Noise Problems in Air Conditioning Installations

By: Engr. Prof. Dr Barkawi bin Sahari[1], Engr. Assoc. Prof. Dr Nor Mariah binti Adam[1] and Mr. Aloysius Decruz[2]
[1]Department of Mechanical and Manufacturing Engineering, University Putra Malaysia
[2]Electrical and Energy Section, University Kuala Lumpur Malaysia France Institute

This paper describes some of the common noise related problems found in air conditioning installations. Some acoustic theory explanations are attempted and solutions suggested. Noise problems are often frustrating bringing together the works of architects, mechanical and electrical (M&E) engineers and the equipments manufacturers under scrutiny. A lack of acoustic analysis (which can be done by inexpensive simulation tools) at the design stage, can end up requiring expensive modifications to meet the specified noise level. A list of related standards is given at the end of this paper.

A source-path-receiver analysis is the basis of a noise analysis. The resulting sound pressure level, (Lp), at a specified point of room, due to identified sources of noises, is to be calculated. In the absence of manufacturer's data, the sound power level (Lw), can be estimated by empirical formula published by ASHRAE or CIBSE. All possible sound paths are then identified. The sound transmission through these paths, by way of sound diminution along straight duct lengths, duct fittings, end reflection, etc are determined. Lw at the point of exposure at the room, such as diffuser, is found and then with the distance and room absorption characteristic the sound pressure at the point of interest is determined. This will be repeated for all possible sound paths and the resultant is added logarithmically to get the resultant Lp.

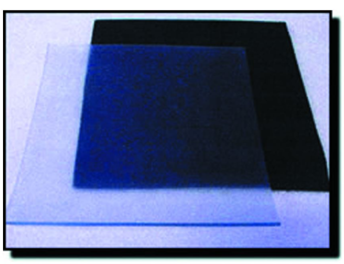

Figure 1: Mass loaded vinyl sheet

Both ASHRAE and CIBSE published algorithms with which simple and inexpensive computer programs can be written, the above analysis can be systematically done and effects of modification of duct network, insulation lining, etc. can be analysed and economic optimum decisions can be taken regarding the system design.

OUTDOOR NOISE PROBLEMS AND CONTROL MEASURES WHEN BUYING A HOUSE

Cooling towers and Condensing units of packaged units, and air cooled chillers are the main sources of outdoor noise. Most of the time limiting outdoor noise is more of question of an acceptable quality of outdoor standard than of meeting any specifications.

A case to case approach is needed because the equipment manufacturers sound data has limited application, due to the fact that tolerances are quite wide (3 to 6 dB for ARI 270 and ARI 370, bigger tolerance for smaller frequencies) and the noise generated depends on the age of the unit and its location of installation.

Units installed against a wall or on or near hard surfaces such as parking grounds will produce bigger noise due to a larger value of directivity index (Q as shown in the appendix 'Background Information')

Doubling of noise source will add 3 dB (= 10 log 2) to the sound level.

The corrective measures for outdoor noise are not easy to implement; limited effects can be produced by the following methods;

- radiated noise from the casing can be reduced by an acoustic panel enclosure
- compressor noise can be controlled by a wrap of mass loaded vinyl and fibre glass (as shown in the picture)
- directional noise transmission can be reduced by noise barrier, which obstruct the view of sight between the source and receiver. The barrier should be solid wall and the sound reduction depends on the frequency and is given by the relation:

$$\text{Barrier attenuation} = 10 \log \left[3 + \frac{20d}{\lambda}\right],$$

where λ [m] is the wavelength of the octave band (=344/frequency) and d [m] is the sound path over the barrier minus direct sound path.

INDOOR NOISE PROBLEMS AND CONTROL MEASURES

Higher design margin and oversized fan is a common cause of noise generation in ducted systems. An inaccurate estimation of system static pressure will result in selection of wrong fan size and when in place this fan will operate at a point of its characteristics where the efficiency is far too low. At the diffuser end a static pressure more than 1 inch Water Gauge (248 Pa) is not recommended even for VAV (variable air volume) box and much less for conventional diffusers.

