Reflection of noise barriers - Measurements at the far sound field

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ABSTRACT

The assessment of the sound reflection of noise barriers is based on different methods like EN 1793-1 by measuring the reverberation time of the diffuse sound field of the room as well as a method for measuring the impulse response by cross correlation according to CEN/TS 1793-5 (Adrienne method) using a non-diffuse sound field near (25 cm) the barrier. These two methods provide different results. The key question, already discussed for several years, is how the sound reflection of noise barriers appears at the acoustical far field which is interesting for consideration of immission points. For this in the course of the research project REFLEX a certain measurement method was developed, which makes sound reflection measurements under certain conditions in the acoustical far field (until 25 m) possible. The research project REFLEX was carried out by the Austrian Institute of Technology (AIT) and the company TAS by order of infrastructural operators (ASFINAG and ÖBB), federal ministries (BMVIT and BMFLUW) as well as 5 federal states and 8 different manufacturers of noise barriers. The measurement setup and the measurement procedure will be explained. Measurement results on different noise barriers will be represented and compared with common methods (reverberation room, Adrienne).

Keywords: Noise barriers, measurements, far sound field
I-INCE Classification of Subjects Number(s): 51.4
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1. INTRODUCTION

The current study was carried out within the frame of the Austrian research project called "REFELEX" under contribution of TAS and AIT as scientific members. The project was supported by a consortium of ASFINAG, ÖBB-Infrastruktur AG, several federal states as Tirol, Vorarlberg, Styria, Upper Austria, Carinthia, two ministries BMVIT and BMFLUW as well as eight different manufacturers of noise barriers.

Noise reflection of noise barriers plays a special role related to complaints of residents. According to them an annoying acoustical effect of noise barriers is often stated.

There are different methods to determine sound reflection of noise barriers (e. g. the method by EN 1793-1 at the reverberation room as well as method called "Adrienne" by CEN/TS 1793-5), which provide different results.

The reason for the different results is mainly due to the different sound fields. In the reverberation room a diffuse sound field exists. When using the Adrienne-method the microphone is located near the noise barrier (about a wavelength of the measured sound). Therefore near field effects are relevant.

With respect to the acoustical effect for the residents neither conditions of the reverberation room nor near field effects can be assumed.

Therefore a special measurement concept was developed in the course of the project, to measure the single sound reflection of noise barriers at the acoustical far field (distance of several wavelength).

Using the results of these measurements the effects at the residents dwellings can be estimated.

The problem of direct measurement of the single sound reflection of noise barriers under real conditions is that mostly the direct noise of the traffic as well as the environmental noise are also measured and the reflected amount of noise cannot be distinctly separated from the other noise.

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2. SOUND EXPOSURE

Current a special setup was developed to measure the reflected sound at the acoustical far field under direct sound exposure. A basic requirement for this is the suppression of the direct sound at the measurement positions. Therefore a special sound source was developed with a directivity to allow measuring of even decreased sound reflections due to the sound absorption of the barriers. Furthermore certain environmental conditions are required (quiet environment, possibility of free sound propagation).

On behalf of sound exposure an oblong box (2 m × 0,8 m × 1,1 m) was coated with sound absorbing material and at the back side the sound source was placed.

Figure 1 shows the principal sketch of the sound source.

