inter.noise
HAMBURG 2016

Noise Control Action Plan Implementation at BorsodChem 1/2

Miklós MÁRKUS[1]; András MUNTAG[2]

[1] FONOR Ltd., Hungary

[2] EnviroPlus Ltd., Hungary

ABSTRACT

This presentation is the first in a two-part series, reporting on the noise control action plan of Hungary's largest chemical factory. The nearly 2.5 km^2 densely built up factory area is wedged into residential areas. More than 20 plants are working constantly on the area with thousands of individual noise sources. The exceedance of the noise limit is significant, however, greatly varies due to the meteorological conditions.

Our task was the exploration of the dominant noise sources, building up a noise model and creating noise control action plan using complex testing methods. The aim of the presentation is to demonstrate the volume of the task, describe the challenges that we face when measuring such a complex system of noise sources.

Hundreds of hours of noise measurements were taken on more than 500 measuring points in the area and surroundings of the facility. Noise monitoring stations were installed at different points of the facility for weather-impact analysis. The measurement of the open air technology or the inclusion of reference points above 30 meters posed a challenge during the model building process. We intend to vividly illustrate the above-described process in the framework of the presentation.

Keywords: Industrial Noise, Noise Control, Action Plan, Noise Model
I-INCE Classification of Subjects Number(s): 04.1, 14.1.8, 52.5, 56.1, 76.1.4

1. INTRODUCTION

The requirements and methodology of a noise control action plan is well known for those experts who are dealing with the environmental noise of industrial facilities. What makes the present case different from an average industrial noise reduction task is its volume. There is a certain theoretical volume limit within which the usual standard methods (surveying and modelling noise sources, selection of dominant noise sources, determining noise control priorities, etc.) can be used safely and without problems. However, in the case of tasks that exceed this theoretical limit, we have to deal with such problems that can be solved only by using unconventional methods.

In our case, the subject of our survey is the industrial area of BorsodChem, which is the largest chemical factory of Hungary. Its total area is approximately 4 km^2. The surveying, modelling and managing of the environmental noise emission and noise pollution of such large industrial areas and the surrounding residential areas is not an everyday task; therefore, it often needs special solutions. [1][2]

2. THE TASK

2.1 Legal Background

In Hungary, the government decree that executes environmental laws prescribes the basic rules relating to industrial noise sources (eg. requirements for establishment, or the designation of the noise impact area), and appoints the environmental authority. According to the law, if the environmental authority finds that the operating facility environmental noise pollution exceeds the limit, the operator of the facility requires to submit an action plan.

[1] markusmiklos@fonor.hu
[2] muntaga@enviroplus.hu

The action plan is only approved by the authority, if the plan demonstrates that the planned measures ensure the reduction of noise pollution under the limit. If the action plan gets approved, the authority obligates the facility operator by setting the deadline to implement the described measures.

The abovementioned action plan must therefore include the following:

a) measures designed to reduce noise emission,
b) the expected outcome of the designed measures,
c) time period required for the technical and administrative implementation of the measures, and its justification.

If the facility operator fails to implement the action plan within the set deadline, or the noise, despite the measures, still exceeds the prescribed limit, the environmental authority, depending on how much the limit is exceeded, could restrict, suspend or prohibit the operational activities of the facility. [3]

2.2 History

Before it became Europe's leading manufacturer of MDI, TDI and PVC materials and special chemical products, BorsodChem was known as Borsodi Vegyi Kombinát (Borsod Chemical Factory Complex). The Borsodi Vegyi Kombinát was Hungary's first chemical facility in Kazincbarcika. It's construction began in 1949, and since 1991 it operates under the name of BorsodChem.

BorsodChem's densely built up factory area is wedged into residential areas. Because of the built-up density and the intertwined technological processes of the area, the limit for the surrounding residential areas has been determined for the entire factory complex as a whole.

In recent years, the continuous development of Borsodchem, which was uncontrolled in reference to noise pollution, led to the exceeding of the noise limit; therefore, the environmental authority ordered the making of a noise control action plan.

