# Noise from elevated sound sources - Results of a dedicated measuring campaign

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## Introduction

For noise assessment purposes, outdoor sound propagation is mostly considered for situations having the source and the receiver close to the ground. For industrial noise source, for example, the prediction scheme of ISO 9613 is applicable to achieve reliable rating levels. For high energy impulsive blasts, the scheme of the noise management directive of the German MOD (Federal Ministry of Defence) is available for predictions at far distances. However, sound propagation from elevated sound sources is out of scope of both regulations. In order to expand the given calculation schemes for these cases and to validate a 3D-ray tracing model developed by the Institute of noise control (IfL), reliable measuring data are needed to test the expansion and the 3D-Model.

## Measurement

The measurement campaign was held at the WTD91 (Bundeswehr Technical Centre for Weapons and Ammunition) in Meppen in Germany in the spring of 2008. The measurements were done in cooperation with EMPA (Swiss Federal Laboratories for Materials Testing), DLR (German Aerospace Center) and the WTD91 noise control team.

### Sources

Professional pyrotechnical equipment was selected to provide blast sources at different altitudes up to 300 m. These blasts are almost omnidirectional and easy to use. However, one disadvantage of the pyrotechnic charges is that the exact blast height can not be controlled. Therefore a video system was used to determine the blast height for each explosion. For different heights we had to use different bombs with different explosion masses and different lift charges. Typically for lower heights smaller charges were used. The maximum of the energy in the spectra were found between 100 Hz for bigger charges and 1 kHz for smaller charges.

### Measurement points

Free explosions in air at different altitudes up to 300 m height were used to produce well-known blasts. The blasts were recorded at 8 directions and at 6 distances up to 2 km (see figure 1). Weather data were acquired at 3 stations up to 400 m height. The measurements were performed at three different meteorological situations: at high, medium and low atmospheric turbulence conditions. The differences of the measured levels between high/medium/low turbulences, high and lower sources, up and downwind conditions are discussed in this paper.

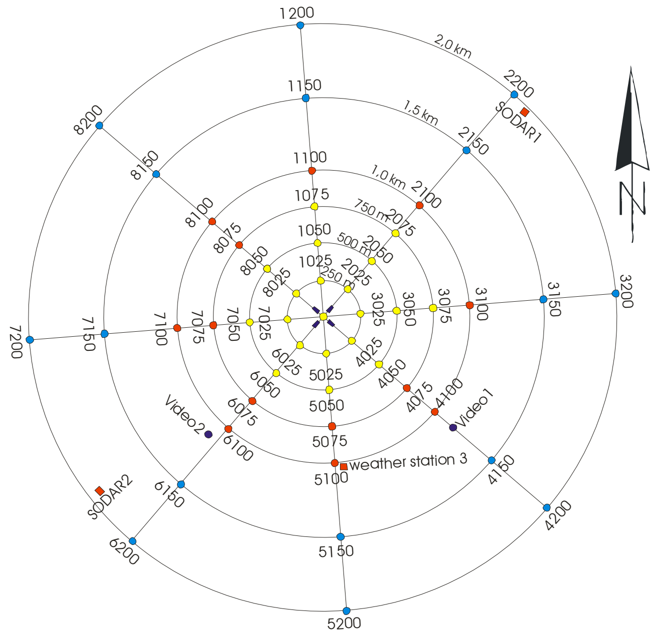


**Figure 1**: Arrangement of measurement positions (the so called spider's web)

### Time schedule

The measurement campaign consists of five series: at 13:50 to 14:10, 17:00 to 17:25, 21:50 to 22:10 on the first day and at 13:40 to 14:00 and 17:00 to 17:20 (GMT+2) on the second day. These periods were chosen to have different kind of turbulence situations: high, low and without turbulence. Each series was made up by seven blocks with five blasts at the ground, 50 m, 100 m, 200 m, and 300 m height. Therefore each series provides 35 single shots.

## Results

### Weather

The campaign took place in a ridge of high pressure. This resulted in a slow change of wind direction over the two days of the measuring period. The wind direction shifted from easterly winds at the first day to south-westerly winds at the second day as seen in table 1.

| series | wind dir. / speed | wind gradient | cloudiness |
|---|---|---|---|
| 1 | 120° / 4-7 m/s | 0.5m/s/100m | 2/8 |
| 2 | 150°-180°/4-7m/s | 1m/s/100m | 2/8 |
| 3 | 125° / 6-8 m/s | 2m/s/100m | 8/8 |
| 4 | 210° / 4-6 m/s | <0.5m/s/100m | 6/8 |
| 5 | 230° / 4-6 m/s | <0.5m/s/100m | 8/8 |

**Table 1**: weather conditions

The change of direction had the benefit that the possible influence of the terrain or measurement equipment on the sound levels can be distinguished from the influences of the wind. The averaged wind gradients were rather low; even at night time we found it to be 2 m/s/100m. With this wind gradient the shadow zone starts for the 300 m height at about 3,2 km distance, for 100 m height at about 1,8 km and at 50 m height at about 1,25 km. This shows that with the maximum measured distances of 2 km only for lower heights the shadow zone shall be visible.

## Acoustical results

Nearly all levels show normal distribution; so the standard deviation is calculated in decibels.