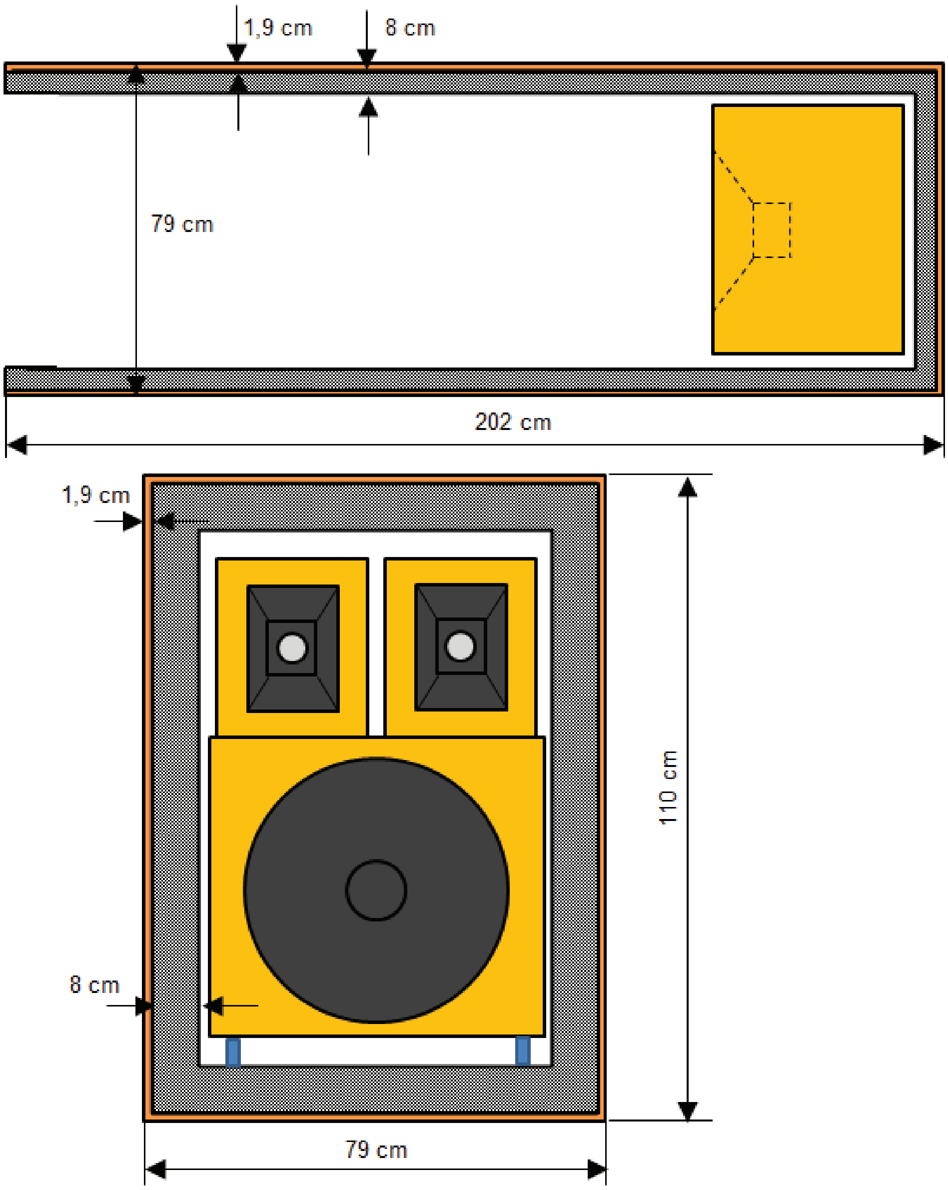

Figure 1 – Principal sketch of the sound source and the screening box from top view (above) and front view (below)

This design shows a considerable directivity with sufficient suppression of direct sound in back- and sideward directions as can be seen in Figure 2.

