Towards a low noise truck specification

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Contents

1 Introduction

This report summarises the most important findings in the research project *Quiter Transport for More Efficient Distribution* aiming at the outline of a sound characterisation specification for noise improved heavy-duty trucks for nighttime distribution of goods. The focus in the project was on the "last mile" of the transport corridor through densely populated city centres, i.e. transport through rather narrow street canyons lined with residential housings. The noise of the loading or unloading of the goods at the destination is beyond the scope of the project.

Section 2 gives the general description of the involved elements; the outdoor truck sound source, the street canyon amplification and reverberation, noise reduction by windows and facades, and the indoor noise levels due to a truck passing by in the street.

Section 3 gives some specific results from the project; the results of the modifications of a truck with the purpose to reduce outdoor and indoor noise evaluated by measurements.

Section 4 summarises the results of the listening clinics; including fundamental and specific results test subjects evaluating their response to real and synthesised outdoor and indoor sound of a heavy-duty truck, a light-duty van and the modified heavy-duty truck.

Section 5 discusses, from various perspectives, sound attributes of a low noise truck suitable for nighttime distribution of goods.

Finally, Section 6 gives the conclusions in a concise format.

2 General description

This chapter gives the general description of the involved elements; the outdoor truck sound source, the street canyon amplification and reverberation, noise reduction by windows and facades, and the indoor noise levels due to a truck passing by in the street.

2.1 Truck noise

Figure 1 shows some typical sound power spectra in 1/3 octave band levels for a truck FH-437 at some different driving conditions measured in the semi-anechoic camber at Volvo Trucks, Lundby, Gothenburg. Andersson (2012b) gives more details and results. Apart from a broadbanded noise centred around 1 kHz there are also strong order related peaks at lower frequencies. Especially the 3rd order, in this example at 80 Hz, gives high levels during acceleration.

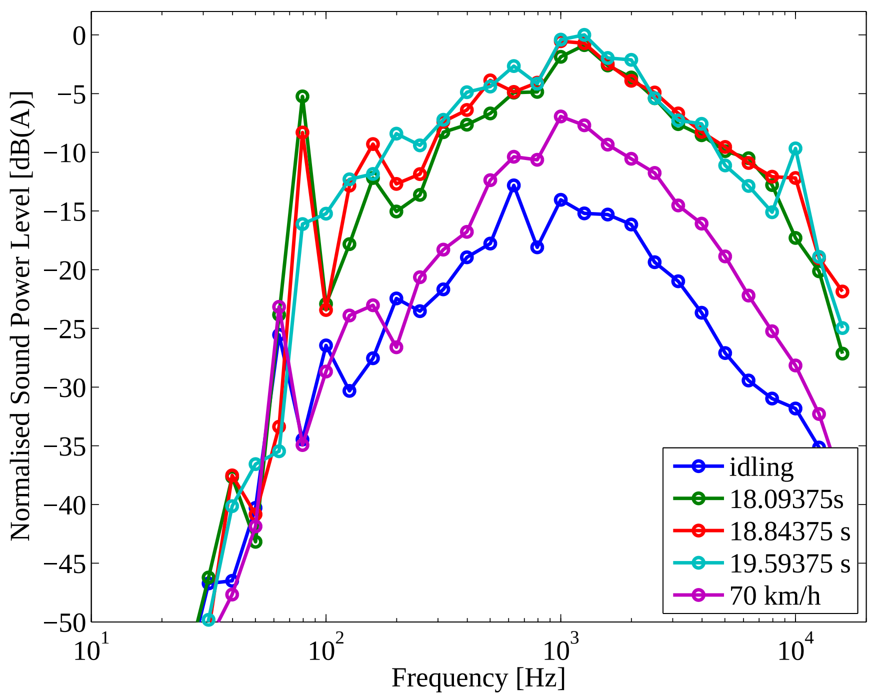

Figure 1: *Normalised sound power levels in 1/3-octave bands at idling, three time instants during acceleration, and constant speed 70 km/h. The sound power levels are normalised to the maximum 1/3-octave band sound power level that occurs for any of the considered cases.*

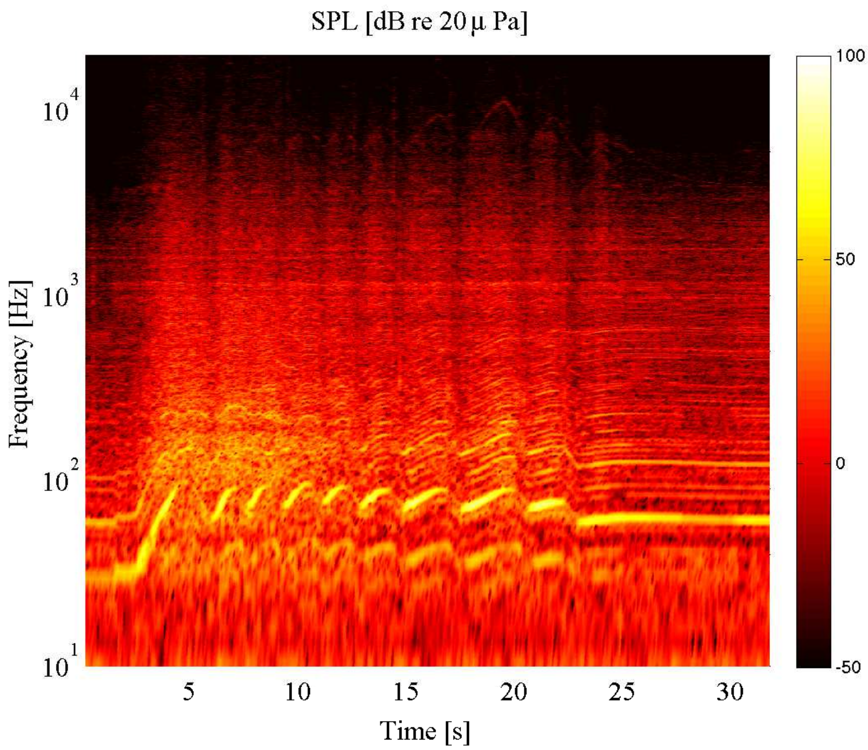

Figure 2: *Spectrogram with sound pressure levels in microphone position at the left side. Time resolution 93.75 ms and frequency resolution 2.667 Hz.*

Figure 2 shows the spectrogram of the unweighted sound pressure levels at a microphone at the left side during a run up. The engine orders, and especially order 3, are clearly visible.

Andersson (2012a) reports on the truck noise separated in different sources and their directivity. The general engine noise and exhaust pipe termination noise dominated for most driving cases. The general engine noise has a broad frequency range that is rather omnidirectional. The exceptions are for locations just in front (and behind) the truck and just above the cabin. The noise at in the front direction has a more knocking character and are up to 5 dB higher levels than at the sides due to the very sound transparent front. For the noise at the exhaust pipe termination, the 3rd order booming noise is rather omnidirectional with a directivity somewhat directed towards the left side (2–3 dB higher) and the 6th order noise has a clear directivity lobe at the left side in slight backwards direction (above 5 dB).

In addition the transmission at the rear, compressor, intake and the fan may be cause audible noise under certain conditions. Figure 3 shows the spectrum of the unweighted sound pressure levels at a microphone in front of the truck during a

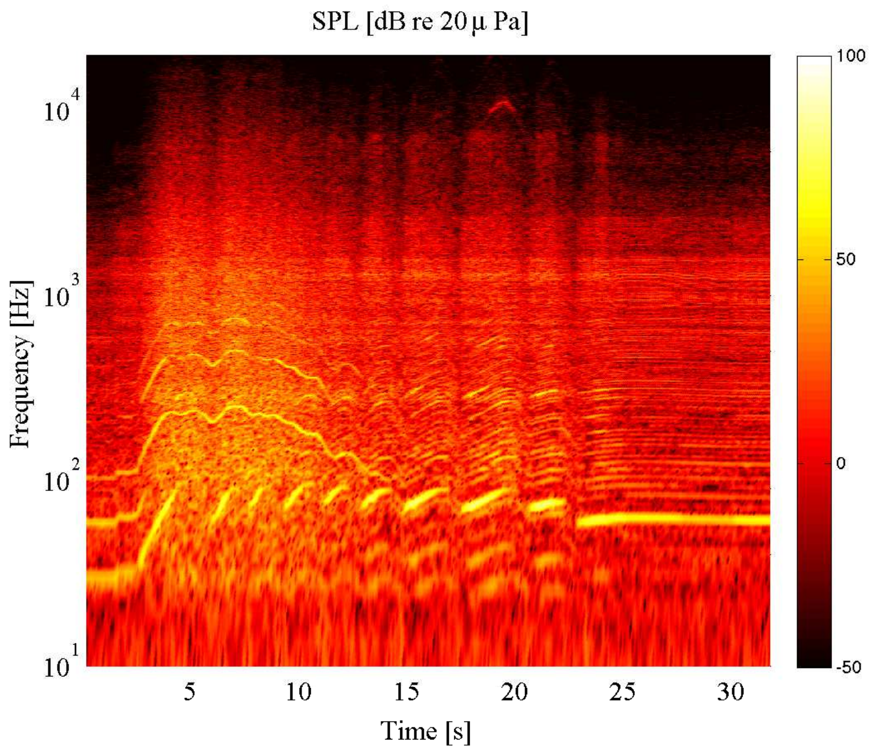

Figure 3: *Spectrogram with sound pressure levels in microphone position at the front. Time resolution 93.75 ms and frequency resolution 2.667 Hz.*

