An update on acoustics designs for HVAC (Engineering)

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Abstract

A person's sense of comfort and their capacity for work and / or their appreciation of leisure activities deteriorate quickly in poor air conditions.

More seriously, a person's general health may be impaired in the long term by being subjected to ill-ventilated buildings and enervating climates.

The relevant factors to be considered are:

- Temperature
- Relative Humidity
- Air Circulation

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The main function of the Heating, Ventilation and Air Conditioning (HVAC) engineer is to engineer ways for keeping these factors under control.

To produce suitable air changes and cooling within an occupied space entails the need to induce and control airflows which is always associated with some level of noise. This noise can in some cases be just as unacceptable as poor ventilation in as far as it affects the capacity to work and / or concentrate.
This paper looks at a set of five typical design cases that arise and methods that can be applied in achieving the HVAC engineer's environmental requirements while minimizing noise generated in the process considering standard methods and more recent techniques used in the design of acoustic measures.

1 Introduction

In this paper we are going to look at a variety of ventilation situations where sound from external sources breaking into and out of spaces and the air movement equipment itself can interfere with the use of the space or dwelling external to a building and consider the acoustic measures that could be applied in each case. Although five cases are offered for consideration there are numerous other situations that could be sited.

The five cases are as follows:

- Entertainment Venues
- Schools
- Board Rooms & Consulting Rooms
- Cabins on Oil & Gas platform topsides.
- Studios

We will deal with each in turn showing the type of acoustic attenuation measures that can be applied.

There are fundamentally three methods of design of acoustic attenuators and these are as follows:

- Absorptive
- Reactive
- Active Noise Control

We complete this with a look at some recent developments in attenuator design.

2 Cases of the application of attenuation measures

2.1 Case 1: Entertainment Venues

Modern entertainment venues and here we mean clubs playing garage, reggae and drum and bass types of music.

Image 1: Typical Entertainment Venue

Such venues can contain 400 to 1000 people and sound systems having significantly high levels of sound. Also they tend to operate from around 22:00 hours to 04:00 hours.

It is clear that a significant amount of airflow would be required in such a case to control the internal environment considering a significant number of the patrons will be dancing. This is achieved by having air moving fans on both the air intake and air extract ducts which is a conventional design of ventilation.

In such cases duct attenuators are required on both the intake and extract to reduce the combined sound of the fans and the music escaping from the space and interfering with local dwellings.

The sound levels within such venues need to be high as this is what patrons are expecting.

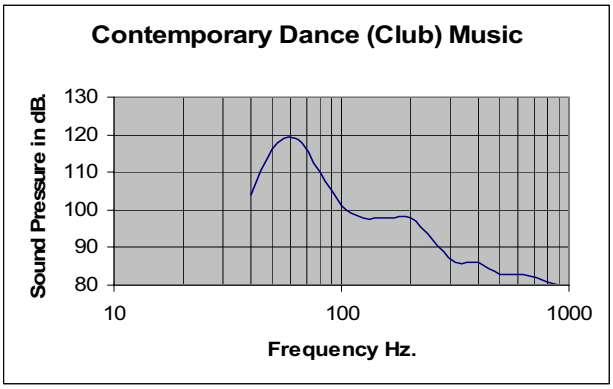
Normally in urban localities where such venues are located the background sound levels in the early hours of the morning are in the order of 40 dB(A).

Therefore acoustic measures need to be applied to not exceed this level of sound.

The attenuators used for this type of application have been mainly absorptive but sometimes we have had to resort to a combination of absorptive and reactive attenuation.

The difficulty in selecting suitable attenuation is that most of this type of music has a high base level at 63 Hz pulsing at around 154 beats per minute which in fact dictates acoustic design.

That is, if we control the sound levels at 63 Hz. the rest of the sound levels at higher frequencies in the spectrum would normally be controlled.



Graph 1: Typical Music Spectrum

Absorptive attenuators up until recently have offered poor attenuation at low frequencies and therefore a long attenuator with a pod will be needed and or a combination of absorptive and reactive attenuation design.

Attenuator are often required both sides of the fans as sound from the fans can have poor effects on the sound expected from the music.

To move the air we would normally recommend axial flow fans so that we minimize any extra low frequency sound levels and the costs of the fans and associated acoustic design.

This is essentially a standard form of ventilation design albeit it is a little extreme design due to the level of sound required by patrons who use the venue.

