

Drophammer Test Investigations on Some Inorganic and Organic Azides

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Summary

A specific drophammer test apparatus for measuring the maximum absolute acoustic level was designed and installed. In this contribution we report the results of the testing of six different explosives. All used substances, which are silver azide, lead azide, cyanuric triazide, 1,3,5-trinitro-2,4,6-triazidobenzene (TNTA), 1,3-dinitro-2,4,6-triazidobenzene (DNNTA) and 1,3,5-trinitro-2-monoazidobenzene (TNMA), contained at least one azide group.

1. Introduction

Due to the use and preparation of explosive materials in our group, especially azides⁽¹⁾ and nitro compounds⁽¹ⁱ⁾, it was useful to build a drophammer test apparatus to investigate the impact sensitivity of the compounds with the possibility of measuring the acoustic levels of explosions. Various drophammers are in use by different institutions and companies in order to investigate the safety characteristics of commercial and military explosives⁽²⁾. Variables are the drop mass and its altitude. In our case the drophammer had always the same height, but it was possible to choose between two different weights (5 kg and 250 g).

2. Drophammer Test Apparatus

A schematic diagram of the drophammer is shown in Figure 1. The apparatus is based on a 600 kg concrete block, on top of which a replaceable polished steel plate (T 316 SS) for the samples was fixed. A 60 cm height metal frame contains the drophammer release mechanism, the light barrier and a sledge with roller bearings for the drophammer. A small box beside the block contains the electronic devices like the light barrier control and trigger delay. The distance between the microphone (from "Beyerdynamic", model M101 N(C)) and the impact area was fixed to 140 cm and the drop height was 52 cm (see Figure 1). For all experiments, the Hewlett-Packard HP VEE software, version 4.01 (1997)

was used. Two programs have been developed based on this program, one for recording the measurements and the other for the interpretation of the data.

The acoustic level operating the drophammer without explosion was 119 dB (zero value) which was significantly lower than the obtained values of 140–150 dB with test substances (logarithmic scale, cf. Eq. (1)).

3. Sample Preparation

All substances used, such as silver azide⁽³⁾, lead azide⁽⁴⁾, cyanuric triazide⁽⁵⁾, 1,3,5-trinitro-2,4,6-triazidobenzene (TNTA)⁽⁶⁾, 1,3-dinitro-2,4,6-triazidobenzene (DNNTA)⁽¹ⁱ⁾ and 1,3,5-trinitro-2-monoazidobenzene (TNMA)⁽⁷⁾ were synthesized by literature methods. The samples for the impact test were dried at 50 °C in an oven over night and placed between two sheets of sandpaper (180 grit).

4. Experiments

The samples (10–40 mg, see Table 1) were loaded between two sheets of sandpaper (180 grit, covered area ca. 0.25 cm²) which were placed directly onto the steel plate (polished stainless steel, T 316 SS) in the impact area. The drophammer impact surface (cylinder with flat round surface, d = 15 mm) also consisted of polished stainless steel (T 316 SS). For data collection the following parameters were used (for software see above): scan rate: 200 000; no. of scans: 65536; range of voltage: ±1.25 V. The drophammer was finally released from a safe place outside the room with a remote control.

5. Results

5.1 Physical Background

To interpret the measured data it was necessary to adjust the specific data of the microphone used by applying the following physical equations⁽⁸⁾:

