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Sound Reflector for Simplifying Sound Intensity Measurements

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Measuring the sound intensity on a full surrounding surface may give problems when the tested object is mounted with pipes, channels etc. One problem is to achieve a uniform integration in time and space when moving the intensity probe. In addition the noise emission from pipes, channels close nearby may not be relevant and is thus disturbing the measurements. A reflector surrounding the object has been tested in order to simplify the sound intensity scanning to just one plane surface and at the same time amplifying the sound intensity and shielding the background noise. Additionally the measurement time is reduced by a factor 4 to 5 as only one surface needs to be measured. The tested reflector has no parallel surfaces and is made of two halve parts in order to be mountable around a ventilation valve including its air channels. The plane measurement surface has an area of 1 m^2, and the sound power is thus equal to the average sound intensity on this surface. The inner surfaces are sound reflecting. The accuracy of the measurements is being tested, and the results until now indicate that the method for this type of measurement objects is very efficient.

1 Introduction

Since round the beginning of the 80's, sound intensity measurement techniques has been used for determining the sound emission from noisy machines in total and for individual parts of a machine in order to compare, quantify and prioritize the fight against noise.

The most used method based on two sound pressure microphones and calculations of intensity from the phase differences is still in use. This gives in good acoustical conditions the possibility of measuring the sound power from individual parts (surfaces) even where the sound pressure levels are mostly determined by the surrounding other sound sources. But no trees grow to heaven….

Some of the demands for summing the total sound power from sound source precisely is that all the measurement surfaces are scanned (or discretized) detailed and uniformly enough, while the noise emission from the sound source and all relevant background sound sources are stable. This can in the real world be very tedious, time consuming and may be impossible to do in practice within reasonable limits of time and economy.

Also no acoustic absorption material must be within the measurement surface volume.

Often the space around a sound source in filled with other machines, supports, pipes, wires etc. making it almost impossible to move a sound intensity probe steadily and uniformly on defined measurement surfaces enclosing the sound source.

2 Challenges in short form

- Measuring sound intensity on a 5-6 faced box shaped measurement surface takes time
- The steady uniform scanning of the probe can be hindered by obstacles.
- Background noise sources may be close to the measuring object.
- Measurement duration may be limited due to changes in levels and possible need for many measurements in different conditions.

3 Measurements of sound from air ventilation units etc.

Measurements of the sound emission from ventilation units like valves, fans, and air condition inlet/outlet openings and 'kitchen' hoods are becoming more and more important for documentation of the noise level.

Several Danish companies within ventilation products are aware of this, and in order to compare with each other and also with foreign competitors they ask for combined measurements for energy relevant parameters and noise emission under relevant conditions.

In practice this can be difficult to achieve in a total energy test setup, where the background noise from supporting fans, heat exchangers, valves and cooling/heating systems can be much louder than the tested unit. Moving the unit to a calibrated low noise acoustical room (reverberant or anechoic) is seldom possible without very difficult sound reduction problems.

Some modifications of a setup have to be implemented. This includes intelligent 'short cuts' and using relevant measurement results found in the energy testing setup like pressure loss, air speed and control settings of the unit.

4 Method developed at Technological Institute.

At Technological Institute / Ventilation & Energy a method and a setup for ventilation units has been developed in order to measure the sound power in the air channel and at the same time the sound power emitted from the surface of a ventilation unit (a valve for comfort ventilation).

In order to do many measurements for several settings of the unit it is important to find a way to be very efficient, that means simplifying the numbers of measurement positions / areas, and minimizing the necessary duration for each measurement.

The air channel is connected to a reverberant room for traditional calibrated measurements of the sound power using a comparison with a calibrated reference noise source. This gives a simple and fast measurement using a multichannel setup (B&K PULSE system and 6 fixed microphones).

Outside the reverberant room the air channels are connected via the tested ventilation valve and several sound mufflers to a fan placed outside the building. Here the measurement of sound power from the outside of the unit is made using a sound intensity system from Brüel & Kjær type 2270G. The intensity probe is scanned over a measurement surface by hand.

The developed method for simplifying the intensity scanning in as short time as possible is to use a hard walled box with one open surface (side) around the ventilation unit as shown on next figure 1.