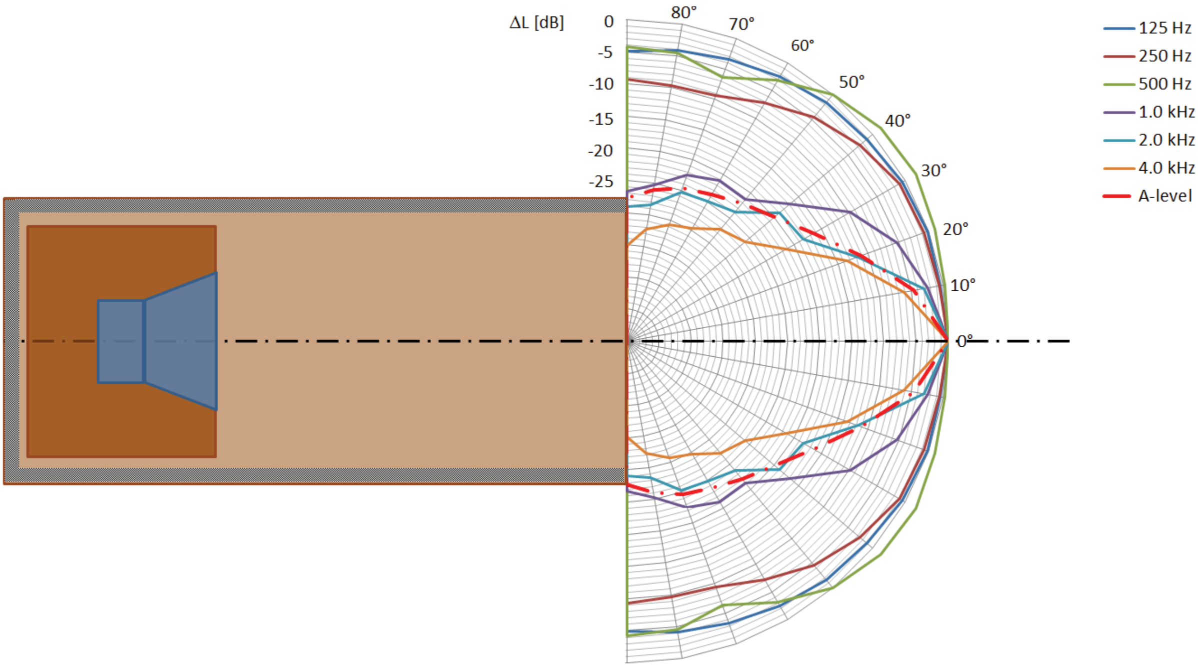

Figure 2 – horizontal directivity of the sound source for several octave bands as well as for the A-level

3. MEASUREMENTS

With the sound system described above different noise barriers were exposed to a sound field. Figure 3 and 4 are showing schematically the situation.