run up for a case when the fan is active. It is seen as an addition of broadbanded noise and tonal components between 100 – 1000 Hz that are not strictly related to the engine rpm and engine order. The fan noise lasts about 15s. At time 19 s and frequency 10 kHz there is a short tone of intake noise. Of these source especially the fan noise may be very pronounced. Thus also a low noise fan is vital for a low noise truck.

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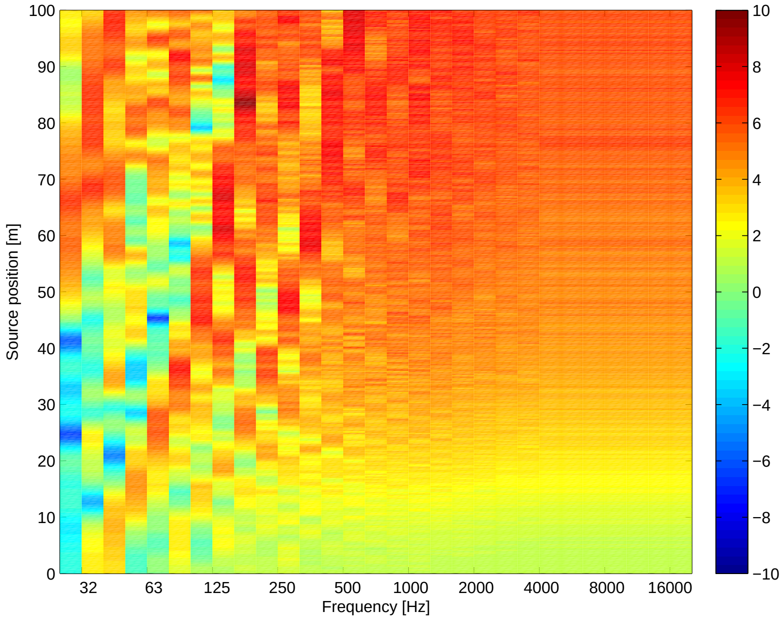

Figure 4: *Calculated gain plotted as level relative to gain of open terrain as function of frequency and source position. The source position is measured as the distance from the receiver along the canyon.*

2.2 Street canyon amplification and reverberation

From the noise source (the vehicle) to the facade the sound is propagating the street canyon. The canyon affects the sound reaching the facade in two ways. First, due to the multiple reflections on the ground, the canyon walls (facades), the vehicle and other objects in the canyon there are many propagation paths causing constructive and destructive interference. Figure 4 shows the interference pattern at the Landsvägsgatan site. The second effect that also stems from the multiple reflections is that of a reverberation time in the canyon. Steady state sounds become more diffuse compared to the case with only the direct sound and impulse-like sounds gets a reverberating tail. The Landsvägsgatan site had a reverberation time of about 1$\pm$0.25 s in the 1/3-octave bands between 63 Hz and 6350 Hz. The street canyon effect is reported in detail by Forssén (2015).

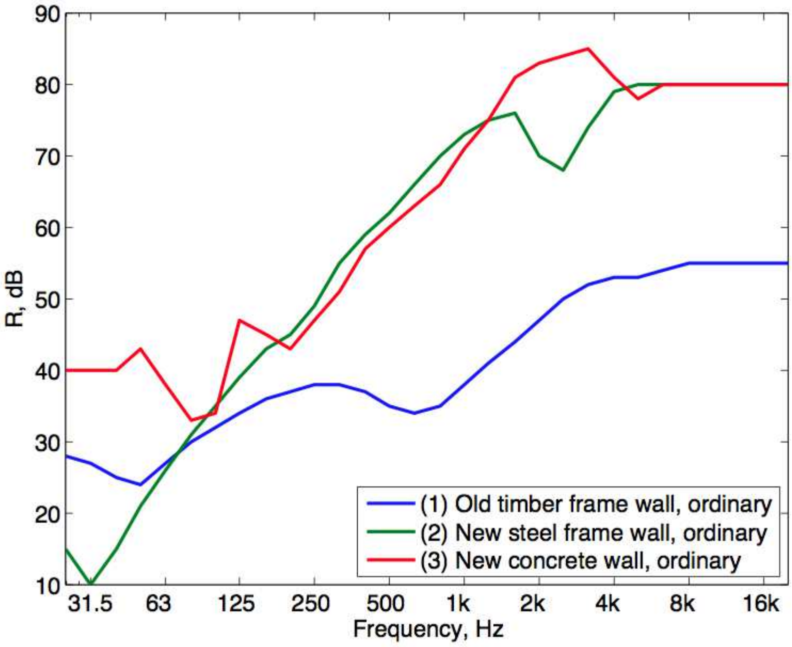

Figure 5: *Reduction indices of walls (see Forssén (2014) for details).*

2.3 Noise reduction by facades

The sound insulation of typical facades, windows and air intake was collected in the project (Forssén (2014)) Figure 5 shows the reduction indices of three typical wall types and Figure 6 shows the same for four typical windows.

Figure 7 shows the same for typical combinations of walls and windows. Case 1 uses a wooden facade, an untreated window and an ordinary air intake. The other five cases all have a better air intake, which can be shown to give a negligible deterioration compared to having no air intake. Case 2 has an improved window (and the better air intake) and shows a significantly better overall sound insulation except at mid frequencies (around 800 Hz) and toward high frequencies. Cases 3 and 4 use both a new steel frame wall and, respectively, two different new windows. The lightweight wall gives very poor performance at the lowest frequency bands and the choice of window makes a significant difference above 100 Hz. Cases 5 and 6 use both a new concrete wall and, respectively, two different new windows. Using the concrete wall is predicted to give a sound insulation at low frequencies that is better than the one from using the lightweight wall, but comparable to the one from using the wooden wall in case 2. Above 100 Hz, the use of the new noise proof window is predicted to result in a very high noise reduction. The types and combinations are further explained and motivated in the report.

