HVAC Systems Noise Control

An Online Continuing Education Course for Engineers

Course Number: HV-6013

Credit: 6 Hours / 6 PDH / 6 CPD

HVAC SYSTEMS NOISE CONTROL

A. Bhatia, Mechanical Engineer

Unwanted noise makes a workplace uncomfortable and less productive. When people are surveyed about workplace comfort, their most prevalent complaints involve the heating, ventilating and air-conditioning (HVAC) systems. The problems they cite most frequently, aside from temperature control, have to do with excessive noise and vibration.

There are practical and economical solutions to almost all noise problems in the built environment. To approach the solution to any specific noise problem, we need to:

- Understand the basic principles of acoustics and how noise — unwanted sound is produced, how it propagates, and how it is controlled.
- Learn the basics of noise control, and how to approach the problem from three standpoints: the source of noise, the path it travels, and the point of reception.
- Become familiar with the treatments and modifications that can be applied to HVAC system to reduce unwanted noise and vibration.

That's what architects, engineers, contractors, and building owners — anyone concerned with solving noise control problems in all types of buildings — will find in this course. It includes information on how to solve specific noise control in HVAC systems. The course is divided into 4 sections:

SECTION -1: THE FUNDAMENTALS OF ACOUSTICS

This section provides a brief introduction to the fundamentals of building acoustics that is necessary to understand the material in the following sections. To emphasize the simplicity of the approach, equations are kept to a minimum.

What is Sound and Noise?

Sound is a form of mechanical energy transmitted by vibration of the molecules of whatever medium the sound is passing through. Noise may be defined as "unwanted or undesired sound", which interferes with speech, concentration or sleep. To control noise or sound, we need to know a little about its fundamental properties such as:

1. Frequency (pitch)
2. Wavelength
3. Amplitude (loudness)

Once these fundamental properties are understood, we can proceed to implement effective noise control measures.

What is Sound Frequency?

The frequency or pitch of a sound wave is the number of times that its basic pattern repeats itself per second. So, a musical note characterized by a pattern of pressure variations that repeats itself 1200 times per second has a frequency of 1200 Hertz.

The frequency - cycles per second - of a sound is expressed in hertz - *Hz*. The frequency can be expressed as

$f = 1 / T$

Where

- f = frequency (s^{-1}, Hz)
- T = time for completing one cycle (s)

Example

Calculate the time of one cycle for a 500 Hz tone.

$T = 1 / (500 \text{ Hz})$

= <u>0.002</u> s

Note - *Sound and noise usually are* ***not*** *pure tones*. Pure tone is described as a simple vibration of single frequency.

The human ear can perceive sounds with frequencies ranging from 20 Hz up to 20000 Hz.

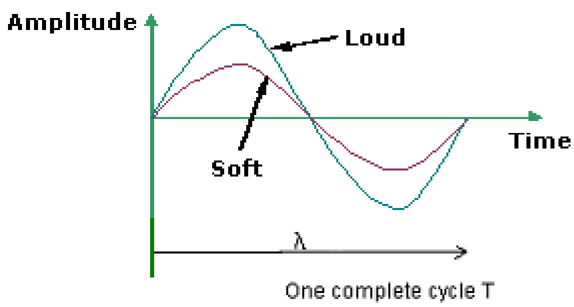
Wavelength

The wavelength of a sound wave is the distance between the start and end of a sound wave cycle or the distance between two successive sound wave pressure peaks. Numerically, it is equal to the speed of sound in the material such as air divided by the frequency of the sound wave. For example:

The wavelength of a 100 Hz tone at room temperature is 1130* ft/sec divided by 100 Hz which is equal to 11.3 ft.

*The speed of sound in air is approximately 1,130 feet per second.

Note - *The higher the frequency the shorter shall be the wavelength.*



$\lambda = c / f$

*W*here,

- λ = wavelength (m)
- c = speed of sound (m/s) (*in air at normal atmosphere and 0°C the sound of speed is 331.2 m/s)
- f = frequency (s^{-1}, Hz)

Example

Calculate the wavelength of a 500 Hz tone considering speed of sound as 331.2 m/s.

λ = (331.2 m/s) / (500 Hz)

= 0.662 m

Note - The velocity is the distance moved by the sound wave per second in a fixed direction i.e. $v = f \times \lambda$

Amplitude (loudness)

The amplitude of a sound wave is the height of the wave form. It is also the maximum displacement for each air particle as it vibrates. The amplitude or loudness of a sound wave is expressed by its sound pressure level. Sounds having the same wavelength (equal frequency) may have differing loudness.

Note - *Human ears distinguish one sound from another by its loudness and pitch. Loudness is the amplitude or amount of sound energy (dB) reaching our ears. Pitch is the speed of the vibrations or frequency used to identify the source of a sound. However, both the loudness and pitch may vary depending upon where we are located relative to the sound and the surrounding environment.*

Sound Power and Sound Pressure

The difference between sound power and sound pressure is critical to the understanding of acoustics.

Sound power is the amount of acoustical power a source radiates and is measured in watts. Sound power is a fixed property of a machine irrespective of the distance and environment. HVAC equipment generates sound power.

Sound pressure is related to how loud the sound is perceived to be to a human ear in a particular environment. It depends upon the distance from the source as well as the acoustical environment of the listener (room size, construction materials, reflecting surfaces, etc.). Thus a particular noise source would be measured as producing different sound pressures in different spots. Theoretically, the sound pressure "p" is the force of sound on a surface area perpendicular to the direction of the sound. The SI-units for the Sound Pressure are N/m^2 or Pa.

The difference between the sound power that the unit generates and the sound pressure that the ear hears is caused by the reduction (attenuation) of the sound along the path to the room, and the reduction within the room (or "room effect") caused by the room layout, construction and furnishings.

How Is Sound Measured?

The term used to describe sound is "decibel" (dB) ... nted in Logarithmic scale. Each 10 dB increase ... e, while each 10 dB reduction represents ...

What is logarithmic ...

For instance, suppose ... und with power W_1, and another playing a loud ... everything else (how far away, frequency) kept ...

The difference in decib...

- 10 log (W_2/W_1) ...

If the second produces ... dB is

- 10 log (W_2/W_1) = ...

If the second had 10 time... ence in dB would be

- 10 log (W_2/W_1) = 10 log 10 = 10 dB

If the second had a million times the power of the first, the difference in dB would be

- 10 log (W_2/W_1) = 10 log 1000000 = 60 dB

This example shows one feature of decibel scales that is useful in discussing sound: they can describe very big ratios using numbers of modest size. But note that the decibel describes a *ratio*: so far we have not said what power either of the speakers radiates, only the ratio of powers.