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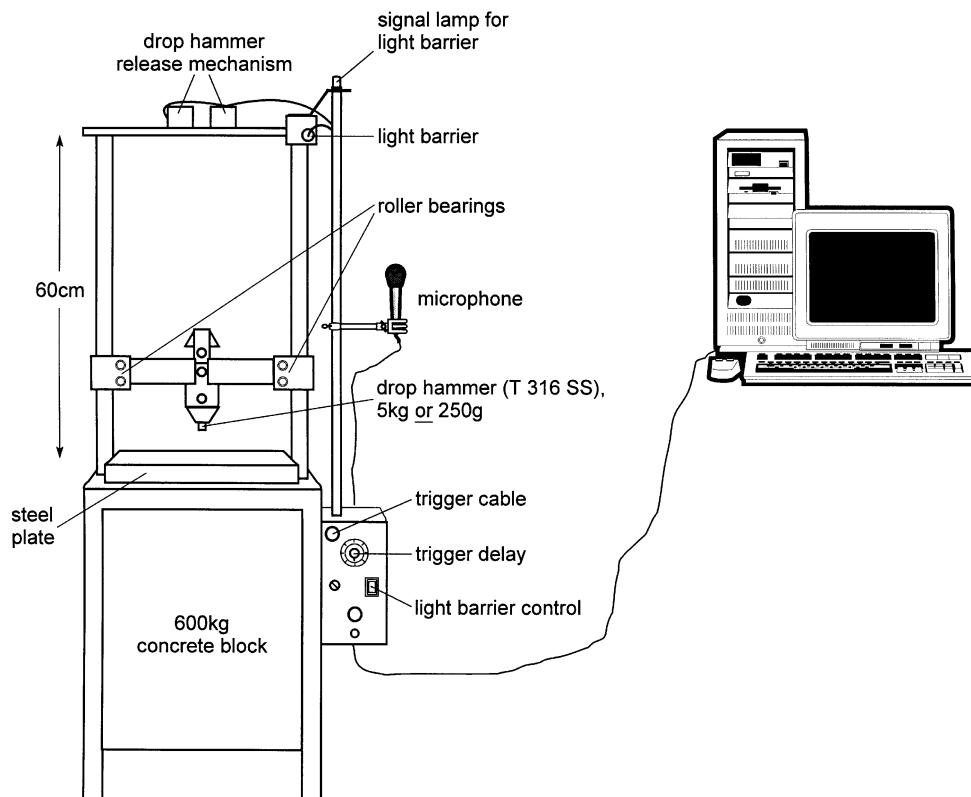


Figure 1. Drophammer test apparatus.

Table 1. Average values of max. abs. acoustic level in [dB] for different chemical substances and different amounts

Substance	Amount [mg]	Average value of max. abs. acoustic level [dB]
silver azide AgN_3	35	149.75
lead azide $\text{Pb}(\text{N}_3)_2$	40	147.84
cyanuric triazide $(\text{N}_3\text{CN})_3$	10	140.09
	20	148.72
	30	152.28
1,3,5-trinitro-2-monoazidobenzene (TNMA)	10	141.06
	20	149.58
	30	151.96
1,3-dinitro-2,4,6-triazidobenzene (DNMA)	10	147.61
	20	151.24
1,3,5-trinitro-2,4,6-triazidobenzene (TNTA)	10	146.28

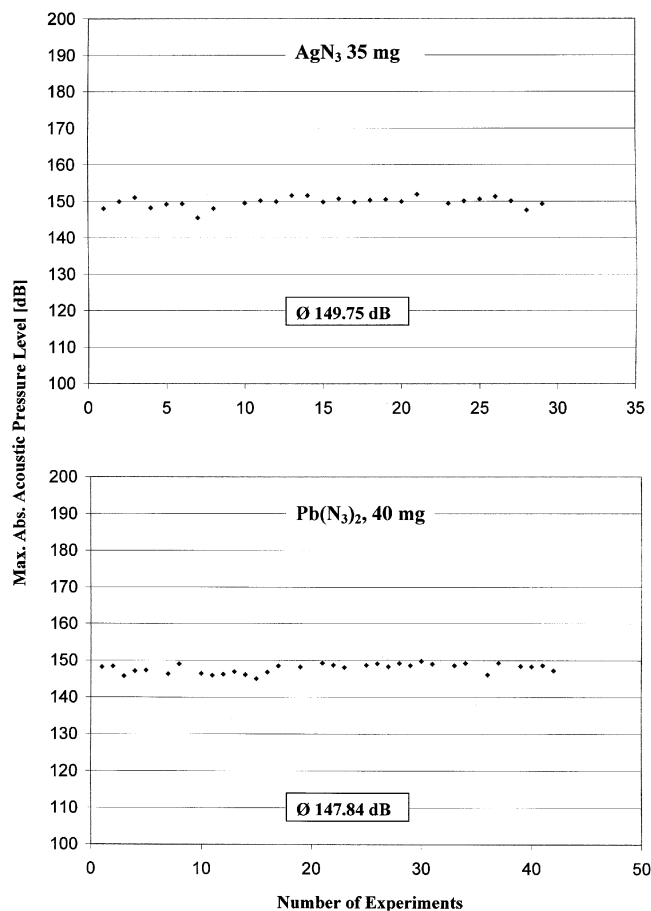


Figure 2. Results (max. abs. acoustic pressure level) of the drophammer tests for AgN_3 and $\text{Pb}(\text{N}_3)_2$.