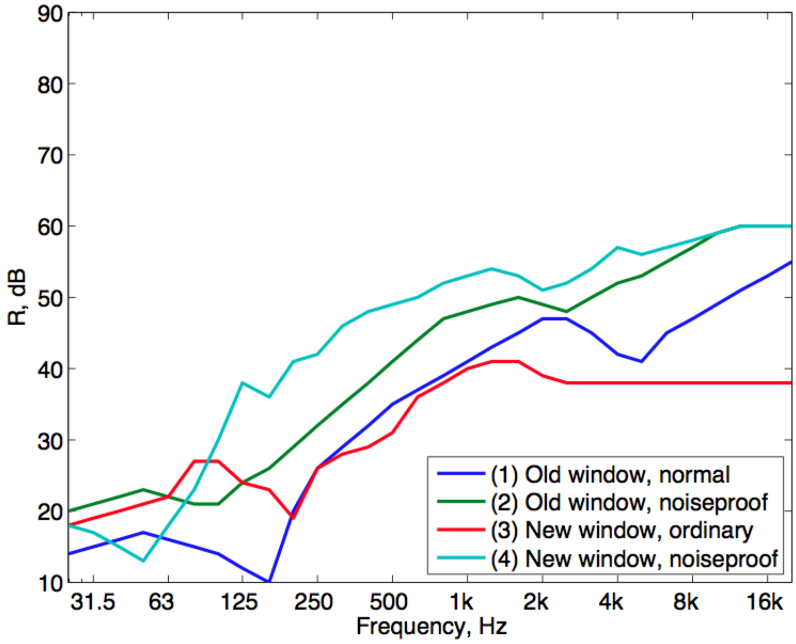

Figure 6: *Reduction indices of windows (see Forssén (2014) for details).*

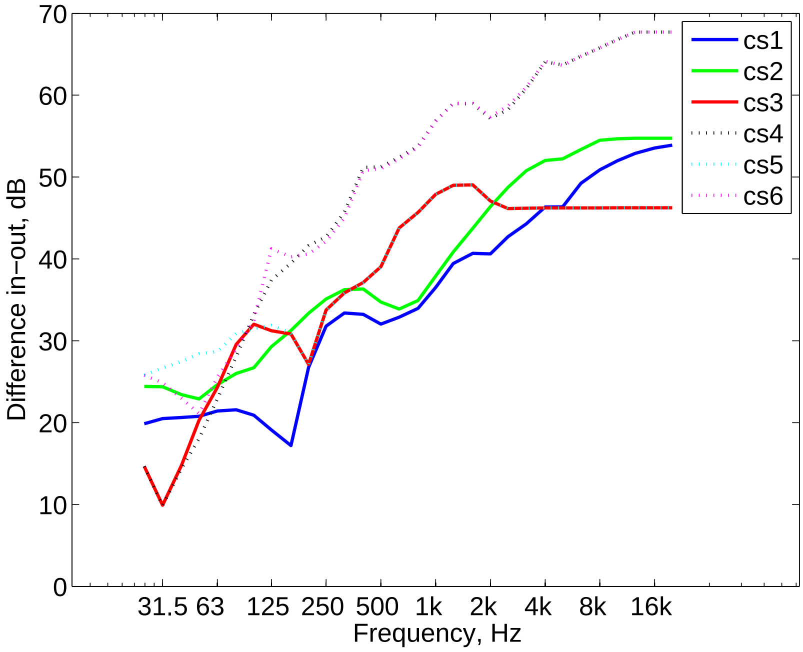

Figure 7: *Reduction indices of facade cases (see Forssén (2014) for details).*

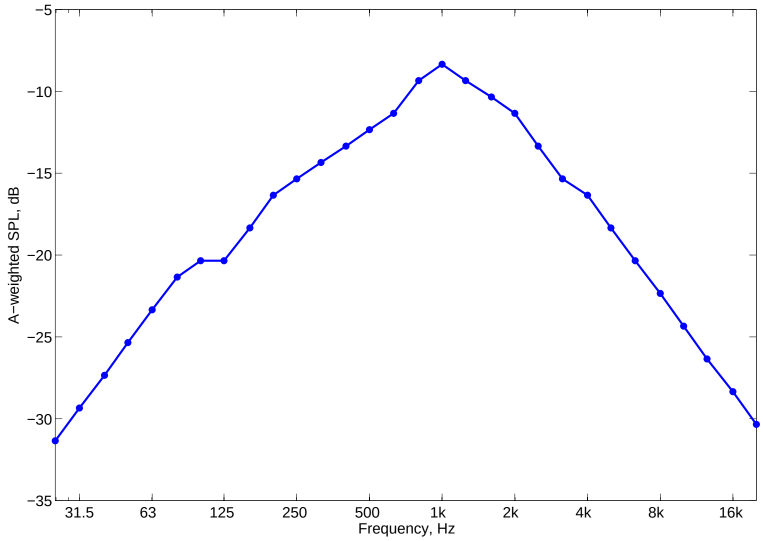

Figure 8: *Ctr spectrum in the frequency extended version used here. Plotted is A-weighted sound pressure level, normalized to 0 dB(A).*

The general tendency is that the sound insulation is low at low frequencies. Especially the new steel frame wall has a reduction index as low as 10 dB at 31.5 Hz. The windows have generally lower reduction indices and also a new 'noise proof' window has a very low reduction index at low frequencies. We see the same tendencies for the combination of walls, windows and air intake (the latter has an insignificant influence if it is a noise proof air intake).

Since the project mainly concerns sounds from trucks, we here make use of the Ctr spectrum (standardized emission spectrum for heavy road vehicles ISO 717-1:2013 (2013)) as an outdoor spectrum to illustrate the indoor levels, after extending the domain from the third-octaves 50Ű5000 Hz to the 25Ű20 000 Hz range used here. The A-weighted spectrum used here is shown in Figure 8 (and listed in Table 1).

Figure 9 shows the characteristics of the indoor noise levels for the six typical facade cases using the frequency extended C_{tr} spectrum normalised to 0 dB(A) as the outdoor source. It is clear that the highest indoor levels is in the low frequency part of the spectra.

1/3 octave band (Hz)	Ctr (dB(A))
25	-31
31.5	-29
40	-27
50	-25
63	-23
80	-21
100	-20
125	-20
160	-18
200	-16
250	-15
315	-14
400	-13
500	-12
630	-11
800	-9
1000	-8
1250	-9
1600	-10
2000	-11
2500	-13
3150	-15
4000	-16
5000	-18
6300	-20
8000	-22
10000	-24
12500	-26
16000	-28
20000	-30

Table 1: *Ctr spectrum in the frequency extended version used here, given in A-weighted sound pressure level, normalized to 0 dB(A).*

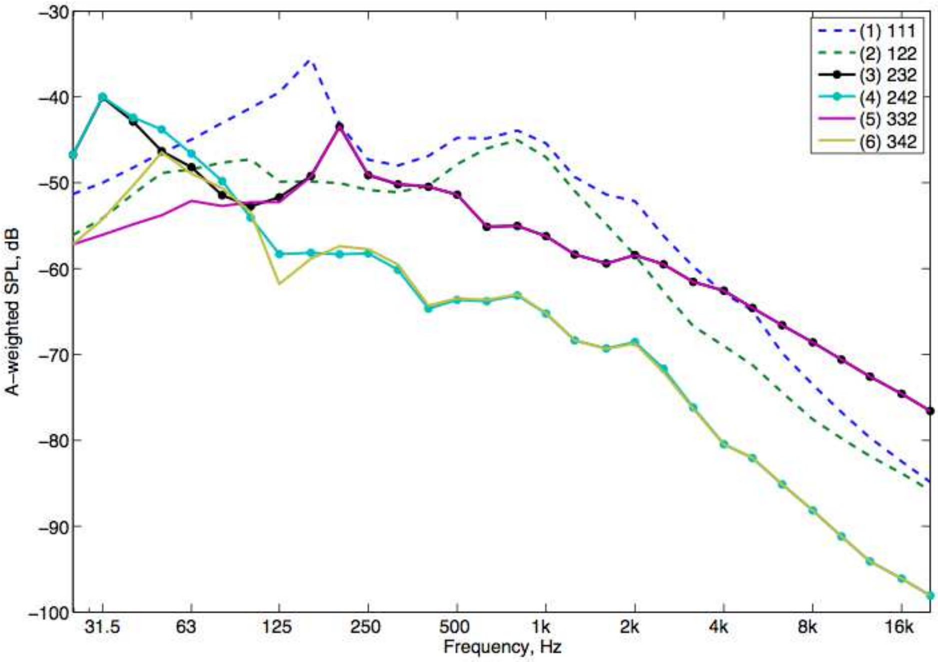

Figure 9: *Calculated indoor noise levels for six typical facade cases. The outdoor source strength is according to a frequency extended* C_{tr} *spectrum normalised to 0 dB(A) (see Forssén (2014) for details).*

2.4 Indoor truck noise levels

Figure 10 shows typical outdoor and the indoor sound pressure levels measured at the Landsvägsgatan site for a standard truck accelerating in the street. It is the low frequency engine orders, especially order 3, that dominates the in door noise. Höstmad (2015) describes the site, measurement setup, data processing and analysis, and the results.

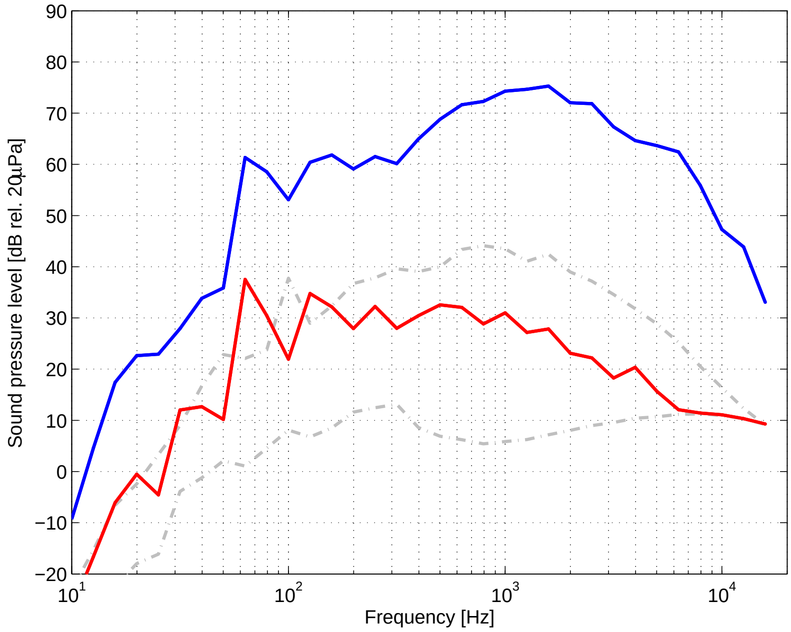

Figure 10: *1/3-octave band spectra at maximum sound pressure level at facade (blue) and in room (red) measured in situ at Landsvägsgatan. The dashed gray lines show the corresponding typical background levels.*

3 Sound from low noise heavy-duty trucks

This section gives some specific results from the project; the treatments and modifications of a truck to reduce outdoor and indoor noise are evaluated by measurements.

