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A simple graphical method for assessing the acceptability of speech privacy.

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1. Introduction

In many buildings, and particularly in offices, the biggest acoustical problem is the isolation of speech sounds. Subjective impressions of privacy correlate with the intelligibility of intruding speech which is determined mainly by speech sounds in the 800-5000 Hz frequency range. Consequently, a single figure for the average transmission loss in the 100-3200 Hz range cannot be an adequate measure of the effectiveness of a partition in dealing with speech. The intruding speech is not heard by itself, but against a background noise which may or may not have a masking effect. The transmission loss, background noise and room absorption can all be taken into account by calculating the Articulation Index of the transmitted speech.

2. Development of the Articulation Index (AI)

Speech intelligibility measured in terms of the percentage of syllables, words or sentences which can be understood is not an additive measure. French and Steinberg (1) measured the intelligibility of speech transmitted by a series of low and high pass filters and were able to define an additive quantity which they called an Articulation Index. Thus, the AI of a particular band of frequencies is equal to the sum of the AIs obtained when the band is subdivided and the narrower bands tested individually. They found frequency limits for bands which each gave 5% of the total AI. Under less than optimum conditions, some bands may contribute less than the maximum 5% and it is found that a 3 dB increase in band level increases a band contribution by 10% of the maximum. Since the range of speech levels is approximately 30 dB, they concluded that the band contribution is proportional to the fraction of the band range that lies above the background noise.

3. Graphical Method

The limits of the 20 bands of French and Steinberg are inconvenient to use in calculation. Figure 1 has, therefore, been constructed from 100 dots which have been distributed to 1/3 octave bands according to the proportion of any of the 20 bands that occur within the limits of the 1/3 octave band. The modification to the equal importance bands given by Beranek (3) to deal with male voices only, rather than male and female, has been incorporated, and the range of levels is from Dunn and White (2). The distribution of dots within a band is non-linear following the actual AI against level variations measured by French and Steinberg.

4. Example of Calculation

The stages in the calculation are: 1) calculate the sound pressure level relative to the power level; 2) add the transmission loss of any partition; 3) add any correctoon for levels in the receiving room; 4) add the background noise in third octave bands; 5) plot the totals on the dot field and read off the AI by counting dots. In practice, the dot field is best used as a transparent overlay. An example of a calculation is given in Figure 2.

5. Speech Privacy Standards

Cavanaugh (4) analysed the subjective response of individuals to intruding speech. The results showed that the most critical 10% felt a lack of confidential privacy when the AI reached 0.05. In a second test it was found that intruding speech was considered likely to interfere with daily work when the AI reached 0.10.

6. Articulation Tests

Figure 3 shows the results of 16 tests using a single speaker and one listener and values obtained by the graphical procedure. The word lists and the curve are from Beranek (5).

7. Background Noise Levels

Published criteria for background noise in buildings, such as NC or NR curves, are levels below which it is desirable to reduce noise to avoid annoyance. They say nothing about what the final noise spectrum should be and their spectra do not agree with the spectra of commonly encountered background noises. For AI calculations, a curve is needed which is closer to actual noises, and to ensure a particular AI, it may be necessary to specify desirable or minimum levels in addition to maximum levels. We have therefore developed a series of BNL (or background noise level) curves which are the same as NC curves below 1000 Hz but at higher frequencies the levels fall off along lines parallel to equal noy contours. The curves are numbered by the level in the 1000 Hz band. We have found that a BNL curve is a much less objectionable noise than an NC curve when generated electronically as well as being a good approximation to noise from well-designed airconditioning systems.

References

1) French NR and Steinberg JC (1947) J.Acous.Soc. Am. 19, 90
2) Dunn HK and White SD (1940) J.Acous.Soc. Am. 11, 278
3) Beranek LL (1947) Proc. IRE 35, 881
4) Cavanaugh WJ, Farell WR, Hirtle PW and Watters BC (1962) J.Acous.Soc. Am. 34, 475
5) Beranek LL (1949) Acoustic Measurements J. Wiley and Sons New York p.770