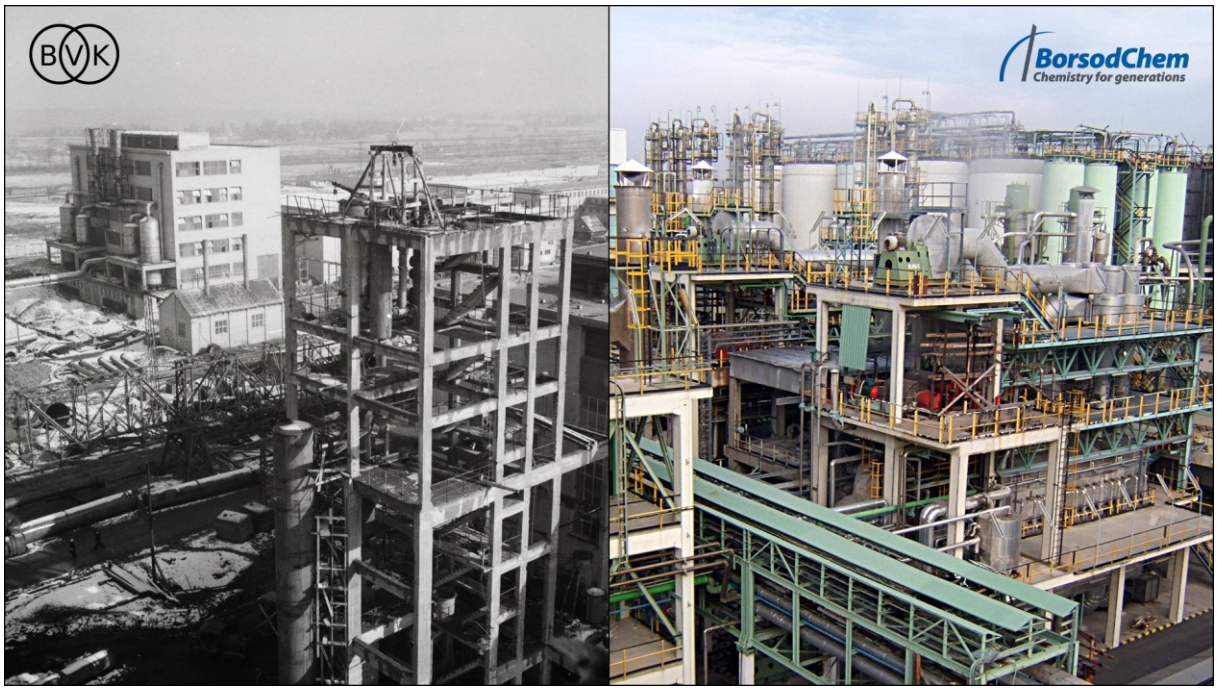

Figure 1 – Borsodi Vegyi Kombinát (1954) – BorsodChem (2014)

2.3 The Aim of the Task

The aim of the task was to prepare a noise control action plan, which meets the aforementioned requirements. However, in order to reduce the noise pollution of such a large industrial facility in an efficient and cost-effective way, the noise sources have to be analysed in detail. It is essential to identify the noise sources causing the exceedance of the noise limit, and to determine their roles played in the exceedance. Next, the order of the noise sources can be established according to their dominance.

We also have to clearly identify those noise sources which do not play a role in the noise pollution. It would be irrelevant to deal with them in reference to the action plan that is the aim of the project. It would only consume time and money.

After that we will have to identify the priorities of noise reduction, determine the noise reduction need of certain dominant noise sources, and also have to explore and analyze the technical noise reduction options. It is quite complicated to work out a series of noise reduction solutions, because we have to consider and manage several factors simultaneously (eg. technological factors, security technology factors, cost efficiency factors, feasibility factors). We also have to carry out the acoustic design of the selected noise reduction solutions, and demonstrate the noise condition that can be expected after the noise reduction.

3. THE VOLUME

3.1 The Industrial Area of BorsodChem

BorsodChem is currently one of the leading chemical raw material manufacturing company of Central Europe. Its premise in Kazincbarcika is Hungary's largest chemical factory, where the main focus of production is isocyanates and PVC. The entire industrial area is nearly 4 km^2, of which the densely built-up production and development area is close to 2.5 km^2. The production area is wedged in between the towns of Kazincbarcika and Berente; therefore, the industrial area is surrounded by residential areas on both sides.

In the industrial area there are more than 20 stand-alone facilities (PVC, MDI, TDI, VCM, Chlorine, Nitric acid, Ammonium, etc.), which operates continuously day and night with thousands of individual noise sources. These facilities are in a close technological relation with each other, so practically the whole industrial area operates as one factory. However, certain facilities belong to independent business organizations; therefore, their interests can be different in terms of investment.

