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NOISE CONTROL FOR QUALITY OF LIFE

The impact of rail grinding on noise levels and residents' noise responses – Part I: Study design and acoustical results

Manfred Liepert¹, Ulrich Möhler², Dirk Schreckenber³, Rudolf Schuemer⁴

^{1,2} Möhler + Partner Ingenieure AG

Paul-Heyse-Straße 27, 80336 Munich, Germany

³ ZEUS GmbH

Sennbrink 46, 58093 Hagen, Germany

⁴ Elberfelder Str. 32, 58095 Hagen, Germany

ABSTRACT

Rail grinding is widely used as a noise mitigation measure. In order to assess the impact of rail grinding a socio-acoustical field survey was carried out. In two sections along a railway line between Bavaria and Baden Württemberg railway grinding was conducted to reduce noise emission. In both sections rail condition before grinding were worse than average.

Before and after the rail grinding both acoustical measurements and interviews of the residents were done. In order to investigate the influence of active information about the rail grinding measure the residents have been informed only in the Baden Württemberg section.

The acoustical measurements before and after rail grinding were analyzed separating the effectiveness of the rail grinding for each type of train. As expected noise reductions were best for disc-braked trains (e.g. ICE and passenger trains about 5 to 7 dB) and less effective for freight trains (about 1 dB). Due to the failure of the rail grinding vehicle the noise reduction in the Baden Württemberg section with information was less than in the Bavarian section.

The effect of grinding on the noise annoyance of the residents is described in part II of this contribution by Dirk Schreckenber [2].

1. INTRODUCTION

Railway noise is a wide spread noise problem in Germany. A common method for reducing railway noise is the building of noise barriers, but in many areas the noise reducing effect of barriers is limited because of topography or the demand of the residents for free view of the landscape. Therefore there is a need for noise emission reducing technologies. In the last two years a couple of new technologies were tested in R&D projects (funded by the 'Konjunkturprogramm II' of the German Government) [3]. Some of these technologies (e.g. rail shielding, rail dampers, bridge dampening, composite block

¹ manfred.liepert@mopa.de

² ulrich.moehler@mopa.de

³ schreckenber@zeusgmbh.de

⁴ schuemer@zeusgmbh.de

brakes etc) are reducing the noise emission. But the only noise mitigation method that can be considered in the calculation methods of German noise legislation is the so called "Besonders überwachtes Gleis", the rail grinding.

Rolling noise is the most prominent sound source of a passing train. On railway lines with heavy traffic a rough rail can increase the rolling noise up to 10 to 15 dB(A). Therefore periodical rail grinding is a common and cost-efficient method of noise reduction in these areas. By grinding the rail the surface can be smoothed with a result of noise decrease up to 10 dB(A) on a smooth wheel. Nowadays it is a well known fact, that the noise reducing effect is depending on the roughness of the passing wheel. Whereas on a smooth wheel the maximum noise reducing effect can be achieved, rolling noise of rough wheels (e.g. from cast iron braked wheels of a freight train) on the rail is only slightly lowered. Despite this fact, there is only a single number correction factor for noise emission reduction caused by rail grinding of 2 dB(A) in the calculation method Schall 03 1990 [4].

In this study the effect of rail grinding on the reduction of noise levels and annoyance by railway noise should be analyzed. Furthermore a possible impact of specific information about the noise mitigation measures on the shift of annoyance should be tested.

2. Study design

The study [6] was designed to investigate the noise impact and the noise annoyance in two geographical widely separated study areas. In these areas noise measurements and socio-acoustical surveys should be carried out before and after grinding the rails of the nearby railway line. In one of the two areas (in the Baden Württemberg section) active information about the noise abatement measure and the expected effect should be given to the residents, whereas in the other area (in the Bavarian section) the survey should be conducted as a "blind" survey without information. In the second area information was given that this questionnaire dealt with general living conditions in the near of traffic lines. In both areas the first survey (before grinding) was conducted without any information about the rail grinding and the aim of the study. Following the rail grinding was done in both areas simultaneously.

In the area with information the local authorities were informed about the rail grinding works and the aim of the accompanying social survey before the grinding work was done. With help of the local press and the local authorities this information was spread amongst the residents. Before the second interview (post-survey) the residents should be given enough time to accommodate to the changed noise situation. Moreover, there should be enough time for the treated track to shift to a steady state of noise emission, because shortly after the grinding a noise increase can occur that diminishes after enough traffic flow.

