Rational regulations for vibrations

Martin van den Berg
Chiaramonte Noise and Transport Consult, Den Haag, Netherlands.

Summary
Few countries have adopted regulations for vibrations and only one made this statutory. In that last case the regulators however fell back on old practices which are based on rather weak evidence on their effectiveness. Partly this seems due to the perceived complexity of vibration issues, partly to a lack of knowledge, partly to the feeling that vibrations are somehow less of a problem. In this paper a procedure is described how to derive a regulatory system for rail vibrations according to WHO-rules for the use of epidemiological evidence in environmental risk assessment on the one hand and information on the effectiveness of measures on the other hand. Recent developments in the EU-projects RIVAS and CARGOVIBES made it possible to get sufficient data to make the first steps. Not all elements that are necessary for a stable regulatory system are available, but at least politicians may be supported much better in the decisions for a better protection of the population. Worrying gaps in knowledge are the influence of night exposure on health, the interaction with noise exposure and the effectiveness of measures..

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1. Introduction

Although exact figures are lacking, there seems to be little doubt that vibrations are less an environmental issue than air pollution or noise. In absolute figures there may still be a considerable problem. In the Netherlands around 10% of the populations is highly annoyed by vibrations from different sources[1] which means over a million people and Switzerland estimates 30.000 highly annoyed from train vibrations only[2]. However, this did not lead to a corresponding effort from the regulators. One can speculate that this is due to the intrinsic technical difficulties with the topic, lack of knowledge and the cost of counter measures. The recent results in the area of railway vibrations (notably through the EU projects RIVAS [3] and CARGOVIBES [4] resolved at least some of the e objections (but not all). It is worth to explore if is now possible to setup decent regulations for (railway) vibrations that take into account as well the improved insights of the past years as well as the gaps in knowledge that still exist. Although it is likely that some of the conclusions will turn out to be valid for other sources, the focus is on vibrations form railways.

2. Quality criteria for regulations

There are several guides for regulators, and doubtless about every nation has its own internal rules for designing good regulations. The OECD(2005) "Principles for good regulation" [5] may serve as a standard that regulations at least most follow . The document starts with a list of recommendations, which could be seen as quality criteria.

OECD principles of good regulation[5]	
i	Serve clearly identified policy goals, and be effective in achieving those goals
ii	Have a sound legal and empirical basis
iii	Produce benefits that justify costs, considering the distribution of effects across society and taking economic, environmental and social effects into account
iv	Minimise costs and market distortions
v	Promote innovation through market incentives and goal-based approaches
vi	Be clear, simple and practical for users
vii	Be consistent with other regulations and policies
viii	Be compatible as far as possible with competition, trade and investment-facilitating principles at domestic and international levels

Much of these principles have to do with the process: identify policy goals, sound legal basis,

cost/benefit analysis, and compatibility which will not be discussed here.
Important for the purpose of this paper are:
ii: sound empirical basis
iii/iv: produce benefits that justify costs
vi/vii: be clear, simple and practical for users and plausible
Translating this to (railway) vibrations the regulations should:
- be based on evidence
- changes with respect to standing practices should be limited and where necessary plausible and explainable.
- lead to a fair balance between costs and benefits
- be easy to implement and transparent for the all the stakeholders.

3. Elements for vibration control

a. General

The purpose of the vibration control regulation described here is to reduce the health impact of the exposure to vibrations. This explicit purpose is different from the - implicit - purposes of most standards that are in use, which aim to check on complaints and physical damage on property. This appears from the general setup: measurements at the exact site of the complaint, and action required to reduce that value under a limit or simply to pay for damages. In the health based approach exposure of a population is the starting point, and measures to reduce levels are set in the context of a cost-benefit discourse. In this view the health regulation is kept best separate from physical damage control: time scales are different, indicators may be different (see next section) and the health effects start at a much lower level than damages. The next sections deal only with health impacts of vibrations assuming that damage control and complaint handling are dealt with separately. This is not a trivial remark: part of the health impact is influenced by the knowledge that the exposure is "fair", that complaints are listened to and damages will be paid for.

b. Indicators

There almost as many vibration indicators as there are countries or studies relating effects to vibration levels. Most of them focus on maximum levels during (short) measurement periods, which is perfectly rational when it comes to assessing levels which may cause damage. Cracks in walls hardly ever repair themselves, so the biggest shake likely to occur is relevant. For assessing health effects the long term exposure over time is more relevant. The RIVAS report [4] gives an excellent overview and concludes that an equivalent-type of indicator is needed for an overall assessment and separately a night value for sleep disturbance.

The empirical evidence (CARGOVIBES,[4] (requirement ii) so far does not lead to a preference for one indicator over the other, so the choice for the indicator must largely be based on requirements vi and vii. Considerations based on plausibility and transparency would lead to an equivalent mean over a long time period with a reference value based on a perception threshold. Although it is plausible to have a separate indicator for annoyance and one for sleep disturbance, there not enough evidence for a stable dose-response relation for sleep disturbance. There is evidence for evening and night penalties in the annoyance indicator [7].

c. Assessment of exposure

For public health purposes an assessment in situ is not required (while for complaints and damages this will usually be necessary). The choice for the assessment point is inside the house or outside on the foundation is a matter of taste. Inside levels will have the advantage that it is easier to explain. The outside levels are much more practical, and make it possible to treat houses which are badly constructed differently.

