**Bergen, Norway**

**BNAM 2010**

**May 10-12**

# Open versus closed ventilation devices – what is the impact on indoor sound pressure levels?

Sigmund Olafsen
Brekke & Strand akustikk as, Hovfaret 17, NO-0275 Oslo, Norway, so@bs-akustikk.no

Norwegian regulations regarding indoor sound pressure levels have been in force since 1997. In existing residences exposed to existing noise sources the regulations state that indoor levels shall not exceed an LAeq,24h of 42 dB. The responsibility of sound reduction measures lies with the owner of the noise source. The regulation states that the indoor level is derived assuming closed windows and closed ventilation devices. A change in the regulation is now being evaluated. It would be more realistic to assume open ventilation devices. Earlier studies have indicated that the critical cases are situations where the ventilation devices face the noise source directly. The presented investigation has concentrated on the difference in indoor levels for two types of ventilation devices common in older houses. Calculations are based entirely on empirical data. The types of noise sources considered are roads, railways, trams and subways, two situations for each source. Five general types of houses of typical Norwegian construction are considered. The paper will present the reported results from the calculations based on field data and considerations on the validity of the methods. The Norwegian Climate and Pollution Agency has commissioned the work, and has permitted the results to be presented at BNAM.

## 1 Introduction

The work was originally presented as a project report [1]. The scope of work was to evaluate the difference in indoor noise level between situations with open and closed ventilation devices and, if possible, to find a way to calculate the level difference between open and closed ventilation devices for a given house. Present regulations concerning noise from existing sources to existing houses [2] state that indoor levels should be calculated assuming closed ventilation devices. Part of the process of updating the regulations was an evaluation of the requirement of closed ventilation devices. A theoretical evaluation [3] of the difference between open and closed ventilation devices was part of the input for the decision whether open or closed ventilation devices should be used in future calculations. This evaluation was based on the standard Norwegian calculation method for indoor noise from outdoor sources [4]. From this earlier work it was clear that the critical cases were situations with ventilation devices on the most exposed façade. It was also clear that only two types of ventilation devices were critical for indoor noise:

- Slits in the window
- Simple openings in the wall

The presented work in this paper uses an empirical approach based on spectra for:

- façade sound insulation measurements
- outdoor immission measurements for different types of noise sources
- measurements of the difference between open and closed ventilation devices

The regulations relevant to this study only apply to older houses with poor sound insulation. The study does not include special noise windows, balanced mechanical ventilation or ventilation devices with special noise treatments. The

calculations were made based on data in our database at the time the study was performed (April 2009). The database is continuously updated, and a new calculation would give slightly different results.

The Norwegian Climate and Pollution Agency recommends that future updated regulations use indoor level calculated assuming open ventilation devices [5].

# 2 Method

## 2.1 Principle

The method calculates the difference between outdoor and indoor A-weighted equivalent level. The basic principles of calculating an expected level difference with closed ventilation devices based solely on field measurements have been presented earlier for road traffic noise [6] and tram noise [7]. The data are taken from a field measurement database [8]. Only the spectrum shape is of interest for this study, thus the levels have been normalized so that the A-weighted level is set to 0 dB for each spectrum, eq. 1:

$$L_{f,normalized} = L_f - L_A$$

In this study outdoor spectrum shapes are selected for 8 different cases. Differences between outdoor and indoor levels are selected for 5 different cases. These differences have been collected using a simplified measurement method [9].

The indoor level, with closed ventilation devices, in dB relative to the outdoor A-weighted level is calculated in 1/3-ocatve bands for each combination of noise source and building type. The difference between outdoor and indoor level is given as the energy average of the A-weighted level difference. The validity of this approach has been discussed earlier [6, 10, 11]. It would seem that the method gives quite good accuracy for existing houses.

Finally, the difference between open and closed ventilation devices has been calculated by adding the difference spectrum from field measurements to the indoor level with closed ventilation. This approach has been described in theory [12], but this is the first practical test of the approach. The quoted results in table 4 are the differences between the calculated average with closed ventilation devices and open ventilation devices.

## 2.2 Selected outdoor spectra

Four types of sources with two situations for each were selected for the study. These sources are shown in table 1 below.