2.2 Case 2: Schools

Schools are an important case as we all suffer if we have limitations placed on our ability to study what ever age we may be.

Image 2: Typical School Class Room

Ventilation of ordinary class rooms is often achieved by natural ventilation between spaces such as the class room and the corridor or the class room and the world outside.

Here ‘trickle’ style ventilation design tends to be popular.

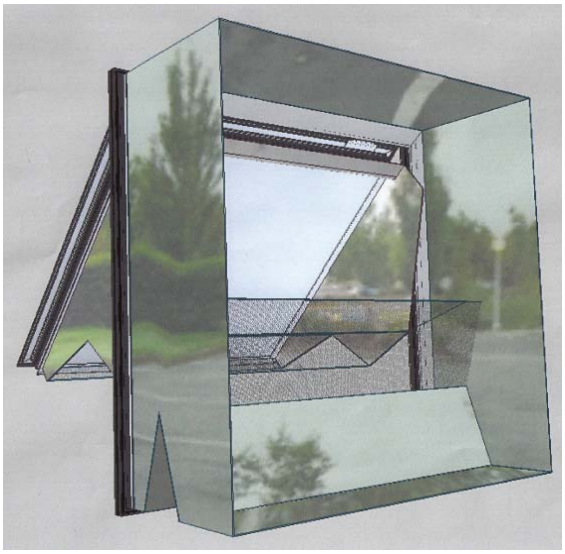


Image 3: 'Trickle Vent' Damper / Attenuator

Such a design can not only prevent 'crosstalk' between adjacent class rooms, class rooms and corridors, it also offers a reduction of sound breaking in from outside the building.

2.3 Board Rooms & Consulting Rooms

Board rooms are often given a low sound level criterion by architects and we have known criterion as low as 20 dB(A). In this case not only are quiet conditions required but also any intelligible conversations breaking out of the room need to be attenuated.

Image 4: Typical Board Room

This again is a case for cross talk attenuation although if a fan driven ventilation system is used although the 'trickle vent' type ventilation concept can be used, practicalities may dictate a more conventional attenuation be used.

Therefore depending on the situation the 'trickle vent' type ventilation concept may be applied as well as the conventional methods.

Consulting rooms used for medical or legal discussions similar to board rooms require relative quiet conditions coupled with the need for discretion.

2.4 Case 4: Cabins on Oil & Gas Platforms

When considering off-shore accommodation it is imperative that personnel have sufficient sleep and rest as working environments can prove dangerous if one lacks concentration.

In most cases it is considered sound levels in cabins are low frequency sound passing through the steel structure from plant and equipment items even if isolation measures have been applied to reduce structure-borne sound.

Image 5: Typical Oil / Gas Rig Cabin

The residual common low frequency sound breaking in to the accommodation may be considered soporific and therefore can often not be seen as a problem.

There are sometimes cases where sound is generated by airflow through terminal units in the accommodation and this sound tends to be higher frequency. This is often a problem and should be controlled using absorptive attenuation measures.

We have had experience of low frequency associated with large centrifugal fans getting into the accommodation ventilations system which was considered a nuisance and had to resort to active noise control (ANC) attenuation methods.

2.5 Case 5: Studios

Intuitively one may assume that quiet conditions are paramount in studios and generally this is the case.

Image 6: Typical Radio Studio

There is one acceptation and this is in radio studios.

Here the criterion is not set to match the sensitivity of the human ear but a spectrum to match the sensitivity of the microphone.

If fact sounds from ventilation systems are adjusted to try and meet the shape of the criterion spectrum as near as possible or else the radio sounds strangely hollow or empty to the listener.

3 Acoustic Ventilation Equipment

The acoustic equipment used to controlling sound levels:

