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NOISE POLLUTION FROM RAILWAY TRAFFIC AND POSSIBILITIES FOR IMPROVEMENT AT SOURCE

A. Zach
Construction Management Swiss Federal Railways, Mittelstrasse 43, CH-3030 Bern, Switzerland

SUMMARY

Extensive legislation in respect of noise protection require railway managements (e.g. in Switzerland) to contain and drastically reduce the noise along new and existing track systems.

Intensified research at an international (UIC/ORE) and a national level is to assist in realizing meaningful measures at source and in the areas surrounding railway facilities.

In Switzerland it is hoped that the putting into operation of an increased quantity of new or reconditioned rolling stock will reduce the threatening cost of passive structural measures of over a billion Swiss Francs. Some additional structural measures, however, are unavoidable. Here, too, new possibilities are sought in the construction of the rails, with sound protection shields and in more intensive maintenance.

1 NOISE PROTECTION LEGISLATION IN SWITZERLAND

The rapid progress in traffic technology has brought us not only a strongly increased mobility, but also negative side effects on our environment. As we can learn from a study by the Swiss Traffic Directorate, these effects vary widely depending on the type of transport operator.

Per passenger/kilometer railways produce roughly six times less noise than road traffic. In addition energy consumption, air pollution and space required are approximately ten times less. Moreover, traffic safety is clearly greater.

In comparison with road- and air traffic, rail traffic on the whole causes less major environmental problems. All the same this should not mean that noise, being one of the outstanding aggravating factors of rail traffic, should be neglected.

On 1st April 1987 the new noise protection regulation (LSV) introduced into the environment act became effective. This regulation provides for the assessment of noise situations and the resulting consequences for the protection of the population in Switzerland. (Lit. 1 and 2)

All regulations are largely based on a uniform schedule of limiting values for all types of noise (cf. Figure 1), which

defines three different levels of limiting values for four sensitivities to noise, divided in accordance with specific periods of the day. Depending on the regulations, which will be clarified in the following, emergency values, limits of immission or planning values become normative. The level of each single pollution limit depends on the operational use and on the anti-pollution tax of the area to be assessed (levels of sensitivity).

Category of sensitivity

Extract from the noise protection ordinance (LSV) of the Swiss Environment Protection Act (USG)

ES I: Zone with increased need of noise protection e.g. recreational areas

ES II: Zone without industries causing annoyance e.g. residential areas

ES III: Zone with industries causing moderate annoyance e.g. busy centres

ES IV: Zone with industries causing major annoyance e.g. industrial areas

Limiting values of nuisance

Category of sensitivity	Planned value		Limiting value of immission		Alert phase value	
	Lr in dBA (Lr=Leq + K)					
	Day	Night	Day	Night	Day	Night
I	50	40	55	45	65	60
II	55	45	60	50	70	65
III	60	50	65	55	70	65
IV	65	55	70	60	75	70

FIGURE 1. Schedule of limiting values for all types of noise.

In order to account for the various disturbing effects of each type of noise, the measured or calculated values of immission (i.e. the mean level taken or the energy-equivalent continuous sound level Leq respectively) are corrected with an added quantity K. For the noise of rail traffic, for example, this correction, depending on the traffic density, amounts to -5 to - 15 dBA., for the noise of shunting, depending on the impulses or the volume to +0 to +8 dBA (cf. Figure 2). In other words, the pure traffic noise of trains is judged to be milder in comparison with, for instance, road noise by 5 to 15 dBA; the more awkward shunting noise levels on the other hand are increased, that is, they are assessed in accordance with more severe standards.

So far for the instruments.

2 REQUIREMENTS FOR NOISE PROTECTION FOR THE TRACKS

What about the consequences?

On the one hand precautionary requirements should ensure that in the future no new noise conflicts of whatever nature are created. Therefore legislation contains requirements for building areas and building permits in areas which are already suffering from noise. But new railway facilities, which are to be constructed and creating noise should also be low-noise ones:

- New railway facilities must be constructed or equipped in such a way that at least the (stringent) **planning values** are adhered to.

Criteria for Railway Noise

Extract from the Environment protection Ordinance (LSV) of the Swiss Environment Protection Act (USG).

$$Lr = 10 \log (10^{0.1Lr1} + 10^{0.1Lr2})$$

$$Lr1 = Leq,f + K1$$

$$Lr2 = Leq,r + K2$$

Leq: Partial and average levels of train passages (f) or of shunting noises (r) only during the time spans, by day (6-22 hrs), by night (22-6.00 hrs) respectively

K1: Correction value running noise in dBA

$K_E = 10 \log \left(\frac{N}{250} \right)$ to which applies $-15 \leq K1 \leq -5$

N = Number of train passages by night or by day resp.