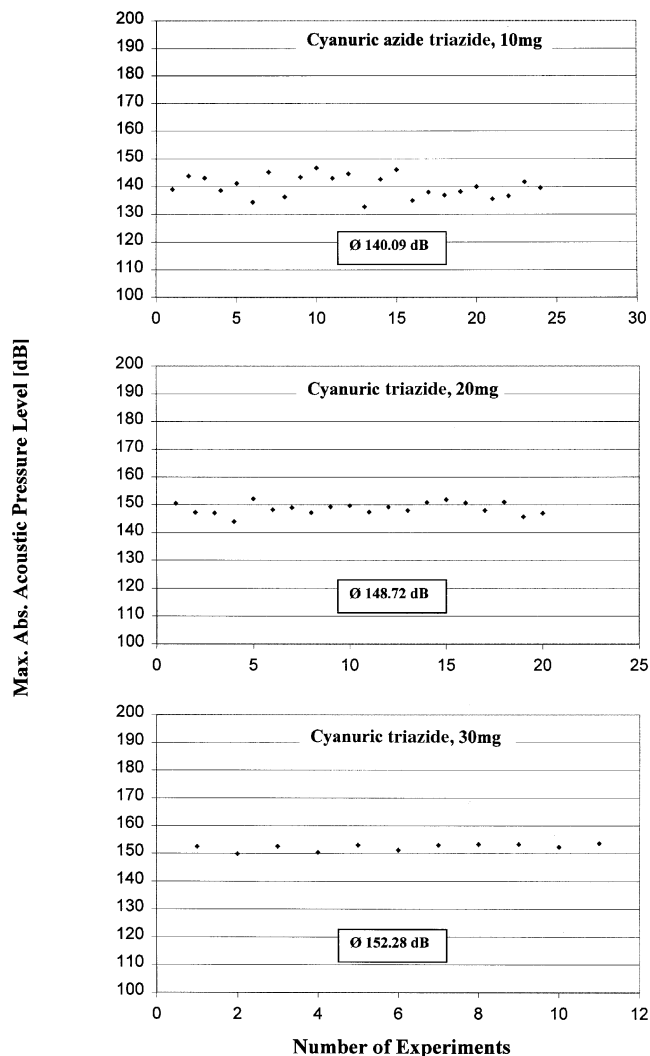


Figure 3. Results (max. abs. acoustic pressure level) of the drophammer tests for cyanuric triazide.

acoustic intensity, I : acoustic energy, which hits one square metre per second; unit [W/m^2].

acoustic level, L' :

$$L' = 10 \cdot \lg\left(\frac{I}{I_0}\right), \text{ unit [dB]} \quad (1)$$

$$I_0 = 10^{-12} \text{ W}/\text{m}^2$$

absolute acoustic pressure level, L :

$$L = 20 \cdot \lg\left(\frac{p}{p_0}\right), \text{ unit [dB]} \quad (2)$$

$$p_0 = 2 \cdot 10^{-5} \text{ Pa}$$

specific data of the used microphone:

$$1.0 \text{ mV} \hat{=} 0.769 \text{ Pa} \quad (3)$$

The Eqs. (1)–(3) were implemented into the interpretation program to analyze the maximum values of voltage, pressure

