inter•noise 96
25th Anniversary Congress – Liverpool

INCE: 24

AN OVERVIEW OF A METHOD TO PREDICT AVERAGE PROPAGATION OF SHOOTING NOISE IN ORDER TO CREATE COMPUTER-GENERATED NOISE CONTOURS AROUND SHOOTING RANGES

F H A Van den Berg, N A Kinneging & E M Salomons

TNO Institute of Applied Physics, Stieltjesweg 1, PO Box 155, 2600 AD Delft, The Netherlands

1. INTRODUCTION

For the Dutch Ministry of Defence a method is being developed to estimate contours of equal annoyance around military shooting ranges caused by shooting noise. The annoyance level will be based on the long-term average sound exposure level of impulsive sounds [1]. Since meteorological variations cause large variations in the sound propagation, the long-term average sound level has to be determined as an average over all prevailing weather conditions.

Computations of sound propagation in an inhomogeneous atmosphere can be performed with a numerical method like the parabolic-equation method (PE method). This method, however, is very time consuming. For a practical model we have therefore chosen a method which is based on three databases:

- a database of emission levels and other source data of weapons;
- a database of transfer functions;
- a database of meteorological statistics for the Dutch situation.

This paper discribes this model which can be used over distances up to 15 km. The model will be valid only for The Netherlands, as the meteorological statistics of our country are used. However, by adapting the statistical database to the local situation, the model could also be used for other locations.

2. DATABASE OF TRANSFER FUNCTIONS

To model the effect of the meteorological situation on sound propagation, we make use of the effective sound speed, which is the sum of the thermal sound speed and the vector wind as a function of the height z above the ground. In the following this function is refered to as the sound speed profile. In our model we distinguish 27 different sound speed profiles to cover a wide range of possible meteorological situations from strong downwind to strong upwind conditions (Fig. 1).

Using the wide-angle PE-method we generated for these profiles a database of attenuation functions as a function of 3 soil impedances, 3 different receiver heigth's and 15 different source heigth's. For the octave bands 16 Hz to 250 Hz these transfer functions are computed up to a distance of 15 kilometers. For higher bands we use a smaller distance, because at large distances these bands are - as a result of molecular absorption in the atmosphere - no longer relevant. The transfer functions are expressed relative to the free field. Geometrical spreading and atmospheric absorption are not included in these functions.

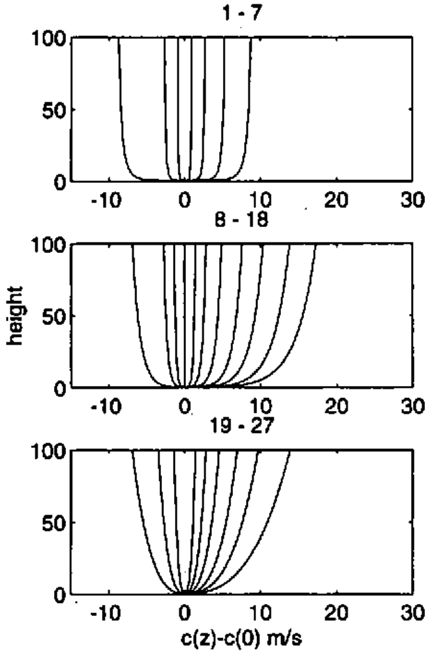

Fig. 1: Meteorological situation characterized by the sound speed profile

3. STATISTICAL DATABASE

The sound speed profile varies with time, as a consequence of variations of the profiles of temperature and wind. To compute the long-term average transfer function one has to know the probability distribution of the chosen set of profiles. With this distribution the long-term average transfer function can be computed as the energetical average of transfer functions weighted with the statistical weights (g(m)) of the profiles:

$$\overline{L_E} = 10\lg\left(\sum_{m=1}^{27} g(m)\ 10^{L_E(m)/10}\right) + C_{wf} \qquad (1)$$

The statistical distribution is derived from a meteorological model in the Netherlands [2]. The parameters of this model have been fitted to data of a large number of meteorological stations in the Netherlands, collected over a period of fifteen years. This model yields the statistical weights of the profiles, depending on two parameters: part of the day (light, dark) and the ground roughness. The ground roughness can be estimated visually, using the Davenport classification.

In the Netherlands south-west winds dominate over other wind directions. The statistical weights are however independent on the source-receiver direction. This is been corrected for by a C_{wl} correction.