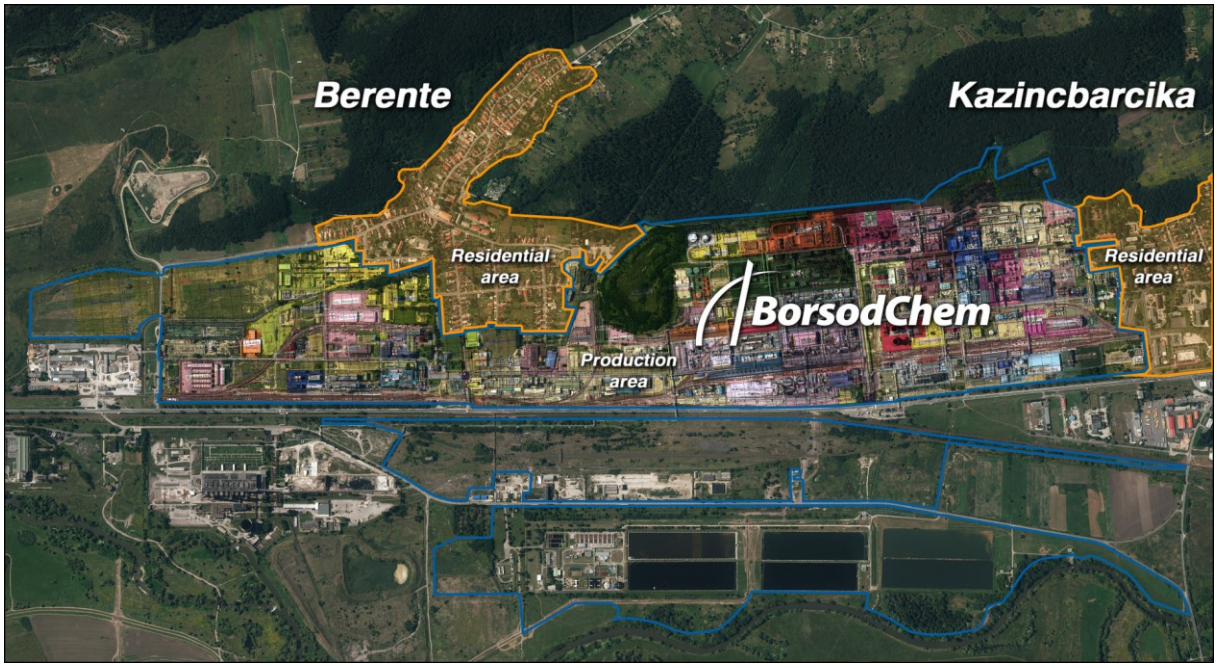

Figure 2 – The production area is wedged in between the towns of Kazincbarcika and Berente

3.2 The Surroundings of the Facility

The populated area of Kazincbarcika borders the industrial area of BorsodChem from northwest. The bigger inner part of the town is located further away, and is shielded by the hills. Adjacent to the industrial area, the factory has its own housing complex which was built in the 1960s to keep the factory workers close to the facility. At the time, the communications infrastructure was undeveloped, so it was essential to have direct access to the workers. However, since the 1990s, the residential community has been replaced with other people; therefore, a significant proportion of those who currently live in the housing complex do not work in BorsodChem's facilities.

The residential area of Berente is virtually "wedged in" the south-eastern part of BorsodChem's industrial area. The township has already existed before the construction of the factory, but in the long series of years the industrial area gradually surrounded a part of the township. Fortunately, the residential area of Berente is partly shielded by a mine spoil, located northwest from Berente, from the noise sources of BorsodChem.

The common border of the industrial area and the residential area is approximately 2.1 km long. From the other directions, the industrial area is surrounded mostly by farmland and other industrial areas. The houses that are the closest to the industrial area are approximately 300 meters away from the noise sources. Furthermore, for example the dominant “PVC 400” facility that causes significant noise 870 meters away from the houses of Berente and 1170 meters away from the houses of Kazincbarcika in a straight line.

The noise limit in both residential areas is exceeded by 8 dB. In addition, the effect of weather conditions is so significant that under the same operating conditions the noise limit went under the limit in both directions. The change in the environmental noise (under the same operating conditions) was exceeded by 20 dB.