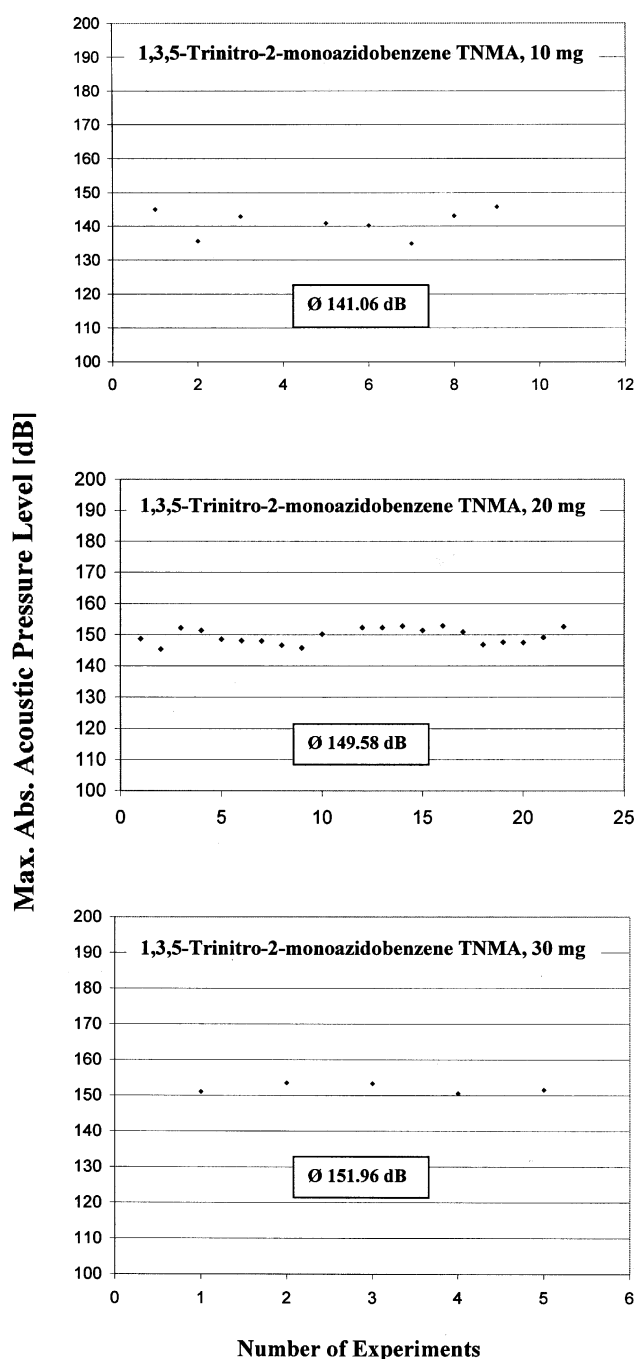


Figure 4. Results (max. abs. acoustic pressure level) of the drophammer tests for 1,3,5-trinitro-2-monoazidobenzene.

level and absolute acoustic level for each measured explosion.

5.2 Experimental Results

Table 1 shows the experimental results. For each substance and each amount 5 to 40 drophammer tests were carried out. The average values (\varnothing) of the above defined acoustic levels are shown.

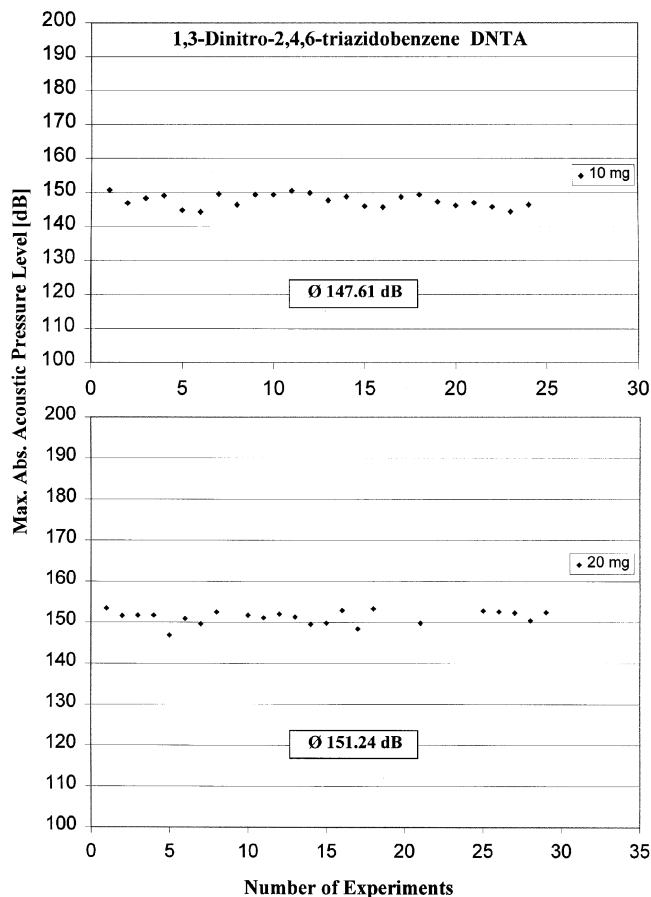


Figure 5. Results (max. abs. acoustic pressure level) of the drop-hammer tests for 1,3-dinitro-2,4,6-triazidobenzene.

Figure 2 shows the max. abs. acoustic pressure level diagrams of silver and lead azide. The average value for silver azide is higher than the one for lead azide, although the amount is lower. This indicates that AgN_3 is a more powerful substance under the test conditions applied in this study than is $\text{Pb}(\text{N}_3)_2$ which is in accord with the literature⁽⁹⁾.

Cyanuric triazide, $(\text{N}_3\text{CN})_3$, seems to be a much more powerful explosive than silver or lead azide. An explosion of 20 mg $(\text{N}_3\text{CN})_3$ has nearly the same acoustic level as generated from 40 mg of $\text{Pb}(\text{N}_3)_2$ or 35 mg of AgN_3 .

