

Assessment of the impact of multiple types of noise sources on humans

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ABSTRACT

Large parts of the population in Germany are affected by noise. Due to a variety of noise sources, numerous people are disturbed by different sources at the same time. According to a representative survey carried out in 2014, about 44 % of the German population feel annoyed by two or more different noise sources. In general, the determination and assessment of noise is conducted for each source separately. Therefore, there is a discrepancy between the usual noise evaluation methods and the reality of life of many people. This raises the question how to access realistically the impact of several types of noise sources on humans. A first step was done with the publication of a German guideline called VDI 3722-2, which describes an evaluation procedure to address this problem. This guideline will be evaluated at a typical example from practice. Based on this analysis, proposals for the further development of the assessment of multiple types of noise sources are presented in this paper.

Keywords: environmental noise sources, noise control planning, annoyance

1. INTRODUCTION

The German Environment Agency regularly conducts representative surveys to determine the noise annoyance of the population in Germany. According to the survey carried out in 2014 (1), about 54 % of those interviewed complained of being disturbed by road traffic in the vicinity of their homes. Air traffic was the second most common source of noise generated by transport. About 21 % complained of being affected by noise from this source. 17 % of the population feel annoyed by railway noise. Noisy neighbours are also an important source of noise. 40 % of those interviewed complained of being affected by noise from their neighbours. Moreover, the survey showed that about 44 % of the population feel annoyed by two or more different noise sources. These results confirm the need to evaluate the impairments by multiple types of noise sources on humans.

2. REQUIREMENTS ON A METHOD FOR THE ASSESSMENT OF MULTIPLE TYPES OF NOISE SOURCES

In general, the determination and assessment of noise will be conducted for each source separately. An example is the establishment of noise protection areas at airports according to the German Act for Protection against Aircraft Noise (2). This act requires that the aircraft noise exposure have to be determined based on detailed forecast data on future flight operations as well as on the description of the flight routes in the surrounding of the airport. Other noise sources of noise like road or railway traffic are not taken into account. For this reason, there exists a discrepancy between the usual noise evaluation methods and the reality of life of many people. Therefore, a method for the determination and assessment of several kinds of noise sources is necessary. This method should meet the following main requirements:

- a noise effected assessment of different noise sources
- a clear field of application

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- a model which is useful in practice
- a precise calculation algorithm
- a quality assured assessment method.

3. GERMAN GUIDELINE VDI 3722 PART 2

An important step towards a model, which complies with the above-mentioned requirements, is achieved by the publication of the German guideline VDI 3722-2 (3). This guideline contains a noise effected model to assess the impact of multiple noise sources generated from traffic. It is based on a plain model, which links the calculated traffic noise exposure to exposure-response-curves. For this task, all noise indicators can be used, in particular the day-evening-night noise indicator (L_{DEN}) and the night noise indicator (L_{Night}) of the European Environmental Noise Directive (2002/49/EC) (4). For the determination of the impairment by traffic noise, four exposure-response-curves are contained in the VDI 3722-2. These functions describe the impairment by traffic noise with regard to annoyance and self-reported sleep disturbance. In line with this, the impairment is distinguished between 24-hours-day and nighttime. The impairment suitable for L_{DEN} could be expressed in the percentage of annoyed persons (% A) or in percentage of highly annoyed persons (% HA). For nighttime it is expressed by the percentage of sleep disturbed persons (% SD) or the percentage of highly sleep disturbed persons (% HSD). These characteristics are based on recommendations of the European Environmental Agency (EEA) and are established at European level (5). They should be used until new reliable exposure-response-curves are available.

The procedure of the VDI 3722-2 consists of the following steps: First, the noise exposure caused by railway and air traffic is calculated. Then the impairments resulting from these noise sources are determined. For this purpose the above-mentioned functions (% A, % HA, % SD, % HSD) are used. The next step is a conversion of railway as well as aircraft noise to road traffic noise so that the different kinds of noise sources can be added. Accordingly, the noise levels of these sources will be converted to a substitute noise level generated by road traffic. Afterwards, the substitute levels of the noise sources are energetically added to a so-called effect related substitute level. Finally, the impairment characteristic will be determined which provides information about the number of person annoyed by traffic noise in an investigation area. The results can be displayed in different ways (e.g., distribution of affected persons on noise level classes).

