creased, communication by speech becomes progressively more difficult and subject to errors; and (2) strong frequency components near the frequencies of speech sounds are more disruptive than very high or low audible frequency components.[97] Special training in speaking and listening can yield very significant improvements in communications under noisy conditions.[98] For instance, the avoidance of words of low intelligibility in the presence of noise may yield valuable improvements in communications. When workmen must communicate frequently in noisy places, a set of gestures and hand signals often develops spontaneously. However, it should be realized that precise understanding of the signals may well be lacking. They may have been established without any special forethought and may be totally inadequate when certain circumstances involving hazards arise. Wherever hand signals are used, it is advisable to review the system critically with a view to determining the dangers of misunderstanding.[2]

The degree of speech communication possible in the presence of noise of given intensities and frequencies has been determined by Rosenblith, Stevens *et al.*, and should be useful for setting maximum permissible noise levels for certain jobs or areas (see Figure 12). At the 55 decibel level (SC-55) conversation is intelligible at a distance of several feet with a normal voice. At the 65 decibel level, however, communication is difficult, while at 75 decibels communication is marginal.[99] It should be noted that the speech communication level expressed in decibels varies with the frequency, or "pitch," of the sound. At low frequencies a given background noise is less detrimental to communication than it is in higher frequencies. In addition, interrupted noise or discontinuous tones are much more annoying than are steady noises. For a complete discussion of noise and its physiological effects upon man in industry see Chapter XVIII.

Vibration may be frequently linked with noise in many industrial jobs since the two often have common origins. The specific effects are not too well known, although it has been definitely established that vibration adversely influences binocular acuity, especially at frequencies between 25 and 40 and between 60 and 90 cycles per second. This may be due to the attempt of the eyes to follow movements of vibrating instruments or because the eyeball is set into resonance with the vibration. Certain reflex actions of the body may be diminished at some frequencies, while others may be completely depressed at different amplitudes.[24] In addition, it is known that people exposed to vibration for long periods of time frequently complain of headaches, exhaustion, and fatigue. Figure 13 shows the subjective responses as determined by three investigators.[98] Since the human body

[97] S. S. Stevens and H. Davis, *Hearing: Its Psychology and Physiology*, Wiley, New York, 1938.

[98] G. L. Dragert, J. C. Kelley, M. W. Buck, and T. D. Hanley, Training manual for portable interphone trainer, *Special Devices Center Tech. Rept. 104-2-12*, Port Washington, N. Y., n.d.

[99] W. A. Rosenblith, K. N. Stevens, and the Staff of Bolt, Beranek, and Newman, Handbook of acoustic noise control: Volume II. Noise and man, *WADC Tech. Rept. 52-204*, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, 1953.

is quite sensitive to the various types of vibration encountered in some industrial tasks and is usually much less capable of tolerating this vibration than is the structure of the machine or environment, it is essential that operators' physiological limits of tolerance be clearly recognized. However, the reaction to vibration varies at different frequencies and amplitudes. In cases where different vibrations composed of varying frequencies and amplitudes are superimposed, the ones with the higher values should be chosen in determining comfort or safety criteria since these will be the more unpleasant, that is, the higher the frequency the lower the

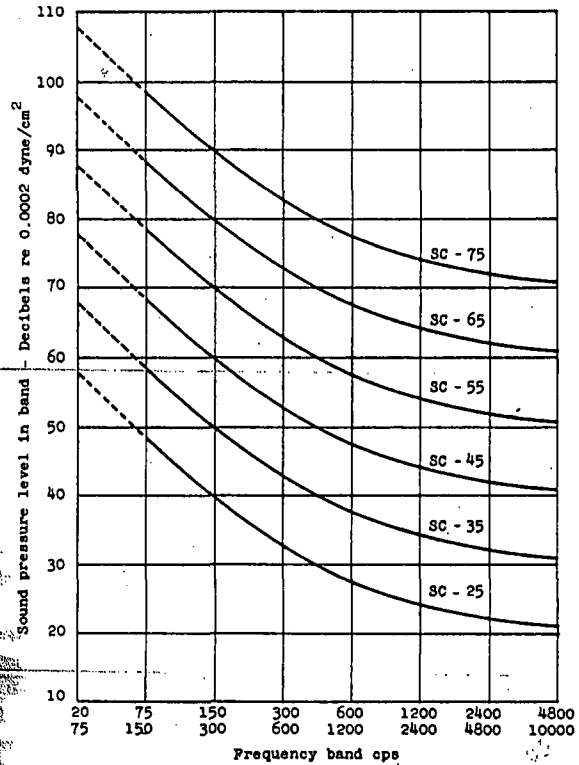

Figure 12. Speech communication criteria (SC). If the sound pressure levels of the environment do not exceed the SC-45 curve at the various frequency bands, relaxed conversation will be possible with a normal voice at a distance of 10 feet. At the SC-55 level communication is possible with a normal voice at 3 feet, with a raised voice at 6 feet, and with a very loud voice at 12 feet. For SC-65 a raised voice is necessary at 2 feet, and a very loud voice at 4 feet. At SC-75 communication is minimal, requiring a very loud voice at 1 foot and shouting at 2 to 3 feet. (After Rosenblith, Stevens *et al.*[99])