Table 1, outdoor spectra included in the study

| Type of source | Selection criteria | # spectra included |
|---|---|---|
| Road traffic | Speed limit 50 km/h, distance less than 30 meters | 222 |
| | Speed limit 90 km/h | 814 |
| Railway noise | Freight trains | 52 |
| | Airport express trains | 58 |
| Tram | SL 79 tram sets | 114 |
| | SL 95 tram sets | 212 |
| Subway | MX 3000 trains | 894 |
| | Older T1000-1300 trains | 1683 |

For the road traffic noise spectra Leq values are used. For the other, railbound sources, the SEL spectra are used.

## 2.3 Selected level differences

There are five types of houses that have been considered in this study. These are described in table 2 below.

Table 2, house types considered

| Wall construction | Type of window | Type of ventilation | # houses included |
|---|---|---|---|
| Heavy wooden, usually timber | Two separate single glasses | Simple opening in the wall | 9 |
| Light wooden structure | Double glazing | Simple opening in the wall | 30 |
| Light wooden structure | Double glazing | Slit in window | 53 |
| Masonry/concrete | Double glazing | Simple opening in the wall | 3 |
| Masonry/concrete | Double glazing | Slit in window | 5 |

Modern Norwegian houses usually have better sound insulation properties than the ones considered in this study.

## 2.4 Selected ventilation devices

The two main types of ventilation openings are simple holes in the walls and slits in the window. The number of cases taken into consideration is shown in table 3 below.

Table 3, ventilation devices

| Type of ventilation device | # cases |
|---|---|
| Simple opening in wall | 20 |
| Slit in window | 35 |

Figure 1 shows the difference between open and closed simple openings in the wall.

