inter.noise HAMBURG 2016

The Translation of the Austrian National Road Emission Data to the Revision of Annex II of the European Environmental Noise Directive 2002/49/EC

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ABSTRACT

On 19th of May 2015 the European Commission established common noise assessment methods according the Environmental Noise Directive 2002/49/EC (1). Member States are required to use these methods from 31 December 2018 onwards. In this directive road traffic sound emission has to be calculated by combining propulsion and rolling noise. For this purpose a set of input parameters are defined for each vehicle class in octave bands. The predicted emission values for the two source types are summed up to get the octave band sound power levels per meter of a source line. The basis for these emission is a virtual reference road surface, while spectral corrections for different road surfaces are applied via the coefficients α and β. Several values for these coefficients are tabulated in the directive. In a practical guide an equivalence table of these road surface data is proposed for various existing national road surfaces. This paper will show by the example of the Austrian road prediction model how to translate the national road emission data to coefficients of the Annex II model fulfilling all national uncertainty requirements and also those of the proposed quality framework.

Keywords: Environmental Noise, Prediction Methods, Road Traffic Noise, CNOSSOS
I-INCE Classification of Subjects Numbers: 52.3

1. INTRODUCTION

On 19th of May 2015 the European Commission established common noise assessment methods according to the Environmental Noise Directive 2002/49/EC (1). This prediction method is commonly known as CNOSSOS-EU. Member States are required to use these methods from 31 December 2018 onwards. Road traffic sound emission has to be calculated according to this directive by combining the propulsion and rolling noise sources. The Austrian road traffic noise prediction model used for noise mapping in the first and second round and also for mitigation planning does not distinguish between those two source types. Also the distribution of the sound levels in frequency bands is independent of the class and velocity of the vehicles. However, the Austrian model is a very valuable state of the art, which has been validated within several projects. The input parameters for the different road surface types have been measured after a representative lifetime and are compatible with the age effect methodology of the CNOSSOS-EU. Therefore the most proper way to implement the prediction model of Annex II is the definition of input data based on the Austrian emission data. Annex II uses road surface and frequency depending α and β coefficients that are defined in octave bands. This paper describes a methodology to determine these coefficients by using the existing values.

In this paper the focus is on light vehicles. Translating the emission data of heavy vehicles has to be in line with the definitions for medium heavy and heavy vehicles and also taking into account the current Austrian method to distinguish special quiet heavy vehicles from normal types,

Two-wheelers need no conversion because their sound power is independent from road surface characteristic. Here only the propulsion noise has to be taken into account.

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2. METHODOLOGY

2.1 Usage of Road Equivalence Tables

In a first step we compared results from road equivalence tables. The European Commission proposed in the so called CNOSSOS-EU Road Guideline (2) to relate specific national road surfaces to published surfaces in CNOSSOS-EU. It is necessary to identify how input data used in existing national method may be represented in CNOSSOS-EU. The road guidelines contain the four types of road surfaces included in RVS 04.02.11:2006 (3). They were matched across the Dutch road surface types of similar physical construction which provide similar step change in levels. It is mentioned, that the dependence of speed and vehicle category in RVS may not be accurately reflected in CNOSSOS. If this level of detail is required additional surface types could be added. For example the road guideline proposed the use of Dutch NL05 (SMA-0/8) for modelling the most common road surface in Austria which is asphaltic concrete.

Figure 1 shows the differences in sound power level per metre between NL05 defined in CNOSSOS-EU and asphaltic concrete according to RVS 04.02.11:2006

