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ACOUSTICAL MODELLING OF INDUSTRIAL FACILITIES - OUTDOOR PLANT NOISE CONTROL DESIGN AND CONSTRUCTION

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ABSTRACT

With the noise prediction software CadnaA it is possible to model industrial plants with all relevant sources, to walk around in a 3-D-model of the plant and to modify objects without leaving this virtual space. When modelling an existing plant, it is advantageous to measure the noise emission of the sources. Some corrections not described in the standards ISO 3744/46 are necessary to take into account the angle error, when sound power levels are deduced from sound pressure measurements. These corrections are discussed and quantified for some source types.

1 - INTRODUCTION

With the enormous progress in calculation speed of computers and in accuracy of software tools for noise prediction it has become possible to model complete industrial plants with all relevant noise sources, to calculate the noise levels in the surrounding area and to present the result as noise maps. With 3-D-view and animation techniques we can move around in these virtual industrial plants and check the position of buildings and noise sources like ventilation openings, cooling towers or high pressure valves. This opens a fascinating world for consultants and planning engineers, because they can demonstrate their customers, who perhaps have not the acoustical knowledge to understand all this in technical terms, the consequence of the installation of a muffler, a barrier or of other noise reducing devices.

The creation of such a computer model of an industrial plant requires an acoustical knowledge, that is comparable to that necessary to make noise measurements and to analyse the results correctly.

If an existing plant is modelled, it is advantageous to determine the sound power levels of the sources on the basis of measurements. Experience with such models show, that an uncritical use of the standards of ISO 3740 – series for this sound power determination of the model-sources often leads to an overestimation of the noise levels in the vicinity of the plant of some decibels. Uncritical application means, that the deviations are not taken into account, that result from the use of sound pressure levels instead of sound intensity levels in the determination of sound power levels.

2 - POINT SOURCES

With small noise sources radiating freely into the environment things are clear. If the radiation is omnidirectional, the sound pressure level is measured at one point in a known distance r and the sound power level is calculated by using the assumption, that the SPL is the same on the full or half spherical surface.

3 - AREA SOURCES

Extended sources can be treated as point sources, if the distance source receiver is larger than twice the largest source dimension.

4 - RADIATING OBJECTS

If the sound power is radiated from an object like a building, this can be simulated by an acoustic opaque object that is covered with radiating area sources. This area sources with sound power level L_W radiate

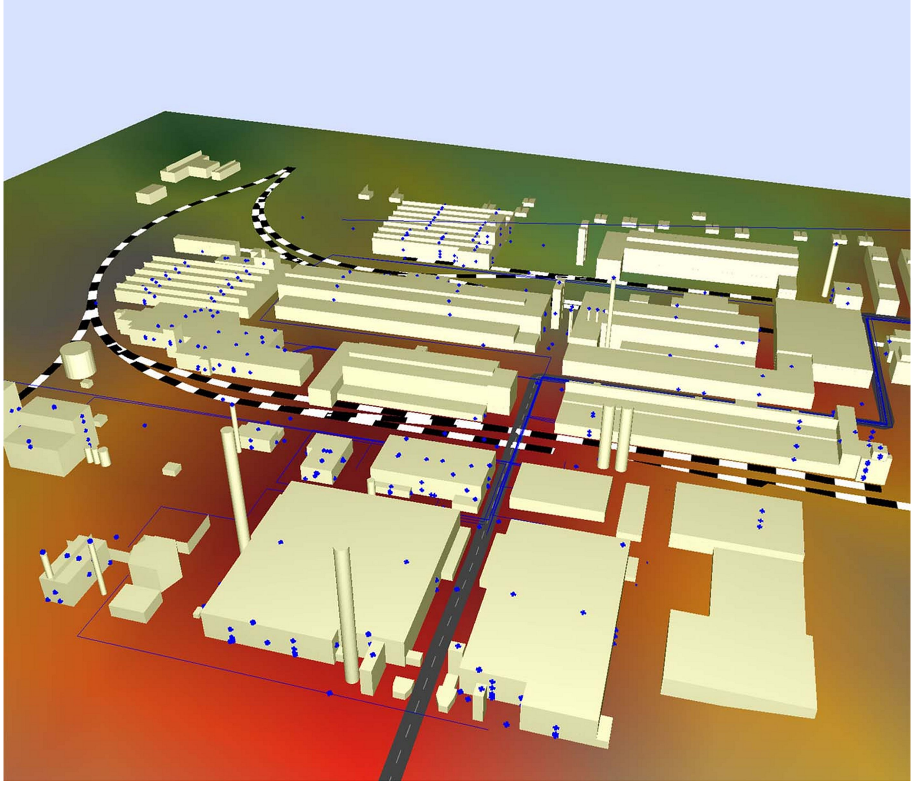

Figure 1: 3-D-view of an industrial plant model.

