

for the average ear at a frequency of 1,000 cycles per second. This reference level also corresponds to a pressure of 0.0002 dynes per square centimeter.

A stated sound level in decibels, unless otherwise defined, will thus be related to a threshold of 10^{-16} watts. For example, a level of 60 db above this reference threshold is 10^{-10} watts. In a similar manner, when sound measurements are given in actual intensity or energy units, they can be converted to decibels by this relation.

Since the decibel is a ratio, it can only be employed when related to a reference threshold level as given. Noise levels, which vary with frequency as well as intensity, must not only be related to this reference threshold level, but also to a reference frequency, which is taken as 1000 cycles. These terms and procedures may be found in Tentative Standards¹ published by the *American Standards Association*.

APPARATUS FOR MEASURING NOISE

Since the relative loudness to the ear, rather than the actual physical intensity, is the quantity in which engineers are usually interested, it has been found necessary to allow for the varying sensitivity of the ear at different frequencies in designing noise measuring equipment. The most satisfactory method of measuring noise is by means of a sound level meter which usually consists of a microphone, a high gain audio-amplifier, and a rectifying milliammeter which will read directly in decibels. This meter is calibrated to give readings above the standard reference level and usually contains a weighing network to make it less sensitive at those frequencies where the ear is less sensitive. For complete specifications relative to the approved type of sound level meters refer to the information² published by the *American Standards Association*.

GENERAL PROBLEM OF SOUND CONTROL

As previously stated, the function of the ventilating and air conditioning engineer is to add no acoustical hazard to the conditions already present in the room or building and the problem can be stated as:

- To determine the noise level existing without the equipment.
- To ascertain the noise level which would exist if the equipment were installed without sound control.
- To provide as a part of the installation sufficient sound control appliances to reduce the noise level substantially to that found in (a).

To accomplish this the engineer should have information of three kinds:

1. A knowledge of the noise levels currently considered acceptable in various rooms in order that he may have a basis on which to proceed.
2. A knowledge of the nature and intensity of the noise created by the various parts of the equipment.
3. A knowledge of how, when necessary, to vary and control the noise level between the equipment and the conditioned space.

In addition, the engineer should have information available to deal with

¹American Tentative Standards for Noise Measurement, *American Standards Association*.

²American Tentative Standards for Sound Level Meters for Measurement of Noise and Other Sounds, *American Standards Association*.

noises which may enter the room due to openings made into it to accommodate the equipment, such as cross talk between rooms connected with common ducts and noise transmitted to portions of duct system outside the conditioned space and through to its interior.

While the general problem may be logically outlined and the items of knowledge necessary to its solution can be listed, the available information at present is lacking in certain respects. However, attention may be directed to that information which is currently available, and to furthermore outline a solution of the noise problem based on these data.

ACCEPTABLE NOISE LEVELS

Measurements of noise levels have been observed by several investigators in various rooms and locations. The information compiled in Table 1 is based on these data, which represent the best opinion on the subject now available. All levels are given in decibels above a reference threshold of 10^{-16} watts (corresponding to a pressure of 0.0002—dynes per square centimeter). Minimum, representative, and maximum levels

TABLE 1. TYPICAL NOISE LEVELS

Rooms	Noise Level in Decibels to be Anticipated		
	Min.	Representative	Max.
Sound Film Studios.....	10	14	20
Radio Broadcasting Studios.....	10	14	20
Planetarium.....	15	20	25
Residence, Apartments, etc.....	33	40	48
Theaters, Legitimate.....	25	30	35
Theaters, Motion Picture.....	30	35	40
Auditoriums, Concert Halls, etc.....	25	30	40
Churches.....	25	30	35
Executive Offices, Acoustically Treated Private Offices.....	30	38	45
Private Offices, Acoustically Untreated.....	35	43	50
General Offices.....	50	60	70
Hospitals.....	25	40	55
Class Rooms.....	30	35	45
Libraries, Museums, Art Galleries.....	30	40	45
Public Buildings, Court Houses, Post Offices, etc.....	45	55	60
Small Stores.....	40	50	60
Upper Floors Department Stores.....	40	50	55
Stores, General, Including Main Floor Dept. Stores.....	50	60	70
Hotel Dining Rooms.....	40	50	60
Restaurants and Cafeterias.....	50	60	70
Banking Rooms.....	50	55	60
Factories.....	65	77	90
Office Machine Rooms.....	60	70	80
VEHICLES			
Railroad Coach.....	60 ^a	70	80
Pullman Car.....	55 ^a	65	75
Automobile.....	50	65	80
Vehicular Tunnel.....	75	85	95
Airplane.....	80	85	100

^aFor train standing in station a level of about 45 db is the maximum which can ordinarily be tolerated.