The pre- and post-interrogations should take place within periods of the year with similar climatic conditions in order to avoid an influence of different habitual window conditions. Therefore the pre-interrogation was planned for the autumn period and the post interrogation for the spring.

In order to control for possible effects of repeated measurements when interviewing before and after the rail grinding only-after surveys in two additional areas with and without information were planned after rail grinding as part of the study design. However, because of a cut of the budget for this study these additional investigations had to be stopped as well as an intended accompanying laboratory study.

The noise impact on the residents had to be described using individual noise levels for each subject. Because the effect of the rail grinding could not well enough be described by calculation only, the emission of the railway line should be measured distinguishing the different types of trains and the different noise reduction for each train type. Based on the emission measurements subject-individual noise levels had to be calculated before and after rail grinding. Accompanying measurements of the rail roughness before and after rail grinding were conducted by the Deutsche Bahn AG.

The following table shows the realized study design:

Table 1 – Realized study design

Study area		t1	t2
		3 months before railway grinding	1-2 months after railway grinding
number of intended (realized) interviews			
With information	Experimental area	250 (190)	250 (163)
Without information	Experimental area	250 (221)	250 (177)

The following hypotheses were tested:

(H1): It is assumed that in line with the decrease in noise exposure after railway grinding noise responses of residents living along a railway line are lower after railway grinding than before.

(H2): In areas where residents receive information about railway grinding and its noise-reducing impact the decrease in railway noise annoyance and disturbances is stronger than in areas where residents do not receive such information.

3. STUDY AREAS

The main selection criterion for the study areas was a rail condition at the beginning of the survey well below an average condition in terms of smoothness of the rail. This was determined by evaluation of the data gathered by a noise monitoring car of Deutsche Bahn. This noise monitoring car records the noise level of the smooth wheel set of the car. Track sections with a noise level of at least 10 dB above average noise level (so called “Grundwert”) were marked on topographic maps; within these sections those areas with residential buildings were visited by the staff.

Further selection criteria for the survey have been:

- Areas mainly with residential buildings
- buildings with an age of at least 5 years (no new residential areas)
- enough suitable (which means noise loaded) residential buildings (ca. 300)
- mixed population in terms of socio demographic characteristics
- no other prominent noise sources (esp. road noise or industrial noise)
- no noise barriers or sound insulation windows in the area
- no additional railbound vehicles in the near (esp. tramway)
- residential building directly neighbouring the track (distance of the first row to the track less than 50 m)

3.1 Areas without information

In order to gain a sufficient number of possible participants the two neighbouring villages Burlafingen and Unterfahlheim were chosen for the condition without information. Both are located south of the railway line Ulm – Augsburg (in Bavaria).

Main urban streets are in both areas in a distance of at least 200 m whereas the distance to the railway line is less than 50 m. The terrain in both areas is almost flat. The buildings in both areas are almost exclusively residential buildings with not more than two floors.

The railway line Ulm - Augsburg is a main line of Deutsche Bahn with an average of about 220 trains per day. Both long-distance ICE-trains and IC trains as well as suburban trains are operating on the line. The percentage of freight trains is about 30 % per day. In both areas the former station is no longer used.

3.2 Areas with information

As area with information the city of Uhingen (in Baden Württemberg) between Göppingen and Esslingen neighbouring the railway line Stuttgart – Ulm was chosen. The study area is in the north of the railway with the first building in a distance of about 30 m from the railway line. The terrain has a slight slope with increasing distance to the railway. The housing consists mainly of apartment buildings with 3 floors, each of them rectangular to the railway line.

The railway line Stuttgart - Ulm is also a main line of Deutsche Bahn with similar traffic to the railway line Ulm – Augsburg and with an average of about 250 trains per day. Traffic is almost the same as in the areas without information; the percentage of freight trains is about 24 % per day.

The station of Uhingen is used by commuters travelling to work in Göppingen or Stuttgart.

3.3 Rail grinding

In all areas both tracks of the railway line were grinded irrespective whether one or both tracks showed a less than average condition before the grinding. Grinding was done on a length which exceeded the area at least 500 m on both ends in order to avoid an influence of the not grinded sections of the track. To determine the effect of the rail grinding the noise monitoring cars took data before and after the grinding. The comparison of the data of the noise monitoring car shows clearly the decrease in rail roughness.

In both areas both the straight track as well as the switches should be grinded. Due to a failure of the grinding machine switches weren't grinded in the area with information. Therefore the overall noise reduction in the area with information was less than in the area without information.