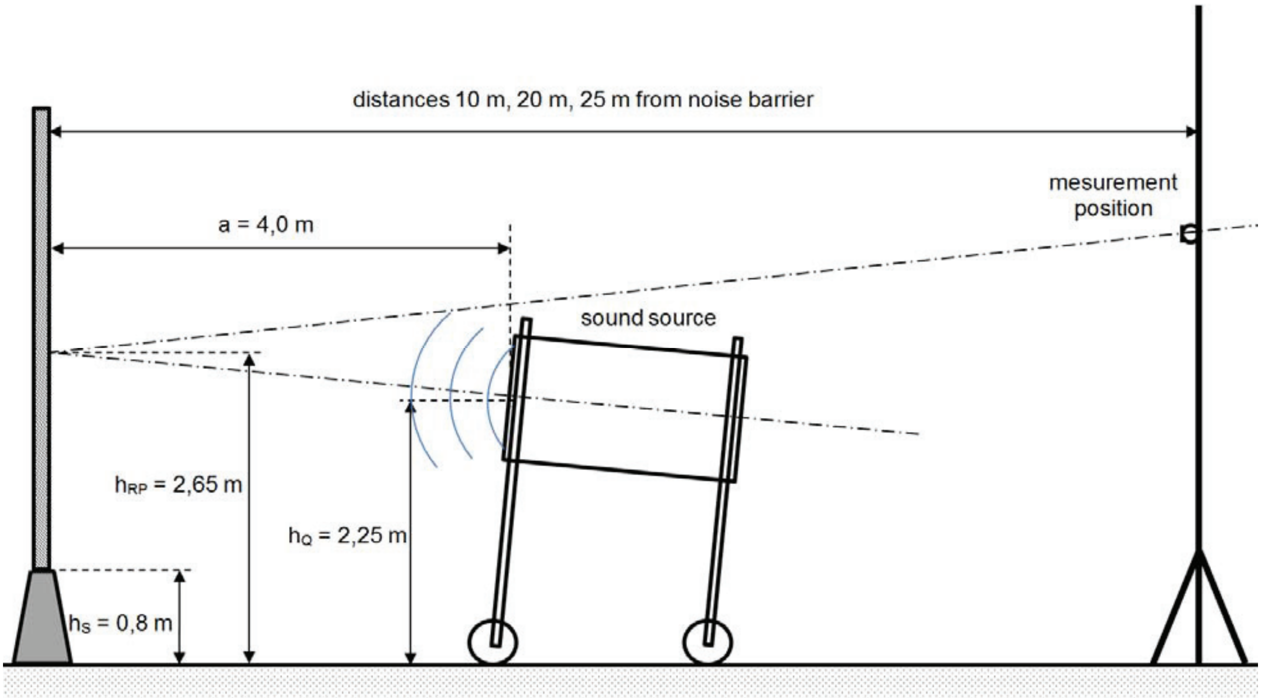

Figure 3 – Position of the sound source in front of a noise barrier

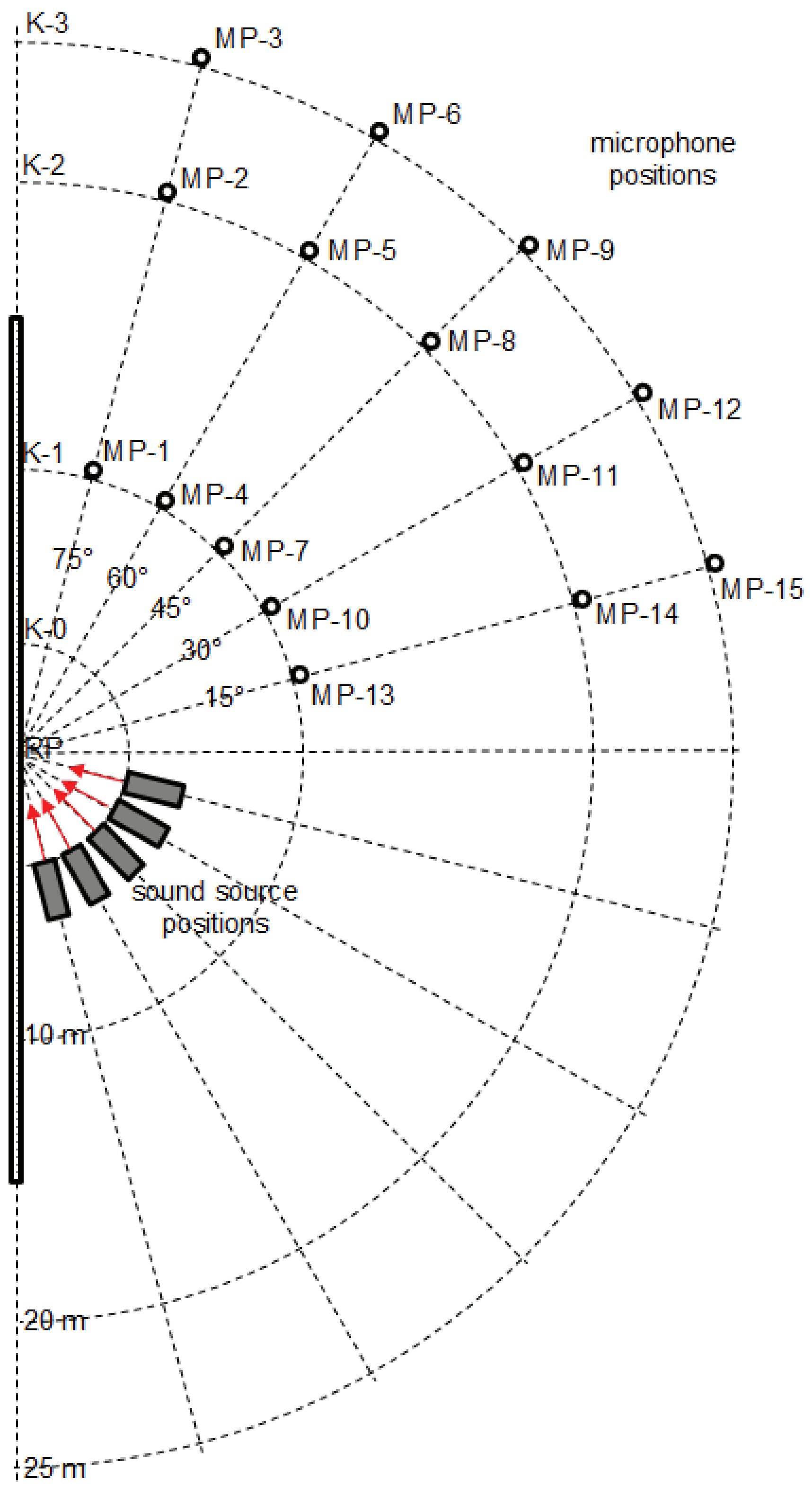

Figure 4 – Arrangement of the sound source and the microphone positions respectively for the measurement of the sound reflection of noise barriers

The sound irradiation was carried out at several angles, distances and heights to the noise barriers and should simulate the situations along the traffic line. Additional measurements at the sound source have been made to correct its influence and also at a totally sound reflecting noise barrier (made from concrete) as reference. Because of the strong suppression of the direct sound produced by the sound source at the microphone positions one can assume that mainly the reflected sound was measured. By comparison with measurement results at the reference barrier one can principally yield the reduction of sound by the measured noise barrier. The place for measurements was chosen so that the environment (quiet, no other sound reflecting objects) was in principle negligible with respect to the measurement results. Figure 5 shows an example of a measurement at a noise barrier.

Figure 5 – Measurement at a noise barrier

