Measuring low ventilation noise level in dwellings

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ABSTRACT

*The Danish standard DS 490:2018 "Akustik – Lydklassifikation af boliger" *1, translated to "Acoustics - Acoustic Classification of Dwellings" relates to many acoustical parameters, and "Noise from ventilation" is now being tested in real life in the Danish "Voluntary sustainability classification" (called FBK *6). The Danish building regulation *2 state a sound level limit in dwellings from all kinds of technical systems at 30 dB(A), equal to the Acoustical class C, comparable with the limit in several countries. Research shows *3 that 30 dB(A) does not ensure acoustic satisfying comfort for all people. The FBK has chosen to lower the noise limit to 25 dB(A), equal to acoustical class B. We need to improve the ventilation systems to reach such lower level of sound emission, and we must be able to measure it implemented in dwellings. This paper describes some methods and in situ experience fighting background noise problems caused by activities and equipment around and in the dwelling, as well as in the measurement systems. A proposal for measuring closer to the ventilation armature and convert data to the prescribed position larger distance is described ant tested. The goal is: Measure and document low noise without a high cost in time and money, which could be a barrier for implementing lower noise levels in dwellings.*

1. INTRODUCTION

A low noise level in dwellings for living is a very desirable goal, and for many years a sound pressure level average of around 30 dB(A) has been a common accepted limit for sound from 'fixed' technical appliances like heating, ventilation, plumbing, water pumps, waste disposal etc. Such systems have little or no control possibilities for the persons in the dwelling and are normally mounted as fixed installations.

In the Danish standard DS 490/2018 **1*, now adapted to ISO/TS 1948:21, "Acoustic classification of dwellings" the 30 dB(A) level corresponds to class "C".

But more and more evidence show that the limit of around 30 dB(A) is too high for many normally hearing persons, when it comes to relaxing and sleeping situations.

The standard DS 490:2018 is aiming at the building acoustics, as well as the noise from the technical systems in a dwelling. This means that not only the insulation from sounds from neighbors (sound insulation and impact noise insulation), but also the sound from each dwelling´s 'self-made' noise in the dwelling is in focus.

Testing the sound and impact insulation using standardized methods and controllable loud 'reference' sound source or impact noise exciter is possible in most circumstances, because the background noise may be 'overruled', even at daytime. The costs for checking such parameters are reasonable.

But measuring the low noise levels below 25-28 dB(A) according to the Danish guide **4* (SBI-Anvisning 217) from well designed 'low noise' technical devices like heating/cooling ventilation

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system may be troublesome at daytime and even in evening and night times due to traffic noise and people in surrounding dwellings, and sometimes sounds from restaurants, music/café activities.

This must not be a barrier for the future implementation and optimization of low noise appliances to achieve Class B (=25 dB(A) and even Class A (=20 dB(A)).
This paper describes in short form the relevant background noises, what to do, the measurement systems for very low levels, best practices for ensuring good and reliable low noise measurements, considerations for alternative methods like calculations of expected sound pressure levels based on sound power data / near field measurements and finally a method for direct measurement of the individual noise source transmission from near field to the 'standardized 1 meter distance' position.

2. Background noise

Type of noise – What to do – notes:

- Traffic noise (cars, airplanes, trains, persons…) - Wait for silent periods
- Weather (windy, rainy) - Wait for less influence. Wind is normally varying up and down in a cyclic pattern like 3-5 minutes. Prepare, check weather forecast and may be cancel before doing anything..
- Person noise in building: It is not easy to be completely quite for more than say 1 minute for most people. Hand / arm movements, breathing, couching etc. will again and again disturb the measurements. When there also may be disturbance from traffic etc. you will waste too much time for bad measurements.
- In the relevant apartment/dwelling inform persons, and if possible, find a time slot when persons are not at home (give them a dinner or cinema ticket). The neighbors should also be informed and if any planned noisy activities can be foreseen then find a less noisy time slot later or next day…
- Technical installations/devices in the building: Only the relevant part should be running, so others must be recognized and if possible closed down. Find the electric fuse box and switch off the relevant BUT be sure you can turn them on in relevant state. So, prepare in time by asking the entrepreneur / landlord what may be turned off and what to check. Examples: refrigerators, freezer, aquaria pump, noisy chargers, lamps, telephones, PC's, laundry, pumps for central heating, wastewater.