4. THE DIFFICULTIES

4.1 Too Many Noise Sources

It is not easy to survey and analyze the noise sources of large industrial areas (eg. oil refineries, petrochemical or chemical plants), and to determine the propagation of sound. The task is complicated by the significant number of noise sources, as well as the open technology and the complicated structures of the buildings that affect the propagation of sound. [2]

There thousands of different noise sources in the area of BorsodChem. A significant number of these noise sources radiate directly into the open air, and their locations are very diverse. For example they can be located more than 30 meters high in very difficult to reach places. The propagation of sound is also affected by the diversely built environment (open technology buildings, tanks, pipe works, pipe racks, etc.) and by the natural, varied terrain (hills, slopes, etc.).

After the first site visits, it is extremely difficult, even for an experienced noise control expert, to identify those noise sources which cause the over the limit noise pollution. During the site visits and surveys we start getting a clearer picture about the noise sources. The typical noise sources are starting to separate from each other but it is a slow process because of the direction of radiation, the sound spectrum and other factors. After a while, we will be able to select the dominant noise sources from the chaotic complexity of different noises. Because usually we do not stay in the factory area all the time, it would take several months before we start to "feel" the facility in such a large industrial area.

Ideally, in order to measure the role of different noise sources in the overall noise pollution, we need to operate these noise sources selectively. If this can be achieved, the time of measurements, which need to be carried out under certain circumstances, will be short; therefore, the influence of weather on the measurement results could not be estimated, which would make the measurement results uncertain. However, the noise sources operating in the industrial area are in close technological relation with each other, the operation of the sources are extremely bound, they cannot be operated independently. This significantly complicates the survey of noise sources, as well as the determination of sound power level and the noise parameters.

4.2 Too Large Distances

Based on the foregoing, the industrial area in question is extremely large; therefore, the distance between noise sources are also significant, and the noise sources are also significantly distant from the residential areas. So the results of measurements carried out close to the noise sources would be different from the result we would get in the evaluation points.

The propagation of sounds between the noise sources and the perception points is greatly affected by the meteorological factors. The influence of meteorological factors on the propagation of sound always makes the results of such surveys uncertain. This uncertainty can be reduced significantly by the increasing number of surveys made under different weather conditions; therefore, we installed a noise monitoring system close to the dominant noise sources and in the areas to be protected, so this way we can analyze the influence of different meteorological factors. The noise monitoring system has monitored the changes in the operating status for several months, and simultaneously, we also got the data of the weather stations operating in the area of BorsodChem.

ISO 1996-2 6.5 set certain requirements for noise surveys carried out in industrial facilities, however, these requirements can only be applied within certain limits. For example, the standard requires that „L_{eq} values measured at a distance long enough to include noise contributions from all major sources and short enough to minimize meteorological effects during certain operating conditions". However, in the case of such large and cohesive industrial areas, this requirement cannot be applied, because in order to measure the effects of all the dominant noise sources we have to be at a distance from where the meteorological factors could significantly affect the results of the measurement. [4]

4.3 Different Aspects

The facilities in the industrial area operated by independent business organizations; therefore, their interests can be different in terms of investment. Since the total cost of the noise reduction exceeds 6 million Euros, a certain tension, caused by the sharing of costs, arose between these business organizations. Because of the technologically-connected noise sources, we have to make it clear that which facilities operates the dominants noise sources, and why are they responsible for the implementation of the noise reduction.

Communication difficulties were experienced mainly in the principal-authority-expert triangle. Typically, the needs of principals often went beyond the content requirements of the action plan that was required by the authority. (For example, we were told to show the noise sources on the noise map that are irrelevant in terms of environmental noise, or to make a noise map that could also be used for occupational safety and health purposes.) These different aspects in relation to the task stemmed from the fact that the applied methods are indeed suitable to cover other tasks as well, however, the available time and budget are only enough to meet those requirements that were set by the authority.

The action plan of BorsodChem is unique in the Hungarian authority practice. This task is challenging one for the experts, but it also put legislation and authority practice to the test. In the case of an industrial facility of this scale, which operates several significant noise sources, the duration of an overall survey and the time required for the implementation of noise reduction measures is not comparable with an average facility.

The duration for the implementation of the entire action plan is 10 years, during which we plan to carry out 34 noise reduction tasks in 3 phases. Of course, after the implementation of the individual noise reduction solutions, the change in environmental noise pollution has to be checked (this will be done partly by the monitoring system), the additional noise reduction phases have to be evaluated, and, in some cases, the noise reduction process must be supervised. If the planned measures need restructuring or modifications, it must be agreed by the environmental authority. Therefore, we need a high degree of flexibility from the authority, which could only be achieved, if we could establish a close cooperation with them that is based on mutual trust.