In addition to the measurements of 8 different noise barriers measurements were carried out for a barrier stepwise reduced in height as well as on the concrete socket and metallic support element inclusively. So the influence of the socket to the measurement results could be determined and corrected.

4. MEASUREMENT RESULTS

In Table 1 one can see the measurement results at several angles of sound irradiation as well as at several noise barriers (A to H) of different materials (concrete, wood, aluminium etc.). DL denotes here the sound level reductions of the reflected sound of the noise barriers with respect to the totally sound reflecting reference barrier in decibels according to the traffic noise spectrum of EN 1793-3.

Table 1 – Measurement results - barrier A to H

angle of sound irradiation	DL [dB]							
	A	B	C	D	E	F	G	H
15°	4,3	5,3	6,8	6,5	5,2	5,5	6,6	4,9
30°	5,0	5,8	7,4	8,0	6,0	6,4	7,7	4,8
45°	5,6	6,4	7,6	8,7	5,8	6,4	7,2	4,7
60°	5,8	5,5	9,3	7,5	5,7	7,1	6,3	3,3
75°	3,4	3,3	4,4	3,6	3,1	5,3	4,3	3,3

Figure 6 shows a comparison of far field measurements (15° spectral average, spectral average) with values DL_{RI} according to CEN/TS 1793-5 for the measured barriers as well as an average effect (for far field measurements) using integration of the angle-dependent sound reflection factors for a imagined traffic situation.

