Noise Management at Civil Shooting Ranges

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1 Introduction

DIN ISO 17201-5 [1] proposes a scheme to set up a daily noise management on civil shooting ranges. The scheme relies on rating levels based either on calculations or measurements of LAFmax at relevant receptor points. In order to employ such a management system, the usage of each shooting position, the type of rifles, the ammunition distribution, the respective acoustical source strength and directivity pattern and the expected number of shots have to be known. For civil shooting ranges however, it is nearly impossible to gather all information in advance and to put everything together in an appropriate computer based management system. An alternative to gathering information in advance is to measure the level of each single shot at reference positions inside the shooting range and transferring these levels into rating levels at the receiver point and accumulating these levels until the noise limit is reached. The system enables the operator to monitor and to control the shooting activities without any detailed information about the operation of the ranges in order to minimize the noise load and maximize the use of the shooting range.

2 Principle of the Noise Management System

The principle set up of the noise management system is shown in Fig. 1. The components of the system are reference microphones, meteorological sensors for wind speed and wind direction and a central unit for data processing. Depending on the number of receiver points several reference microphones (RM) can be employed. Taking the single shot levels at the RM and the met data from sensors on the facility, the system applies a transfer matrix to predict the contribution of each shot to the rating level at each relevant receiver point. The coefficients of the matrix are determined from the measured level difference between the RM and the receiver points. Since the coefficients of the transfer matrix depend not only on the relative position RM - receiver point, but also on the meteorological propagation condition, the matrix is divided into two parts: one part representing the average correction and a second part accounting of the meteorological influence (eq. 1). To determine the influence of the meteorology only by measurements can be very time consuming and costly, since for each propagation class sufficient data must be gathered. In order to reduce the costs and to simplify the procedure a combination of measurements and general assumptions about the influence of the meteorology on the sound propagation can be used to set up or complete the matrix for the met. correction respectively.

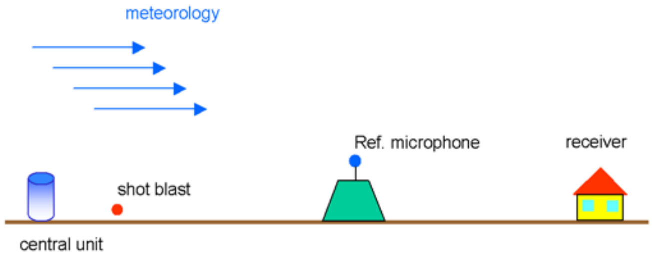

Fig. 1: Noise management system

$$L_r = 10 \bullet \log\left\langle \sum_{i=1}^{N} 10^{0.1*(L_i - T - M\ )} \right\rangle + \mathrm{K\ dB(A)} \qquad (1)$$

N = number of shots per day
L_i = single shot level (LAFmax)
T = transfer function for distance+screening
M = meteorological correction
K = conversion factor for rating level

The management system will document all measured single shots as well as the rating levels for each relevant receiver point, thus allowing an effective noise management.

3 Transfer Matrix

The transfer matrix must be derived from measurements. The basic problem with this method is, that in most cases it is difficult to get sufficient data for all sound propagation conditions (SPC). Even classifying the SPC only in 12 classes, 3 wind speed and 4 wind direction classes not all the coefficients of the matrix can be determined from the measured data, since not all SPC will occur at a sufficient frequency. Another problem is to derive the “proper” meteorological parameter, i.e. to find a representative position for the met. sensor. The examples in Fig. 2 show the distribution of wind directions measured at two different points in the vicinity of a shooting range.

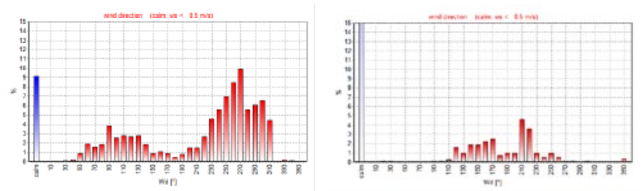

Fig 2: Distribution of wind direction at different sites

The different distributions are due to the effect of the shooting range itself (large screens influencing the local wind field) and the surrounding topography (trees). Thus, in certain cases, it will be very awkward to derive the meteorological correction coefficients only from measurements. Instead a combination of on site measurements and general information about the met. influence on sound propagation can be used. An example for the calculation of the met. correction **M** is given in eq. 2 [2]

$$M = \frac{1}{n}\sum [f(ws) - f(ws)\cdot\cos\{(\alpha-\beta) - 45\cdot\sin(\alpha-\beta)\} + C1]$$

ws = wind speed; α = wind direction; β = angle source receiver, C1 = adjustment

Different to the original equation in [2] the term **f** is not constant but is assumed to be a function of the wind speed and perhaps distance. Dividing the wind speed into 3 classes 0-1.5 m/s, 1.5-3.5 m/s and > 3.5 m/s, **f** and C1 can be set to, for example, 1.2/-0.77, 2.4/-1.54 and 3.7/-2.4. The values of the two parameters are chosen in such a way that the max. correction M for any of the 4 wind direction classes is ≤ 4 dB and the sum over all M in each wind speed class is zero, i.e. the average met. correction will be zero. Fig. 3 shows an example of the met. corrections for f = 3.7 and C1 = -2.4.