The advantages of this reflection box method are several:

- A box with one open surface with chosen area $1m^2$ gives Sound Power = Sound Intensity in average.
- Hard walls gives sound reflecting inner surfaces => All sound energy reflected out of the open surface => increase in S/N ratio is theoretically up to 10 * log(6) = 7.8 dB.
- External background noise reflected back again….
- Only one simple surface with easy access => 5-6 times less time consumption…
- No parallel surfaces => No standing waves and thus less variation of sound levels on measurement surface.
- Demountable => Usable on existing installations if space enough around object…
- Variable sizes of holes for ducts and pipes using inserts as needed.

Some of these advantages are illustrated on the next figure 2.

Figure 1 Ventilation unit mounted in sound reflector box. Opening surface area is 1 m^2.

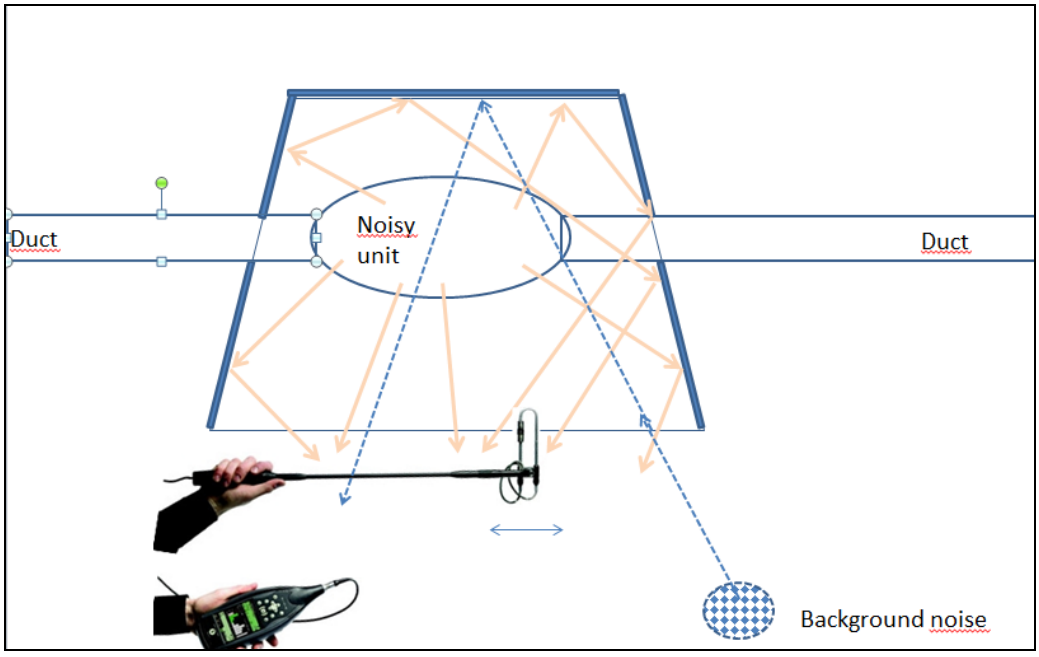

Figure 2 Principle for reflection of emitted noise and background noise. Intensity probe is moved on the opening surface in a systematical pattern (scanning).