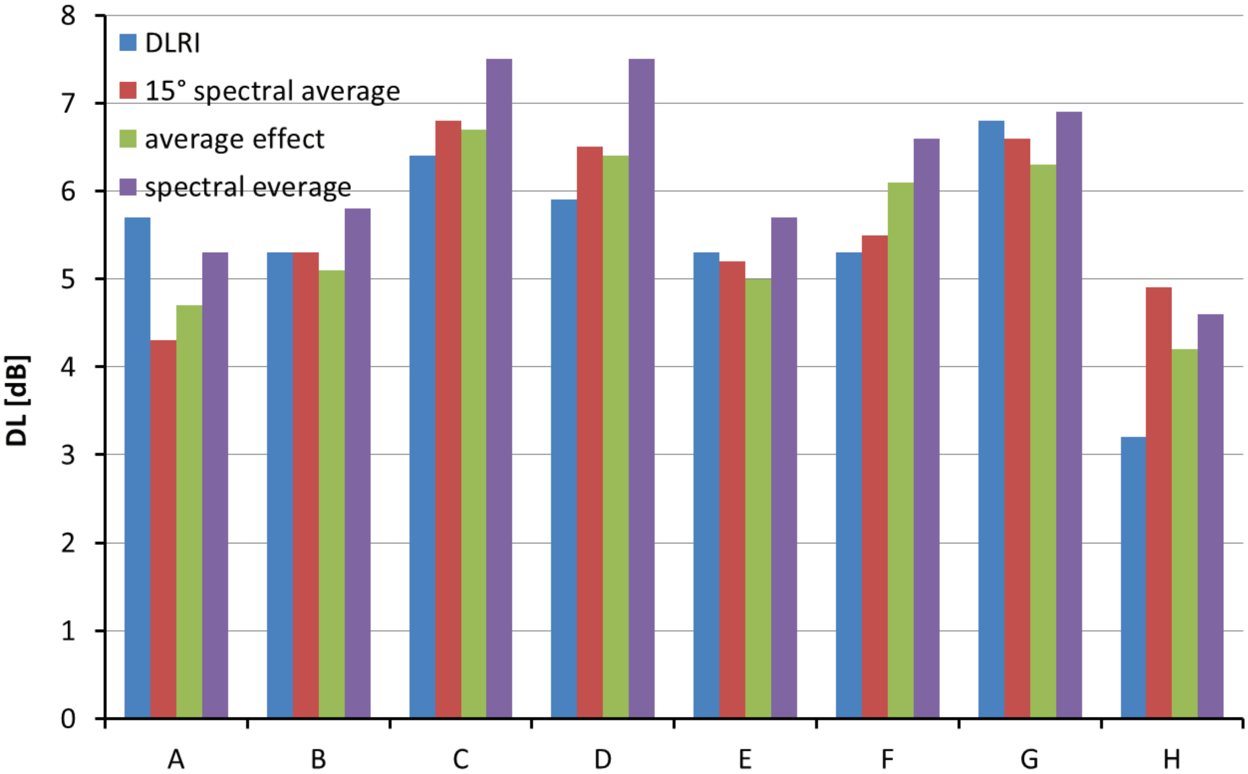

Figure 6 – Comparison of the results of different measurement methods using the road traffic noise spectrum in CEN/TS 1793-5

In Figure 7 a comparison with results of measurements using a reverberation room for the considered noise barriers is depicted.
Noise barrier H is a combined construction for which a comparison of the different measurement methods is not immidiatly possible. The results shown here refer to road traffic noise spectrum according to EN 1793-3. Also investigations with rail traffic noise spectrum were carried out. The values for these are in common higher.