3. Acoustic measurement system noise

- Use low noise microphones. 10-15 dB(A) inherent noise is possible but expensive.
- The preamps and the sound level meter / digital recording system should be of 'best class'
- Our system is a 2 channel Brüel & Kjær 2270, if needed special low noise microphones Brüel & Kjær type 4145. Typical combined lower limit is 14 dB(A)
- A digital recording system (SoundDevices) is reported to be as low as 12 dB(A)
- Do on-site check measurements with an acoustic 'no noise' adapter or a turned-off acoustic calibrator mounted on the microphone (place it on a vibration insulation matt and be quiet)
- Be careful with range setting. Automatically ranging may cause to low setting due to irrelevant intermittent background noise. Do more than one measurement at each position.

4. Best practice for low noise measurements

Some may be basic for an experienced noise measure'r, but not for all 😉

- Always systematically note the time, position, condition/setting, and visually read values of A-weighted level like L_{Aeq} and L_{PA}-slow. The variation of $L_{pA\text{-}slow}$ during measurement period tells if the level is not stable due to background and/or ventilation system. Also note if tonal noise /

systematical variations / ticks / clicks are heard. This may save your day if the system breaks down… And it helps you to optimize your measurement strategy on the fly.

- Take pictures of positions and if possible, settings of the 'noise source' (rpm of fans)
- When measuring stay in visual distance of the sound level meter. Use extension microphone cords.
- Use closed headphones for monitoring linear signals (not A-Weigthed). Do not use it all the time… but for finding background noises and in-time reactions on variations of levels.
- If possible, use a measurement system with logging. At least the total A-weighted level as function of time, and if possible, frequency spectra, more than one channel, and ideally also a real time multichannel recording (Wav?).
- Unattended digital recordings are not a good strategy. The time used for qualifying/ deleting data afterwards will not be worth it. At least be on the site at the beginning of long recordings, as this will give you direct hints on what to include or not, and the ranging of measurement systems.
- If possible and relevant use in addition a microphone placed outdoor. This may be your on line help for choosing when to measure or not, like waiting for the car to pass, or the dog to be quiet. And for later to check for explanations for strange variations of the measured values.

5. Control of the measured device

- Some devices/systems are simple to control; they may be on/off or with a few fixed steps.
- Some may be influenced of the load, CO_2, and temperature. Then you need to ask and get instructions or assistance of qualified persons to achieve reliable sound measurements.
- Measurements on advanced systems like a ventilation system may be tricky to control and document before, during and after sound measurements are carried out. It may be a locked "black box" controller, sometimes remotely controlled if needed.
- As a minimum the default conditions must be set and verified by somebody with relevant qualifications and equipment, and this must have been done just before the acoustic measurements are made.
- If needed for an accredited verification, it should not be made by the company/entrepreneur who build/mount the system ??

6. Calculation of sound pressure levels

In principle it is possible to use given/measured data for the sound emissions from each relevant component combined with a 3D acoustical model of the rooms in the dwelling to calculate the expected sound pressure levels at defined positions. But implementing the actual influence of different settings and loading conditions will give very unprecise predictions, as they are often not documented at the actual site.

Simpler situations like the sound transmission outdoor with less reflected sound and less interference/shadowing is for many years been calculated using computer models. But complex situations like empty dwellings with long reverberation times is not easy and will be very costly.

7. Why not "TURN UP THE VOLUME"?

If the background noise is around 20-25 dB(A) all day and night you will not be able to measure noise sources lower than 25-30 dB(A) with a sufficient accuracy.

A pragmatic suggestion is to measure closer to the sound source and then calculate the conversion factors to estimate the expected sound pressure at the longer distance like "1 meter".

