The Integration of a Noise Calculation Method in Federal Administrations

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ABSTRACT

Noise calculations are performed to secure people from negative effects not acceptable. In case of existing situations the calculation links the noise levels with all the parameters influencing the emission of the sources and the propagation from the source to the receiver. It is therefore possible to check if modifications and improvements are possible to reduce these levels. In case of planned projects the expected noise levels can be predicted and compared with limiting values that shall not be exceeded. The result of such calculations can decide about acceptance or rejection of largest projects and about the need of largest financial investments. It is therefore necessary that the methods applied are transparent and agreed between the relevant experts in a country. The measures necessary to support the integration of such a methodology in the economic and political administration are discussed. It is shown how research, standardization, quality assurance and software integration can be linked to allow for a consistent approach in the environmental administration of a country. Existing systems are analyzed and pros and cons are discussed.

1. INTRODUCTION

Noise mapping has become an important tool in the global fight against noise. The most important push in the development of software that is able to handle largest areas and even complete cities was the implementation of the European Directive about environmental noise 2002/49/EC [1]. It is obvious that a rule that binds all cities and generally agglomerations with more than 100000 inhabitants to produce noise maps and action plans will accelerate such procedures and therefore very powerful software packages have been developed and are available for everybody.

But it should be realized that this Environmental Directive was proposed and brought into force by countries with a long lasting history in noise regulation and with a well established system of environmental laws. These laws are the basis of effective noise abatement and it would be the wrong way for “hungry” tiger states with an exploding economy to invent something like the Environmental Directive and to force cities to produce noise maps if this is not flanked by other legal procedures. The basis must be an existing framework of legal requirements that allow the control of all planning activities to prohibit the generation of future problems.

2. FRAMEWORK OF A LEGAL SYSTEM

The general target of all activities is to avoid unacceptable negative noise effects – therefore the first and most important step is to introduce noise indices that are sufficiently correlated with these negative noise effects. It is highly recommended to keep this system of noise indicators as simple as possible, because complex systems may be more accurate with respect to human responses on noise impact, but such systems may overstrain all those responsible for implementation of the rules in laws and decrees. It is by far better to apply an assessment system that is simple and may therefore not

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reflect all known dependencies between annoyance, sleep disturbance and sound impact but that is easy to handle and additive in the sense that the total noise level at a position can be calculated from the partial levels related to different sources. Such a simple system that is legally fixed, administratively implemented and can be applied to have control about all noise relevant planning activities is much better than a scientifically ambitious system of noise description that cannot be applied systematically in all practical cases.

A typical example for such a system is based on noise limits that are expressed as A-weighted equivalent sound pressure levels L_{day} averaged 16 hours and L_{night} averaged 8 hours.

The requirements should be dependent from the type of land use or – in planning cases – of the intended land use according to the planning principles of the community. The following table is a somewhat simplified system of limiting values as it is applied similarly in European countries.

Table 1 - Example of limiting values

Land use	Source type			
	Commercial and industrial		Road and railway	
	L_{day} dB(A)	L_{night} dB(A)	L_{day} dB(A)	L_{night} dB(A)
spa areas, hospitals	45	35	57	47
pure living areas	50	35	60	50
general living areas	55	40	60	50
mixed areas	60	45	65	55
commercial zones	65	50	70	60
industrial areas	70	70	-	-

Beside these equivalent sound pressure levels that are averaged over the day and night period it is advantageous to add an additional requirement for maximal levels: The limiting values of table 1 shall not be exceeded by single events more than 30 dB day and 20 dB night.

Now it is very important to accept that such requirements may be fulfilled for new planned facilities, but that it is an unwinnable fight to fix these values as absolute limits for existing cities and to accept that people go to court if measurements show that they are exceeded. Therefore it is important to treat the demands of exposed inhabitants differently to the administrative control of the expected noise exposure caused by planned noise relevant projects. Further it is advantageous with respect to the practical implementation to treat commercial and industrial facilities on one side and traffic sources on the other side separately. These different approaches are discussed in the following.