3.1 Splitter Attenuators

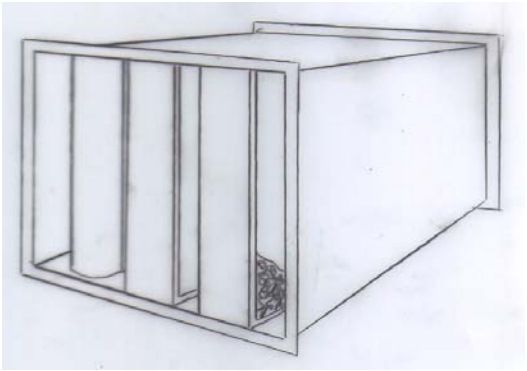


Image 7

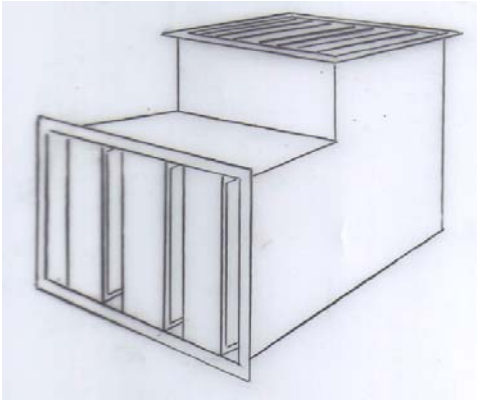


Image 8

3.1 Circular Attenuators

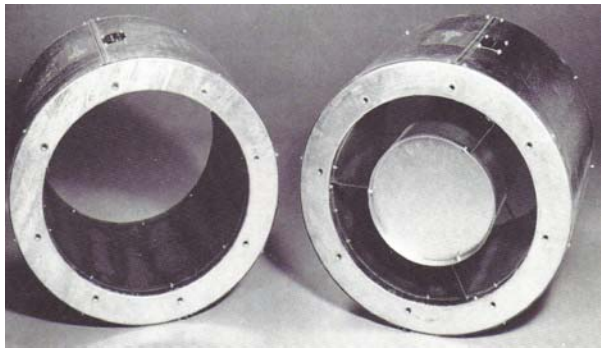


Image 9: Two Circular Attenuators one with Pod

3.2 Acoustic Louvers

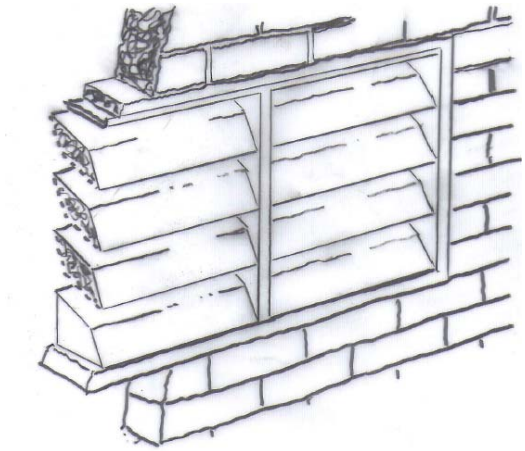
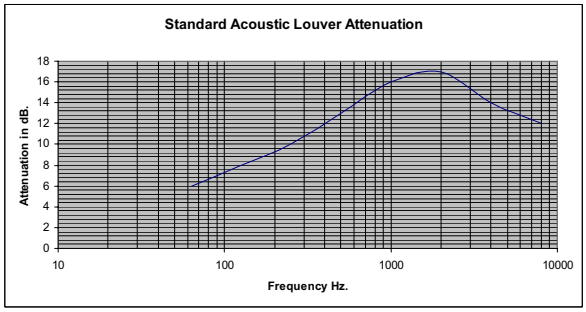