It has been tested to measure at a distance of 25 cm from the center of the ventilation armatures synchronously with a measurement at the prescribed position at 1 meter horizontal distance and height

1,5 meter above the floor according to the Danish guidance “Udførelse af bygningsakustiske målinger. SBI-Anvisning 217” [*4] (Translated to “Building acoustical measurements. SBI-guide 217”)

7.1. Transmission measurements

Two possible noise sources may be used

- The actual ventilation noise, when setting is at maximum (manually set or by setting the hood at maximum). This gives a spectrum which mainly is an amplified version of the sound at minimum ventilation setting.
- A simple small wireless loudspeaker (Bluetooth) placed IN the ventilation channel behind the armature. A pink-noise generator app on a smartphone gives the relatively loud broad band noise, which will be much louder than the actual background noise and even the ventilation noise. Fig.1

Figure 1: Simple and cheap noise source using Bluetooth connection from App noise generator.

The microphone close to the armature is then placed on the line from the ‘1 meter position’ to the center of the armature at a distance like 25 cm. This single position may be the best choice for combining directivity of the sound emission from the armature, and the local sound reflections.

Remember this is a ‘relative’ measurement for estimation of the transmission difference between the two microphone positions. The absolute level is not important; however it must be at least 10 dB louder than the background sound levels at position 1 (1-meter) in the relevant frequency range. Normally not difficult.

After having measured the transmission factor the normal ventilation situation is measured with basic airflow and no loudspeaker mounted. The same position close to the armature is used. This level is then converted with the measured transmission factor giving the final estimate for the sound pressure emitted from the armature, as if it could be measured at the “1 meter position” without the present background noise.

7.2. Survey test in real life

In a renovated dwelling the proposed method was tested in two empty rooms (A and B). Fig.2.

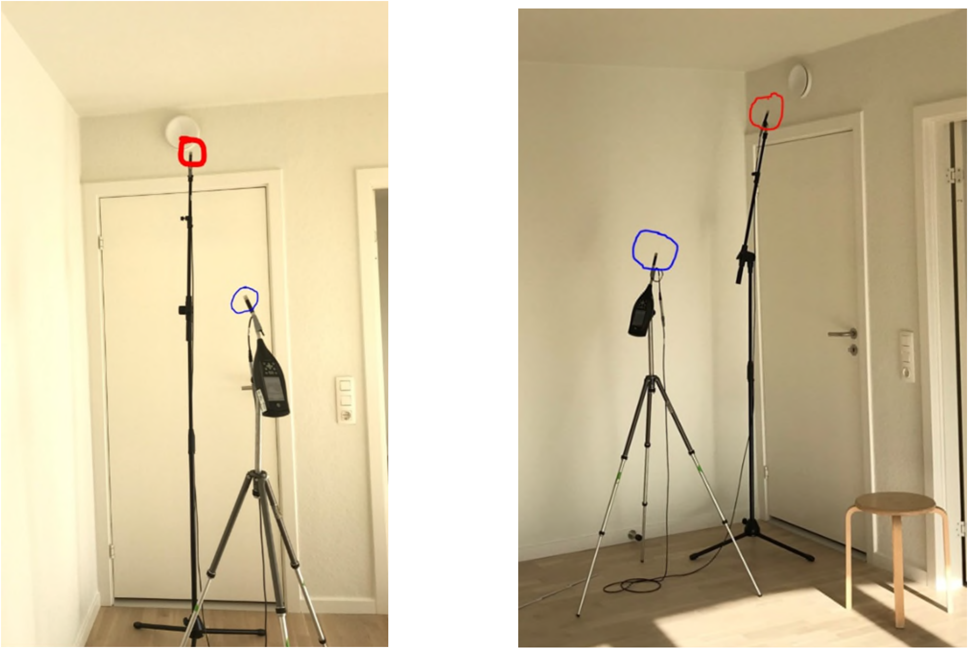

Figure 2: Measurement setup in large living room A. Blue circle is "1 meter" position and red circle is at distance 25 cm from center of armature. Armature close to ceiling and corner.

Comparison of measurements as 1/3-octave levels:

Four noise situations: Loudspeaker only, MaxVentilation (hood on forced), Basic ventilation (minimum ventilation), and Background noise only. The letter A og B refers to tested room. Number refers to microphone 1 = "1 meter", 2= close to armature =25 cm. Fig.3.

