce the chances of causing noticeable hearing loss for everyday speech to a negligible value for even the most sensitive individuals, the octave band levels in the mid-frequency range (300 to 2400 c.p.s.) should probably not exceed 85 db for the noise exposure described. More careful study of the relationships between noise exposure and hearing loss may show that this criterion is unnecessarily low. At the present time, however, there is at least a 10 db spread between the levels that are estimated likely to affect a significant percentage of those exposed and levels that can be considered safe for almost everyone. Were the levels in the mid-frequency octaves as high as 105 db, it is likely that most of the group would incur at least noticeable hearing losses under the circumstances of the exposure described.

It is possible to summarize this set of criteria in terms of the approximate effect on a group of workers subjected to each of four ranges of noise exposure.

[22] J. H. Sterner, Standards of noise tolerance, *Ind. Med. and Surg.*, **21**, 165 (1952).

If the levels in the mid-frequency octaves are less than 85 db, a negligible fraction of the group will probably incur noticeable hearing loss after exposure for a score of years under the circumstances described above. If these levels are between 85 and 95 db, the fraction will be small; if they are between 95 and 105 db, the fraction will be large. It may be remembered that changes in the temporal pattern of the noise, the length of exposure, and the definition of noticeable hearing loss and unusual changes in the frequency distribution of the noise will alter the effect of the noise on the group.

U. THE RELATION OF NOISE EXPOSURE TO SOUND ENERGY

A convenient assumption used extensively in recent years states that noise exposure is directly proportional to sound energy, the product of sound intensity and time. This assumption is not directly supported by, nor does it contradict, any existing data. Although it provides a method for comparing noise exposures of differing durations, large variations in the pattern of the noise exposure in time cannot be taken into account with confidence. If there is error in the assumption, however, the evidence does seem to indicate that slightly more sound energy can be tolerated when the noise exposure is irregular than when it is steady.

The assumption that noise exposure is proportional to sound energy can be used, for example, to revise the above DR criteria to apply to a three-hour daily exposure to noise. The exposure time will then be $^3/_8$ of the original eight-hour exposure. To maintain the same sound energy the intensity must be multiplied by $^8/_3$. The ratio of the resultant intensity to the original intensity is equivalent to an intensity level difference of about 4 decibels. Therefore, each of the criteria described above could be raised by 4 decibels without altering the total sound energy involved in the exposure. Using the assumption that sound energy is proportional to noise exposure, these new higher criteria can be applied to the three-hour exposure without altering the effects estimated for the original criteria and the eight-hour exposure.

IV. Noise Control

The basic methods of noise control are well known. A survey of the literature discloses the familiar theme "Control the noise at its source!" in the articles of a generation of authors. From an acoustical point of view this is still good advice, but practical difficulties may make it advisable to reduce the amount of noise transmitted to exposed persons instead. If this method of noise control is also impractical, protection of the individual is the only remaining alternative. Thus, listed in the order of desirability, the point of attack for the three methods of noise control is: at the source, along the transmission path, and at the man.

The difficulties associated with noise control should be recognized explicitly so that they may be circumvented whenever possible. One such difficulty is the serious lack of understanding of the principles of noise control among