inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 2.3

LOW-FREQUENCY PROJECTILE NOISE FROM FLAT HOWITZER SHOTS

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Keywords:
PROJECTILE NOISE, HOWITZER, SHOOTING NOISE, BULLET NOISE

ABSTRACT
For noise prediction purposes it is important to know how great is difference between the muzzle blast and the projectile noise. Therefore, measurements were conducted to determine the source level and the propagation of both the muzzle blast and the projectile noise. Both types of noise are low-frequency high energy blasts. The paper reports on tests at the Bergen training area. The blasts were measured from direct howitzer shots at targets at distances of about 1000 m. The measuring positions were close to the line of fire and along the expected propagation path up to a distance of round about 2 km a height of 5 m above local ground.

1 - INTRODUCTION
For the assessment and prognosis of noise from military training facilities, the consideration of both the muzzle blast and the sonic boom from the projectile is mandatory for certain directions. However, source levels and the propagation characteristics are not sufficiently known for sonic boom. There are theoretical source models, but these models are not validated in the far field. Therefore, a normal training session of the Dutch military with the howitzer M109, cal. 155 mm on a shooting range at Bergen training area was used to acquire more test data. The howitzers were fighting targets at distances of 800 m to 1200 m. These measurements were conducted in the last year.

2 - METHOD
A microphone array was set-up in an area parallel to the trajectory according to the sketch in Fig. 1. The microphones line up in such a way that the propagation direction − calculated with respect to the speed of the projectile and its decrease along the trajectory − matches the three paths in Fig. 1.
Microphone positions at two different heights were used to investigate the propagation close to the ground (0 m) and at 5 m altitude. The three paths in Fig. 1 allows to measure the sonic boom at different distances from the source at the trajectory. All signals were measured simultaneously and tape recorded for later analysis. The sonic boom and the muzzle blast were analysed separately, in particular with respect to the C-weighted Sound Exposure Level CSEL and the linear peak level. Furthermore, the sound pressure time history and the one-third octave spectrum was analysed.

3 - MEASUREMENTS
Three M109A3G howitzers, calibre 155 mm, were firing from the concrete plate of the range; they were 30 m apart. The howitzers were fighting targets at 800 m, 1000 m and 1200 m using 7 white bags as propellant. The projectiles were HE DM21(M107) that went off when they hit the ground. 40 shot were measured.
The microphone array consists of 19 devices: at 9 positions with two microphones, each one at the ground and the other at 5 m height and at one position at a height of 10 m, s. Fig. 1. In addition to the array, at 3 measuring positions (M11 to M13) the muzzle blast was recorded in order to get a reference. The last microphone lay on the ground in 250 m in front of one howitzer. This signal was observed during the measurement. For the microphone M10 a height of 10 m was used to get free field sonic boom signals, because at this position there is a clear time gap between the direct sound and the ground reflection.

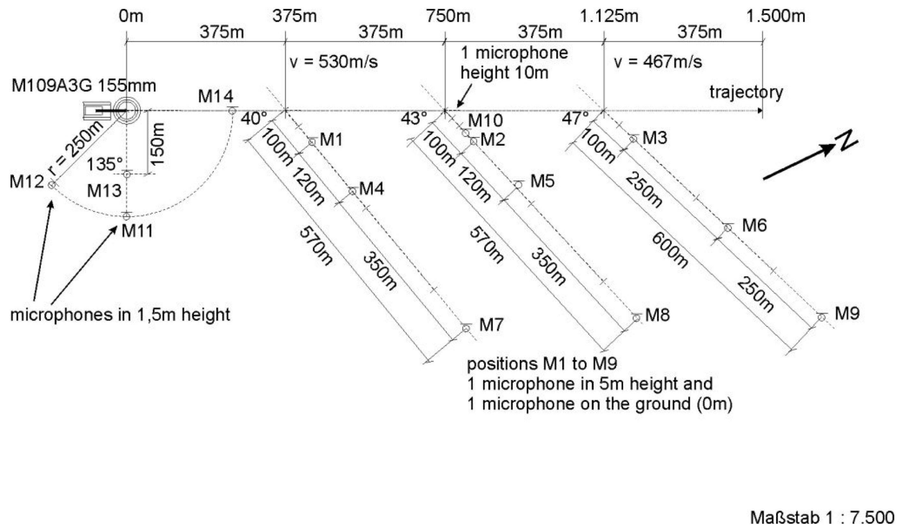


Figure 1: Sketch of the microphone array.