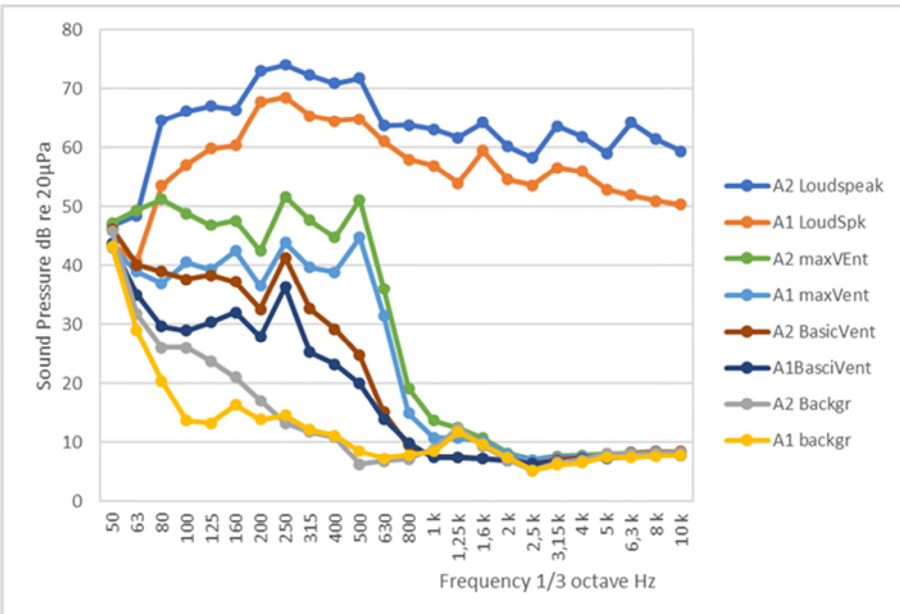

Figure 3: 1/3 octave sound pressure levels in room A.

The sound from the ventilation in room A does not have significant levels above 800 Hz, so using loudspeaker at higher frequencies may be not so important.
The sound level at position 1 (“1 meter”) at basic ventilation is too close to the background level for a large part of the frequency range. However, in this room the total A-weighted level is around 30 dB compared to background level around 21 dB(A).

This gives estimates of sound transmission factors from position 2 (close) to position 1 (“1 meter”) for the 3 situations measured. Fig.4.

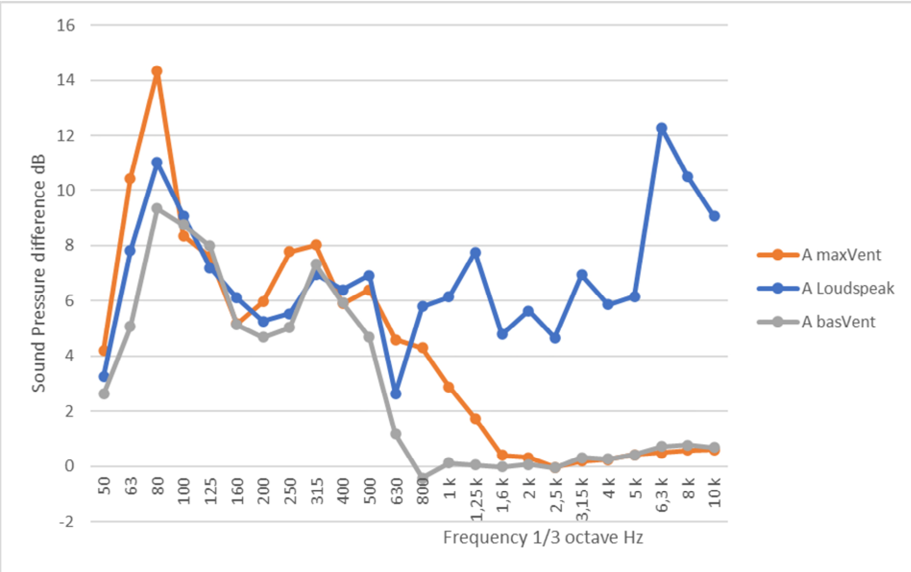

Figure 4: Estimated transmission factors from close position to “1 meter” position, room A.

It is observed that only the use of loudspeaker gives an usable estimate in a broad frequency range, as the problem with background noise then is eliminated.