3. MEASUREMENTS OR CALCULATIONS

At a first glance it may be the better and more reliable way to measure existing noise levels to check if legal requirements are fulfilled. But this is only possible to check existing situations – if the compatibility of planned facilities with defined noise limits shall be investigated calculations are the only possible way. Because it is by far more important to ensure conformity of new planned projects with legal requirements about noise limits than to realize such noise limits for the existing situation – in fact it is generally often not possible to tackle the existing traffic chaos – the calculation and not the measurement is the most important tool to support the noise policy of a community. This is true for all noise source types – roads, railways, airports and even industrial facilities or commercial activities.

The tremendous progress in the political and administrative integration of noise control in administrative and legislative bodies was only possible because the relation between the technical parameters of these sources and their sound emission has been investigated and was laid down in formalised form as guidelines or standards. These relations linking the system parameters with the sound emission are and should be legally fixed – all experts in the country must apply them in the same way and even better knowledge in some cases should not be a reason to use another calculation method.

It is highly recommended to select this legally fixed noise calculation method very carefully – important features of such a method are accuracy, precision and transparency.

Accuracy is a measure for the conformity of calculated results with those that can theoretically be obtained with an ideal measurement (with negligible errors). As no measurement is free from errors, its uncertainty has to be taken into account if results from calculations and measurements are

compared.

Precision is a measure for the conformity of predicted values if different experts apply the same calculation method on the same scenario. It is a subset of accuracy, but should for practical reasons be treated as an own important property of a calculation method.

Transparency is a property of a calculation method supporting the application in practice, because only with a full understanding of the strategies behind the algorithms there is a chance to find the reason for unexpected results. It is not acceptable for noise experts to be the slave of software that is a black box for them.

All three properties should be taken into account if a decision about a legally fixed calculation method shall be taken. If more and more complex algorithms and computer strategies are implemented with the aim to increase accuracy this may cause an unacceptable decrease of precision and transparency. Any increase of complexity of a method should only be accepted if an adequate increase of accuracy in typical applications has been proven.

Measurements can be an indicator for the correctness of the assumptions made if a project has been realized. If measurements show that limiting values are exceeded although this was not foreseen by the predictions further examinations are necessary and should be undertaken by those responsible for the project.

4. CALCULATION METHODS AND SOFTWARE TOOLS

As it was mentioned above, the calculation method should be precise and transparent if it shall be applied to check the conformity of planned projects with legal requirements. Each increase of necessary input parameters increases the number of screws allowing an adjustment of the results obtained.

The calculation method should be described clear and unambiguously in a published document. This description should be complete in the sense that no other source should be needed to implement the method in one of the existing software platforms like [2] or to develop own software code. The documentation should preferably be a standard or a guideline to open it for expert discussion and to ensure a revision if necessary. The documentation should also describe the measures like test problems with acceptable result-intervals to check the correctness of any software implementation.

It is highly recommended to use one of the existing calculation methods and not to develop a new one or to create a national solution by modification of an existing one. Such a calculation method is a complex mechanism and it is not possible to modify it in some detail without interfering with other parts.

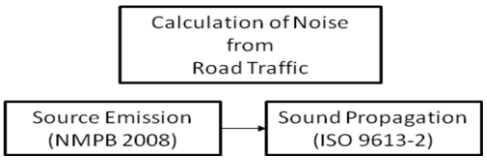

Figure 1 - Example for a national calculation method based on standards

The example shown is on one side based on an International Standard [3] to calculate sound propagation and on a national solution [4] for the source part. Such a modular system is advantageous, because the propagation part can be the same for all sources road, rail and industry while the source part must be revised from time to time to adapt it to new developments in the construction of cars and trains.

Such calculation methods should be integrated in professionally developed software platforms. The administrative strategy of noise control in a country should not be based on "laboratory-developed-software" without a continuous adaption to the development of software techniques and a stringent update service or on "centralized" own software development without any competition. Existing examples show that such "stand-alone" applications are far from "state of the art" and defy any control by other national noise experts.

The above mentioned software platforms offer many possibilities to calculate and assess the noise levels caused by the abovementioned sources.

The first step is to create a model of the scenario comprising the relevant sources, the receiver positions or residential areas where the noise levels shall be determined and the environment in an area where the sound may propagate between sources and receivers.