To achieve a constant noise reduction effect at least 500.000 tons of traffic weight had to pass the areas before the whole effect could be achieved. Therefore the pause between the grinding and the beginning of the post-survey had to be more than at least two weeks.

4. INFORMATION

The public relations work in the area with information should not be noticed in areas without information. Therefore the areas with or without information should be separated by a long enough distance. Local press and media should not be the same in both areas. As far as the evaluation of the interviews showed no participant of the area without information had any information about the rail grinding neither in his area nor in the other area with information.

4.1 Areas without information

In the area without information the purpose for the repeated survey was hidden. As justification for the repeated interrogation possible changes in the perception of noise caused by possible change of traffic or weather condition were mentioned. Questions concerning the change of noise perception were referred to the "time since last autumn".

4.2 Areas with Information

In the areas with information public relations (PR) work was done in order to sensitize the residents to the noise abatement measure. The PR work consisted of:

- personal letters to the possible participants with detailed information about the aim of the study
- distribution of a flyer informing about the rail grinding technology and its application in the area
- a press conference in presence of representatives of the local authorities and of the Deutsche Bahn.

For the information of the residents a flyer was created with all necessary information about the time, the location and the expected effect of the rail grinding works. In the same flyer information was given about the aim of the interrogation of the residents. In order to achieve a wide distribution of the flyer it was sent by mail to all addresses in the study area 2 weeks before the beginning of the interrogation. Additionally the flyer was attached to the letter, in which participants of the study were asked to take part in the survey.

After the distribution of the flyer a press conference was held in presence of representatives of the

Deutsche Bahn and of the local authorities. In this press conference additional information was given to journalists of local newspapers and local radio stations. Subsequent to this press conference multiple newspaper articles were released in the local press and radio interviews were broadcasted.

5. ACOUSTICAL MEASUREMENTS AND RESULTS

5.1 Methods

Acoustical noise level values should be determined for each participant individually. Because of the great number of interviewed residents this couldn't be done by measurements alone. Calculations on the other hand couldn't consider the realistic noise reducing effect of the rail grinding. Therefore the noise emission and thus the change of noise emission was measured and the propagation in the study area was calculated.

The combination of both methods should supply as far as possible a realistic description of the noise impact on the residents.

5.2 Noise emission

Measurements of noise emission were taken in both areas before and after rail grinding. After the grinding work a pause of at least two weeks between grinding and measurements was necessary where the noise emission could normalize to a steady state. Noise emission measurement lasted 24 h hours in both areas both before and after rail grinding. The measurements were taken at a distance of 25 m from the track on normal working day with average traffic density.

Additionally all relevant parameters of the passing trains were documented, including train type, train speed, length and percentage of disc-braked wagons. Particularly the values of train speed and percentage of disc-braked wagons differ significant from the values that can be obtained by the railway infrastructure companies. This is in case of the speed due to the low distance to the next station and in case of the percentage of disc-braked wagons due to the renewal of vehicle fleet.

Additional to the noise emission measurements sample measurements were taken in front of the buildings of preselected participants. This was done for about 5 to 10 buildings per area. The sample measurements were taken simultaneously to the emission measurements with duration of about an hour. The aim of these sample measurements was to validate the propagation calculations. All the measurements were recorded on tape for further investigation or use in a laboratory study.

The measurement points before and after rail grinding were chosen identically. In order to avoid an influence of different traffic density between the measurements before and after rail grinding each train pass by was evaluated separately: The equivalent sound pressure level of each train pass-by was normalized according to calculation method "Schall 03" [4] to an average sound pressure level (so called "Grundwert") using the parameters train type, train speed, length and percentage of disc-braked wagons. The difference between the nominal „Grundwert“ (which is 51 dB) to the measured value describes the condition of the rail/wheel contact. For each train type an energy equivalent average of the difference between the nominal "Grundwert" and the measured value was calculated separately for each study area and the measurements before and after rail grinding. These average differences were used as correction factors for further calculations. The slightly different traffic densities in the measurements before and after rail grinding were neglected by calculating a mean traffic density considering both measurements.

The following tables 2 and 3 show the noise emissions for both study areas before and after rail grinding as well as the difference in emission between the measurements for each train type. The hereby shown emission values were used for the further propagation calculations in the study areas in order to obtain values for each subject.