3.1 Comparison of standard and treated Volvo trucks

Sound pressure in the street, at the facade and in a room of a flat as trucks pass by was measured at a Landsvägsgatan in Göteborg. Three different types of trucks where considered

- Std.: Standard heavy-duty truck FM-499.
- Mod 1.: A similar heavy-duty truck FM-490 that has been treated with extensive handmade encapsulation of the drive train (e.g. additional shields and absorbers) and an additional laboratory silencer designed to eliminate exhaust orifice low frequency noise.
- Mod 2.: The same treated heavy-duty truck as Mod 1. but with modified drive train behaviour.

Table 2 list the driving cases considered and Höstmad (2015) describes the measurements and reports the results. Andersson and Seward (2014a,b,c) describes in detail the noise emissions of the trucks. A complementary test was made in the semi-anechoic chamber at Volvo Trucks to investigate the effect of encapsulating the exhaust pipe to suppress exhaust outlet noise. The measurements were analysed and reported in (Andersson (2012c)). The encapsulation of the exhaust pipe affects the bands that contains the 3rd and 6th engine order i.e. 50 Hz and 100 Hz bands for 20 km/h, and 80 Hz and 160 Hz band for 50 km/h, while other bands are rather unaffected (Figure 11). Especially the 3rd order is substantially reduced.

Figure 12 shows the measurement site at Landsvägsgatan and the standard truck FM-499 and Figure 13 shows the sound pressure levels inside (and outside) for the three vehicle cases for acceleration and for running at a fixed gear at maximum allowed rpm. It is seen how the treatments to the FM-490 truck (blue line) reduces the levels compared to the standard FM-499 truck (red line): The additional silencer substantially reduces the 3rd order in the 63 Hz band and the high frequency noise is reduced by almost 10 dB in some bands. However, the 6th order in the 125 Hz band is not reduced and which lead to that the high noise levels recorded indoors in the apartment, as it coincide with a room resonance, remains in this example. The modification of the drive train behaviour reduces the levels a little more and the 6th

Label	Descrpition
Idling	Standing still outside the appratment with the engine idling.
Idling + Compr.	Idling with the air compressor active.
PTO	Standing still outside the appartment with the engine in power take-off mode.
Acc.	Driving with full accelaration past the appartment.
Fixed gear	Driving with full throttle on a fixed gear past the ap-pratment.
Fixed gear + Compr.	Fixed gear with the air compressor active.
Fixed gear + Fan	Fixed gear with the engine cooling fan active.
20	Driving 20 km/h past the appartment.
30	Driving 30 km/h past the appartment.
40	Driving 40 km/h past the appartment.
Background	Typical background noise levels when no vehicles are passing by in the closest steet.

Table 2: *Driving cases considered in the measurements at Landsvägsgatan.*

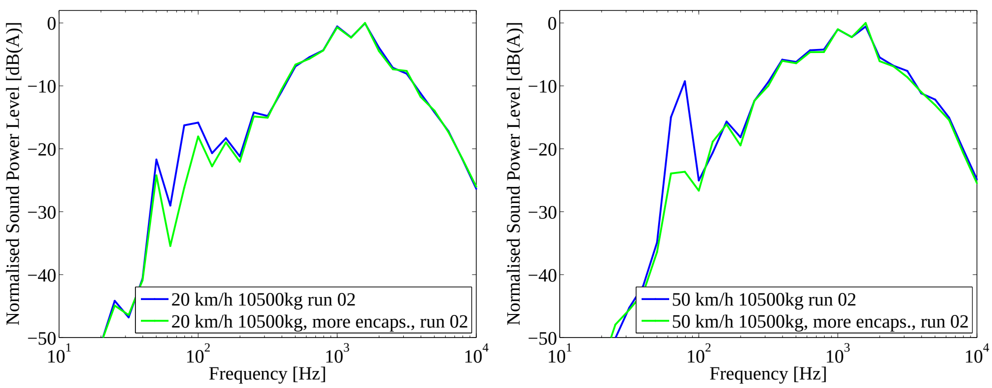

Figure 11: *Total normalised sound power levels for 20 km/h and 50 km/h with exhaust outlet noise (blue) and with suppressed exhaust outlet (green). The sound power levels are normalised to the maximum 1/3-octave band sound power level that occurs for any of the considered cases. Results from measurements in semi-anechoic chamber.*

Figure 12: *The investigated Volvo truck FM-499 at the Landvägsgatan site just outside the flat. The flat is the French balcony just above the swap body.*

order peak indoors is substantially reduced (green line), partly because of different run-up.

The lower figure shows the same results but for the Case 7 Fixed gear. The tendency at high frequencies is even clearer here; the noise levels are reduced from the standard truck to the treated truck to the treated truck with modified drive train behaviour. However, the 6th order of the latter is at 140 Hz (1400 rpm) and it strongly excites one of the resonances in the room resulting in a clear booming noise. The treated truck with nominal engine data setting has the 6th order at 210 Hz (2100 rpm).

Figures 14 and 15 shows the maximum sound pressure level for time-weighting Fast L_{AmaxF} of all the successful measurements for closed and open window respectively. Notice that the outdoor levels are measured at the facade and are presented with the contribution from the facade reflection included (i.e. about 6 dB higher levels than without the reflection).