4. EMISSION DATABASE

Shooting noise may have three components: muzzle noise, due to the explosion of the propulsive powder; bullet noise for supersonic bullets and detonation noise for a detonating charge. From the emission database the (direction dependent) source levels for the muzzle and detonation noise can be derived. A source level for bullet noise can be calculated on the basis of the dimensions of the bullet and its speed [3].

5. LONG-TERM AVERAGED LEVEL

Combining these 3 databases, the octave band (f) sound exposure level L_E can be calculated for a certain meteorological situation (m) and geometry using:

$$L_E(s,f,m) = L_{EW}(s,f) - \sum A_i(f,m) \quad (2)$$

where $L_{EW}(s,f)$ is the octave band source level of some weapon (s); and $A_i(f,m)$ is the octave band attenuation in dB that occurs during the propagation from the source to the receiver. We distinguish 4 attenuation terms (index i) due to geometrical divergence, air absorption, the ground effect [4] and due to screening. The last two terms are dependent on the meteorological situation.

This strongly resembles the basic equation of the ISO standard 9613-2.2. The main difference is that in this standard the attenuation is calculated for only one downwind condition. The long-term average level is calculated by means of a (frequency independent) meteorological correction. In our model however this average level will be calculated as a weighted average over 27 meteorological conditions (eq. 1). Especially at large distances a more accurate result can then be obtained.

On the basis of the long-term averaged sound exposure level a rating sound level can be determined [5].

6. RESULTS

Due to the fact that this model will be based on a statistical distribution not only can contours be constructed around shooting ranges, but it is also possible to obtain a statistical level distribution at some receiver point. Figure 2 shows an arbitrary example. A distribution is given for the A-weighted level for a situation with and without screening. As parameter in the figure the windspeed at a height of 10 m is given. Positive values stand for downwind conditions, negative values for upwind conditions. From the figure a sharp transition in level can be seen for the situation without a screen. For the situation with a screen this transition is much less pronounced. This proves that the statistical distribution is strongly dependent on the local circumstances.

For strong down- and upwind conditions the attenuation due to the screen is very small. The attenuation is only significant for moderate downwind conditions. If the effect of the barrier were to be estimated on the basis of measurements, this result shows, that a single measurement is not sufficient, but that several measurements have to be carried out.

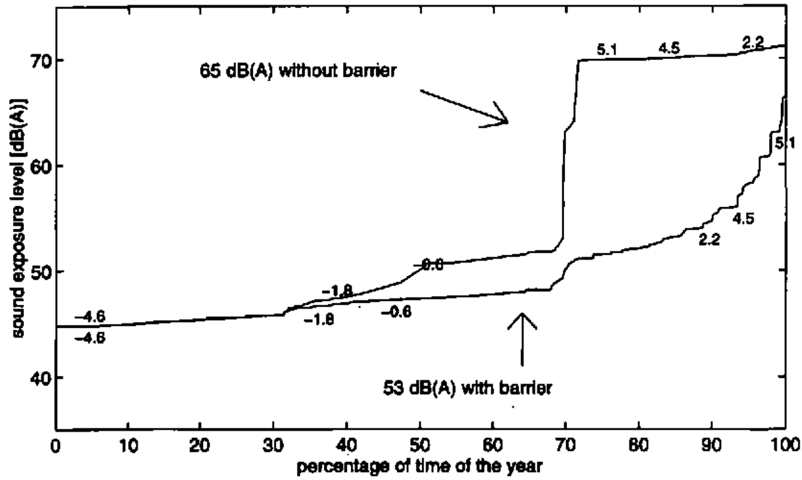

Fig. 2: Distribution of the A-weighted sound exposure level for a situation with and without screening. The long-term averaged level is given in the figure.

Acknowledgement
The research has been supported by the Dutch Ministry of Defence.

References

[1] J.Vos, Proc. Internoise '95 (Newport Beach, CA) Vol 2, 875-878 (1995).
[2] E.M. Salomons, F.H.A. van den Berg, H.E.A. Brackenhoff, 6th int. symp. on Long-Range Sound Propagation (Ottawa), 209-228 (1994).
[3] N.A.Kinneging, F.H.A. van den Berg, Internoise '96 (1996).
[4] EM Salomons, F.H.A. van den Berg, InterNoise '96 (1996).
[5] J.Vos, Proc. Internoise '96 (1996).