Image 10: Layout for Standard Acoustic louver



Graph 2: Attenuation offered by Louver

3.3 'Trickle Vent' Attenuator / Damper

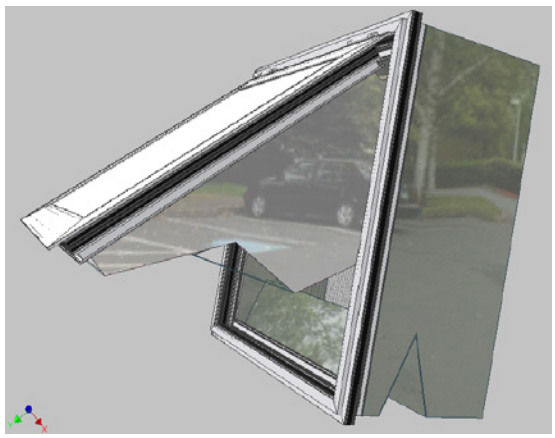


Image 11: 'Trickle Vent' Damper / Attenuator

3.4 Reactive Attenuators

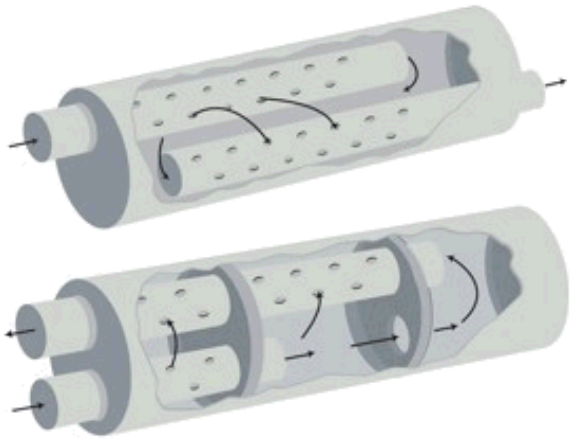


Image 12: Internal View of Reactive Attenuator

3.5 Active Attenuators

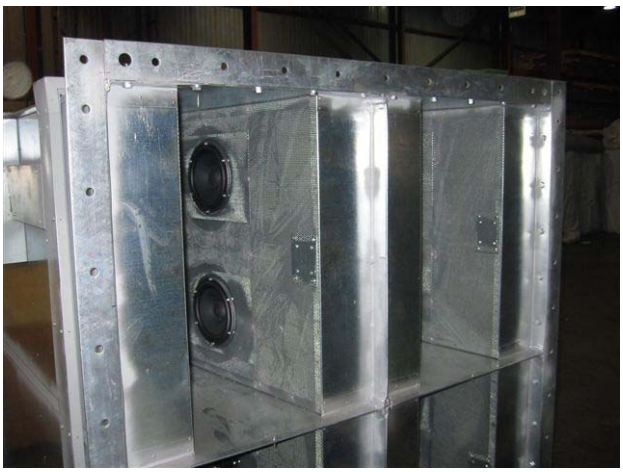


Image 13: Active Noise Attenuator Showing Speakers

4 Recent Improvements in Ventilation Attenuation

There are two main improvements made recently to a couple of the standard acoustic attenuation products.

But the improvements mean that acoustic hardware can be smaller and offer less resistance to air flow for a given specification.

The improvements in design were discovered in the following way.

We were asked to give acoustics advice to clients who have been manufacturers of non-louvers and dampers amongst other products for many years.

They wished to include an acoustic element to their product range and we gave advice on materials used in a design and their limitations and applications.

The products which underwent acoustic design were as follows:

- Acoustic Louvers
- Attenuated 'Trickle' Vents

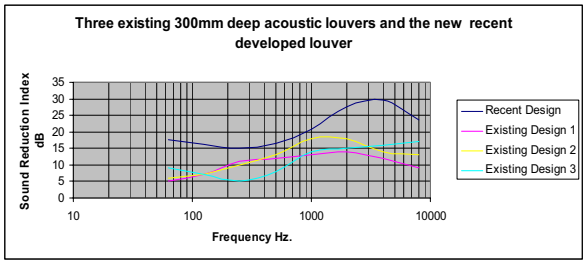
The actual development was carried out in house by the company who using the principles of acoustics explained and material suggested.

As consultants we had no other input other than checking test results and occasionally answering a technical question.

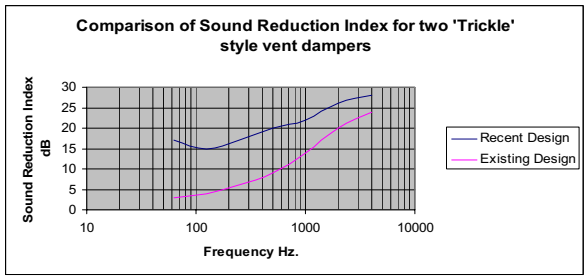
The company then had these two products acoustically tested at an internationally known acoustic laboratory in the UK to an international standard acoustic testing method.

The interesting situation that arose was that the results obtained for both louvers and 'trickle' vent showed unexpectedly enhanced attenuation at low frequency.

They also showed a typically expected attenuation for the rest of the octave band spectrum.



Graph 3: Improvement of new design over standard



Graph 4: Improvement of new design over standard

5 Conclusions

We conclude that the methods of application of the acoustic material used has in some way produced products that offer improved attenuation at low frequency with a low pressure loss.

Where larger splitter attenuators would normally be required to attenuate the low frequency sound also these improvements would suggest that significantly less space would be required in applications such as plant-rooms.

We intend to look at the design in more detail with the client to establish an understanding and explanation for these improvements in low frequency attenuation and consider other products for possible applications.

Acknowledgments

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