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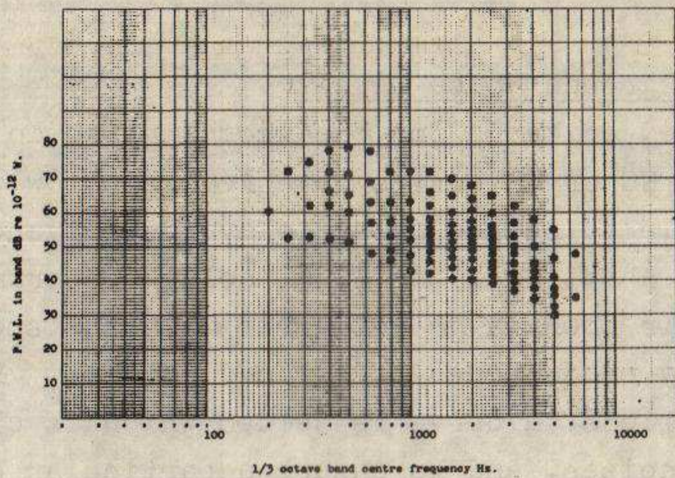

Figure 1

each dot represents 0·01 of the total AI

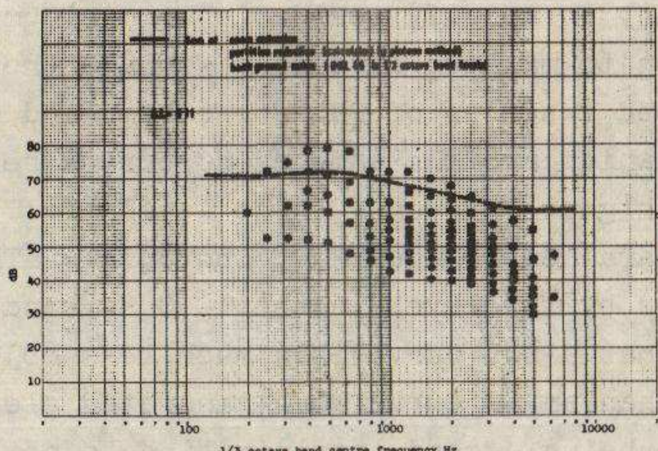

Figure 2

example of use of dot field

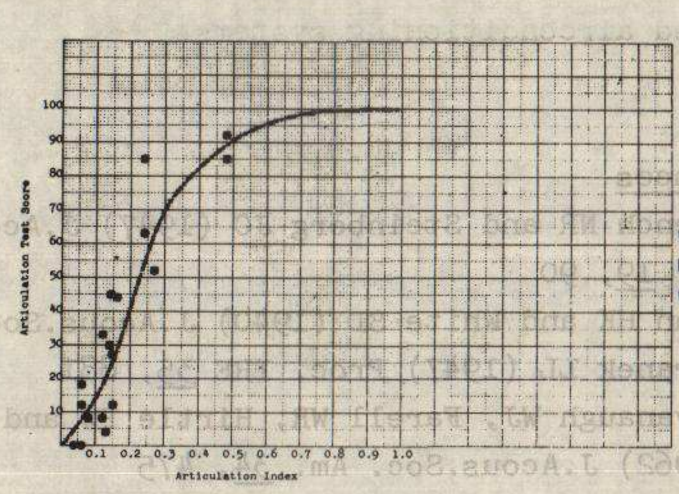

Figure 3

comparison of measured and calculated intelligibility

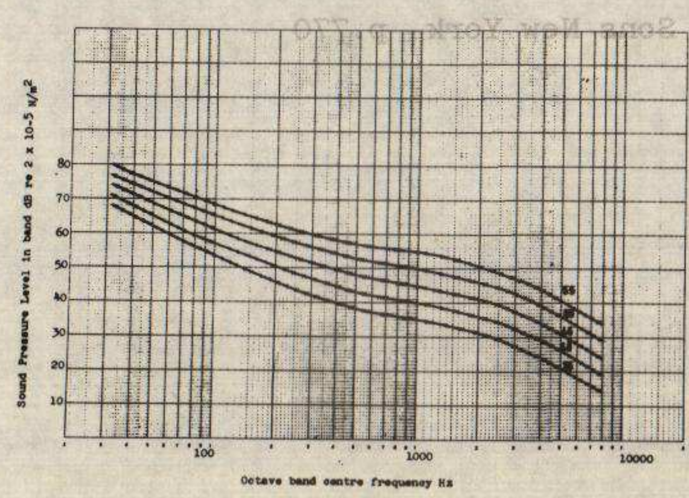

Figure 4

BNL curves