Table 2 – Noise emission values in the study area without information (Burlafingen and Unterfahlheim)

	Train Speed (km/h)	Number of Trains		Noise emission levels				$\square L_{\text{bef./aft.}}$ dB(A)
				Before grinding		After grinding		
				dB(A)		dB(A)		
	N_{Day}	N_{Night}	$L_{\text{mE,D}}$	$L_{\text{mE,N}}$	$L_{\text{mE,D}}$	$L_{\text{mE,N}}$		
ICE-Train	155	33	1	57.2	45.0	49.0	36.8	-8.2
IC-Train	153	29	1	59.9	48.2	54.9	43.2	-5
IR-Train	149	15	1	57.3	48.6	50.2	41.5	-7.1
Commuter Train	122	62	10	65.3	60.3	63.4	58.4	-1.9
Freight train	89	32	33	68.1	71.2	66.6	69.7	-1.5
Total:		171	46	70,7	71.6	68.6	70.0	D: -2.1 N: -1.6

Legend: bef/aft.: before/after (rail grinding); D: daytime; N: night-time

Table 3 – Noise emission values in the study area with information (Uhingen)

	Train Speed (km/h)	Number of Trains		Noise emission levels				$\Delta L_{\text{bef./aft.}}$ dB(A)
				Before grinding		After grinding		
				dB(A)		dB(A)		
	N_{Day}	N_{Night}	$L_{\text{mE,D}}$	$L_{\text{mE,N}}$	$L_{\text{mE,D}}$	$L_{\text{mE,N}}$		
ICE-Train	135	35	2	59.4	49.9	52.0	42.5	-7.4
IC-Train	135	30	4	62.5	56.8	57.3	51.6	-5.2
IR-Train	139	26	4	62.5	57.3	55.3	50.1	-7.2
Commuter Train	83	80	17	65.8	62.1	66.2	62.5	0.4
Freight train	89	22	41	69.6	75.3	69.0	74.7	-0.6
Total:		193	68	72.4	75.7	71.2	75.0	D: -1.2 N: -0.7

Legend: bef/aft.: before/after (rail grinding); D: daytime; N: night-time

The effect of rail grinding shows very clear differences concerning the train types:

The effects can be classified considering the type of brakes. Regarding the disc braked train types (ICE, IC und IR) with a smooth wheel noise reduction values between 5 and 8 dB(A) can be observed. The differences between the study areas are negligible. The train types with cast-iron block brakes (commuter trains and freight trains) show clearly different results. In both areas the noise reduction is for both train types less than 2 dB(A). In the study area with information the grinding machine for switches failed and therefore the effect for the train types with cast-iron block brakes clearly is hardly existing in this area.

Regarding the resulting overall emission level the train types with cast-iron block brakes are dominating the noise level. This is the case especially for the night time noise levels. As a consequence

the overall noise reduction due to rail grinding is about 2 dB(A) in the area without information and 1 dB(A) in the area with information.

5.3 Noise immission

Noise immission values for each subject were calculated using propagation software "Silentium für Windows" according to Schall 03. The calculations were conducted regarding shielding by buildings as well as their reflections. Correction values for perceived annoyance (e.g. rail bonus) were neglected.

For each subject the noise immission level for daytime (6-22 h), night-time (22-6 h), and the whole day (24 h) was calculated for the situations before and after rail grinding. The distribution of the 24 h-noise level in classes of 2.5 dB(A) before and after rail grinding separately for the both study areas is shown in the following figures:

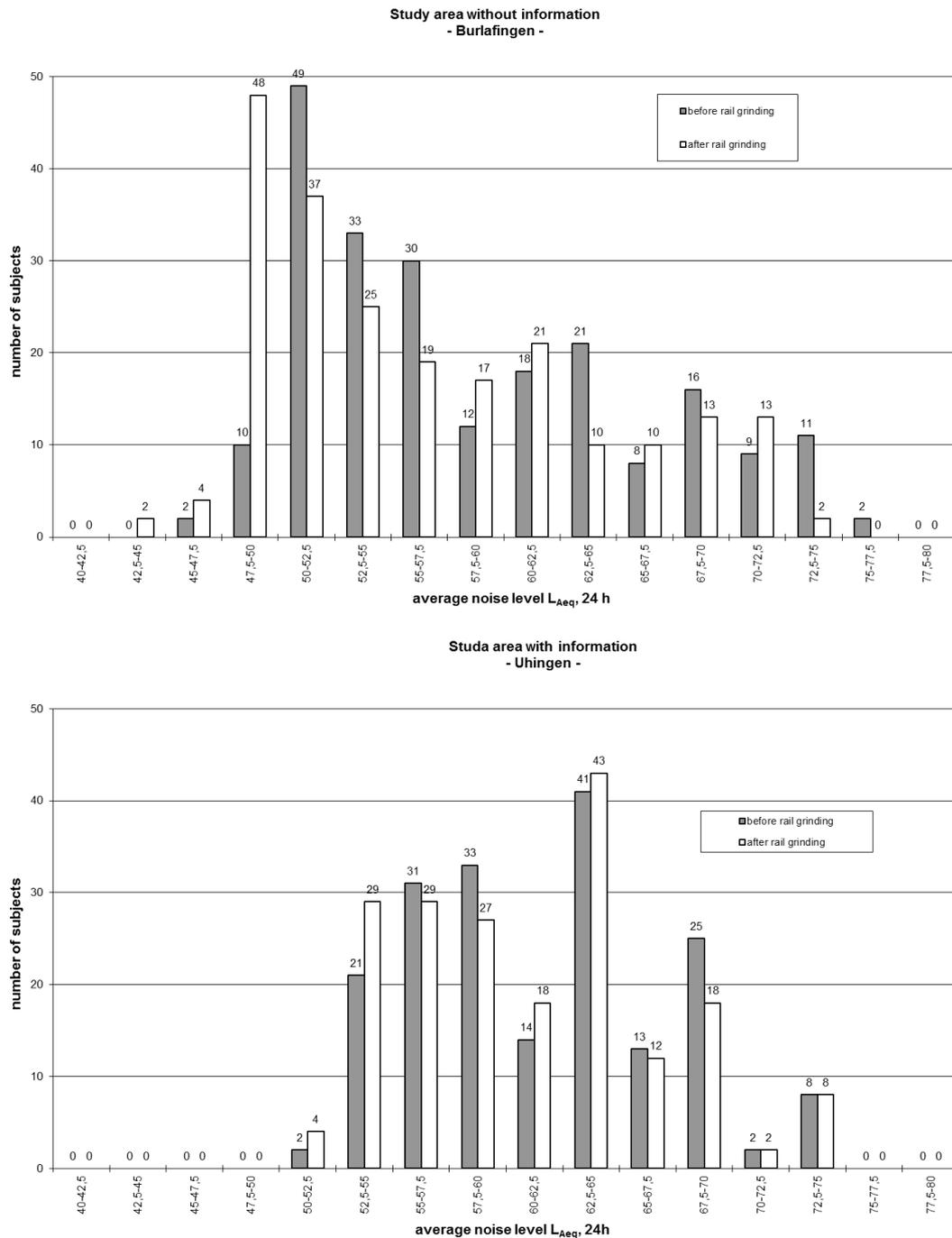


Figure 1 – Distribution of subjects over the range of average noise levels $L_{Aeq,24 h}$ for both study areas

Both figures show the slight shift of noise levels after rail grinding towards lower level values. Whereas in the area without information the shift is clearly visible, because the noise reduction of about 2 dB(A) is similar to the class width of 2.5 dB(A), in the area with information only few subjects shift to a lower level class.

The distribution of noise levels is slightly different between the two area types. In the area with information there are more subjects in level classes above 55 dB(A) where there are fewer in the area without information. This is due to the higher distances to the railway line in the area of Burlafingen and Unterfahlheim.

6. CONCLUSIONS

The study was designed to investigate the changes in noise exposure due to the noise reducing effect of rail grinding in two types of areas, one where residents were informed about the intended noise reduction and the other without such information.

The expected noise reduction of rail grinding was about 2 to 3 dB(A) in the overall noise levels. Measurements of passing trains before and after rail grinding have shown that there is a clear difference between the effect on trains with smooth wheel (e.g. ICE Trains) and trains with a rough wheel (esp. freight trains). In both areas noise reduction for train types with smooth wheels was about 5 to 8 dB(A) which is compliant to the expectations. Unfortunately the noise reducing effect was not the same in both area types for the train types with rough wheels. Whereas in the area with information there was nearly no noise reduction due to a failure of the grinding machine for switches, in the area without information the expected noise reduction of about 2 dB(A) could be achieved.

In the area with active information about the rail grinding the active information showed a good success. About 75 % of the participants quoted to have heard about the noise reducing measure in their area by press or the flyer.

The paper by Dirk Schreckenberger et al. (Part II of this study) [2] will describe the effect of the noise reduction on the annoyance of the residents and the additional influence of active information in detail.

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