For all three types of noise situations an interesting peak is seen around the 80 Hz band, which indicate that room resonances and the chosen microphone position close to the armature near a room corner is influencing the estimate significantly.

However, as the A-weighted spectrum for the basic ventilation noise situation is dominated of frequency bands from 125 Hz to 500 Hz this is off little importance for the total A-weighted estimate. This is shown on next fig.5 with the A-weighted 1/3 octave levels for the basic ventilation situation.

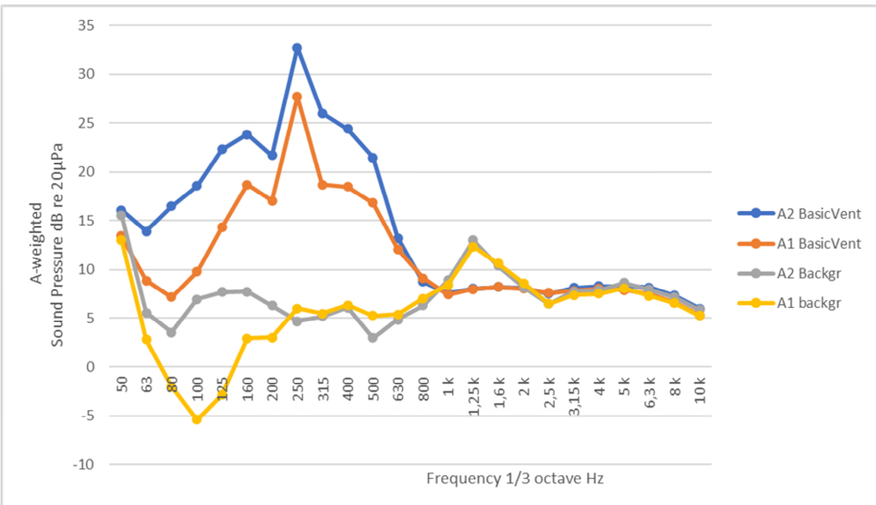

Figure 5: A-weighted sound pressure levels for basic ventilation situation in room A

Test in room B, which is only about a third of the size of room A. Fig.6 & 7 & 8:

Figure 6: Setup in room B. Armature downward, near wall. Right picture shows the alignment of microphones pointing at center of armature.

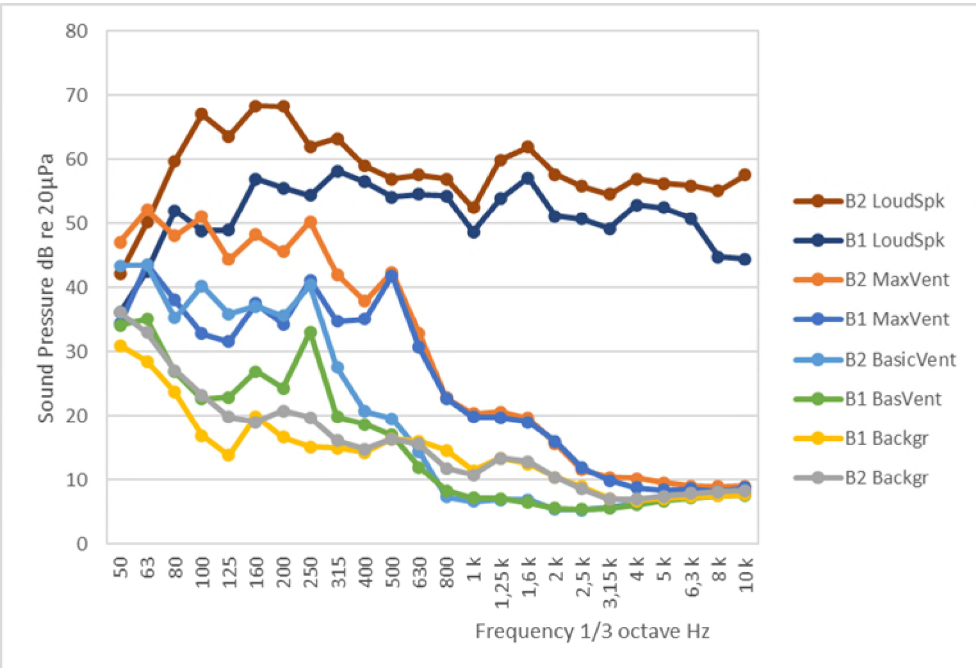

Figure 7: 1/3 octave sound pressure levels in room B.