At positions M1 to M3, expecting a sound propagation path of 100 m, 1/4" microphones measured the signal at both heights. At positions M4 to M6, expecting a sound propagation path of 350 m, 1/4" microphones recorded the signal at the ground and 1/2" microphones at 5 m height. At the locations 600 m away from the source on the trajectory 1/2" microphones were used. Close to the source, after 40 m propagation, a 1/8" microphone recorded the expected high levels.
All time histories are stored in a database. Dedicated programs allow to separate parts of the signals and determine acoustical levels and one-third octave spectra for the parts of interest. In addition, a real time analyser (Norsonic 840) and a digital oscilloscope (Gould Data Systems 740) serves to validate the levels and spectra.

4 - WEATHER CONDITION

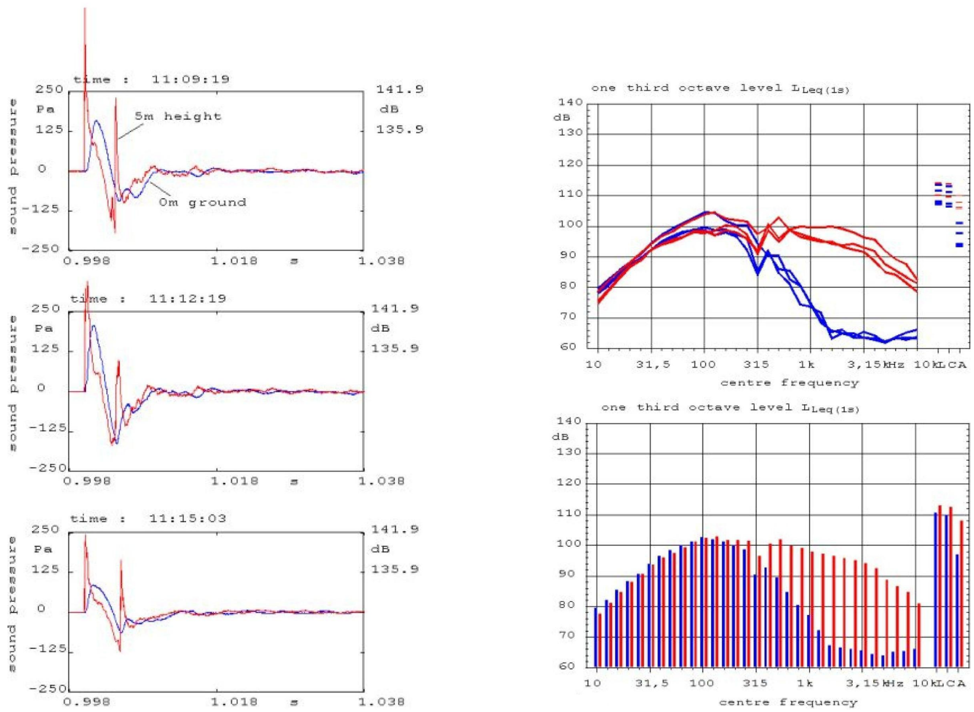
The following conditions were recorded as average for the time period of the training session from 9:00 to 12:00: air temperature 25°C, relative humidity 35%, ambient pressure 1001 hPa, easterly to south-easterly winds with 0.5 m/s to 3.0 m/s.