To have a closer look at the different weather situations, the figure 2 shows the level distribution of the CSEL of series 1 to 3.

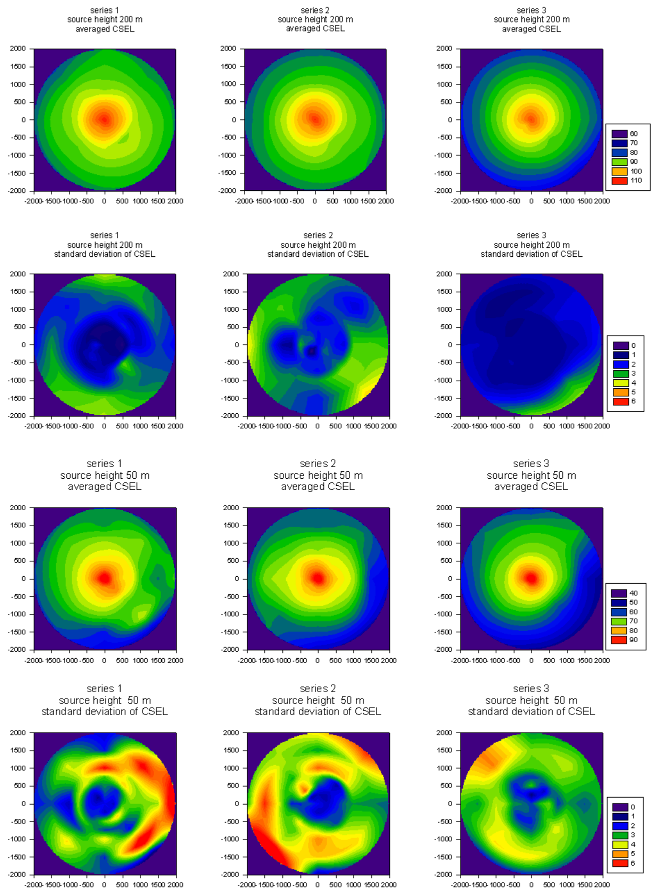


**Figure 2**: Contour plots of the mean CSEL and its standard deviation in decibels for series 1 to 3 at 200 m and 50 m source height covering a range of 4000 m x 4000 m

The level distribution is similar in series 1 and 2 whereas in series 3 the standard deviation is much less and the influence of the wind direction on the level and the deviation can be found (south-easterly wind). This corresponds to the calculated beginning of the shadow zone; for the 300 m source height the influence is only visible in the deviation of the levels; for 50 m source height the shadow zone can be found at about 1.5 km distance for series 3.

A cumulative frequency distribution (figure 3) was done to find the difference between the shadow zone and the ensonified situation as documented in Ref [4]. The two different changes are found in the figure where the higher ones (200 m and 300 m) have less spreading than the lower ones (0 m to 100 m source height). The shadow zone seems to have no significant influence in this statistic analysis.

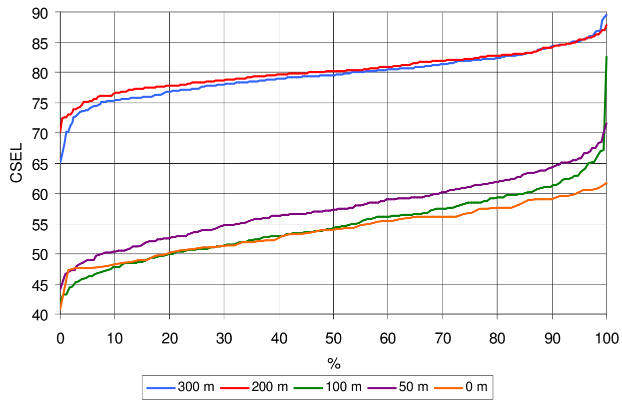


**Figure 3**: Cumulative frequency distribution of all measured data in 2000 m distance

To extract the influence of the source height independent from the source charge, the attenuation factor was calculated for the different source heights in dependency of the frequency. The measured levels for the lower source heights have a similar geometrical spreading as proposed by the ISO 9613-2; for the higher source heights (above 100 m) the attenuation factor is found to be higher. This has to be proved by the further investigations.

# Conclusion

This paper only gives qualitative statements. The ongoing analysis will focus on quantitative statements and building a model extension for the influence of the source height. Furthermore the angle of incidence will be evaluated for all measurements to get an indicator for the sound path and its curvature and to compare this with the calculated curvatures from the wind gradients.

## Acknowledgements

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# References

[1] Hirsch, K.-W., Zangers, J., “Ray-Tracing in a 3-D Wind Field for Prediction Purposes of Shooting Noise, Part I”, Fortschritte der Akustik, Strasbourg 2004

[2] Zangers, J., Hirsch, K.-W., “Ray-Tracing in a 3-D Wind Field for Prediction Purposes of Shooting Noise, Part II”, Fortschritte der Akustik, Strasbourg 2004

[3] P. P. Sullivan et al., “Structure of the Entrainment Zone Capping the Convective Atmospheric Boundary Layer”, Journal of atmospheric sciences, 99, 3042-3064 (1998).

[4] P. Schomer: A Revised Statistical Analysis of Blast Sound Propagation, Noise Control Eng. J. 42 (3), 1994