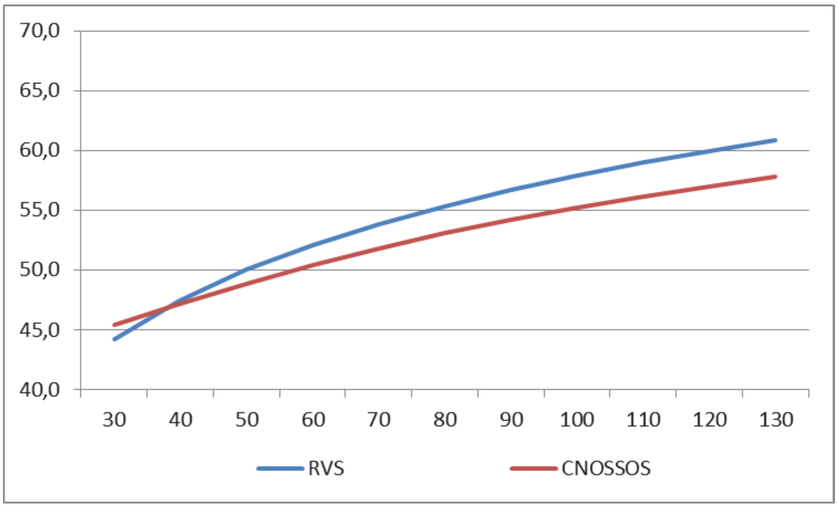

Figure 1 – Comparison of NL05 with CNOSSOS and Austrian asphaltic concrete with RVS 2006

Unfortunately, a revised edition of RVS 04.02.11 was released with new emission data in 2009, which was not taken into account in the equivalence document. In figure 2 the same differences are shown.

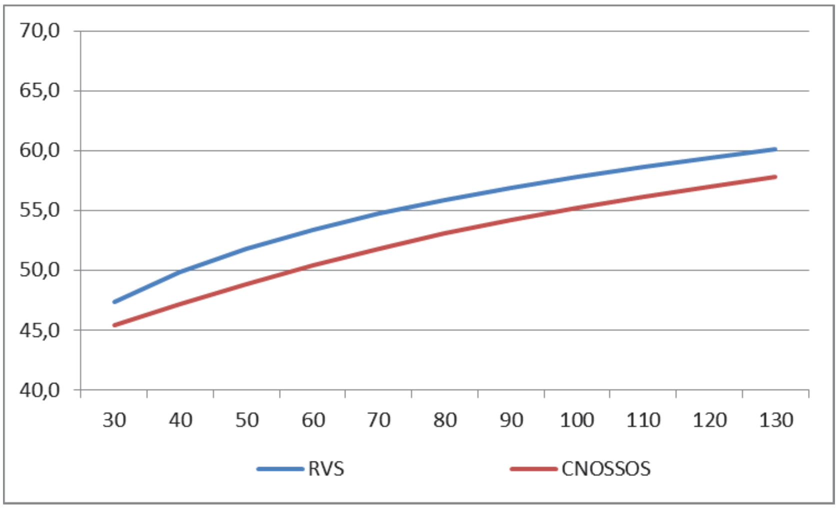

Figure 2 – Comparison of NL05 with CNOSSOS and Austrian asphaltic concrete with RVS 2009

The prior procedure was done for all vehicle classes and road surfaces. As shown in figures 1 and 2 this strategy leads to unacceptable results already for light vehicles. At 100 km/h the difference is approximately 3 dB. The accordance between those two methods for heavy vehicle is even poorer than for light vehicles. So there is a need to define the Austrian Road surfaces in a more detailed way by defining new α and β values for each road surface.

2.2 Generic guidelines for translating 3rd party datasets into CNOSSOS-EU

For the purpose of translating existing road emission data into member states generic guidelines for translating 3rd party datasets into CNOSSOS-EU are recommended by the European Commission (4). These rules are essential to establish source data from existing calculation methods or measurement data to an input database for CNOSSOS-EU. Both ways – measurement and existing calculation methods are suitable to find appropriate input values for CNOSSOS-EU. The standard procedure for making calculation is to start from emission level, which is in the most ideal situation the real sound power, calculate the propagation to come to the immission level at a receiver point close to the road.

This translation guideline makes clear, that there is no need to create completely new source data by measurement. It is also suitable to take 3rd party datasets from existing national methods.