5 - RESULTS

Due to the different firing positions of the three howitzers, the length and angle of the propagation path of the sonic boom to the measuring positions vary slightly. Results, presented in this paper only refer to the first two lines. The last measuring path only got 4 sonic boom signals for those shots that were fired at targets at a distance of 1200 m.
Fig. 2 shows the unweighted pressure time histories of sonic booms in M2, (path length app. 100 m) at both heights 0 m and 5 m. There is a big difference between the shapes of the time history in these two heights. At the ground, the signal is not looking like an N-wave. An explanation will be published /1/. The measured spectra at the ground is missing most of the levels above 315 Hz compared to the spectra at 5 m height.
At larger distances, at M5 (220 m), see Fig. 3, and in particular in M8 (570 m), see Fig. 4, the pressure time history also at 5 m height is not a N-wave anymore. However, the high frequencies are still clearly lower at the ground compared to the data at 5 m height.
Fig. 5 shows the CSEL versus distance (i.e. the length of the propagation path). For both measuring heights the logarithmic slope is nearly the same, appr. 24 dB per decade in distance. It is obvious, that this decay with distance for distances greater than 100 m can not be explained by the geometric spreading of a line source (10 dB/decade) but more as spherical source (20 dB/ decade).

ACKNOWLEDGEMENTS

The German Ministry of Defense supports these investigations.



(a): Unweighted pressure time histories at the ground (0 m) and in 5 m height.

(b): One third octave spectra.

Figure 2: Sonic booms in M2, path length app. 100 m.

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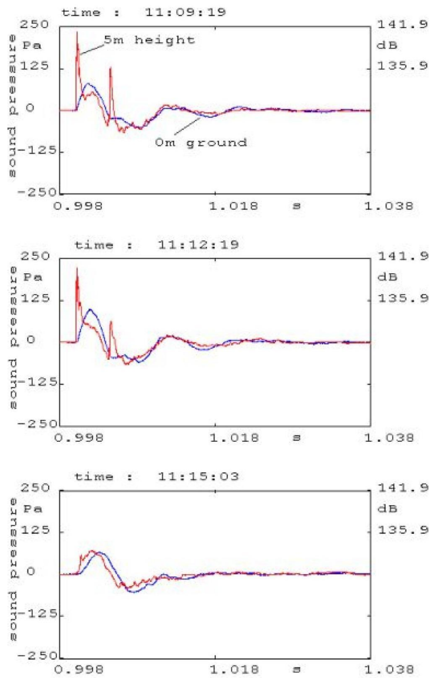
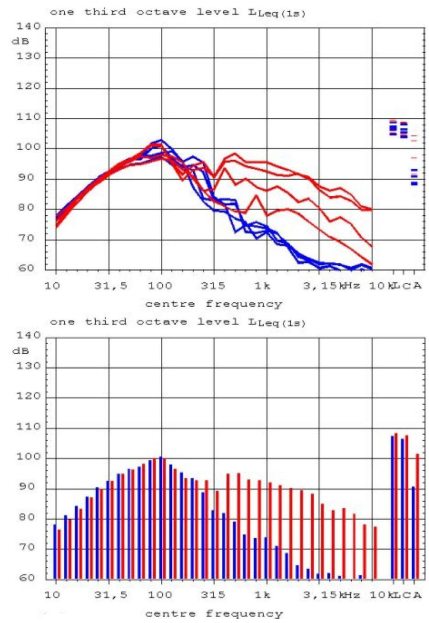
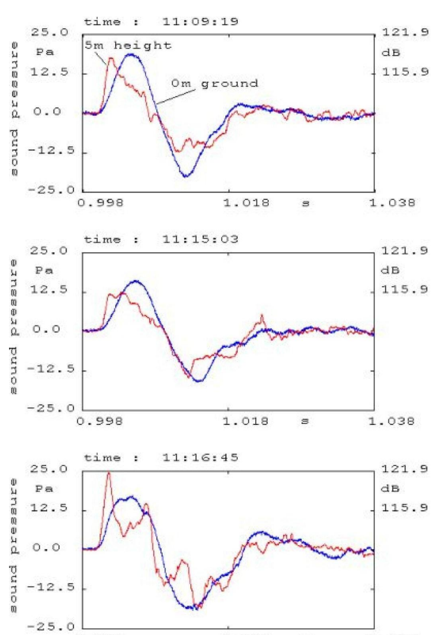


(a): Unweighted pressure time histories at the ground (0 m) and in 5 m height.