Depending on the task the calculation can be performed for receivers at specified positions (fig. 1),

for receivers arranged on a regular grid to show the spatial distribution of noise levels as noise map (fig. 2) or at receivers distributed around the facades of residential buildings (building noise maps – fig. 3 and 4).

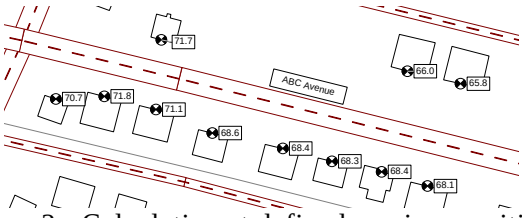

Figure 2 - Calculation at defined receiver positions

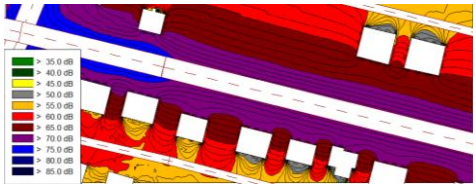

Figure 2 - Calculation at grid points to generate a noise map

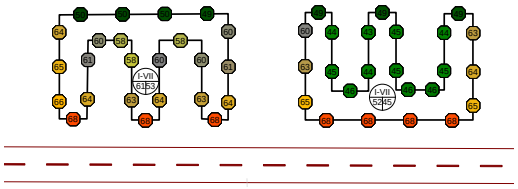
Figure 3- Calculation at facade points distributed around the building at all floors

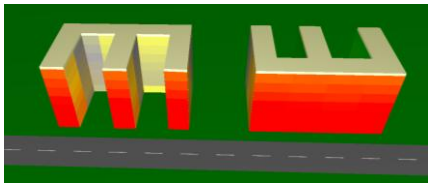
Figure 4 - Presentation of noise levels calculated at facade point as “building noise map”


Figure 5 - Building noise map to determine facade transmission loss for the airport center

Such building noise maps are an effective support if indoor levels caused by sources outside shall be determined. Figure 5 shows as an example an office building near Frankfurt International Airport – this calculation was performed to define the necessary transmission loss of the glass facades to prevent the employees inside from unacceptable aircraft noise.

These techniques are the basis for all noise calculations. Fixed receiver positions are applied to check the noise impact and to get all necessary information about the contribution of the relevant different sources, grids are mainly used to see the spatial distribution of noise levels and facade levels or building noise maps are used to get the link to the noise impact inside the building.

5. NOISE FROM ROADS AND RAILWAYS

5.1 Modification of existing or planning of new roads or railway lines

The control of the noise caused by planned new or modified existing roads should be a legal requirement and laid down in an own law or decree.

This decree should apply for the construction of a new or the significant modification of an existing road or railway section.

A modification is significant if

the capacity of a road shall be increased by new traffic lanes or if a railway line is extended by one or more new rails

or if the noise impact caused by an existing traffic lane (road or railway) is increased by 3 dB(A) or more due to a significant modification of its construction

or if due to such a modification the noise impact reaches or exceeds 70 dB(A) daytime or 60 dB(A) night-time. The noise exposure levels caused by this new planned or modified section of the road or railway section shall not exceed the limits shown in table 1 for road and railway traffic.

It is of fundamental importance to understand the philosophy behind – not the noise level caused by all traffic sources together is limited, but the noise level caused by this part of the road or railway line that is newly planned or modified substantially. This is the compromise to ensure noise control with all new and future developments even if the existing traffic system is noisy and there is no chance to reduce these existing noise levels substantially.

In practice this means that the scenario is modeled – similar to fig. 1 or 2 – and the new or modified part of the road is treated like an own new source SN. Only the noise caused by this part is calculated and the conditions mentioned above are controlled.

5.2 NOISE REDUCTION PLANS

It is a question of the budget available if the total noise level caused by all existing traffic sources together can be tackled by planning and implementing an action plan. In this case a complete noise map is calculated, an action plan is developed and the noise reduction expected to be realized should be checked by an additional calculation including these measures. These are exactly the procedures implemented in Europe by the Directive about Environmental Noise 2002/49/EC. Strategies and examples have been developed in the frame of the European project "Quiet City Transport".

But it is important that these noise maps and action plans make only sense if the production of new problems during the continuous development of a community is suppressed by an effective legal system of noise control as described in 5.1.

