New Concepts for the Description of Railway Noise in Germany

R. J. Diehl\textsuperscript{a}, U. J. Kurze\textsuperscript{a}, and J. Onnich\textsuperscript{b}

\textsuperscript{a}Müller-BBM GmbH, 82152 Planegg, Germany, Rolf.Diehl@mbbm.de
\textsuperscript{b}Deutsche Bahn AG, 80939 München, Germany

The present German guideline Schall 03 for the calculation of railway noise is based on the equivalent A-weighted level with a specific normalization. A new concept is presented which conforms to the European commissions demand and was developed following the ideas of the Austrian and the Dutch regulations. The new proposal is source oriented, based on empirical data and involves the physical interpretation of phenomena. It includes spectral data.

INTRODUCTION

The present German guideline Schall 03 for the calculation of railway noise is based on the equivalent A-weighted level at a distance of 25 m from a ballasted track in average condition carrying one disc-braked train per hour of 100 m length at a speed of 100 km/h. Level differences are added for different track (including bridges and crossings), train, operating and maintenance conditions.

Due to innovations in high speed vehicle and track technology and in view of regulations in other European countries [2,3] and the process awaited from the European Commission [4] in this respect new concepts for the calculation of railway noise should be developed to offer improved methods taking equally account of the interest of railways and citizens to be protected from noise by the regulations thanks to a more complex model closely related to actual physical noise generation phenomena. Initiated by Deutsche Bahn AG and the Ministry of Transportation a working group was formed to develop a proposal. This paper describes the conceptual approach developed.

CONCEPT AND PROCEDURE

The working group decided that the new concept shall be based on a source oriented approach taking, as far as necessary, account of rolling, aerodynamic and machinery noise as well as noise generated by the vehicle superstructure. The methodology of source description should be in accordance with general standards, e.g. [5]: single sources characterised by geometrical position and sound power level and line sources with a sound power level normalized to the length of the distance travelled within one hour. In general the use of octave bands is required, A-weighted single number values shall be added.

To take account of the different characteristics of vehicles, categories were developed, based on operational units with similar acoustical properties. For the model prediction, a train will then be composed of vehicles selected from these categories. For each category source data must then be provided for rolling noise radiated by track and undercarriage, by the vehicle superstructure and
by the track substructure (e.g. bridges), for aerodynamic sources located at and above the roof and at the wheel height and for machinery noise at two different heights. The consideration of different heights is utterly important to allow the inclusion of the effects of sound barriers, which may not mitigate sound from high sources.

The description of the sources shall be done for the nominal maximum operational speed $V_0$ of the vehicle category. The basic distinction of the categories is between railways and rapid transit systems, the latter consisting of subways and street cars. Railways are diversified into high speed material either with distributed traction (e.g. ICE3) or with traction head (e.g. ICE1 and ICE2), EMUs, DMUs, E-locos and D-locos and types of rolling stock described by their nominal speed (corresponding to the traction units, locos) and braking system.

The general speed dependency expected for the different types of sources is depicted in Figure 1.

![Figure 1](image)

**Figure 1. Schematic representation of the speed dependent contributions to the normalized sound power.**

For each of the contributions a sound power level per unit length $a$, replacing the “basic value” (Grundwert) of the present German regulation, has to be found for the nominal speed $V_0$, a correction term $b$ is taking account of the correction for speed $V$ and a value $c$ of the speed independent influences, e.g. track type and condition, giving a formula: $L = a + b \log \left( \frac{V}{V_0} \right) + c$. As in the Dutch regulation [3] the sound power level of one vehicle unit per hour shall be referred to the distance travelled at the speed $V_0$. The factor of 20 in the notation of 20 $\log \left( \frac{V}{V_0} \right)$ dB used in the present German standard for rolling noise will be replaced by an individual factor $b$. The reference speed $V_0$ is selected such that the vehicle in its standard operating condition at maximum speed is sufficiently described with the value $a$, therefore $b$ being of minor importance and thus the speed correction less prone to errors.

For the inclusion of the spectral values, an octave band correction term $\Delta a$ is used for the single value $a_A$ describing the A-weighted overall sound power level per unit length. The acoustic corrections for track types, e.g. slab track versus ballasted track, shall be done independent of speed with value $c$, however, depending on the vehicle type. The quality of the rail and wheel surface roughness, as presently applied for BüG (specially monitored track) or for the differences be-
tween disc, composite and cast iron block braked wheels, shall be represented in the model using separate vehicle and track dependent excitation terms for rolling noise (representing the wheel and rail roughness) and a mechanism for their combination to form an effective roughness excitation term. Both values \( b \) and \( c \) shall include spectral correction terms for the speed dependency and for the speed independent correction.

**PRACTICAL APPLICATION**

The concept outlined in the previous section is implemented for further testing and discussion as a model together with a database for the comparison of results of the new model, present Schall 03 [1] and measurement values to allow for the determination of the model parameters. The reference speed \( V_0 \) was chosen as 250km/h for high speed trains, 160km/h for intercity, 100km/h for regional and 80km/h for freight rolling stock. Vehicles are divided into 10 categories, 6 powered, 4 unpowered. The source heights basically follow the scheme shown in Figure 2 for a high speed powered vehicle.

The sources are basically the same for all other vehicles, but aerodynamics are not included for non-high-speed vehicles. Machinery noise may be included for all powered vehicles and air conditioned rolling stock.

A first set of data was developed for rolling noise using converted values from [1,2,3], for aerodynamic sources based on the experience that they are of equal importance at speeds around 250km/h and for machinery noise using sound power measurements at still stand. The determination of practical model values for all vehicle categories must be based on a statistical evaluation of the level differences of model results and measurement values aimed at an average of 0dB. As the capabilities to precisely attribute sound power to different sources, when measured concurrently, is rather limited, the emphasis in respect to precision must be on the determination of the dominating sources: at stand still and low speeds machinery noise, for standard traffic rolling noise and for high speed vehicles rolling noise at moderate speeds and aerodynamic noise.

**Figure 2. Schematic representation of source heights for high speed powered vehicle.**

The sources are basically the same for all other vehicles, but aerodynamics are not included for non-high-speed vehicles. Machinery noise may be included for all powered vehicles and air conditioned rolling stock.
at high speeds. The rolling noise contribution from the vehicle superstructure as known from tank cars or rattling of moving parts has not yet be known to attribute significantly to the A-weighted total noise; the same may apply to other contributions for various types of vehicles, which may after close scrutiny then not be considered further in the model until other evidence is presented.

At present measurement data, provided by different sources, is included in the database to establish and improve the reliability of the model. The data includes values for single trains but also data averaged for several trains including the corresponding standard deviation, thus allowing a corresponding inclusion under extended statistical considerations. Based on the information provided for vehicles, track, substructure and measurement conditions, the data is allotted to the respective collective thus allowing the improvement of the respective model values. Special care is needed to identify the values for bridges with and without noise mitigation measures, crossings, BüG (specially monitored track) and slab track.

CONCLUSIONS

A new concept for the calculation of railway noise is developed. In its main points it conforms to the European guideline 2002/49/EG [4] and standard acoustical standards [5]. The concept is closely linked to the existing Dutch [2] and Austrian [3] regulations. The use of different source heights and source mechanisms take account of the underlying physical principles, like the track vehicle interaction known from scientific models.

REFERENCES