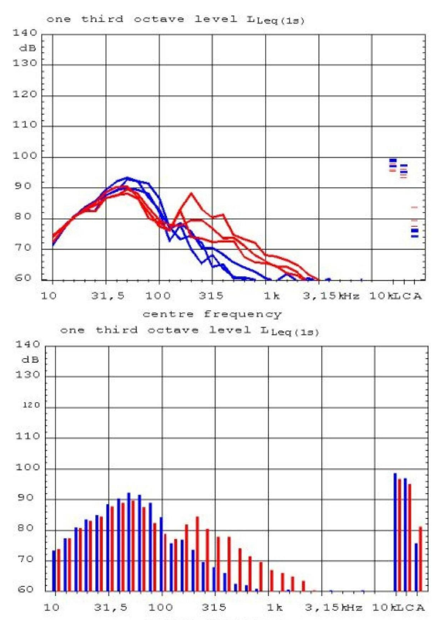


(b): One third octave spectra.

Figure 3: Sonic booms in M5, path length app. 220 m.



(a): Unweighted pressure time histories at the ground (0 m) and in 5 m height.



(b): One third octave spectra.

Figure 4: Sonic booms in M8, path length app. 570 m.

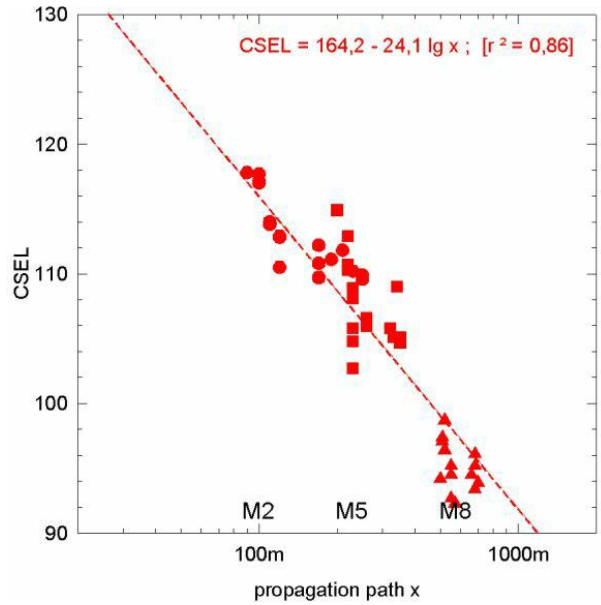


Figure 5: Δ CSEL in 5 m height versus distance (i.e. the length of the propagation path).

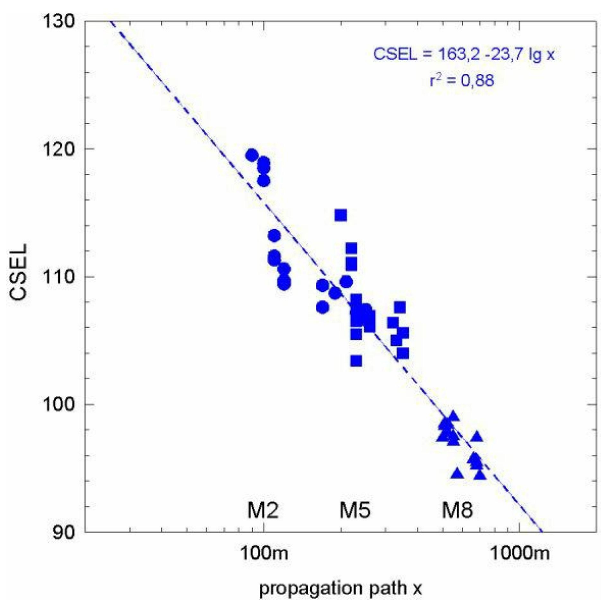


Figure 6: Δ CSEL on the ground (0 m) versus distance (i.e. the length of the propagation path).