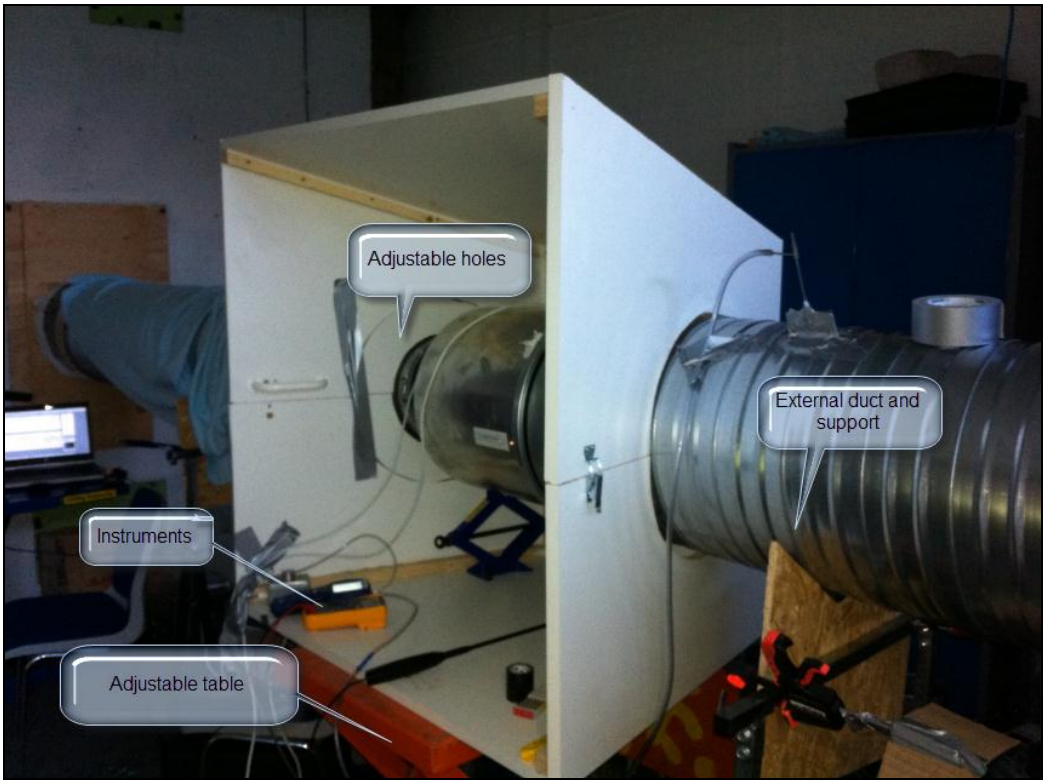

Figure 3 Example of a setup for measuring very sound power levels from a ventilation unit in a laboratory with other background noise sources. Pressure loss is measured on the suction side of the ventilation unit.

There are two possible pitfalls, which shall be mentioned.

- The connection channel or pipe should ideally be mechanically disconnected using flexible, but still sufficient sound reducing hoses on both sides of the valve.
- The supports of channels and ventilation unit must not transmit surface vibrations to the reflection box.
- The channels / pipes inside the reflection box should be covered with sound reducing cladding **if** the emitted noise from their surfaces is comparable with the noise emission from the unit.

These demands can be tested by sending loudspeaker noise into the channel (no airflow), deducing the sound reduction from inside to outside of channel / flexible hose, and then compare with measured in channel sound power from the ventilation unit.

It may be simpler to test by covering the channels and ensure that the noise in the reflector box is determined by the ventilation unit. Also a test with no ventilation unit but the same flow and fan settings should be carried out.

5 Verification of Sound Power Level

A small loudspeaker setup (‘Low-Fi’ PC monitor system with a small subwoofer and two high frequency tweeters) was measured in the calibrated reverberation room using electronic pink noise as input. The loudspeakers were then placed in the reflector box, directing one high frequency speaker forward and the other in to the box. Three scans were made in order to check scanning velocity and possible deviations of sound intensity.

Other different positions and directions were tested, but not reported here.

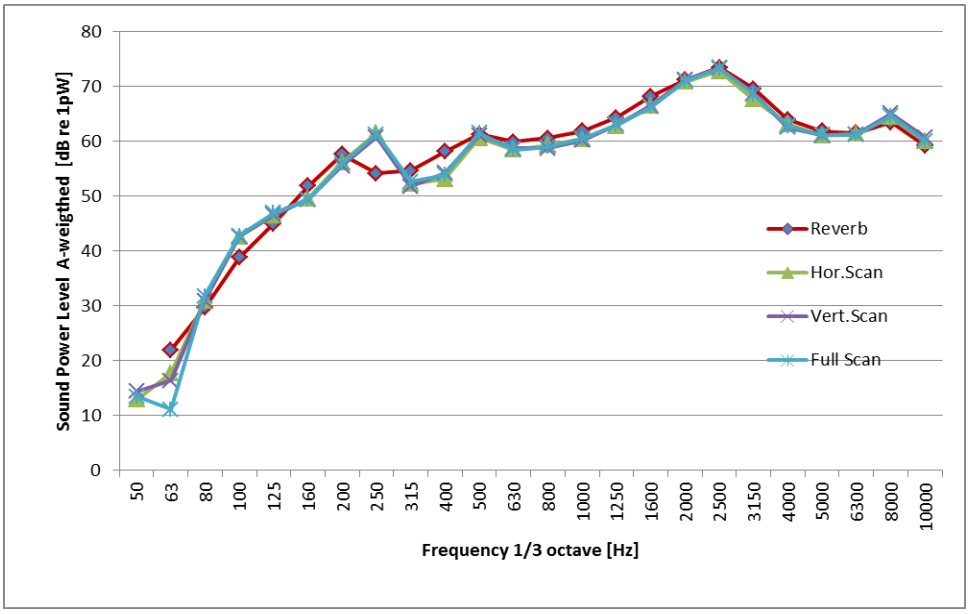

Figure 4 Test Sound source measured in Reverberation Room, and in Reflector box using Horizontal, Vertical and Full scan.