To assess long term exposure levels within a reasonable margin calls often for measurements in combination with calculation methods.

d. Policy goals

As stated before, in formulating policy goals a clear distinction between public health goals, complaint handling and physical damage is necessary. Physical damage is not dealt with in this paper, but it is evident that levels that cause damage to property are much higher than the levels that cause annoyance or other health effects. Also complaints probably start at relatively high levels, but the individual spread is high. Anyway, complaint handling requires a different approach (more individual) than public health.

Setting realistic goals for vibration is difficult because of the large uncertainties in exposure levels, health effects and cost and effectiveness of measures. It helps usually to distinguish between new situations (new houses near existing sources

or new sources near existing houses) and existing situations. In new situations it is easier to estimate the costs and costs are much lower. In existing situations the costs of measures can be so high that they exceed the benefits by a large margin.

A detailed analysis of exposure, possible measures and their effects is the basis for a political decision on limit values, which may very well be different for new situations (lower costs and less uncertainty) than for existing situations. But then what?

e. Limit values

Suppose that after the analysis described under policy goals a choice for limit values is made. A number of questions then have to be answered. How is the exposure value to be assessed? Measured or calculated? And what is the assessment point? Inside at the most sensitive spot? Or outside on the foundation? More important still: how will compliance be tested?

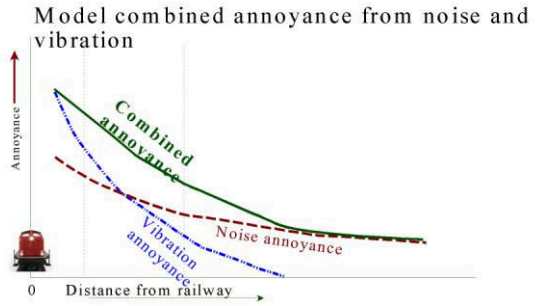
And what will happen when non-compliance is proven? Things to figure out on beforehand, instead of leaving that to the poor stakeholders. Criteria vi asks for clear, simple and practical rules, and a situation in which it is unsure how to comply is not practical. The next section deals with this in more detail.

f. Governance

Limit values are only one element in the regulatory system. This starts with the relation to the planning regulations. It is important that the in a very early stage the effect on the environment is considered. In part the EU rules on the environmental impact assessment take of this, The efficiency of that system in achieving the policy goal depends also on the control instruments. A high limit value can be more effective if it is strictly adhered to than a low one with weak control. As with the current available methods it is still difficult to predict the effect of measures, the regulation need to take that into account. A strict method of dealing with uncertainty is to leave the risc entirely to the "producer", and promise high fines when they get caught. That leads to very cautious behaviour, and this approach is therefore more suitable for eg speed limits. At the other end the regulation takes over the risc, by for example allowing an exceedance before corrective action takes place. In order to avoid that limit+allowance becomes the limit, some form of guarantee has to be build in. That can take the form of contra-expertise on the reports that propose measures, monitoring actions etc. That means more regulatory burden, but is unavoidable under the circumstances.

4. Interaction with noise

Several studies point to a strong interaction between vibration and noise [6],[7]. Applying Miedema's model for combined exposures [8] for a situation along a railway line (where this may play an important role given the elevated levels of noise and vibrations) the following visualisation of combined annoyance depending on the distance from a railway track can be made.



Figuur 1. Model for combined annoyance noise and vibration

Close to the track vibration levels are high so vibration annoyance may dominate, but further

away the interaction makes that the combined annoyance is higher than each occurring separately. In this area (the majority of the situations) it may seem that vibration annoyance is raised by the presence of noise and vice versa, but the actual state of affairs is that the exposures combine to increase the effect. From the sleep study from CARGOVIBES [4] it appears that for sleep disturbance this occurs also.

This leads to an interesting regulatory possibility: if this could be given a firm scientific basis, the regulations for noise and vibrations could be combined. This would lead to a more efficient use of resources, because lighter measures may be sufficient for as well noise as vibrations if taken together. One could also consider to extend the noise legislation already at hand with a "correction" for vibration. In that way one does not have to worry about limit values as the "acceptable" levels for noise are taken for granted..

5. Conclusions & recommendations

Regulations for vibration exposure can be constructed using the same principles as for noise or other environmental exposures. Thanks to recent efforts and data from EU-research projects a working regulation for railway vibrations is feasible. Although details are matter of taste and local culture, ideally the regulation is build around the following elements:

- one indicator for annoyance and for sleep disturbance, based on equivalent long term (at least 3 months but preferably a year) vibration exposure.

- assessments be based on the foundations of sensitive buildings, by means of calculations or measurement-supported calculations.

- limit values are to be based on a social cost-benefit analysis of vibration exposure and the cost to reduce the impacts. The limit values are preferably different for new and for existing situations. A lower threshold based on health consideration and an upper limit based on cost-benefit may induce stakeholders to be more cautious.

- The lower threshold is also the trigger to consider vibrations early in the planning process (as well infrastructure projects as sensitive building projects)

- In view of the uncertainties predicting effects of measures a mechanism should be included to correct errors.

In the short run, there is not sufficient evidence to calculate cost-benefits for sleep disturbance. As the first results show a strong effect of vibration on sleep, this calls for application of the precautionary principle.

6. References

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