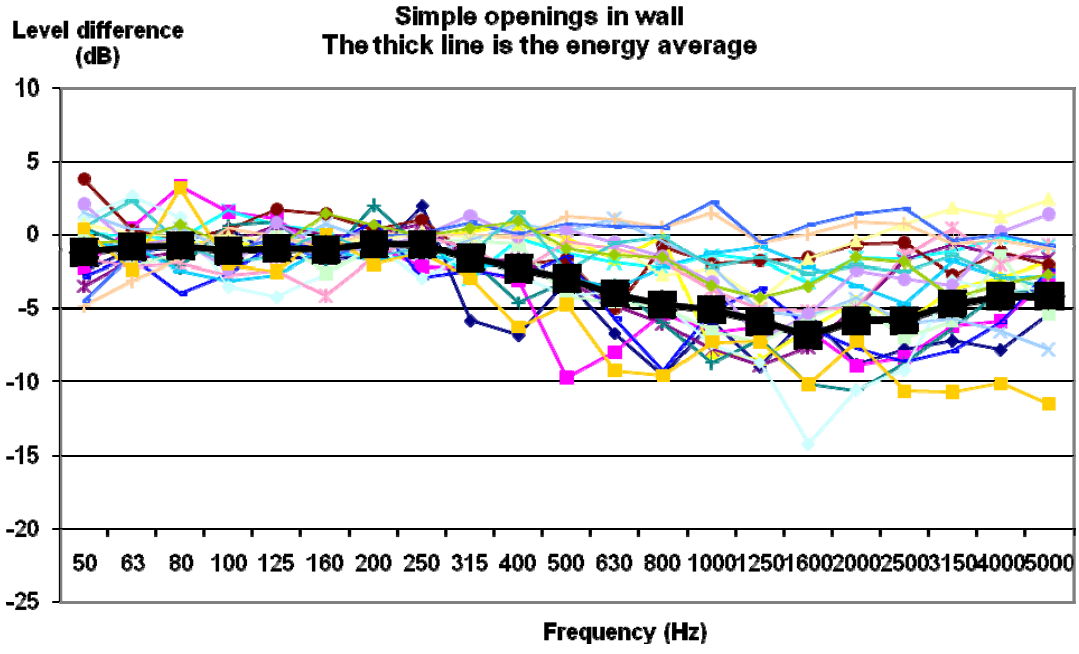


**Figure 1**

**Level difference, simple openings in wall**

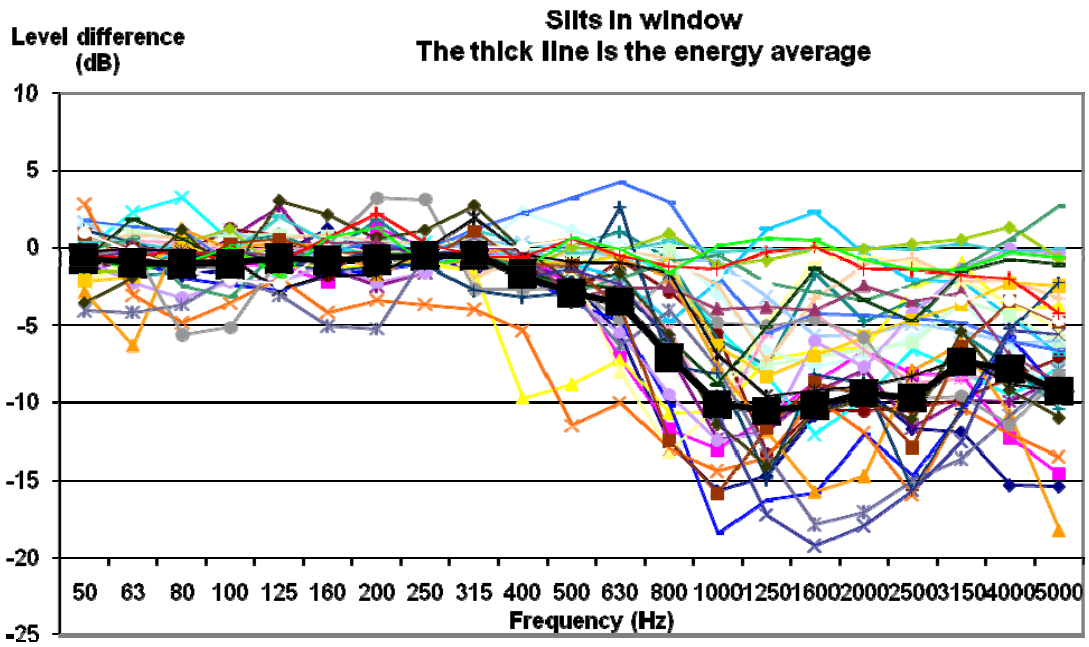


**Figure 2**

**Level difference, slits in window**

# 3 Calculated results

The results of the calculations are presented as the difference between open and closed ventilation devices. Table 4 shows a summary of the results. These results are the averages obtained by calculating all relevant combinations of noise source, construction type and ventilation device. The given values are the differences between the A-weighted indoor equivalent level with open and closed ventilation devices.

Table 4 - Summary of results

Difference between open and closed ventilation device (dB)

| Noise source | Situation | Heavy wood, two single windows, hole in wall | Light wood, double glazing, hole in wall | Light wood, double glazing, slit in window | Masonry/concrete,double glazing,hole in wall | Masonry/concrete, double glazing, slit in window | Average for all types of construction |
|---|---|---|---|---|---|---|---|
| Road traffic | 50 km/h, distance less than 30 meters | 2,5 | 3,4 | 3,4 | 4,5 | 3,1 | 3,4 |
| | 90 km/h | 3,2 | 3,9 | 3,8 | 4,9 | 3,6 | 3,9 |
| Railway | Freight | 2,2 | 2,8 | 3,1 | 3,7 | 2,7 | 2,9 |
| | Express | 2,5 | 3,2 | 3,6 | 4,2 | 3,4 | 3,4 |
| Tram | SL 79 | 2,2 | 2,8 | 3,4 | 3,6 | 3,1 | 3 |
| | SL 95 | 2,6 | 3,3 | 3,1 | 4,2 | 2,8 | 3,2 |
| Subway | MX | 1,8 | 2,3 | 3,2 | 3,1 | 2,8 | 2,6 |
| | T1000-1300 | 1,9 | 2,3 | 3,1 | 3,1 | 2,8 | 2,6 |
| Average for all noise sources | | 2,4 | 3 | 3,4 | 3,9 | 3 | 3,1 |

# 4 Discussion

There are three main points of discussion:

- Validity of the method
- Application of the results
- Practical recommendations

## 4.1 Validity of the method

The method has been suggested as a theoretical idea [12]. It's clear that the same ventilation device will give one difference spectrum between open and closed position in one facade, and another difference spectrum in another facade. It could be argued that it would be better to calculate the increase in sound level going through the open ventilation device. Such an approach would seem to avoid the problem that the effect of opening the same ventilation device gives different results in different facades.

There is a problem in determining the amount of sound going through the ventilation device in a field situation, however. The achievable accuracy of the measurements may not be good enough to give a good indication of the sound insulation properties of the ventilation device.

The question requires further research.