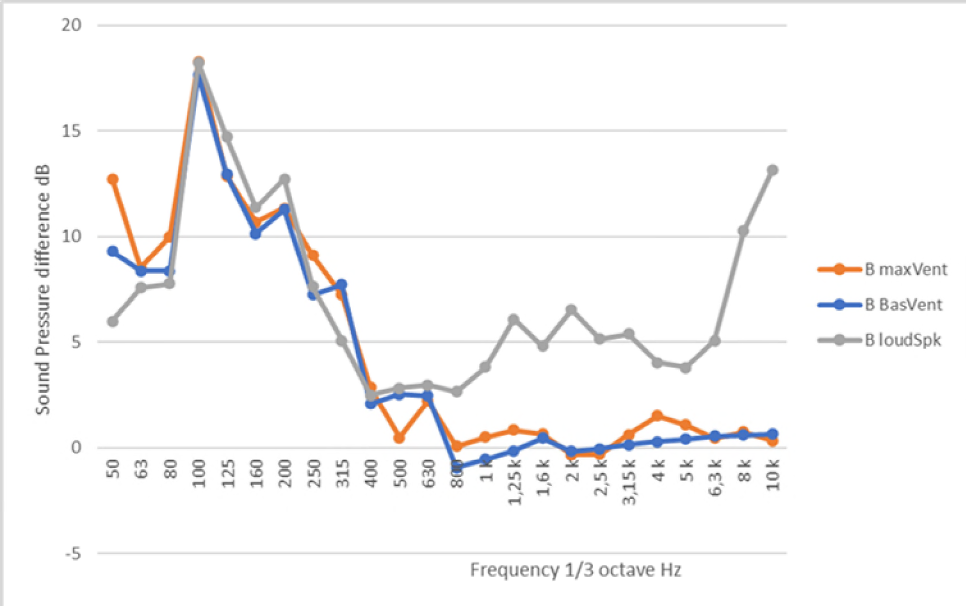

Figure 8: Estimated transmission factors from close position to “1 meter” position, room B

Here the low frequency peak moves upward to 125 Hz and gets a little more pronounced, compared to room A.

The high frequency (above 5 kHz) factors for the loud speaker test may be explained by the microphone position very close to two sound reflecting surfaces, causing the levels close to the armature to increase.

The same arguments concerning the dominant frequency range gives the same main ‘conclusion’ concerning a reasonable method for estimating the ‘average’ conversion factor from a close position to the “1 meter position”. When the noise source is ventilation armature and the main test is an estimate of the total A-weighted sound pressure level the following

7.3 Main results of total levels:

The measured A-weighted differences are for the two tested rooms : Table 1:

Situation	**A LoudSpeak**	**A MaxVent**	**A BasicVent**	**B LoudSpeak**	**B MaxVent**	**B BasicVent**
Difference dB	6,1	6,7	5,3	5,3	4,9	7,4

Table 1: Measured total A-weighted sound pressure level differences for a close position and a “1 meter” position in room A and room B using three types of noise emissions.

8. CONCLUSIONS

When measurements of low noise levels from ventilation armatures in dwellings are disturbed by background noise many techniques and ‘best practices’ may be relevant. These are described in this paper.

When levels below 25-27 dB(A) are to be measured, it is suggested to estimate the total A-weighted sound pressure for a position 1 meter horizontal from the armature based on measurements closer to the armature. Test examples in empty rooms indicate a conversion factor of 5 to 6 dB to be subtracted from the level at the close microphone position (25 cm)

For measuring the conversion factor, it is possible to use either noise from the ventilation system if it can be forced to a maximal setting, or better by using a small loudspeaker mounted in the duct behind the armature. This can be done for each armature relatively simple and cheap.

Further test and possibly some standardization may be relevant to estimate the uncertainty and evt. critical microphone positions of this proposal.

9. REFERENCES

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