The procedure describes that with existing calculation methods the noise immission levels can be determined at a certain distance from the road. The results are processed in a diagram in which the sound exposure level is a function of the vehicle speed. The initial calculation direction from source to receiver must then be reversed from receiver to source using the CNOSSOS-EU propagation method. Some predefined parameters like number of sources and source height are necessary. From the result of the calculation from the other prediction model the noise spectra must be determined in octaves or by using a reference noise spectrum. From this information regression lines of various octaves are determined. This regression lines must be in the format shown in equation 1.

$$L = \alpha + \beta \cdot lg\left({}^{v}/_{v_0}\right) \quad (1)$$

where the α and β are the input values for the database.

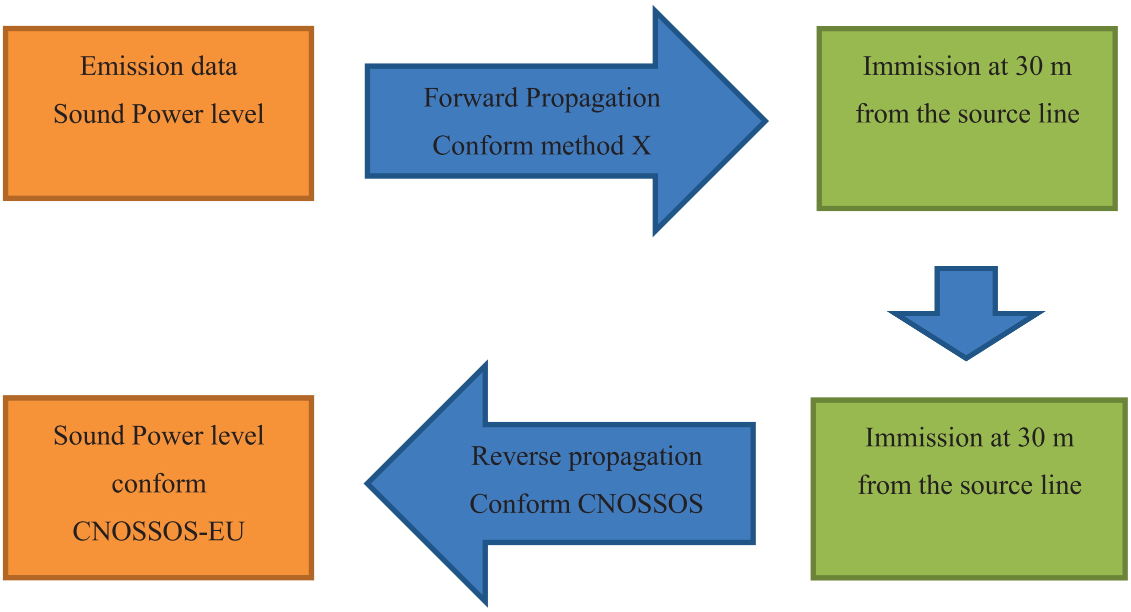

Figure 3 – recommended intermediate steps to find sound power levels conform to CNOSSOS

The method for calculation of reflection and absorption on the ground is essential for the determination of the corresponding sound power level. It may be clear that subsequently, for the forward calculation from sound power to receiver level the result must be the same as for the reference situation.

All the translation is made for pass by of vehicles with constant velocity, no acceleration or deceleration and no longitudinal gradient.

2.3 Translating Austrian Road emission data

In the Austrian sound propagation model RVS 04.02.11 the emission data of a vehicle is not defined by a sound power level. The emission data is given by a single source line in a height of 0.5 m above the road surface. At 1 m distance of this line source a sound pressure level is defined related to one pass-by per hour for all types of vehicles and surfaces. This so called emission sound level $L_{A,eq}{}^{1}$ is adjusted to different velocities and road gradients. By summing up all emission sound levels for all categories of vehicles and number of vehicles given in the section you may calculate the descriptor of the complete road.

The translation procedure can be done for each vehicle class for all surface types. The translation guideline emphasize that a precise translation has to take into account the ground effects in a correct way. It is important to know, that the Austrian source date were collected from pass by measurements in 7.5 m distance from the driving axle over reflective ground. The emission sound level $L_{A,eq}{}^{1}$ was calculated by simply geometric spreading over a semi cylinder surface not taking into account the atmospheric absorption. The absorption characteristic of the road surface is included in the emission sound level. In addition to the translation guideline it is also essential to consider the sound propagation conditions that might be homogeneous or favorable. This is very important, because there may be a difference in the reverse propagation with CNOSSOS-EU depending whether the attenuation conditions are homogeneous or favorable even at narrow distances. As we know in Austria that the road emission date was collected under homogeneous condition and even if there were favorable conditions they had no measurable influence we can suppose that homogeneous conditions are the best assumption.