## 4.2 Application of the results

Our calculations give a grand total average of the difference in indoor level between open and closed ventilation devices. This means that the results from table 4 can be used for large scale evaluations of regulations. It seems difficult to give any guideline as to how to calculate the effect in a given case for a single house. From figures 1 and 2 it would seem that simple openings in the wall give slightly more indoor noise at mid-frequencies and much less indoor noise at high frequencies (above 1 kHz) than slits in the window. Still, there are large variations between individual cases.

## 4.3 Practical recommendations

An open ventilation device will lead to a higher indoor noise level than a closed device. Our investigations so far give no basis for a prediction of this increase in noise for a given house and a given noise source. For all the studied combinations of noise source, building construction and type of ventilation device, the difference in A-weighted $L_{eq}$ is between 1,8 dB and 4,9 dB. It would seem that a grand average of 3 dB would be a reasonable estimate for any group of houses and any noise source. For a single house, the difference in indoor noise level could be anything between 0 and 10 dB.

It's not considered desirable to have to revert to measurements in order to determine the effect of open ventilation devices for a single house. There's no certain way to predict the effect of open ventilation devices from our study. We would recommend further investigations based on field data, specifically aimed at finding a reliable and practical method of predicting the difference between open and closed ventilation devices.

# 5 Summary

The difference in indoor noise levels from outdoor sources between open and closed ventilation devices has been investigated. The scope of the study is limited to simple openings in the wall or slits in the window, directly facing the noise source. This study is based on field measurements of façade sound insulation and the difference between open and closed ventilation devices. The grand average of the difference is about 3 dB. There's no certain way to predict the difference in A-weighted indoor level in any given single case, it could be anything between 0 and 10 dB.

# 6 Acknowledgements

The work has been commissioned by the Norwegian Climate and Pollution Agency. Our contact was *Anne Gislerud*. Thank you very much for the support, for the permission to publish this work and for important suggestions during the preparation of the paper.

And thanks to all my excellent colleagues at Brekke & Strand akustikk. For this work I would like to extend special thanks to:

*Ragnhild Slettebø* who helped me convince the Norwegian Climate and Pollution Agency that the empirical approach was applicable for this task

*Ingjerd Aaraas* who went through the report and gave valuable advice before we submitted it

*Knut Haugen* who programmed our StairWay database calculations

The responsibility, however, remains mine.

# References

[1] AKU-02, *Forskjell mellom åpen og lukket ventil,* (in Norwegian), project report from Brekke & Strand akustikk to the Norwegian Climate and Pollution Control Agency.

[2] *Forskrift om begrensning av forurensning (forurensningsforskriften), Kapittel 5. Støy - kartlegging, handlingsplaner og tiltaksgrenser for eksisterende virksomhet*. This regulation (in Norwegian) gives the requirements for indoor noise levels for existing houses exposed to noise from existing sources.

[3] SINTEF Byggforsk, Trafikkstøy. *Nye vurderinger av konsekvensen av å regne med åpen vs. lukkede ventiler etter Håndbok 47* (in Norwegian)

[4] Byggforsk Håndbok 47, *Isolering mot utendørs støy,* (in Norwegian with only summary in English)

[5] *Forslag til: Endring av forurensningsforskriften kapittel 5: Konsekvensutredning av endrede beregningsforutsetninger og grenseverdier*. In Norwegian, a description of the consequences of changing the regulations concerning indoor noise levels in existing houses from existing noise sources. SFT (now climate and pollution agency) december 2009.

[6] S. Olafsen, *An empirical way to calculate indoor noise from road traffic*, proceedings EuroNoise 2003, Napoli

[7] S. Olafsen, *Towards an empirical model for sound insulation against tram noise*, proceedings BNAM 2006, Gothenburg

[8] *Stairway* databank, a database and a collection of documentation about field sound measurements compiled through 20 years and stored at Brekke & Strand

[9] S. Olafsen, *Sound insulation against traffic noise in wooden houses*, proceedings BNAM 2002, Lyngby

[10] S. Olafsen, *Accuracy of indoor traffic noise determination, part I, calculations, part II, measurements*, proceedings of Uncertainty Noise Symposium, Le Mans, 2005

[11] S. Olafsen, L. B. Hov, *An improved empirical method for indoor noise prediction*, BNAM Mariehamn 2004

[12] S. Olafsen, *StairWay – a new approach to modeling of physical or perceived noise*, proceedings Euronoise 2006, Tampere