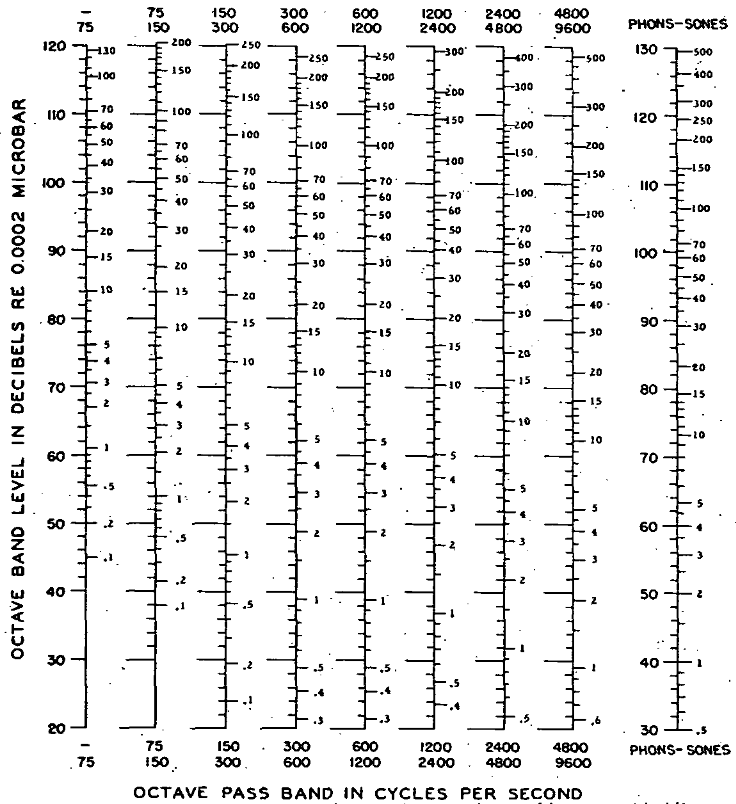

The calculated total loudness in sones can be converted to loudness level in phons by means of the nomogram at the right.
(From Reference 3. Used by permission.)

Fig. 2 . . . . Nomograms Relating L_p in Octave Bands to Loudness in Sones

Introduction of a continuous spectrum noise properly distributed as a function of frequency produces a *quieter* condition even though the background noise is actually higher. Rumbles, rattles, audible single frequency components, beats between components, and intermittency in a noise often make it objectionable even though the noise as measured seems to meet the criterion.

Noise Specification

There are at least four possible ways of specifying the noise. The first way is simply to give the octave band spectrum of the noise. This method provides the information that is essential to the design engineer and no substitute can suffice. The other three of these methods of specifying noise are single-number numerical quantities that indicate something about the influence of the noise on the average human being. These three methods are useful as summaries of the octave band spectrum, but, taken separately, they are of limited value to the design engineer. The definitions of each of four commonly used ways of specifying noise are as follows:

1. *Octave Band Spectrum*. The octave band spectrum is comprised of the readings of sound pressure level in the eight octave frequency bands (see the section on Acoustical Terminology). The readings are taken with the sound level meter weighting

networks set on *flat* (C-scale) and the units are decibels (dbc). The specification of a complete octave band noise spectrum is necessary for satisfactory acoustic design in all cases.

2. *Speech Interference Level* SIL. The speech interference level is a single number found by taking the arithmetic average of the sound pressure levels in the three octave frequency bands 600–1200, 1200–2400, and 2400–4800 cps. The unit is the decibel (db). The speech interference level indicates the ease of speech communication in the presence of the noise so rated.

3. *Loudness Level* L_N. The loudness level is a single number computed from octave band levels according to the procedure following. The unit is the phon.

To obtain the loudness level in phons, obtain the sound pressure levels in the eight octave bands and read from Fig. 2 the loudness in sones for the respective bands. The sum of the loudnesses will be:

$$\Sigma N = N_1 + N_2 + N_3 + N_4 + N_5 + N_6 + N_7 + N_8 \quad (10)$$

The loudness in *sones* of the total noise is given by

$$N = N_m + 0.3\ (\Sigma N_i - N_m) \quad (11)$$

where

N_m = the loudness of the loudest band.

ΣN_i = the sum of the loudnesses of all eight bands.