4.4 Technological Capabilities

The noise sources operate with open technology on the entire production area. This technology, which has a typically sound permeable structure, but still dampens the propagation of sound to some extent, affects the volume of the task in such a way that - in the absence of noise sources which are isolated inside the buildings - every noise source of the industrial area takes part in the development of environmental noise. Furthermore, due to the open technology which affects the propagation of sound, the survey and identification of the noise sources, as well as the modelling of sound propagation, becomes very difficult. [5]

The most commonly used method for modelling the environmental noise of industrial facilities is the calculation procedure of ISO 9613-2; however the application of this standard is limited in several aspects. [2] Chapter 7.5 defines certain procedures for the calculation of reflection, but for the application of these procedures the value of sound reflection factor of open installations is set to 0 (zero) in chart no. 4.: "Open installations (pipes, towers, etc.): 0". [6] However, based on our experience and other studies, the effect of open technology on the propagation of sound is not negligible. [2]

One of the main difficulties of surveying the noise sources is the fact that some of them are located more than 30 meters high, so the survey is virtually takes place in the air. In addition, since we dealt with dangerous chemical technology, we had to comply with strict safety regulations, and the protective equipment we had to wear made our task even more difficult.

5. SOLUTIONS

5.1 Use Our Ears!

During site visits, subjective analysis made by simple listening plays a great role. This kind of analysis together with decades of professional experience provides invaluable information to complete the task.

Our ears are uniquely sensitive equipments, and have such qualities which in a certain way overtop the capabilities of sound level meters and noise analyzers. Thus, by using his ears, an experienced specialist is able to implement a significant part of noise source identification and analysis. By using both ears, we are able to identify the direction of sound sources, and thus we can recognize those sources which are responsible for the development of noise pollution. Furthermore, we are also able to determine the physical characteristics (sound pressure, spectrum, frequency and time function) approximately based on our subjective acoustic experience (loudness, timbre, pitch and perceived change over time) that was developed by our sensation of hearing. [7]

The ears of a noise expert, who has years of experience, have become particularly sensitive biological instruments; therefore, they are perfect for doing on-site investigations. Of course, the ears are not able to determine exactly the quantitative amount and nature of the noise, and therefore, instrumental analyses are also essential.

The task was carried out by several noise control experts who, as a matter of fact, are also trained in music. The trained hearing helps the expert to identify the sound source even from 1 kilometre by following the narrow-brand noise generated by the source. Therefore, starting from the residential area, we often managed to identify the typical noise sources by using only our hearing. (Experts with half-perfect pitch can identify the frequency of the noise source more precisely than the 1/3 octave resolution by using a tuning fork.) However, this procedure is not standard at all. Only by the cooperation of several experts can it be objective to some extent.

5.2 Teach the principal!

When they announced the task, the environmental protection department of BorsodChem has expressed the need for a course related to noise modelling. According to the mutually drafted plans, the complete noise model would be a strategic tool for managing the environmental noise emission of the facility, and it would also be a part of those decision support systems which are related to the investments. During the noise modelling courses, several elemental acoustic and measurement issues arose (eg. the methods for producing source data), and the answers for them brought the aspects of principals and experts closer to each other. By teaching the specialists of the principal, we managed to reach the point when “we spoke the same language”; therefore, BorsodChem formulated such aspects and needs towards the upper management and the individual facilities, which we preferred as well. According to our experience, if the principal becomes part of the expert team, it would make the implementation of the task much easier.

Those who have been working in the industrial area for decades could also help us identify the dominant noise sources, as these noise sources often significantly affect the workplace noise. Interestingly, however, these people sometimes do not even realize noise sources which are dominant in terms of the environmental noise, and these noise sources may only be identified by those who live in the nearby residential area. However, it is quite natural that noise sources that are located 25-30 meters high are not conspicuous for the workers. Therefore, we also started to teach the workers of the industrial area, which has proven very useful when they later helped us survey the noise sources and explore different noise reduction possibilities.