K2: Correction value shunting noise in dBA $(0 \leq K2 \leq 8)$

K_R in dBA	Frequency of noises		
Audibility	rare	occasional	frequent
weak	0	2	4
clear	2	4	6
loud	4	6	8

FIGURE 2. Criteria for Railway noise.

Apart from the precautionary requirements Swiss legislation on noise protection also imposes stringent requirements on noisy installations already in existence.

- Even unadapted existing installations must be 'cleaned up' within 15 years, in as far as **immission values** are exceeded. These values must be adhered to through emission protection throughout the installation.

Often the required sound level reductions can only be achieved at unacceptable additional costs to the operators and by using absurd wall heights. However, in the case of rail tracks, which after all represent a public interest, the rules can incidentally be eased. But then measures must be taken in respect of the buildings affected, instead.

3 ACTUAL NOISE SITUATION AT SBB

Let us consider the noise problems at SBB per line segment:

Depending on the operating discipline (train density, lengths of trains and speed) and the carriages put on the following crucial point arise:

- On the lines where the emissions are more critical during daytime, i.e. between 6.00 and 22.00 hours, than at night, in general the regional passenger traffic is taken as standard for the immission protection. This is simply done, because here mainly old rolling stock is put on. On these stretches the immission limiting values are usually taken from a lateral distance of 15 to 30 m. In other words: only residential buildings that are nearer to the railway than 15 to 30 m must in principle be protected.

- On the ancillary stretches, that are more critical at nighttime, the goods traffic during the night – especially on the goods transit services – is taken as the limit of noise annoyance. Due to the fact that the limiting values at night are more stringent by 10 dBA, conflicts with the environment are seriously aggravated. Along single sections residential buildings must be protected against noise up to a distance of 300 to 500 m from the track.

People who know Switzerland know that the goods traffic arteria through Switzerland, in particular the Gotthard and the Simplon routes, run through densily populated areas. Therefore it is an understandable wish on the part of the population that this traffic is transferred as much as possible from the road to the railway, which is more friendly to the environment. For that reason Switzerland is prepared to make great efforts to intensify T.O.F.C. traffic (trailers on flat cars).

And so it is the more important, also for Switzerland, to which extent the noise of railborne goods traffic can be reduced throughout Europe in the near future .

On the basis of the present traffic (volume of traffic, vehicle and operation) the total cost of the construction of noise protection barriers along the existing tracks can be estimated at approximately 1 to 2 billion Swiss Francs. Quite a considerable investment, which the SBB has to make during the next twelve years.

4 NOISE PROTECTION AT SOURCE

Already more than 10 years ago people became aware of the decisive influence the braking system of a coach can have on the reradiation of noise. The cast brake blocks that have been in use so far and operate directly on the running tread, have the unpleasant effect that during the braking action the wheel treads become roughened and furrowed due to movement of the material.

This causes continuous increases in rolling noise often exceeding 10 dBA, i.e. a subjectively noticeable doubling of the noise. Realizing this the SBB has since changed course:
- For instance , new passenger carriages of the SBB are

exclusively fitted with disc brakes. These carriages whose brakes do no longer operate on the running thread travel with roughly 10 to 15 dBA less noise.

- For the existing rolling stock with brake blocks, that will still be in service for another 20 to 30 years, new solutions are being researched intensively. On the overhauled carriages of the earlier generation new types of brake blocks are tested in order to reduce the wheel furrowing. Clear results have already been achieved with brake shoe inserts made of synthetic material, sintered metal and recently semi-metal. These measures could reduce the running noise by as much as 4 to 6 dBA.

- Moreover, the old, noisy light-steel carriages will successively be taken out of service between now and the year 2000.

With the increased introduction of new or reconditioned rolling stock the SBB hopes to reduce the cost of structural works by several tens of millions. Forced, active noise protection, as far as SBB can manage it on its own, has top priority and should share the benefits of the additional investments equally between residents near railways and travellers (upgrading of comfort).

In spite of intensive international efforts unfortunately no adequate possibilities have developed in respect of goods carriages. In view of the much greater braking force we are still facing a number of problems. In addition the international interchange of carriages entails the necessity for all national railway systems in Europe to cooperate in order to achieve noticeable results. It should be mentioned that only one third of the goods carriages operating on the SBB tracks belong to the SBB itself!