6. NOISE FROM INDUSTRY AND COMMERCIAL FACILITIES

6.1 Definition of noise limits in the development plan

Similar as it was explained in 5.1 for roads and railways, the noise control of newly planned or substantially modified industrial facilities should be legally fixed in a law or a decree. But different to roads and railways the limiting values of table 1 should be the maximal acceptable noise exposure levels at residential buildings caused by all industrial activities together.

Communities should define the areas where industrial activities are planned – otherwise a mixture of residential and industrial areas will cause later problems and make an acceptable development impossible. Therefore the areas where industrial facilities or buildings with purely commercial activities shall be settled should be defined as industrial/commercial zones and this should be published in the land-development-plan. Such a plan that organizes rights and duties for everybody who wants to buy land and settle an enterprise should also contain the information about the maximal acceptable noise emission or the maximal noise impact caused by this estate at defined critical points – these are generally the nearest residential buildings.

The noise requirements laid down in the land-development-plan are based on a noise-quota-system. It ensures that the first industrial facility being built and operated cannot produce so much noise that all others following are not allowed to radiate any noise. Therefore a noise contingent is defined for each m^2 of the total area that ensures that limiting values of noise levels at neighbouring residential areas will not be exceeded even if all planned industrial facilities have been built and are in operation.

This legally fixed procedure of noise quotas shall only be stated here with the important steps:

The critical positions of nearest residential buildings are modeled as receiver points and the industrial zone as area source.

Now the emission of this area source is adjusted so that the calculated level at one of these receivers equals the limiting value. The A-weighted sound power level of the area source defines the absolute maximum of the acceptable emission.

If someone buys an estate inside the industrial zone the individual – and in comparison to table 1 reduced – limiting values can easily be derived by covering this estate in the model by an area-source with the area related sound power level published in the land-development-plan and calculating the levels at the critical receiver positions in the neighbouring residential areas.

After installation and start of operation of the industrial facility measurements have to be made to proof that this operation is in accordance with the requirements in the land-development-plan.

6.2 Modification of existing or planning of new industrial plants

If a new industrial facility is planned, the first step is to check the noise requirements. For stand-alone industrial plants the levels of table 1 should not be exceeded in the neighbouring residential areas if table 1 is the legally fixed requirement. If the plant is part of an industrial zone then the "reduced" noise emissions or noise levels at these neighbouring residential buildings are relevant.

In any case a noise prediction calculation as part of an expert opinion is necessary to proof that these requirements will be fulfilled with the planning that is presented to the appropriate authority responsible for permission.

This proof should be undertaken with the national and legally fixed calculation method, e.g. ISO 9613-2. This calculation method is based on slight midwind conditions and the calculated levels may overestimate the long term average levels by 0 – 3 dB.

The technique to model industrial facilities and to calculate the noise levels at the residential areas in the neighbourhood is well developed and many companies and administrations rely on these calculations if the acceptability of a new plant shall be checked. The comparison of predicted noise levels with those obtained by measurements afterwards showed in most cases that short time levels may vary due to meteorological conditions, but are most of the time covered by the values predicted with ISO 9613-2.

Figure 6 shows a model of a power plant with two cooling towers as an example – for all relevant parts radiating noise the sound power spectra are taken from a program-internal database and with each new model these databases are extended more and more.

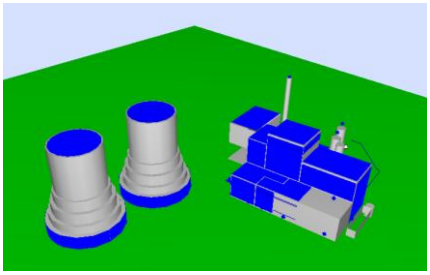

Figure 6 - Model of a power plant with cooling towers (blue -> radiating points and areas)

Finally it shall be stated that a stringent noise control system should be based on calculations where the calculation method should preferably be standardized and anchored in laws or decrees. Validation measurements after realization should be made to check that emission values applied in the calculation are not exceeded and that the model used for the calculation is in accordance with the realized reality. But as the calculation method is defined to be the reference, short time variations of measured levels and even some noise peaks exceeding the limiting values in seldom cases cannot be a reason for an issue.

REFERENCES

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