5.3 Application of Complex Instruments

The preparation of the action plan - since we have to deal with operating noise sources - is always based on on-site measurements. During the instrumental analyses, we carry out measurements in the area that needs protection from the noise, in the industrial area and near the noise sources as well. During the survey, the source data of the noise sources will be determined (sound power level, directivity, etc.). The analysis of the frequency spectrum of the noise sources helps us identify sources with typical spectral characteristics. The results of the long term analyses, carried out by the noise monitoring system, together with the simultaneously recorded meteorological parameters, identify the propagation characteristics of the sound and the effects of the weather.

Noise modelling helps the identification of the dominant noise sources responsible for the noise pollution, but we have to be aware of the limitations of the calculation method and the characteristics of the propagation calculation. By taking them into consideration, we would be able to overrule the results of noise modelling due to our experience and the measurement results. However, at the same time, we also have to overrule our own prejudices. The subjective, on-site experience of the experts, the instrumental analyses and the standard calculation methods have to be applied independently to some extent. Therefore, the various methods have to form the overall image together, and their complex application helps the detection of errors.

The uncertainty of the complex survey procedure can be reduced by having several experts who carry out the tasks simultaneously, check the results of each other continuously, and if necessary, questions these results. Therefore, it is practical to have some who undertake the role of the sceptic during the gathering of on-site, subjective experience, and during the analysis of the results of modelling. For the implementation of our task, we had three expert teams who worked together. As a result, certain facilities were surveyed independently as well, the noise sources were identified in several ways, and during the preparation of the noise model, certain facilities were prepared in various versions. By discussing the results that we got from the different professional experience and aspects, the detection of errors became easier, and we got confirmation in respect of the final result.

5.4 Classification of Noise Sources

Because the surveyed area is very large, and the distances between the noise sources are also great, the noise sources can be classified depending on which area's noise pollution they affect significantly. Therefore, the noise source's order of dominance can be established according to the directions or the areas that need protection from noise pollution.

It is not necessarily required to model the technologically connected noise sources as separate noise sources. We need a professional classification, which records the following statements:

1. which are those noise sources that are definitely dominant in the noise pollution of the residential area (primary sources);
2. which are those noise sources that are not dominant, but possibly become a determining factor in the noise pollution after the reduction of the dominant noise sources (secondary sources);
3. which are those noise sources that are in no way involved in the development of environmental noise pollution.

5.5 Adding Measuring Points to the Analysis of Sound Propagation

We set 500 measuring points in the industrial area between the noise sources and the residential area in order to learn how the building structure of open technology affects the propagation of sound. The results of the reference measuring points were put in the noise model, and by calibrating the noise model continuously, and using an iterative we bought the calculation model closer to reality.

During the survey of noise sources that are located at a considerable height (eg. 30 meters high), the propagation of sound has to be analyzed at the height of the noise source by gradually moving away from it. The environmental noise pollution of those noise sources that are located high cannot be surveyed close to the ground, because the noise emission of the other noise sources would make it impossible to get exact results. In order to carry out this extraordinary measurement task, we needed the help of the factory's own fire department. The firemen lifted us up with a boom lift, so we could survey the propagation of the sound up in the air as well.

Figure 3 – Sound propagation measurements up in the air with the help of the fire department

6. FINAL REMARKS

This presentation is the first part of a two-part presentation dealing with the noise control action plan of BorsodChem's industrial area. The second part will present solutions for the difficulties and special situations that were partially outlined above in the underlying investigation phase, and in the implementation phase that is currently going on.

REFERENCES

1. Ing. T.J.M. van Diepen, Ir. J.H. Granneman: Benchmark indicators for industrial noise emission, , Proceedings of INTER-NOISE 2015, San Francisco, California, USA, August 2015.
2. Takahiro HIDA: Field noise measurement in the huge industrial plants for accurate prediction, Proceedings of INTER-NOISE 2014, Melbourne, Australia, November 2014.
3. 284/2007. (X. 29.) Government Decree on the rules of protection against noise and vibration
4. ISO 1996-2:2009 Acoustics. Description, measurement and assessment of environmental noise. Part 2: Determination of environmental noise levels
5. Wolfgang Probst, Heinrich A. Metzen, Ingo Rabe: Noise Prediction for Industrial Facilities, Proceedings of INTER-NOISE 2010, Lisbon, Portugal, June 2010.
6. ISO 9613-2:2005 Acoustics. Attenuation of sound during propagation outdoors. Part 2: General method of calculation
7. Tamás Tarnóczy: Sound Pressure, Loudness, Noisiness. Published by Akadémiai Kiadó, Budapest, 1984.