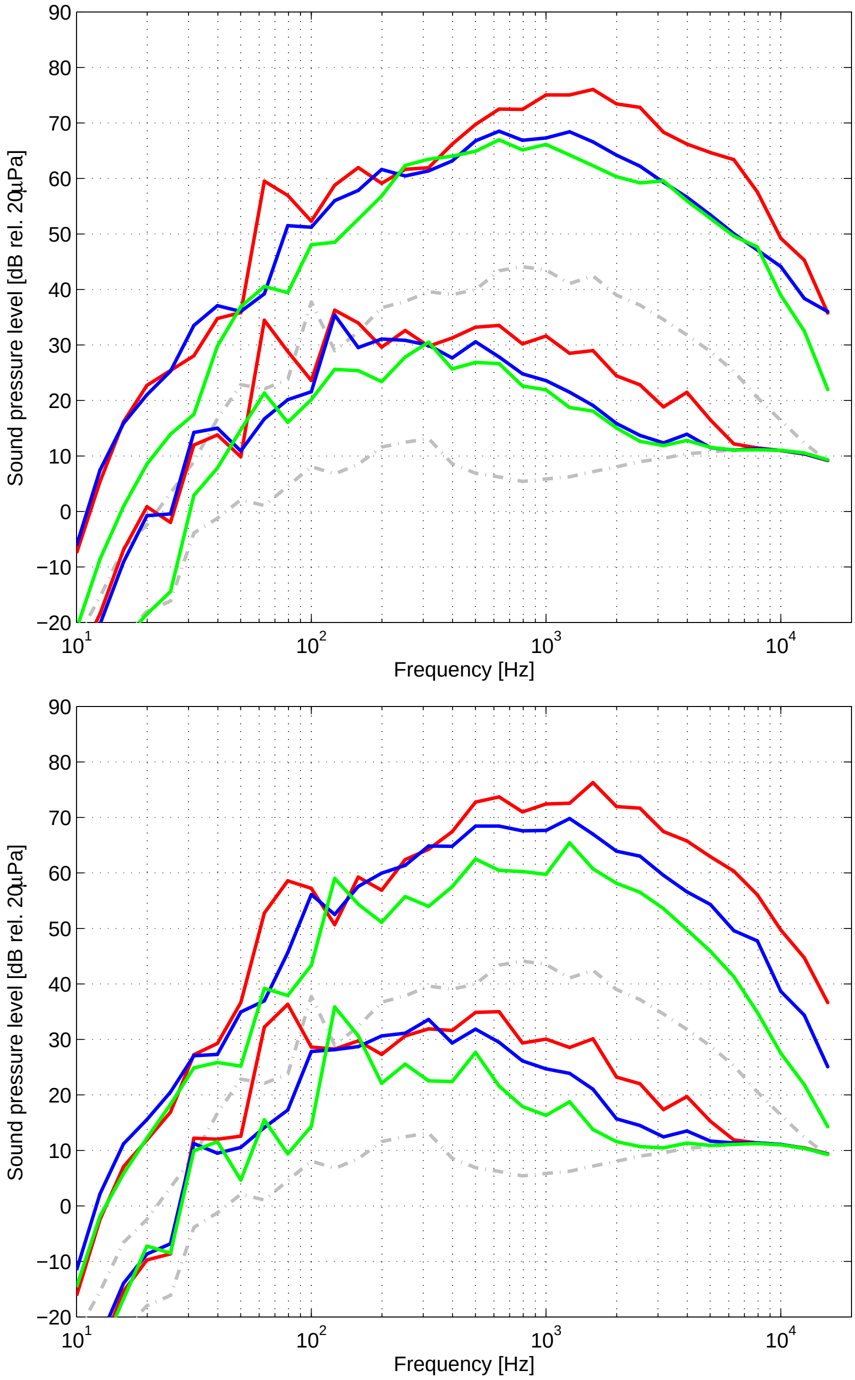

Figure 13: *Maximum in A-weighted sound pressure level using time-weighting "Fast" for the Case 5 Acceleration (upper) and Case 7 Fixed gear (lower) with closed window. Truck: Std. (red), Mod 1 (blue), Mod 2 (green) and Background (dashed grey).*

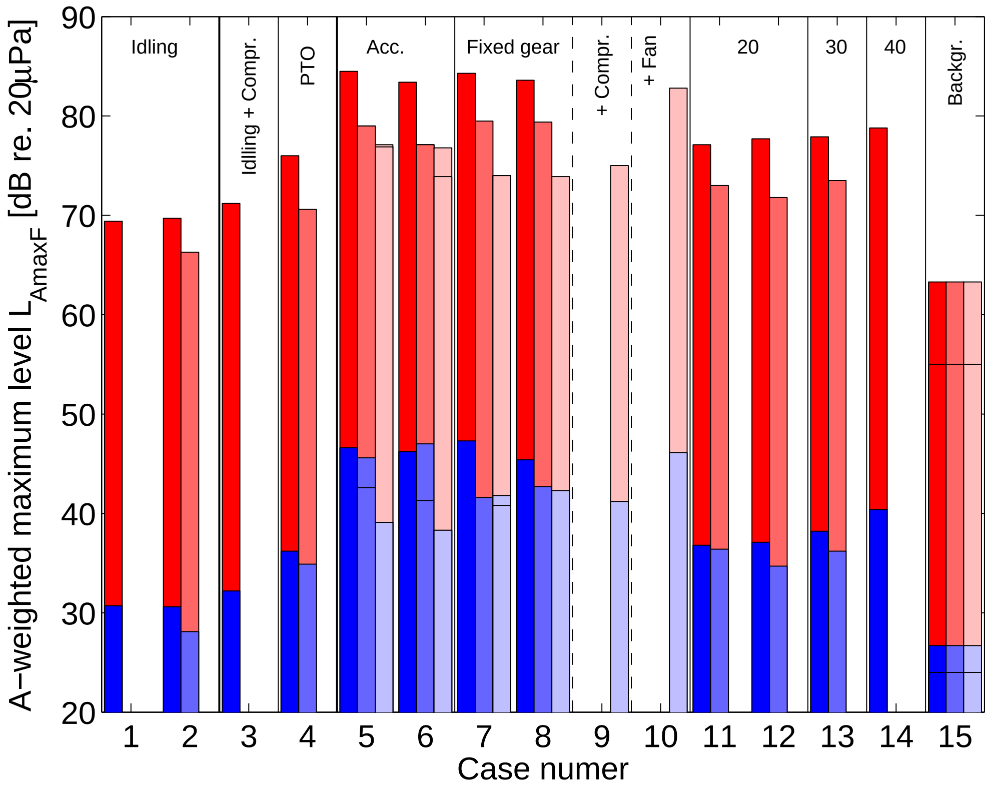

Figure 14: *Maximum in A-weighted sound pressure level in situ at Landsvägsgatan using time-weighting "Fast" for the case with closed window, at the facade (red) and indoors (blue) for the standard truck FM-499 (dark), the modified FM-490 with nominal drive train behaviour (lighter), and the modified M-490 with modified drive train behaviour (lightest).*

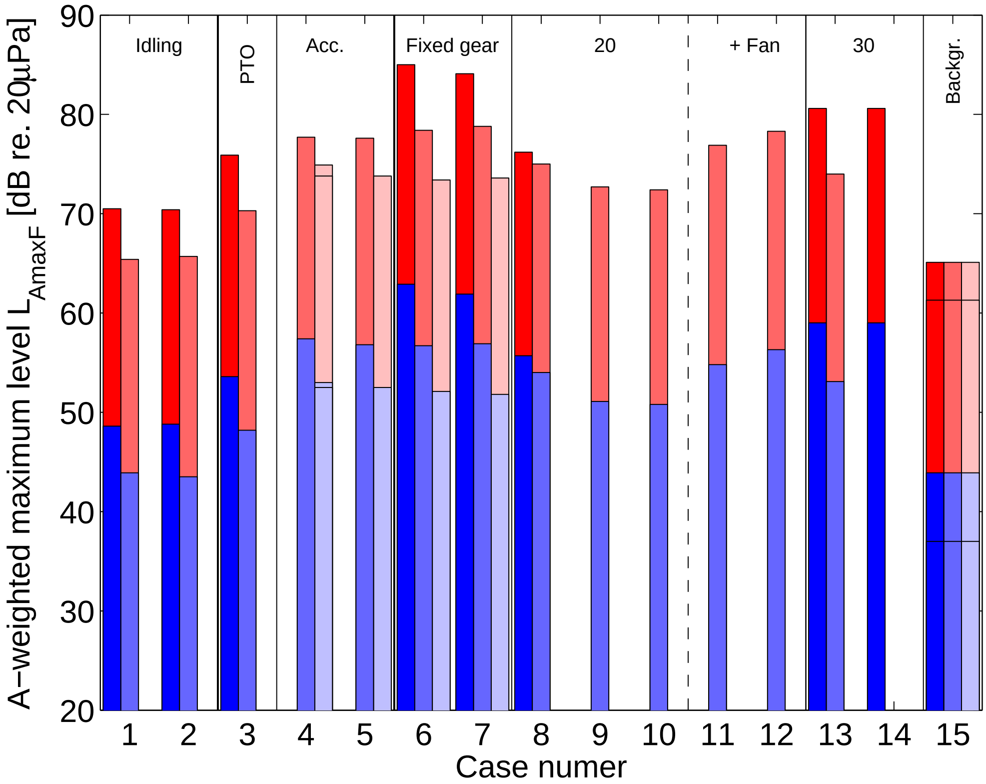

Figure 15: *Maximum in A-weighted sound pressure level in situ at Landsvägsgatan using time-weighting "Fast" for the case with open window, at the facade (red) and indoors (blue) for the standard truck FM-499 (dark), the modified FM-490 with nominal drive train behaviour (lighter), and the modified M-490 with modified drive train behaviour (lightest).*

4 Listening test evaluation of truck noise

This section gives a brief overview of the results of the various listening tests that has been conducted.

4.1 Validation of auralisation model

Listening tests have been conducted to both test an auralisation approach and to asses the truck noise itself. In brief, the listening tests shows that the auralisation technique works, which was reported in (Forssén et al. (2013)).

4.2 Basic results

Listening tests were set up for dedicated changes to find out if there are clear relations between reductions in some octave bands or parts of the spectra. The first test on outdoor noise showed that all changes led to higher annoyance, likely due to changed level of recognition.

More dedicated test indoors showed that reduction of noise at the higher frequencies were positive for the valance experience (pleasantness). Reduction of noise at the lower frequencies gave reduced arousal (roughly stress).

Thus, valence and arousal that together is the basis of annoyance is affected by changes in different parts of the spectra. Most important at nighttime is to reduce the arousal levels (since in principal all that is increasing arousal is also negative for valence), but during evenings when people are awake also valance is important.