Yet the increasing acceleration of the goods traffic connections are accompanied by increased requirements for operational stability and, in addition, indirectly for quiet running. Seen from this angle alone new goods carriages will gradually become quieter. Likewise succesful additional measures, as in the case of passenger carriages, must, however, first be discovered.

Based on this viewpoint the SBB is very much interested in research work, which is carried out together with the larger European railway companies. A committee of experts of the Research and Experimental Office of the International Railway Union ORE, which has its head office in Utrecht, is now conducting an intensive study into the question, whether and how the running noise of railways can still further be significantly reduced. (Lit. 3)

The noise reradiation mechanism are analyzed with the use of the most sophisticated techniques for measuring the intensity of sound. Until today it has, for instance, already been established that also in the case of goods carriages noise originates mainly from the running gear and not from the coachwork. A type of graph of the sound emission of a travelling wheel on the rail clearly shows that the emissions in the middle frequency range 500 to 1000 Hz stem from the contact zone between wheel and rail. Closer observation makes it clear that the rail immediately underneath the wheel radiates a considerable share of the emissions. Therefore it is obvious that at present changes to the rails are studied (Geometry, metal cladding, damping etc.).

It has also become clear that the higher frequencies are evenly reradiated from the wheeldiscs. Meaningful noise reduction in the wheel-rail system can only be expected when simultaneously measures in respect of the wheel discs are taken. To this end several systems in the standard-gauge railways are already being tested with varying degrees of success. (Lit.4) The aim is to suppress the vibrations of the wheel by means of absorbers and to shield off the emitting surfaces.

When the results of the ORE research are positive, it will become evident whether international cooperation will be able to drastically reduce the sound emissions by rail traffic in time.

5 PASSIVE SOUND PROTECTION ALONG THE RAILWAY LINES

The remaining conflicts in Switzerland must in any case be removed by the construction of sound-proof barriers along the tracks before the end of the year 2002. Sound propagation is limited by means of the well-known earth walls, screens and even by means of partial or complete masking (in the case of new installations).

These measures, already familiar sights along motorways, are based on the physical fact that sound, when forced by an obstacle to divert, loses much of its intensity. And the greater the diversion the more the sound is reduced. The geometric laying out of the obstacles in relation to the source of the sound (in the case of railways the wheel-rail zone) also plays an important part in attaining optimal effect. The smaller the distance from the screen/wall or the higher the top of the screen/wall respectively, the greater the effectiveness.

In the case of rail tracks, because of their low situation, solutions in the clear space near the track, and therefore in the immediate vicinity of the rails, can now be prepared instead of sound protection screens that are too high and consequently mar the beauty of the landscape. At present such systems are widely tested in Switzerland.

6 REORGANISATION OF SOUND-PROTECTION ALONG THE SBB NETWORK

To carry out all these tasks to reorganise noise abatement the SBB has to proceed with proper coordination and step by step:

- First of all it should be a matter of prime importance for the assessment to prepare an exact emission model. The already known approaches to solutions in the formula L=A+Blog (v) for the emissions were refined per category of train on the basis of a widely implemented measuring campaign. [Lit.6]

- These emission formulas, that depend on the rolling stock, are the basis of a detailed network-wide emission-data-bank containing the annual averages of emission values (theoretical value at a distance of 1 m from the axis of the track), which are annually and automatically updated on the basis of the new schedules. In particular this data bank serves to make an initial rough distinction between the possible areas of conflict, i.e. areas where the limiting values are exceeded, by means of a simple distance model.

- These source values are also employed by the consultant firms who have been commissioned by us and who as a next step will advise us of the object-related data within the possible areas of conflict. To this end they will work with a special computer software programme put at their disposal by the SBB and so their work will be verifiable, rational and in accordance with uniform criteria [Lit.5]. With a digitizer the terrain data are taken from the schedules and so the absorption of the propagated sound and the immission values in the surrounding built-up area are exactly calculated. The data bank should be updated and completed as and when necessary.

- As is required by law we shall periodically work out an actual noise annoyance cadastre from two additional data banks, in order to deliver the proof of the progress in the reorganisation of sound protection to the supervising authority and to the interested members of the public.

- Beside further theoretical preparations the possible noise control structures are further developed at present. In particular we are trying to find solutions in the clear space area, which may be erected instead of high walls. Geometric and material tests have been undertaken in a large pilot plant in the Basel area since one year ago.
  Clear outlines of requirements for network-wide noise control screens will result therefrom and these will also satisfy a tourism oriented Switzerland.

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