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CHAPTER 25

SOUND CONTROL

Acoustical Terminology; Apparatus for Measuring Sound; Approaches to the General Problem of Noise Control; Criteria for Noise Control; Kinds of Noise; Noise Generated by Fans, Grilles, and other Sources; Sound Attenuation in Ducts; Determination of Room Levels; Cross Transmission between Rooms and through Duct Walls; Controlling Vibration from Machine Mountings

THE NOISE created by heating, ventilating, and air-conditioning equipment has become an important factor in modern building design. Related to this, and of equal importance, is the problem of the transmission of speech or music from one part of the building to another through ventilating and air-conditioning ducts. The architect and the acoustical engineer cooperate to produce rooms that are satisfactory for speech, music, or other intended uses. The ventilation and acoustical engineers cooperate to ventilate and air condition these rooms to be physically comfortable without adding noise in excess of established requirements. This chapter is planned to supply part of the information needed to achieve adequate quietness in rooms that are ventilated and air conditioned through supply ducts. The quieting of unit heaters and coolers is assumed to be the job of the manufacturers and is not covered here. Remaining information on cost, availability, durability, and ease of installation can come only through experience with practical installations.

ACOUSTICAL TERMINOLOGY[1]

Sound Power W is the power in watts produced by a source of sound. This power may be (*a*) the total power radiated by the source over its entire frequency range, (*b*) the power radiated in a limited frequency range, (*c*) the power radiated in each of a series of contiguous frequency bands, or (*d*) the power radiated in a certain direction. The frequency range or frequency band should be clearly stated.

Sound Intensity I is the power radiated in a specified direction through unit area normal to this direction, e.g., watts per square meter, watts per square foot, or watts per square centimeter.

Sound Pressure p is the root-mean-square incremental pressure produced when a sound wave passes through an otherwise undisturbed medium. The unit is the microbar (1 dyne per sq cm or 0.1 newton per sq m).

Frequency f is the rate of repetition of a periodic phenomenon. The frequency is the reciprocal of the period, or the time necessary for the phenomenon to repeat. The frequency f of a single tone sound wave is equal to the ratio of the speed of sound c to the wavelength λ of the tone. $f = c/\lambda$, or $c = f\lambda$. The unit is the cycle per second, or cps.

Decibel db is a dimensionless unit for expressing the ratio of two numerical values (usually electrical or mechanical power) on a logarithmic scale. The number of decibels is ten times the logarithm to the base 10 of the numerical ratio of the two quantities. For example, let W_1 and W_2 designate two powers; or I_1 and I_2 designate two sound intensities, and let M designate the number of corresponding decibels, then

$$M = 10 \log_{10} \frac{W_1}{W_2} \tag{1}$$

or,

$$M = 10 \log_{10} \frac{I_1}{I_2} \tag{2}$$

Alternatively, the ratio of two sound pressures squared is expressed in the same units,

$$M = 10 \log_{10} \frac{p_1^2}{p_2^2} = 20 \log_{10} \frac{p_1}{p_2} \tag{3}$$

These relations tacitly assume that: $W = p^2/Z$, which means that Z, the acoustic impedance, is real, and that for p_1 and p_2, $Z_1 = Z_2$. This is not usually the case, but because sound pressure is the easiest variable to measure in a sound field, the relation:

$$M = 20 \log_{10} \frac{p_1}{p_2} \tag{4}$$

is commonly used. Thus, in a sense when used in this way, the decibel is redefined on the basis of a pressure squared ratio rather than a power ratio.

Octave Frequency Bands. The frequency range of a noise is frequently broken up into octave frequency bands where, in principle, the upper frequency is twice the lower frequency of the band as shown in the following tabulation.

Band Number	*Usual Frequency Limits*	*Approximate Geometric Mean Frequency*
1	20 to 75 cps*	40
2	75 to 150	105
3	150 to 300	210
4	300 to 600	425
5	600 to 1200	850
6	1200 to 2400	1700
7	2400 to 4800	3400
8	4800 to 10,000*	6900

* The highest and lowest bands as usually used, contain somewhat more than one octave as indicated.