4.3 Evaluation of recordings

An untreated standard Volvo truck has been compared to a light-duty van using recordings from Landsvägsgatan. The test subjects hear the difference in the different characters of the sound of the vehicles. The emotional response including, for instance, annoyance and attention demanding is the same for both, i.e. the light-duty vehicle is not perceived as less annoying. For both vehicles there are differences between acceleration and constant speed 20 km/h. Thus, the emotional response is influenced by the driving behaviour, that eventually could be controlled (e.g. acceleration or rpm limits). The driving behaviour is more important than the type of vehicle for the emotional response, except at night-time since the levels are different.

Recordings at Landsvägsgatan are used to compare the standard FM-499 truck to the treated and modified FM-490 truck. As expected, the FM-490 truck is better than FM-499 in all aspects.

However, final evaluation of the *synthesised* pass-by simulations showed that the test subjects do not differentiate between FM-499 and FM-490, but between the different vehicle speeds. It is unclear why the listening test on the recordings and on the synthesised signals gives different results. Additional tests to check the validity of the auralisation model are needed.

5 Discussion of specifications

This section gives an outline of a low noise specification for heavy-duty vehicles for nighttime distribution of goods.

5.1 Limiting levels of today

In the project Forssén (2012) discussed the Swedish regulation for night-time noise. Since that report was issued, the responsibility for the indoor noise has been moved from the National Board of Health and Welfare (Socialstyrelsen) to the Public Health Agency of Sweden (Folkhälsomyndigheten), which has adopted the same guidlines. Today, the Public Health Agency of Sweden (Folkhälsomyndigheten) recommends that the maximal indoor levels during night-time (22.00–06.00) does not exceeded 45 dBA more than three times per night when using integration time F-Fast. The National Board of Health and Welfare (Socialstyrelsen) also recommended that the maximum level at the facade is not exceeding 55 dBA between 22:00–07:00. The National Board of Housing, Building and Planning also recommends maximum 45 dBA but that it may be exceeded with up to 10 dB five times per night.

The Public Health Agency of Sweden (Folkhälsomyndigheten) has also specific recommendations on indoor low frequency noise for equivalent sound pressure levels from installations in spaces for sleep and rest. The values are adopted from the National Board of Health and Welfare (Socialstyrelsen). These limits are for continuous noise and may therefore be used for the case where a vehicle is standing still with the engine idling. The values are listed in Table 3. There is also a low frequency guideline curve from the Dutch Association for Noise Annoyance (Geluidhinder (1999)). It is based on the 90 % hearing threshold for an average group of people between 50 and 60 years old. The values are listed in Table 4.

The WHO report *Night noise guide lines for Europe*, 2009, list levels that causes different effects on human:

- 32 dBA: the onset of motility starts,
- 35 dBA: changes in duration of various stages of sleep, in sleep structure and fragmentation of sleep, and
- 42 dBA: waking up in the night and/or too early in the morning.

WHO guidelines recommend that outdoor equivalent night noise levels do not exceed 40 dBA and levels above 45 dBA in the bedroom should be limited as much as possible.

1/3 octave band (Hz)	SPL (dB)
31,5	56
40	49
50	43
63	41.5
80	40
100	38
125	36
160	34
200	32

Table 3: *The Public Health Agency of Sweden's values for low frequency (linear, not A-weighted).*

1/3 octave band (Hz)	SPL (dB)
20	74
25	62
31,5	55
40	46
50	39
63	33
80	27
100	22

Table 4: *The NSG's values for low frequency (linear, not A-weighted).*

In the project Bergman (2013) summarised the present knowledge on how road traffic noise affects sleep quality, annoyance and restoration. It is concluded that to determine the possibility to use silenced heavy trucks for distribution at night evaluation needs to be conducted for how these changes affect loudness, roughness and tonality and thereby the main acoustical contributors to annoyance. Nonacoustical factors that may contribute to annoyance and reduced possibilities for restoration includes the emotional response to the sound of the heavy truck as well as the participants' sensitivity to noise.

5.2 Regulation of weight is not regulation of noise

Figure 16 shows the maximum sound pressure levels indoors and outdoors for a standard truck and a light-duty van (MP Sprinter). This is an interesting comparison because today residential areas in centres of in Swedish cities are commonly restricted to only allowing light-duty vehicles a nighttime (typically 22-06). The investigation shows that the light-duty van has in general more than 10 dB lower noise than the truck, but for the full acceleration case the noise levels are the same, and even higher for the van. Thus, carful driving of heavy-duty trucks emits less noise that an carelessly driving of a light-duty van. The listening tests showed that the test subjects hear the difference in the characters of the sound of the heavy-duty and light-duty vehicles. The emotional response including, for instance, annoyance and attention demanding is the same for both, i.e. the light-duty vehicle is not perceived as less annoying.

This underlines that any regulation of low noise vehicles should be a regulation considering the noise emissions and not the duty weight. It also highlights that the way the vehicle is driven may be more important than the type of vehicle.

5.3 Difference between indoor and outdoor noise character

The general properties of the sound insulation of facades and windows with low insulation at low frequency and higher insulation at higher frequencies, gives a very different character of the indoor and outdoor spectra. In general, indoors the engine orders at low frequencies (50–250 Hz) have to be considered, while outdoors the highest noise levels are generally around at 500–3000 Hz. Thus, a regulation using the maximum total A-weight level measured outdoors does not correlate strongly enough with the level changes and disturbance indoors. Thus, a regulation for low noise vehicles focusing on the closed window case should have a special design that put the focus on the reduction of the low frequency noise.

5.4 Comparison of different facades

In Figures 17–20 the measured spectrum indoors is recalculated into spectra assuming model façades 1–6 that are briefly described in Section 2.3 and in detail in Forssén (2015), for three different driving conditions with the modified truck (idling, acceleration, and acceleration with fixed gear) as well as a background measurement. For this, the reduction index of the measured façade, R_{Ref}, is exchanged for the reduction index of model cases 1-6, $R_{\mathrm{i}}, i = 1...6$, i.e. a correction $10\log(R_{\mathrm{ref}}/R_{\mathrm{i}})$ as function of frequency. It should be noted that low signal-to-noise ratio indoors affects the results at the higher frequencies, above ca 8kHz. In the plots, the spectra have been shifted by a constant value such that the indoor levels

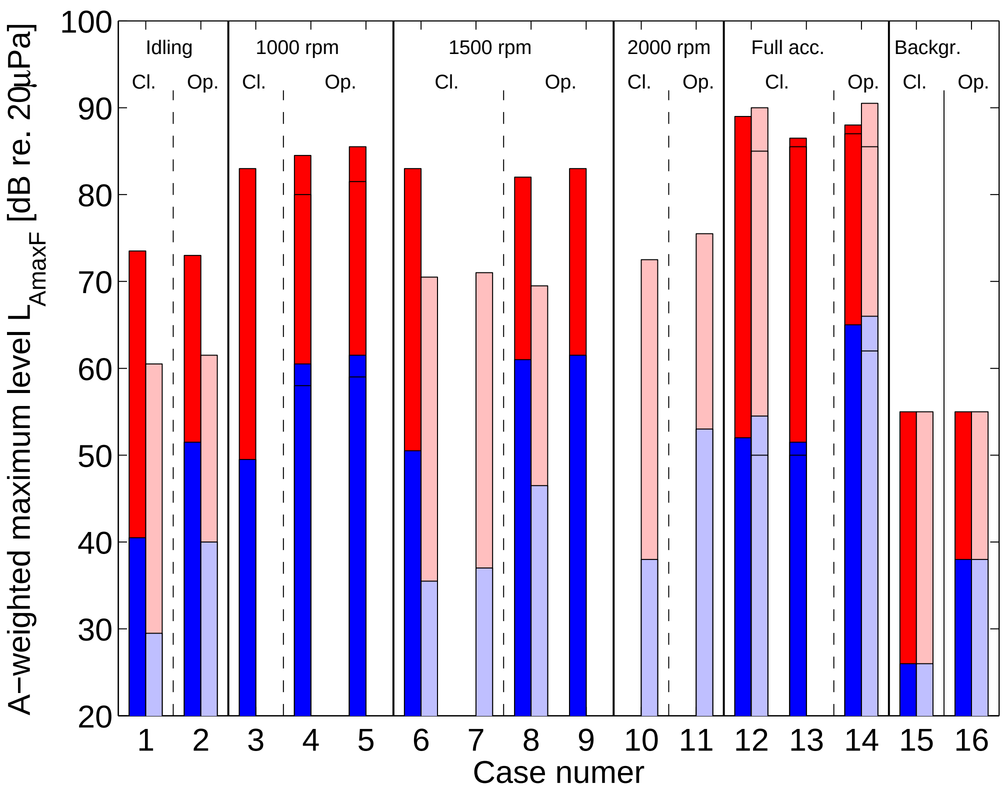

Figure 16: *Maximum in A-weighted sound pressure level using time-weighting "Fast". For the truck at the facade (red) and indoors (blue), and for the MB Sprinter at the facade (light red) and indoors (light blue). Cl.-Closed window and Op.-Opened window.*

for measured façade attains the LAFmax value of the corresponding driving condition. Since the results plotted here are for a flat at 3rd floor, the levels are expected to increase more close to ground. Based on measurement results, the increase when going to ground floor is around 5–6 dB.

