

The support should be so compliant that the natural frequency of the mass of the machinery on its elastic support will be low in comparison with the vibrational frequencies which are to be insulated.

6 • What means should be utilized for preventing air-borne noise from the ventilating equipment from being transmitted through the walls, ceiling, or floor of the equipment room?

Treat the interior walls and ceiling of the equipment room with absorptive material; see that all doors and windows to the equipment room fit tightly in their frames; and use wall, and floor and ceiling partitions which have an insulation value of not less than 50 db.

7 • Name effective methods for reducing the transmission of sound through ventilating ducts.

Line the ducts with sound absorptive material, or use suitable sound filters made up of long channels of small cross-sectional area, lined with sound absorptive material.

8 • What are the effects of humidity and temperature on the absorption of sound in air?

The absorption increases with a rise in temperature, and decreases for relative humidities above about 20 per cent. A relative humidity of 55 to 60 per cent is advantageous acoustically in large auditoriums.

9 • How may sound be measured and what are the advantages of the methods available?

Three practical methods are now available to the heating and ventilating engineer, namely:

- The noise meter method.
- The audiometer and ear method.
- The tuning fork and ear method.

Except for instrument adjustments and the use of the eye in reading a meter, the human element does not enter into measurements made with the noise meter, so it is to be preferred, if available. The tuning fork method is relatively cheap and simple and sufficiently accurate for most field work. The audiometer and ear method ranks between these two in preference.

10 • What are some of the more important sources of noise in buildings, for which the heating and ventilating engineer may be held responsible?

- Furnace room equipment.
- Radiators and piping.
- Uncalked openings in walls around pipes and ducts.
- Ventilating fans, if noisy in operation and not isolated from the building structure by properly designed vibration damping foundations.
- High air velocity in ducts.
- Ventilation fan rooms not insulated acoustically from parts of the building where noise would be objectionable.
- Ventilating ducts without flexible non-metallic sleeves in them to break metallic sound conducting paths.
- Cross connection of rooms acoustically through ducts.
- Ventilating ducts without sound absorbing lining, if required.
- Unit heaters and ventilators.
- Unit air conditioners.

11 • The noise level in the fan room directly under the main floor of a theater is 70 db. The floor is constructed as described in Item 5, Table 3. What is the fan noise level in the theater?

According to Table 3, the average coefficient of sound transmission, t , of such a floor construction is 0.0000020. The transmission loss through the floor, expressed in db, is:

$$TL = 10 \log_{10} \frac{1}{t} \\ = 10 \log_{10} \frac{1}{0.0000020} \\ = 57$$

The fan noise level in the theater would, therefore, be 70 db less 57 db, or 13 db, which, according to Table 1, is an acceptable level.

Another way of arriving at the same result is by use of Formula 3, in which I' is the intensity of fan noise as measured in the theater, and I'' its intensity as measured in the fan room, I_0 being the reference intensity in both cases, while τ is 0.000002 or 2×10^{-6} .

$$\frac{I'}{I_0} = 10^7 \\ \frac{I''}{I_0} = 10^7 \times 2 \times 10^{-6} = 20$$

$$\text{Noise level} = 10 \log_{10} 20 = 13 \text{ db.}$$

12 • Measurements made separately of the noises from different sources prevailing in a large, noisy banking room revealed the following average noise levels:

- From the street through windows, doors, and walls, 40 db.
- From adding machines, typewriters, human movements and conversation, 60 db.
- From the ventilating system, 50 db.

What was the total noise level of the room?

Calling I_s , I_b , and I_v the intensities of the street, banking room, and ventilation noises, respectively, and I_0 the reference level, we have:

$$\frac{I_s}{I_0} = 10^4 \quad \frac{I_b}{I_0} = 10^6 \quad \frac{I_v}{I_0} = 10^5$$

The total intensity, I , will be $I_s + I_b + I_v$

$$\begin{aligned} \text{The intensity level is } 10 \log_{10} \frac{I}{I_0} \\ = 10 \log_{10} \frac{(I_s + I_b + I_v)}{I_0} \\ = 10 \log_{10} (10^4 + 10^6 + 10^5) \\ = 60.4 \text{ db} \end{aligned}$$

Note that the total loudness level is not much above the level of the loudest noise. While noise intensities may be added arithmetically, noise levels expressed in decibels cannot be so added.

13 • A ventilating fan room 30 ft by 30 ft by 12 ft has brick walls, a concrete floor, and a concrete ceiling. How much will the noise level of this room, expressed in decibels, be reduced by applying sound insulating material (coefficient of absorption 0.6 at 512 cycles) to two walls and the ceiling?

Use Formula 2:

$$\begin{aligned} I &= \frac{I'S'}{a} \text{ before applying material} \\ I_1 &= \frac{I'S'_1}{a_1} \text{ after applying material} \\ \frac{I}{I_1} &= \frac{\frac{I'S'}{a}}{\frac{I'S'_1}{a_1}} = \frac{a_1}{a} \end{aligned}$$