The new German prediction model for railway noise „Schall 03 2006“ – Potentials of the new calculation method for noise mitigation of planned rail traffic

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Summary

The German prediction method for railway noise from new railway lines was revised by an expert team during the last five years. The draft issue of “Schall 03 2006”[1] is available now. The calculation model is based on octave-band sound power levels describing the emission in different heights of different vehicles, noise sources and parts of noise sources, e.g. roughness of wheels and rails, pantograph noise, and engine noise. The description of sound propagation follows the methods of ISO 9613-2 [2]. The new calculation method allows taking noise reductions into account that are based on technical progress or improvements. To this end, a scheme is described in “Schall 03 2006” [1] for introducing new measures of noise abatement and environmental protection. This includes measures for rolling stock, for rail and track, for bridges, and even measures in the propagation path. The effects of the parameters used in “Schall 03 2006” [1] on noise immission in general and on special existing noise abatement measures, e.g. low noise composite breaks and rail grinding, are presented.

1. Introduction

A calculation method for Railway noise, including the noise of tramways and shunting yards, for new constructions of railway tracks was updated and revised; the new calculation method “Schall 03 2006” [1] shall be implemented in 2008. In comparison to the “Schall 03” this calculation method introduces octave band emission levels and three different heights of sound sources. The sound sources taken into account are distinguished by their mechanisms of appearance. The calculation method of sound propagation now considers buildings as noise barriers.

The guide line is structured according to German and European standards and contains a comprehensive description of acoustic calculation methods for sound emission and sound propagation as well as a calculation of a rating level which shall be used for comparison with the applicable noise limits. Furthermore this directive includes a method to take into consideration new railway technology and innovations which will have effects on sound emissions.

The consequences of possible noise reduction measures will be shown after a short introduction of the calculation method. Finally the procedure of issuing new technologies will be illustrated.

2. Main Features of new „Schall 03“

The calculation methods are detailed in „Schall 03 2006“[1] (see also [3]). In “Schall 03 2006” [1] seven types of powered vehicle units, three types of un-powered vehicle units and three types of trams are distinguished. For these types of vehicle units four types of sources consisting of a total of nine types of partial sources are distinguished. The parameters to be considered are listed in Tab. 1.

Type of vehicle	Type of source	Partial sources
high-speed traction unit	rolling noise	rail roughness
high-speed coach	aerodynamic noise	wheel roughness
high-speed train-set	equipment noise	Structure-borne sound of tank wagons
high-speed tilting tech.	propulsion noise	Pantograph
rapid transit train set		grills of cooling systems
electric locomotive		Bogies
diesel locomotive		Ventilators
passenger coach		exhaust gas system
freight wagon		Engine
Low - floor tram		
high - floor tram		
Metro		

Table 1. Parameters of sound emission, used in Schall 03 2006.

The partial sources of each type of vehicle are assumed to be located and energetically summarised at three different heights: 0 m, 4 m and 5m above railhead.
In figure 1 the different sound sources of an ICE1 traction unit are shown as an example.

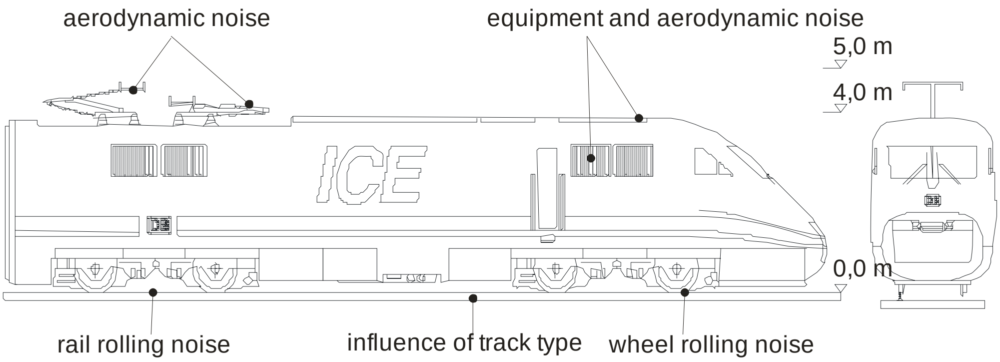

Fig. 1. Noise sources and corresponding heights of an ICE traction unit.