The low frequency guidelines of the Public Health Agency of Sweden (Folkhälsomyndigheten) (previously of the National Board of Health and Welfare (Socialstyrelsen)) and of the Dutch Association for Noise Annoyance (NSG) are included in the idling case (Figrue 17). The Swedish guidelines are fulfilled for all façade cases with a margin. For flat at the ground floor that are exposed to 6 dB higher levels, only the façade cases 2, 6 and 5 fulfills the quidlines. Only case 5 fulfills the Dutch guideline with 2.5 dB on the 3rd floor, but not on the ground floor. Non of the other façade cases fulfills the guideline.

5.5 Open or closed window

So far the discussion has been focusing on the indoor levels for a closed window case. However, it may be argued that to have the possibility to have the window open is an important quality. Figure 15 shows that all the indoor levels for the open window case, except the idling of the modified truck, is above Socialstyrelsens recommendation 45 dBA. The levels go up to 52.5 dBA for the acceleration case of the treated and modified truck. Thus, it is more that 7.5 dBA above the recommendation of Socialstyrelsen at the 3rs floor. A flat on the ground floor would have levels are 5–6 dB higher, demanding a decrease of the vehicle noise by up to 13.5 dB. Designing a low noise truck that is 7.5 dBA or 13.5 dBA lower than the already treated and modified truck is likely to requiring a change of technology, e.g. a complete encapsulation of the combustion engine or switching to an electrical motor.

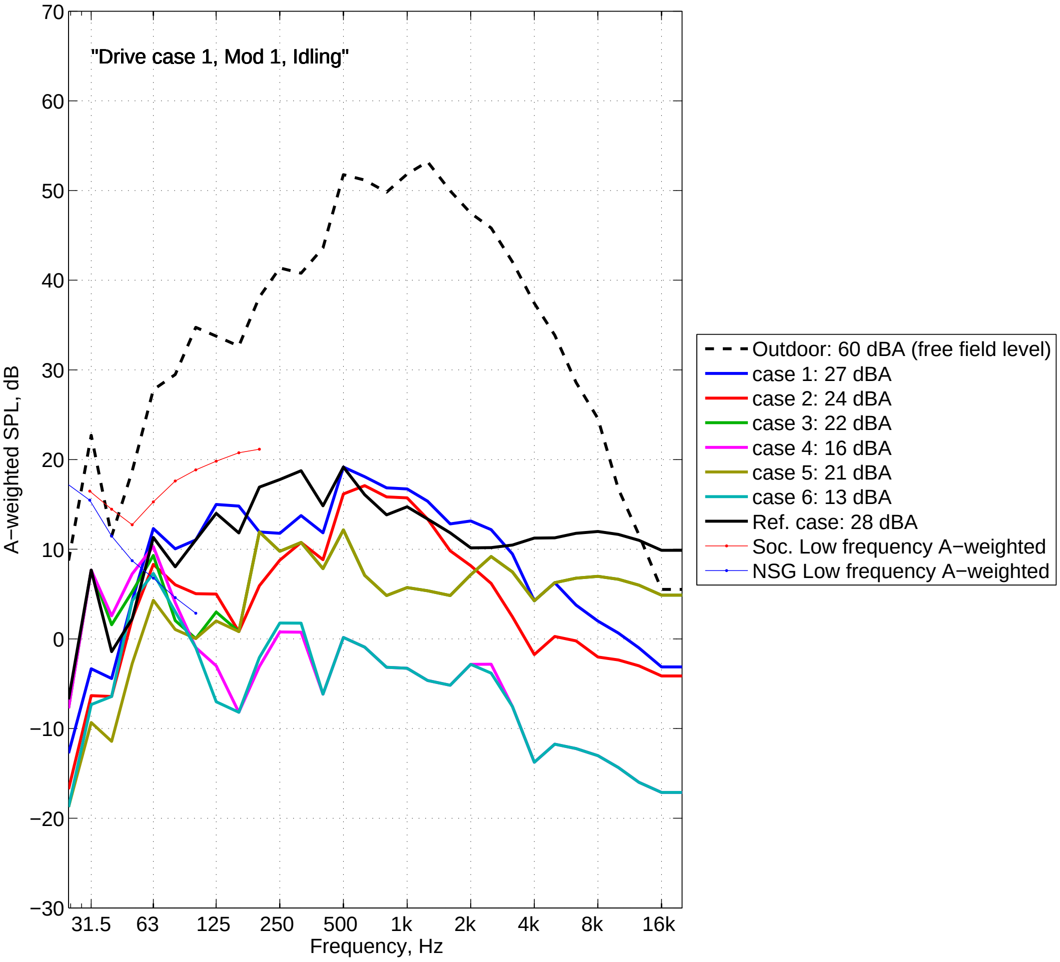

Figure 17: *Indoor noise levels calculated for model façade cases 1-6 with the measured façade as reference.*

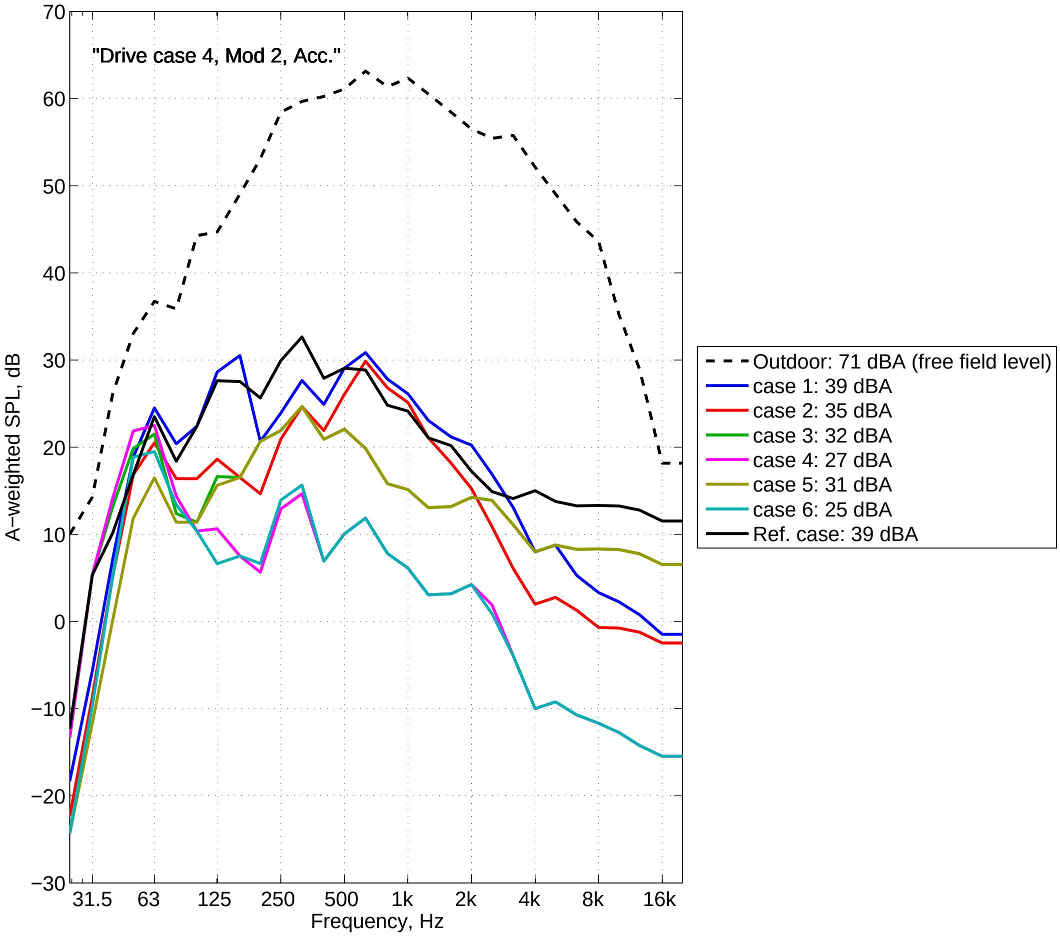

Figure 18: *Indoor noise levels calculated for model façade cases 1-6 with the measured façade as reference*