To convert from loudness in sones to loudness level in phons, use Equation 9 or the nomogram at the right-hand side of Fig. 2.

The loudness level in phons indicates the subjective loudness but does not indicate the ease of speech communication.

4. *Sound Level*. The sound level is a single reading taken on the sound level meter with the meter operated as follows:[3, 4]

Sound-Level Range	*Weighting*	*Unit*
Below 55 db.	A	dba
55–85 db.	B	dbb
Above 85 db.	C (Flat)	dbc

Sound level measured with the A-scale can be correlated most closely with speech interference level but the two are not numerically the same. The C-scale is *always* used with the octave band analyzer and is used where otherwise specified.

Criteria

Noise criteria have been developed from detailed studies and engineering experience in a number of architectural spaces.[6] The acceptability of background noise for various types of activities normally performed in rooms and enclosures can be related to two principal characteristics of the noise: (1) Speech interference level, SIL, and (2) Loudness level, L_N. Definitions of these two quantities are given in the preceding section on Noise Specification. The speech interference level is governed by the amount of high-frequency noise (between 600 and 4800 cps) and the loudness level is governed by both the high- and low-frequency noise.

For most types of spaces the loudness level in phons is 22 to 25 units higher than the speech interference level in dbc. However, for factories, sports coliseums, restaurants, and similar spaces where cost of acoustic treatment dictates a maximum amount of compromise, the loudness level may rise as much as 30 units above the speech interference level.

Acceptable background noise criteria have been established for these two conditions and are presented in Figs. 3 and 4. Each curve is designated by a number indicating the speech interference level obtained. The numbers in the first column of Table 1 and Table 2 identify the curve which defines recommended noise levels for the various types of spaces listed.

With regard to the choice between Figs. 3 and 4, Fig. 3 should be used whenever possible, particularly where there is a possibility that the sound may be fluctuating, such as often occurs with turbulence in a ventilating system. Fig. 4, or numbers in the range between Figs. 3 and 4, may be used when economic factors dictate a compromise and when there is a definite assurance that the noise will not be of a fluctuating type.

In engineering design, all eight octave band levels selected from the curves of Fig. 3 or 4 should be used. In construction specifications, reference may be made to The Guide and the selected *NC* or *NCA* curve may be referred to by number, e.g., *NC*-35.

Where octave band analyses of the noise cannot be made and a rough approximation of accepted criteria must be obtained by use of a sound level meter only, the A-scale values which would be read for the noise spectra specified in Column 1 are given in Column 2 for comparison purposes. It should be understood, however, that an A-scale reading gives a measure of the overall noise using a weighted network; it does not specify the spectrum. For example, the noise spectrum shown as *NC*-25 in Fig. 3 would give an overall A-scale measurement of 35 dba, but a measured value of 35 dba does not mean that the actual noise measured has the same spectral shape or is as satisfactory as the specified *NC*-25 spectrum. The lack of octave band analysis can be partly offset by a subjective observation; if the noise sounds unnatural because of excessive amounts of high pitched or low pitched noise or has particularly noticeable amounts of pure tones, the spectrum will probably depart widely from the specified one. In such cases it is advisable to make an octave band analysis of the noise, if possible.

KINDS OF NOISE

The noise introduced into a room or building by ventilating or air-conditioning equipment may be divided into two general kinds, depending on how it reaches the room:

1. *Noise transmitted through the ducts.*
   a. From equipment such as fans, motors, sprays, etc.
   b. From outside, and transmitted through duct walls into air stream.
   c. From duct wall vibrations, transmitted into air stream.
   d. From air currents, including eddying noises.
   e. Cross talk and cross noises between rooms connected by the same duct system.
   f. From dampers and air valves located near branch duct take-offs and outlets.
   g. Noise produced by grilles or diffusers.
2. *Noise transmitted through the building construction.*
   a. From machine mountings as vibration.
   b. From equipment through room wall surfaces.

The following text will present data and discussion of methods whereby solutions of the noise problem can be obtained when the allowable room noise level, and the path through which the noise reaches the room, are known.

NOISE GENERATED BY FANS

Aerodynamic noise from all types of fans may be broadly divided into a rotational component and a vortex component. The rotational component is associated with the impulse given to the air each time a blade passes a given point and is hence a series of discrete tones at the fundamental blade passing frequency and harmonics thereof. The vortex component of noise is largely due to the shedding of vortexes from the fan