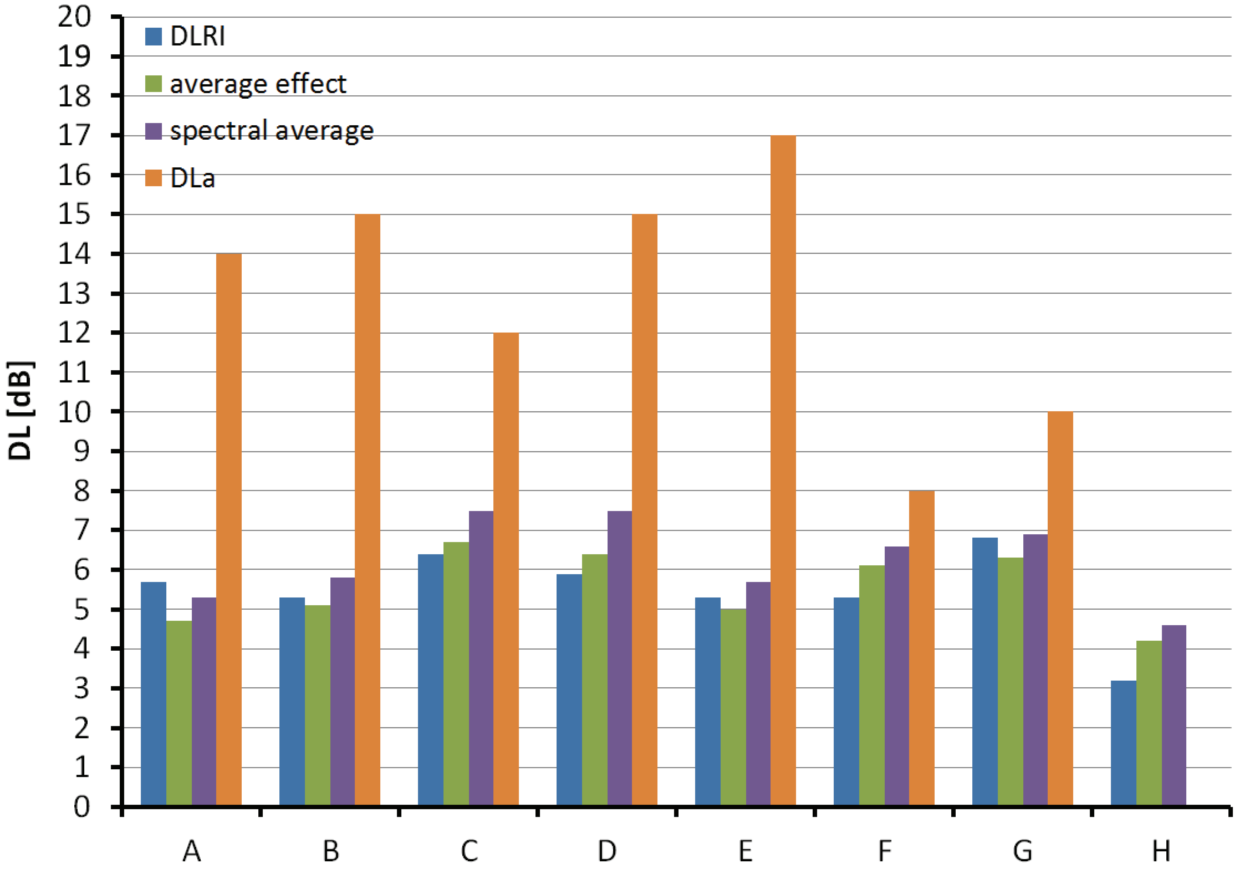

Figure 7 – Comparison of the results of different measurement methods using the road traffic noise spectrum in CEN/TS 1793-5

5. SUMMARY

The special measurement method developed in the course of the project proved itself in practice for measurements of sound reflection of noise barriers in the acoustic far field. A sufficient shielding of the direct sound reflection was realized. Environmental effects were negligible.

The measurements of the single sound reflection were carried out in situ at the noise barriers.

In this project a broad spectrum of types of noise barriers of different construction was investigated.

The results are shown for road traffic noise spectrum according to EN 1793-3. They are in principle also available for rail traffic spectrum and show commonly higher values.

The far field measurements show tendentially higher values for the spectral average absorption values than the in situ method according to CEN/TS 1793-5.

The absorption values of the reverberation room according to EN 1793-1 are significantly higher than these according to CEN/TS 1793-5 as well as according to the far field measurements carried out here.

The influence of the socket in the course of the sound propagation has to be considered.

A direct use of the values achieved with in situ measurement methods for the calculation of noise maps however is not possible with respect to the current knowledge.

Measurements of product properties (f. i. acceptance tests, in situ test of the installation quality, long time quality test etc.) are however possible.

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