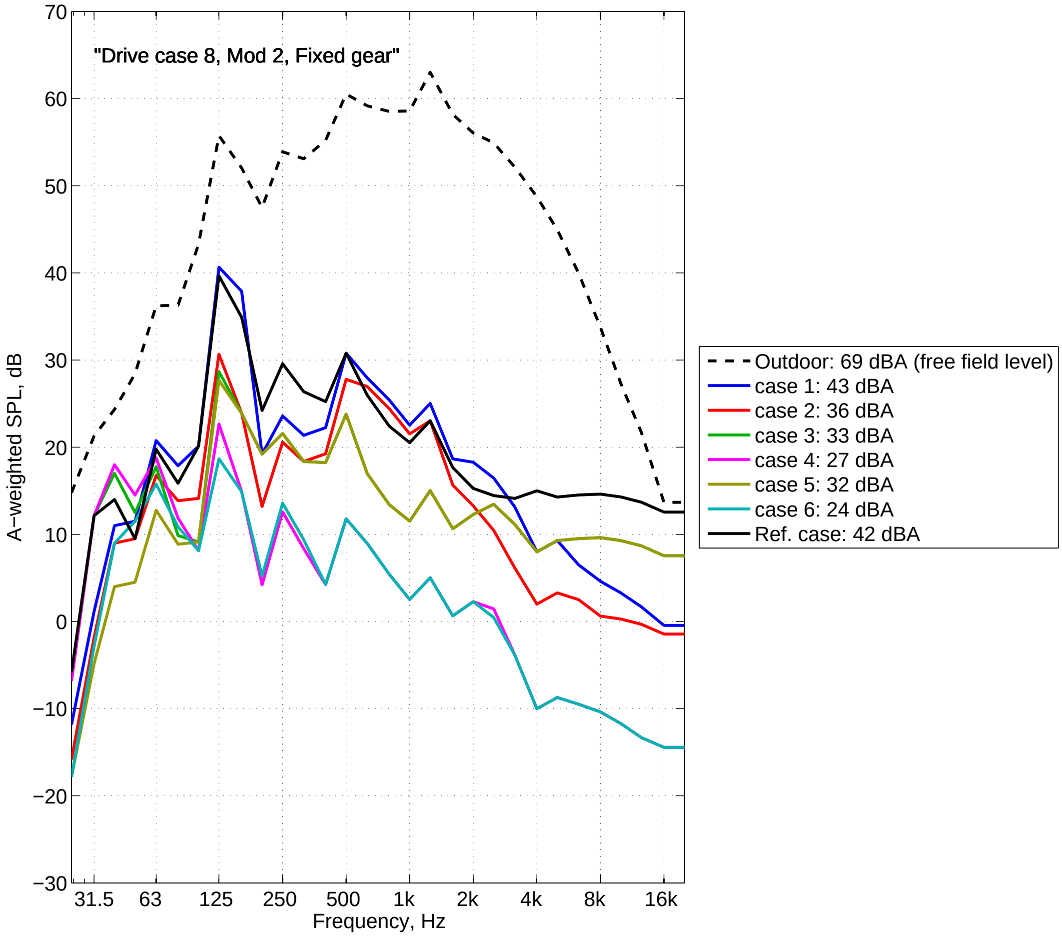

Figure 19: *Indoor noise levels calculated for model façade cases 1-6 with the measured façade as reference.*

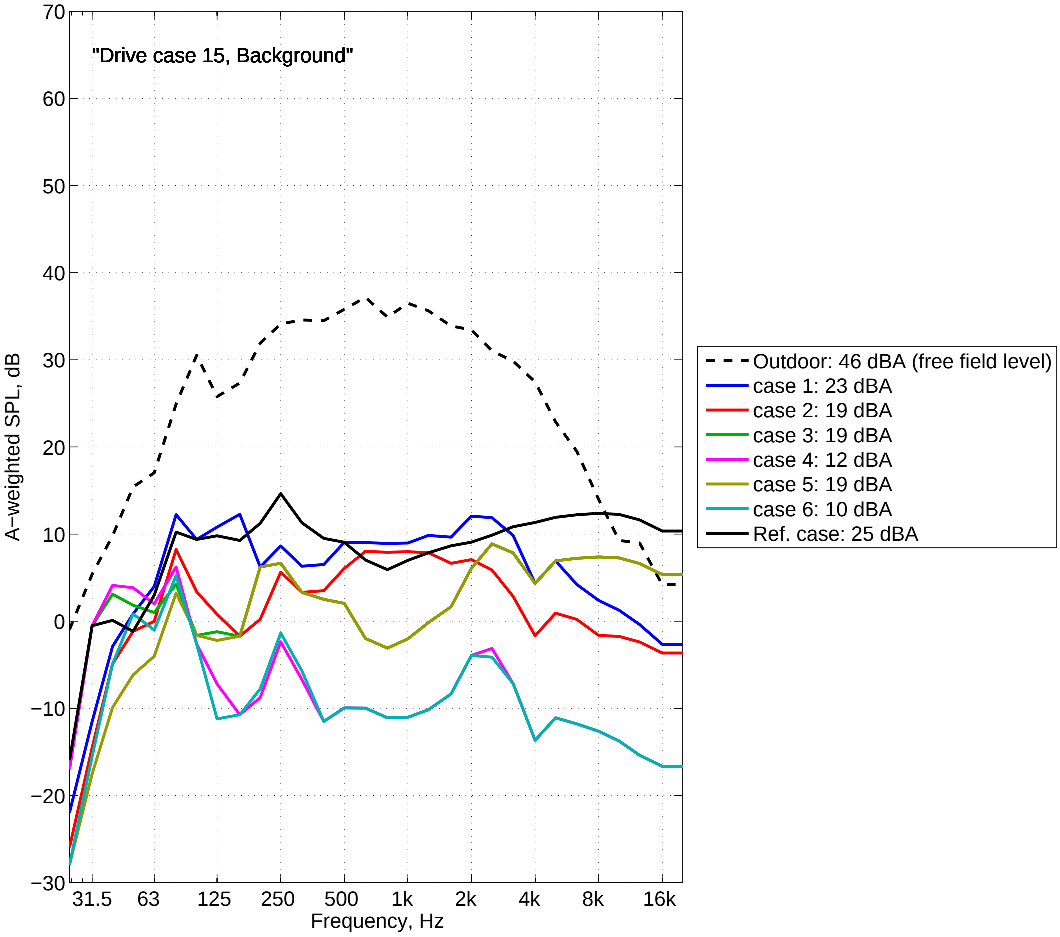

Figure 20: *Indoor noise levels calculated for model façade cases 1-6 with the measured façade as reference.*

6 Conclusions

The following conclusion are made:

- How the vehicles are driven has a substantial affect on the noise emissions and accelerating a light-duty van might give higher noise than for a heavy-duty truck (Section 5.2).
- The emotional response (including annoyance, attention demanding, ...) is the same for a light-duty van and a heavy-duty truck, i.e. the light-duty vehicle is not perceived as less annoying (Section 4.3).
- Therefore, a low noise specification must be set directly on noise emissions, and not on indirect factors with weak relation to noise like the duty weight of the vehicle.
- The specification must include the fact that low frequency noise are important indoors, while high frequency noise is the major contributor outdoors. Thus, a total A-weighted levels measured outdoors has too weak relation to the indoor levels when the windows are closed (Section 5.3).
- Every apartment has one or more low frequency resonances, which have to be considered when defining basic sound criteria of the source and the building (Section 3.1).
- The listening test revealed that the low frequency noise is strongly coupled to the degree of arousal (stress) and that lower low frequency noise is therefore important at nighttime (Section 4.2).
- A characterisation that meets the requirement of 45 dBA for a healthy indoor environment for a case with closed windows was achieved with our modified truck that is driven by a responsible driver (Section 3.1), and by using "noise proof" windows (Section 5.4) with higher sound insulation. For the idling case, the Swedish "building directive" low frequency guideline is fulfilled for all façades at the 3rd floor and for three at the ground floor, while the Dutch requirement is only fulfilled for one facade at the 3rd floor (Section 5.4).
- A specification for a case with slightly open window would require a further reduction of 10–15 dB of the noise emissions of the treated truck (Section 3.1). It is not within an easy reach today without change of technology, and it can be argued that it would be realistic to include the open window case in a low noise specification.

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