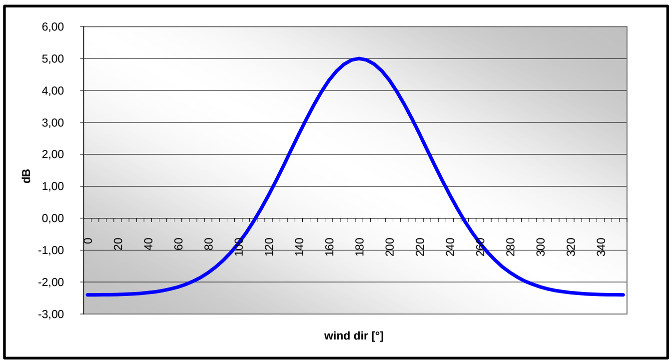

Fig. 3: Met. correction: 3.7-3.7*cos[γ-45*sin(γ)]-2.4; γ=α−β

In Table 1 an example of the met. transfer matrix derived from eq. 2 is shown. The down wind direction is WD1 (315°-45°).

Ws Class	**WD 1**	WD 2	WD 3	WD 4
1	**-0.8**	-0.2	1.3	-0.3
2	**-1.5**	-0.5	2.6	-0.6
3	**-2.4**	-0.8	3.9	-1.0

Table 1: Met. transfer matrix

4 Example

One noise management on a shooting range was installed in 2007. This system has 3 reference microphones in the directions of the relevant receptor points in the north, west and south (Fig. 4). Measurements for the determination of the transfer matrix has been carried out over a period of about 5 weeks at the receptor sites storing acoustical data as well as met. data. In Fig. 2 the distribution of the wind direction at two sites is depicted. This example demonstrates one difficulty of determining the met. components of the transfer matrix, since the wind direction is a function of the location. Nevertheless, taking the available data the transfer matrices T and M can be set up. Table 2 and 3 gives an example for the two matrices

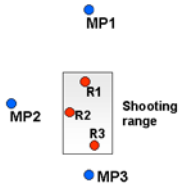

Fig. 4: Shooting range, receptor points, ref. microphones

RM	MP1	MP2	MP3
RM1	34.4	29.48	36.1
RM2	44.58	40.56	48.7
RM3	44.79	36.22	43.5

Table 2: Transfer matrix T

wind dir.	North			East			South			West		
Ws	I	II	III	I	II	III	I	II	III	I	II	III
MP1/R1	1.9	2.7	-0.9	2.2	-1.7	*-0.2*	-0.3	-2.2	**-4.0**	3.7	2.2	-2.6
MP1/R3	0.9	**4.0**	*2.6*	2.6	*-0.5*	*-0.8*	**4.0**	**-4.0**	**-4.0**	1.5	1.9	-2.4
MP1/R2	2.9	2.9	1.6	1.3	-0.6	-0.9	-1.3	-2.8	-2.3	1.6	-0.8	-1.7
MP2/R1	0.8	0.8	-0.2	-1.1	-2.6	**-4.0**	3.4	-0.5	-0.7	2.8	0.7	1.7
MP2/R3	0.2	*-0.5*	*-0.8*	*-0.8*	*-1.5*	*-2.4*	-1.9	-1.8	0.0	1.5	1.4	0.3
MP2/R2	0.8	1.5	2.3	-1.0	-1.7	-2.3	-0.3	-0.6	-2.1	-0.9	2.5	2.0
MP3/R1	-1	*-1.5*	*-2.4*	-0.1	*-0.5*	*-0.8*	-0.1	2.6	*3.9*	-1.6	0.1	*-1.0*
MP3/R3	0.3	*-1.5*	*-2.4*	0.5	*-0.5*	*-0.8*	-1.2	*2.6*	*3.9*	0.5	*-0.5*	*-1.0*
MP3/R2	-0.2	0.1	*-2.4*	0.0	0.2	0.2	0.1	0.3	-1.9	0.1	1.4	*-0.8*

Table 3: Transfer matrix M, combination of meas.+*calculation*

The matrix M in Table 3 is a combination of measured values and data taken from Table 1. The coefficients in Table 3 are limited to a maximum of 4 dB even if the measurements are suggesting larger corrections. In some cases the calculated values are not entirely consistent with the measured values, which is explained by the difficulty of relating the wind direction and wind speed to the actual propagation condition. Since the main aim of the management system is to control a “long-term” rating level, the met. corrections are limited to 4 dB even if the variance of single shot levels is much larger.

5 Conclusion

Employing the concept of a noise management system based on a combination of measurements and empirical derived propagation model allows to minimize the noise load on the neighborhood and to optimize the operation of the facility.

6 Literatur

[1] DIN EN ISO 17201-5, Geräusche von Schießplätzen – Teil 5 Lärmmanagement

[2] Hinweise zur Bestimmung der met. Dämpfung; LANUV NRW