Rolling noise is dominating under free-field conditions in the velocity range from 70 to 250 km/h. To keep the calculation procedure practicable, a minimum fictitious velocity of 70 km/h for railway vehicles and 50 km/h for trams is compulsory to account for all additional sound sources in and next to stations, e.g. brake squeal.
Total noise data collected during the pass-by of about 10,000 trains at various tracks in Germany have been supplemented by special measurements involving phased microphone arrays and by enveloping measurements on powered vehicles at rest [4, 5, 6]. Rolling noise and aerodynamic noise were determined by evaluating the pass-by of different trains varying parameters like train type, track type etc. [4]. Other types of noise sources (such as equipment noise) were determined by measurements of vehicles at rest. The results were compared to the results from a theoretical model

for noise emission, which is described by equation (1) and provides the basis for determining the sound emission from “Schall 03 2006” [1]:

$$L_{W'A,f,h,m,Fz} = a_{A,h,m,Fz} + \Delta a_{f,h,m,Fz} + 10\lg \frac{n_Q}{n_{Q,0}} \text{dB} + b_{f,h,m} \lg\left(\frac{v_{Fz}}{v_0}\right) \text{dB} + \sum c_{f,h,m} + \sum K \qquad (1)$$

with

$a_{A,h,m,Fz}$	A-weighted overall level of the sound power per unit track length emitted from the height range h for the source type m of one vehicle unit Fz, equipped with the reference number $n_{Q,0}$ of sound sources, running at the reference velocity $v_0 = 100$ km/h, on a ballasted track with average condition of the rail surface, neither on a bridge nor on a curved track, in dB
$\Delta a_{f,h,m,Fz}$	level difference between overall level and octave band level in the octave band f, in dB
n_Q	number of sound sources of a vehicle unit
$b_{f,h,m}$	velocity factor
v_{Fz}	train velocity, in km/h
$\Sigma c_{f,h,m}$	level corrections for type of track and rail surface condition, in dB
ΣK	level corrections for bridges and particular nuisance of noise, in dB

The speed dependence of these factors is taken into account for rolling noise and aerodynamic noise. In the case of equipment and propulsion noise the speed dependence is disregarded, because no relevant influence of speed on the total noise is expected**.** The validity of equation (1) is documented in [4] in terms of small mean values and standard deviations for the differences between measured and calculated data. The acoustic parameters were summarized on data sheets for each of the ten types of vehicles (see table 1). Correction terms for the track type or for bridges were determined by comparing the results of pass-by measurements on ballasted track to those on different track types or types of bridges (see [4] and [10]).Examples for the velocity dependence are plotted for complete trains in Fig. 2.