The total A-weighted sound power levels in dB re 1pW are determined to:

Reverb	78,5
Hor.Scan	77,6
Vert.Scan	78,0
Full Scan	78,0

This shows that the deviations of the total A-weighted sound power is almost nothing. However the deviations at 250-400 Hz up to 5 dB are not explained and will be tested further.

There seems to be no problem in the scanning method, indicating that short duration measurement is possible.

6 Survey test of vibration Isolation and Background noise reflection

Further tests were made using the loudspeakers emitting the same pink noise as the former sound power measurements.

Survey test of possible vibration transmission from loudspeakers to the reflector box was made by inserting soft material under the bass loudspeaker and do a full scan. Se figure 5.

The loudspeakers were then placed outside the reflector box at a distance of 1 meter and then doing a full scan.

The total A-weighted sound power levels in dB re 1pW are:

Reverb	78,5
Full Scan	78,0
Vibr.Isolat	77,0
BackGrnd	64,3

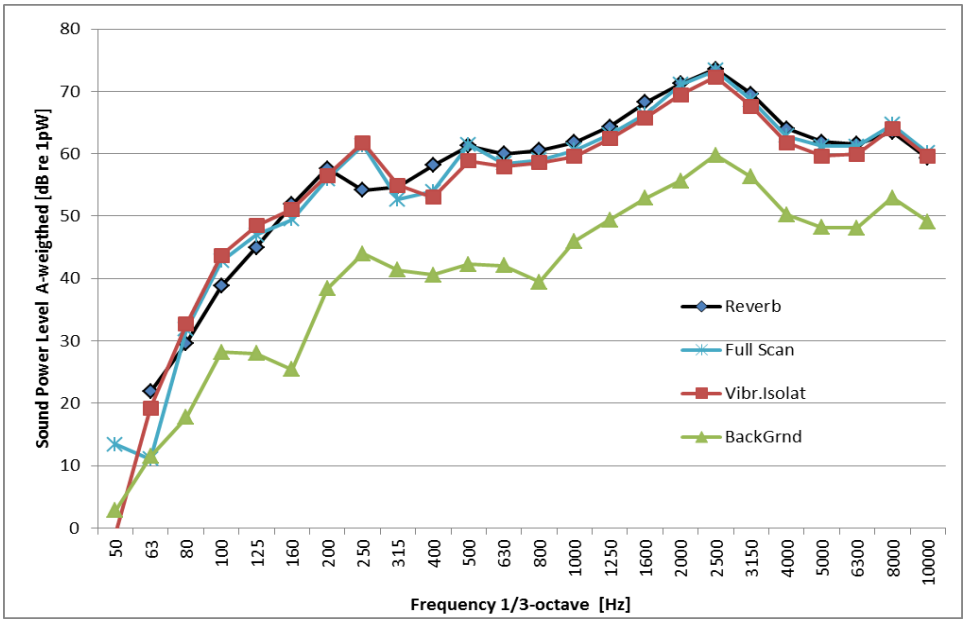

Figure 5 Survey test of vibration isolation of loudspeakers and of background noise source outside the reflector box.

Thus the vibration isolation in this situation has only a small influence, and is not an explanation of the deviations around 250-400 Hz between reverberation room measurements and sound intensity measurements.

The background sound source measurements are in fact mostly showing the residual intensity, as the levels are 'reduced' 10-15 dB while the sound pressure at the measurement surface is almost unchanged.

7 Summary

A sound reflecting box enclosing 5 surfaces around a sound source (ventilation unit) has resulted in a simpler and faster measurement of sound intensity from a ventilation unit mounted in a test rig with airflow and connected to air channels.

The prototype functions well and only minor improvements seems to be relevant. Some minor deviations are to be investigated. Influence of irrelevant sound emission from the air channel / pipe inside the reflection box must be tested / controlled. A possible method could include a movable sidewall, adjustable to actual 'length of the ventilation unit.

The accuracy of the measurements has been tested, and the experience until now indicate that the method for this type of measurement objects is very efficient and within acceptable limits.

8 References

[1] DS/EN ISO 9614-2 "Acoustics – Determination of sound power levels of noise sources using sound intensity - Part 2: Measurement by scanning."

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