In a first step it is useful to transform the emission sound level $L_{A,eq}{}^{1}$ to a sound power level per metre length $L_{W'}$. There is no general rule for this procedure. By integrating of a moving point source with constant sound power along a virtual infinite source line we see, that in this incoherent sound radiation the association between these two levels is as described in equation 2.

$$L_{W'} = L_{eq}{}^{1} + 3 \text{ dB} \tag{2}$$

This relationship is frequency independent and also valid for A-weighted levels. The translation guideline recommends to predict the sound pressure level in forward direction at narrow distance of 30 m and from this point backward by CNOSSOS. As at homogeneous condition over reflecting ground all terms in RVS 04.02.11 and CNOSSOS are the same, we can simplify the procedure as seen in figure 4 below:

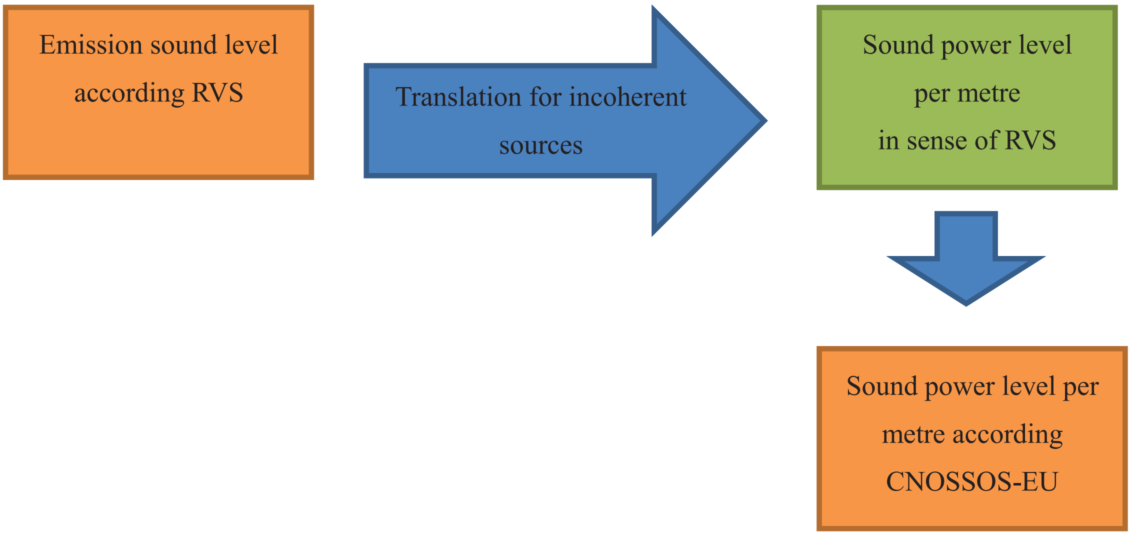

Figure 4 – abbreviate steps to find CNOSSOS conform sound power levels

Two parameters have to be corrected. First the average yearly temperature is 10°C while the reference temperature in CNOSSOS-EU is 20°C. Second the reference spectrum in RVS 04.02.11 over the eight octave bands is, when summed up not 0 dB, so a correction value of -0.44945 dB has to be added. This correction is important to avoid systematic deviations. This will lead under the given limitations to the same results than the procedure in the translation guideline.

The prediction method CNOSSOS-EU distinguishes between the sound emission components between rolling and propulsion sound. Both components depend on vehicle velocity. On the contrary RVS 04.02.11 uses a reference spectrum very similar to the ISO 717-1 traffic spectrum which is valid for all vehicle classes, velocities and road surfaces. To get a precise fit it is necessary to predict the A-weighted sound power level for different velocities with both methods. For example we chose for light vehicles a velocity range from 50 to 130 km/h divided in 10 km/h steps.