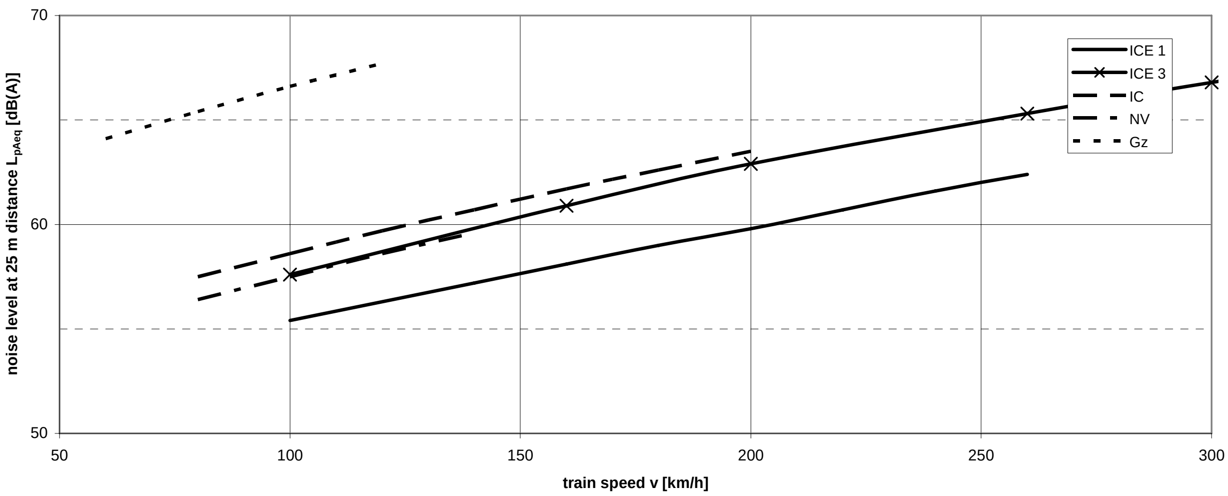

Fig. 2. Dependency of velocity on calculated noise levels L_{pAeq} at 25 m distance for different train types with 1 train per hour according to “Schall 03 2006”.

3. Effects of Noise mitigation according to "Schall 03 2006"

"Schall 03 2006"[1] allows to deduce noise reducing measures for particular brakes or for especially maintained tracks. In the following a description of the effect of disc brakes, cast iron block brakes and composite block brakes in co-action with rail grinding is shown:

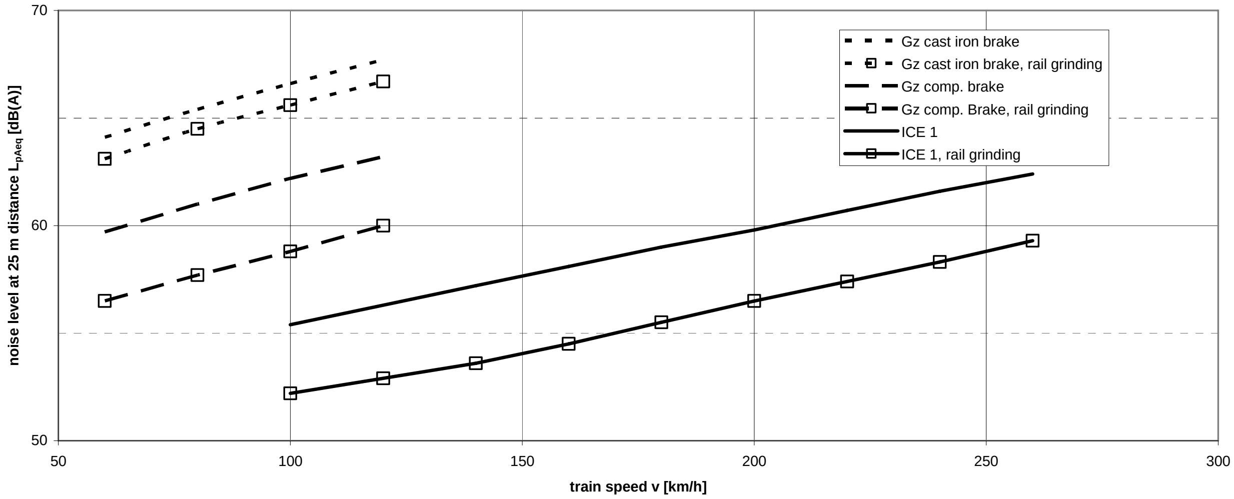

Fig. 3. Calculated noise levels L_{pAeq} for trains with cast iron brake and composite brake with and without rail grinding according to "Schall03 2006".

From figure 3 it can be deduced that e.g. the usage of composite block brakes instead of conventional cast iron block brakes for freight trains results in a reduction of about 4 dB(A) for an average maintained track. Using rail grinding in combination with cast iron block brakes allows a reduction of only approx. 1 dB (A), however in combination with disc brakes (ICE1) approx. 4 dB(A). Combining composite block brakes with rail grinding will result in a reduction of about 8 dB(A) compared to conventional cast iron block brakes.