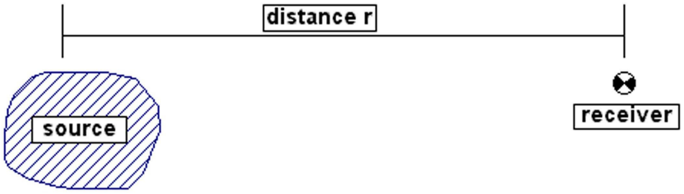

Figure 2: Calculation of the noise level caused by an extended source.

their sound energy into the half space in front of the wall or roof − this can be taken into account with two methods. One method is to use a directivity index of $D_c = 3$ dB according to ISO 9613-3 for these area sources. The other method is to calculate free radiation and to take into account reflections with mirror images produced by the surface of the object. In both cases the radiation from the object surface is modelled properly and the calculation of the sound pressure level at a receiver point far away gives the same value as if the radiating object is replaced by a point source with a sound power level L_W, that is the energetic sum of the sound power levels of the area sources.

If we use the second method, where the radiation of surfaces is described by sources in front of a reflecting surface, we can additionally determine the diffracted sound caused by these sources (not the image sources!). If the first method is applied, the diffracted sound may be overestimated by about 3 dB.

The simulation of radiating surfaces by sources on the outer surface is possible for all object-geometries. If area sources are used, these can be subdivided in smaller parts dynamically in dependence of distance and screening objects between radiating surface and receiver point. The method described in ISO 12345 with a fixed grid of point sources is not recommended.

The sound power level that is radiated from large openings like open doors or ventilation outlets can be determined by scanning the area of this opening with an intensity probe with it's axis vertical to the cross section of the opening. When measuring the mean sound pressure level in the open surface, a correction of 3 dB should be subtracted to take into account the different angles between sound rays and the cross section area.

When measuring the sound power level of big objects or extended areas with envelopping surface method

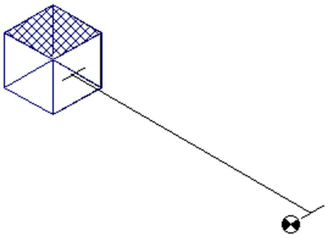

Figure 3: Radiating object, that is acoustically opaque.

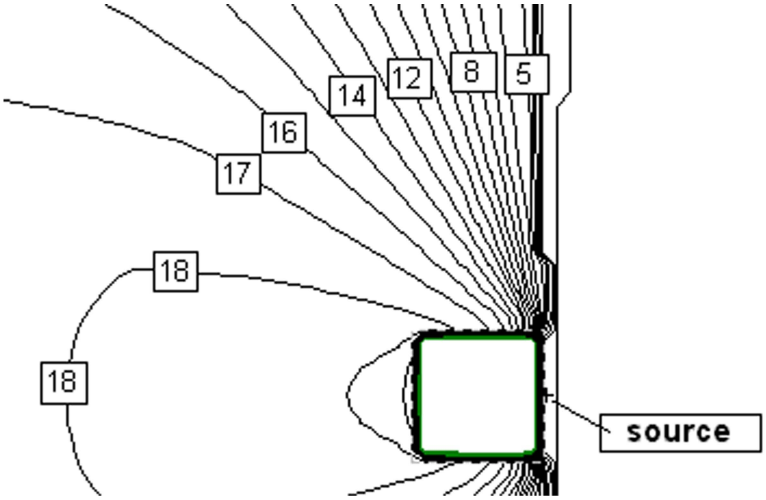

Figure 4: Noise level reduction by self-screening of an object 10 m × 10 m × 10 m.

according to ISO 3744/46, a similar correction to account for this angle error should be applied. This corrections depend on the size of the object in relation to the measuring distance. They are derived from numeric simulations /2/ and presented in Table 1.

L/d	B/d	H/d				
		1	2	3	4	5
1	1	1.1	1.3	1.4	1.6	1.8
2	1	1.4	1.6	1.8	1.8	2.0
4	1	1.6	1.8	1.9	2.1	2.3
8	1	1.9	2.1	2.3	2.4	2.6
16	1	2.1	2.4	2.6	2.8	3.0
32	1	2.2	2.6	3.0	3.3	3.4
64	1	2.7	3.2	3.5	3.7	3.8
2	2	1.7	1.9	2.1	2.1	2.2
4	2	1.9	2.1	2.1	2.2	2.3
8	2	2.2	2.3	2.5	2.5	2.6
16	2	2.4	2.6	2.7	2.9	3.0
32	2	2.5	2.7	3.0	3.3	3.4
64	2	2.7	3.2	3.4	3.7	3.7
4	4	2.1	2.2	2.2	2.4	2.5
8	4	2.3	2.4	2.4	2.5	2.6
16	4	2.6	2.7	2.7	2.9	3.0
32	4	2.7	2.9	3.1	3.3	3.4
64	4	2.8	3.2	3.3	3.6	3.7
8	8	2.6	2.6	2.7	2.7	2.7
16	8	2.9	2.9	2.9	2.9	3.0
32	8	3.0	3.1	3.2	3.3	3.4
64	8	3.4	3.5	3.6	3.7	3.8
16	16	3.3	3.3	3.3	3.3	3.3
32	16	3.7	3.7	3.7	3.7	3.7
64	16	4.1	4.1	4.1	4.1	4.1
32	32	4.2	4.2	4.2	4.2	4.2
64	32	4.6	4.6	4.6	4.6	4.6
64	64	5.1	5.1	5.1	5.1	5.1

Table 1: Correction in dB when sound power levels are determined on the basis of sound pressure measurements on an envelopping surface (ISO 3744/46); L, B, H dimensions of radiating object, d measuring distance.

REFERENCES

1. **W. Probst**, *Checking of Noise Emission Values*, 1999