4. DETERMINATION OF AN INVESTIGATION AREA

The guideline VDI 3722-2 requires the definition of an investigation area. This area can be defined by the course of streets or railway tracks or even by the number of affected municipalities. The extent of the investigation area depends on the task:

- As an example, different planning alternatives should be evaluated under consideration of different types of noise sources. Generally, there are three possibilities to define the basic totality:
 - a zero value of the exposure-response-curves could be used (e.g., $L_{DEN}=37$ dB(A) for the function of annoyed persons (% A))
 - noise protection zone at an airport could be used as a borderline of an investigation area
 - an immission value (e.g., $L_{DEN} = 50$ dB(A) or $L_{Night} = 40$ dB(A)) could be used.

It is recommended to define the totality by a firm number of municipalities because the number of affected persons remains constant. On this basis, the percentage of persons affected by noise could be given relatively to the number of inhabitants. Furthermore, the consideration of the complete municipal area has the advantage that its results can be better communicated to the public.

- Another example is a municipality, which is interested to know the number of persons affected by multiple traffic noise sources. In this case, the investigation area comprises the complete municipal area.

After having defined the investigation area, it is necessary to choose the immission points within this area. They are related directly to the number of persons exposed by traffic noise. In principle, the noise level can be calculated in front of any window and for any flat including the effects of screening. However, the results will stand in no adequate relation to the efforts expended in the calculation. In addition, the uncertainties of the quality value are substantially determined by other input parameters. For these reasons, it is sufficient to lay one immission point in the surface of the building and in a

middle height for every dwelling house. The number of inhabitants of a building can be often derived from statistical data of the available dwelling floor space per inhabitant. Alternatively, it can be determined according to a method described in a German document called “Preliminary Calculation Method for Determination of the Number of Persons Exposed to Environmental Noise (VBEB)” (6).

5. PROCEDURE FOR IMPROVING NOISE SITUATIONS

At present, there are no noise limits concerning the impact of multiple type’s of noise sources on humans either at EU level nor at national level. Consequently, the results of such a calculation cannot be compared with noise limits. This makes it difficult to analyze the effects of different planning alternatives on the population. Therefore, it is proposed to use the following procedure, which is based on a Land Utilization Ordinance (7) in Germany. This ordinance contains a classification of areas according to the type of land-use as well as the type of enterprises and particular requirements. According to this regulation, for example purely residential areas are only used for living. In contrast to this, village areas may also contain agricultural and forestry holdings. For the individual types of land-use planning appropriate area-related immission values are defined in different noise protection regulations in Germany. For instance, the 16th Federal Immission Protection Ordinance (16. BImSchV) (8) contains noise values, which depend on the type of land-use and are distinguished between daytime and nighttime. They are given in table 1.

Table 1 – Obligatory immission values according to 16th Federal Immission Protection Ordinance in Germany (8)

Types of area	Day	Night
	6 p.m. - 10 a.m.	10 a.m. - 6 p.m.
for hospitals, schools, spa areas, and nursing homes	57 dB(A)	47 dB(A)
purely residential areas, general residential areas, small residential states areas	59 dB(A)	49 dB(A)
core areas, village areas and mixed-use zones	64 dB(A)	54 dB(A)
commercial zones	69 dB(A)	59 dB(A)

The 16th Federal Immission Protection Ordinance applies to the construction of new roads or railway tracks or the expansion of existing ones. It is proposed to expand this scope and use the immission values also as noise limits for an assessment of combined noise sources. For this purpose, the traffic noise exposure should be calculated based on the actual situation according to VDI 3722-2. Then the results are compared with immission values of the relevant type of area. For example, for general residential areas 59 dB(A) for daytime and 49 dB(A) for the nighttime are valid. The number of people, which is above these noise limits, should be reduced until these values are reached. For this purpose, a variety of individual tools to reduce noise can be used. For instance, a reduction of the maximum permissible speed from 50 km/h to 30 km/h on streets. Additionally, an open-pore asphalt could be laid on the road.

6. CONCLUSIONS

Due to a variety of different noise sources, numerous people are disturbed by multiple noise sources. In general, the determination and assessment of noise will be conducted for each source separately. A first step has been done by the publication of a German guideline called VDI 3722-2. It describes a

procedure on traffic noise concerning annoyance and self-reported sleep disturbance. In the future, this method should be further developed. Within the framework of this task, noise generated from industrial plants should be taken into account. Moreover, a financing concept is required. In particular, this concept should deal with distribution of cost on the owner of transport modes for noise abatement measures. For these tasks, further research activities are necessary. Therefore, the German Environment Agency has commissioned a research project on this topic (9). Results of this ongoing study will be available in 2019.

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