DUCT SILENCERS

An acoustic attenuator is recommended to place at the duct wall of the plant room. The fan produces noise prominent at low frequencies and the conventional static duct silencer produce good insertion loss (IL) for these frequencies (Insertion Loss-IL, Transmission Loss-TL and Sound Level Difference –D are parameters which give an arithmetic difference of dBs across a wall structure, duct wall or along a duct; the usual dB arithmetic as explained in the appendix is not applicable for these quantities).

There are three types of attenuators:

- Absorption type attenuator dissipates away the sound energy in an absorbing medium. They are available, such as elbow, T-, Y- or Z-fittings, to suit the duct geometry at the site. They work better for high frequency noise, and can be custom made to address specific noise frequency.

- Spring type, which has a mass-spring arrangement to produce an anti-noise, 180 degrees out of phase with the original noise, superimposing and cancelling it. It address strictly specific frequency noise.
- Active type silencer which continuously measure noise on a microphone, and through a feedback control and digital signal processing, produces the anti-noise of the same frequency, in opposite phase with a speaker, which will cancel the original noise. Unlike the case of absorptive type silencers, there is no duct pressure drop involved and the power consumption is very minimal, of the order of Pico watt (10^{-12}). This type works better for low frequency rangenoise.

A non hardening sealing to close the gap between duct and wall is necessary.

STRUCTURE BORNE NOISE

Vibration isolation to AHUs, chillers, packaged units, especially those located above ground floor is of utmost importance. We have the experience of detecting a structure borne noise off a decorative suspended ceiling, due to the physical contact between duct and the structure framework of the suspended ceiling.

Some design features worth emphasising:

- A flexible connection between the main duct and AHU to isolate AHU vibration is necessary. But, being a material of density lesser that of the duct wall this will be a path for the air borne noise to escape to the plant room. The flexible element material should be of the highest possible density that the vibration isolation property permits and the break-out noise is to be accounted for downstream of the noise path.
- Pumps also should be isolated from the rest of the piping network by flexible couplings
- Spring mounted or neoprene supported pipe hangers of minimum length 18 in (0.46m) is required. The installer should be aware of the requirement of vibration isolation; it is not uncommon to see some of these mountings with screw tightened all the way through to compress the spring fully, leaving no gap allowance for the isolating function.

Figure 2: Pipe hangers with vibration isolation

DUCT BREAKOUT NOISE

Round duct reduces the breakout, because it has minimum surface area for a given duct cross section and the velocity profile is uniform with less turbulence.

An internal duct lining for the first 10 ft (3m) is a good acoustic design practice but has serious condensation risk in our country. Air leaving the AHU often has a dry bulb and wet bulb temperature of less than 1°C difference which would cause condensation anywhere down the duct where there is turbulence.

To reduce breakout, duct insulation can be done on the outside of the duct. This will consist of a foam layer, such as fibre glass and a cover such as mass loaded vinyl. Foam by itself is not a sound insulating material.

Although for thermal requirements return duct need not be insulated, if it is identified as a potential noise path (sound with a velocity 344 m/s as compared to air velocity of the order 5-8 m/s could travel backward through the return air duct to the occupied space) it need to be insulated.

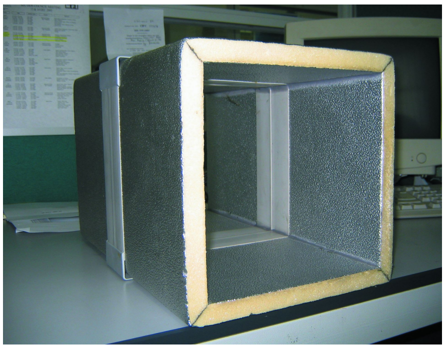

Figure 3: Pre-insulated aluminium duct material

A new duct design, of pre-insulated Aluminium duct, is now available with duct sections factory assembled and mounted with special joints on the site. Excellent sound transmission qualities were observed, but the price is many times higher than conventional GI duct.

CLOSING THOUGHTS

Meeting acoustic criteria of an installation requires a variety of steps to be taken. Coordinated design job onset with the involvement of acoustic professionals (not during the commissioning time as is often practiced) is required. Design goals have to be realistic as tighter specifications make the project costlier. ■

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