The higher variation of the acoustic pressure level at an amount of 10 mg is normal, because of the higher absolute weight deviation, which is more dramatic in small amounts than in higher ones. The results of the explosion tests for cyanuric triazide in the amounts 10, 20 and 30 mg are shown in Figure 3.

Beside the more inorganic compounds described above we also tested some organic nitroazide compounds. But even the weakest of these organic explosives has a higher acoustic level than AgN_3 or $\text{Pb}(\text{N}_3)_2$. The order of the acoustic level is $\text{TNMA} < \text{DNTA} < \text{TNTA}$, but the values for DNTA and TNTA are very similar. Figure 4 shows the results for 1,3,5-trinitro-2-monoazide, Figure 5 for 1,3-dinitro-2,4,6-triazidobenzene and Figure 6 a comparison for TNMA, DNTA and TNTA for 10 mg substance.

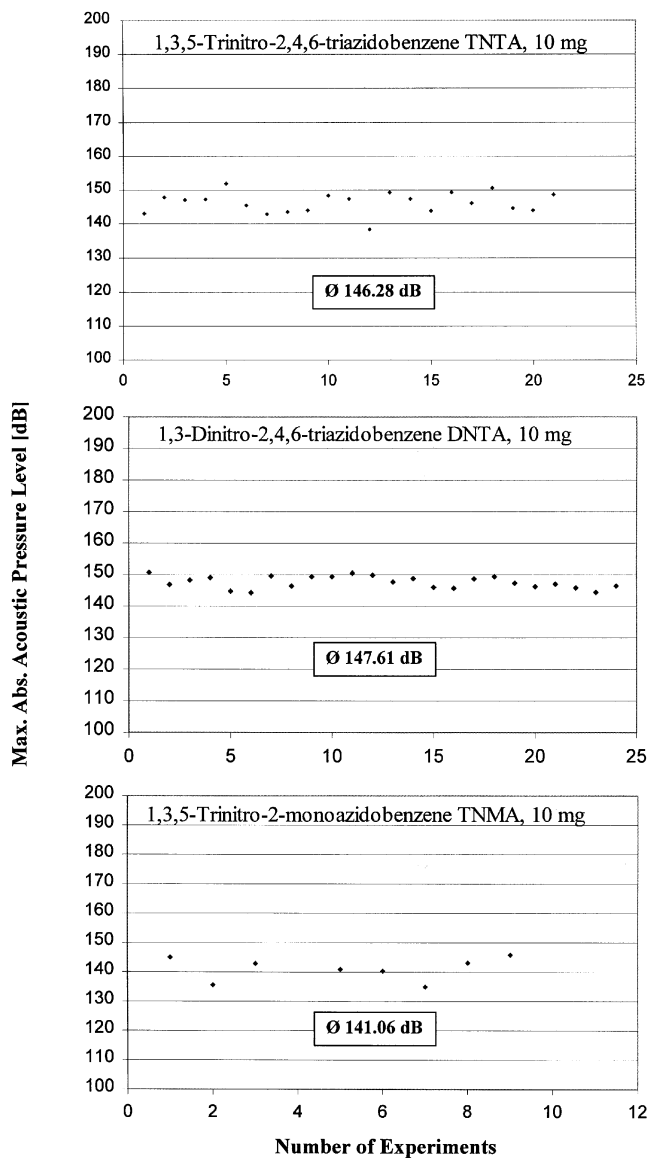


Figure 6. Results and comparison (max. abs. acoustic pressure level) of the drop-hammer tests for TNMA, DNTA and TNTA for 10 mg substance.

6. Conclusions

The designed drop-hammer apparatus has been claimed to be a very useful tool for research purpose and the handling sensitivity. The values of the measured max. abs. acoustic levels provide a valuable quantitative scale for the explosives to generate acoustic pressure levels under the drop-hammer stimuli. Even the weakest of the investigated organic explosives (TNMA) shows a higher acoustic level than AgN_3 or $\text{Pb}(\text{N}_3)_2$. However, it is not clear whether the acoustic level can be directly correlated to the detonation power. Nonetheless, as already mentioned in the literature⁽¹⁰⁾, the drop-hammer impact test is easy to carry out, but the results from different research laboratories are sometimes not easily comparable. However, the method provides a relatively easy and straight-forward technique to qualitatively screen the reaction power of different explosives under this investigation.

7. References

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