From figure 3 can also be deduced the poorer performance of rail grinding for ICE 1 at higher speeds (above approx. 200 km/h) and at low speed (approx. 100 km/h). In these cases the influence of other sound sources, such as equipment noise at low speed and aerodynamic noise at high speed, can be seen. These effects are negligible in the case of freight trains, where rail grinding causes a constant decrease of noise. Figure 4 shows the influence of the kind of track and the possible measures to reduce noise level.

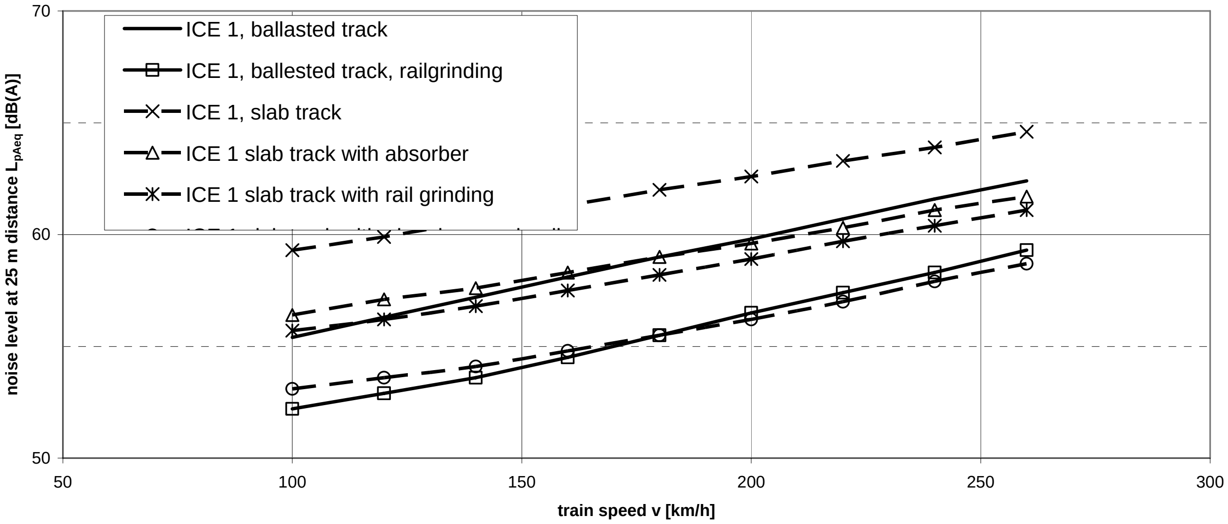

Fig. 4. Calculated noise levels L_{pAeq} for trains on different tracks according to “Schall03 2006”.

From figure 4 it can be deduced that slab tracks with absorbers will have approximately the same acoustic properties as ballasted tracks. Comparing ballasted tracks and slab tracks (with or without absorbers) the effect of rail grinding is approximately the same. Slab tracks with absorbers and rail grinding cause the same noise levels as the ballasted track with rail grinding.

The reducing effect of sound insulation walls for freight trains and ICE trains is shown separately in the following chart:

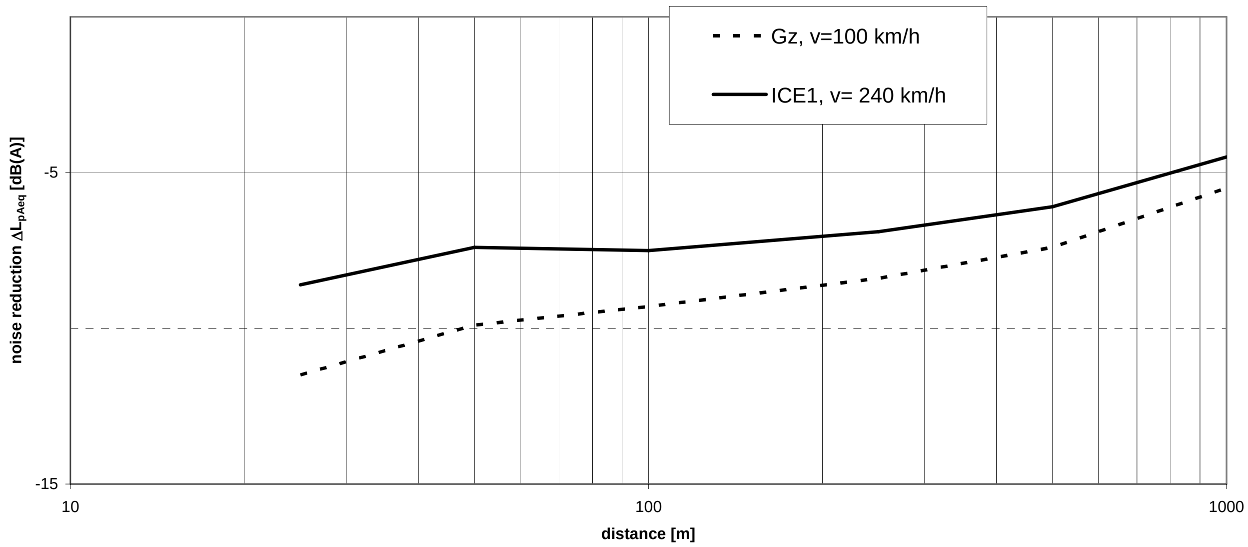

Fig. 5: Difference in calculated noise levels L_{pAeq} with and without noise barrier depending on the distance to the track according to “Schall 03 2006” (h=3,5 m, reference level 6,0 m).

From figure 5 it can be deduced that the reducing effect of sound insulation walls is significantly higher for freight trains compared to high speed ICE trains. This effect can essentially be put down to the reduced effect on high positioned noise sources as aerodynamically caused noises by the pantographs. Experimental results of this effect can be seen in [5].

4. Procedure of Introduction of Innovations

New railway technologies, which are not mentioned in spreadsheets and data sheets of "Schall 03 2006" [1], can acoustically evaluated according to a defined method. These railway technologies are including:

- Types of vehicles
- Components of vehicles
- Components of railroad shunting yards or container terminals
- Types of tracks
- Bridges
- Maintenance methods of tracks and wheels
- Railway specific sound insulations in the direction of sound propagation whose shielding effectiveness is not appropriately described in "Schall03 2006" [1].

The acceptance procedure requires a formal application, the confirmation of the acoustic improvements by a defined measuring method subject to railway techniques mentioned above and passes the following steps:

- Application
- Certification of acoustic improvements
- Survey by authorised institution
- Certificate
- Publication

To confirm the acoustic improvements, the results of e.g. at least three measurement of pass-by noise testing and stationary noise measurement according to DIN EN ISO 3095 [7] and TSI [8] are required. Shielding devices and similar measures whose effects can not be calculated, are to be described in accordance to existing regulations. To verify the modifications measurement results are to be named as differences in the eight octave-bands with centre frequencies of 63 Hz to 8 kHz to the calculated differences according to existing calculation methods. The authorised institution has to verify if the object of application differs from the directive. As a rule, a significant deviation is on hand if for a part of the source the deviation of the A-weighted overall level of the sound power is greater than 2 dB or in single octave-bands greater than 4 dB.
The authorised institution has to issue a certificate for the subject of application if a significant deviation is on hand. This certificate allocates the subject of application to the existing spreadsheets and textual specifications of this guide line and describes the deviation of sonic effect.

5. Conclusion

With the new calculation method of "Schall 03 2006" an up to date method for the calculation of noise immissions caused by railway lines is available. Noise emission is separated in different types of sound sources at different types. Each vehicle can be described by these sound sources with their specific contribution.
Therefore noise abatement measures, which are implemented to a specific sound source, can be taken into account. The noise reducing effect can be taken into account by developing a new data sheet for the improved vehicle.

References

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