Expressed as a mathematical task we have per vehicle class and surface 9 variables (eight α and one β coefficient) which have to fit for each velocity bin. An explicit solution is impossible. So for regression it must be defined, which deviations are acceptable for each outcome. The highest priority was to determine the A-weighted sound power levels in each velocity class between 50 and 130 km/h with less than 0.2 dB deviation from the existing fit. To get steady crossovers from one octave band to the next the best strategy we found is optimizing α values with the rules of linear regression. The values of α and β with a default set of 0 like the reference surface were varied as long as the variance converged to a minimum and the determined precision was fulfilled. This could be done for all light vehicles and all road surfaces. As mentioned in the introduction, the translating procedure of heavy vehicles has additional and special rules. A maximum deviation of 0.2 dB in each velocity class between 50 and 130 km/h is fulfilled.

Table 1 shows the approximation of the A-weighted sound power level for the most common road surface in Austria – asphaltic concrete

Table 1 – Example for α and β values – light vehicle asphaltic concrete

α_{63}	α_{125}	α_{250}	α_{500}	α_{1000}	α_{2000}	α_{4000}	α_{8000}	β
0,0	0,0	0,0	0,1	2,7	1,1	0,1	0,0	-2,5

Figure 5 shows the approximation of the A-weighted sound power level for the most common road surface in Austria – asphaltic concrete.

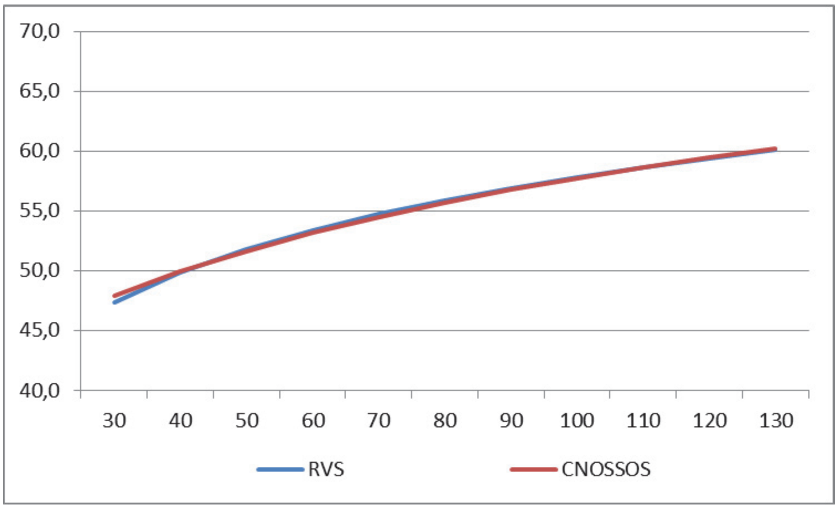

Figure 5 – Comparison light vehicle on asphaltic concrete using recommended α and β values

3. ACCURACY

Under the following definitions:

- Yearly average temperature of 10°C
- Longitudinal gradient 0%
- Steady motion (no crossings, junctions)
- Long and straight road

all emission sound levels $L_{A,eq}$[1] are correctly expressed by the new found α and β values

- for each category of vehicle
- for each to optimize velocity band
- for each road surface

with a precision of ± 0.2 dB for the A-weighted sound power level per metre

4. CONCLUSIONS

During the implementation process of CNOSSOS-EU it was seen that simple usage of reference road surfaces as recommended in the CNOSSOS road equivalence guidelines leads to unacceptable differences to the Austrian prediction method. Therefore for all vehicle classes and road surfaces α and β values were derived to meet the state of the art Austrian emission data. This was done by regression analysis under determined rules. The main priority was to achieve the A-weighted sound power level per meter with not more than 0.2 dB deviation between the new CNOSSOS-EU model and the existing Austrian RVS method. To minimize the deviation between the octave bands a linear regression was calculated.

ACKNOWLEDGEMENTS

The Authors would like to thank Mr. Christof Rehling, Austrian Ministry for Transport, Innovation and Technology, Austria, for his technical and scientific support.

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