CHARACTERISATION AND EXPLOSIVE PROPERTIES OF FOX 7

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Abstract:

The new High explosive FOX 7 was tested in view of German Test methods. Impact- and friction sensitivity were tested and experiments for assessing the performance were conducted. FOX 7 proved to be an insensitive high explosive with a performance comparable to RDX. It has a great potential for substituting the standard high explosives, which are in use today.

1 Introduction

Since many years, around the world, one tries to synthesise new explosive materials, which can substitute the high explosives in service today. Such new material should have a better performance at the same sensitivity level or should be less sensitive at the same performance level.

Such a compound, which has been synthesised is CL 20, a high explosive with an excellent performance but it showed, that it is quite sensitive and behaves like a primary explosive.

Since a short time a new explosive, produced in Sweden, called FOX 7 is available. The molecule , 1,1dinitro 2,2 diamino ethene, unlike e.g. CL 20, is a very simple one.

In order to asses whether this substance exhibits the potential to replace the standard high explosives (TNT, RDX, HMX) in Germany, FOX 7 was tested with German test methods. The thus obtained results are reported in the following.

2 Experiments

2.1 Characterisation

For characterisation the substance, microscopic and SEM pictures were taken and the grain size distribution was determined. Furthermore for identification purposes, the material was investigated by x-ray diffraction.

2.2 Chemical/thermal stability

The chemical/thermal stability of FOX 7 was assessed by Differential-Thermo Analysis/Thermogravimetry (DTA/TG).
The heating rate was 5 K/minute, the sample size 200 mg.

2.3 Sensitivity

In order to get an idea of the sensitivity of the substance, impact and friction sensitivity were determined.
For determining impact and friction sensitivity the BAM test set up was used. The evaluation of the impact data was different to BAM method. Instead of 6 trials per energy level ten trials were performed. The results were evaluated by a procedure described in [1].
The main point of this procedure is to estimate the probability, with error limits, for reaction (or no reaction) at each energy level, then to fit a function which runs in its whole course within the error limits. The function used in this procedure is the Weibull distribution, which proved to be very useful for this purpose.

2.4 Performance

The performance of FOX 7 was determined by a modified impedance mismatch procedure.
For the tests, pressed cylinders of the pure material (without any phlegmatizer) were used.
The length of the cylinders was 20 mm, the diameter 21 mm, they were pressed to a density of 1,7 g/cm³. Five such cylinders were assembled to a column, which was initiated by 10 g of RDX/WAX (95/5). At end of the column an aluminium disc was fixed and the free surface velocity of the disc, caused by the shock wave transferred into the aluminium by the detonation of the material, was measured. This measurement was done by two velocity pins.
Beside the free surface velocity, the detonation velocity of the material was determined. For this measurement simple compression probes were used.
The experimental set up can be seen in figure 1.

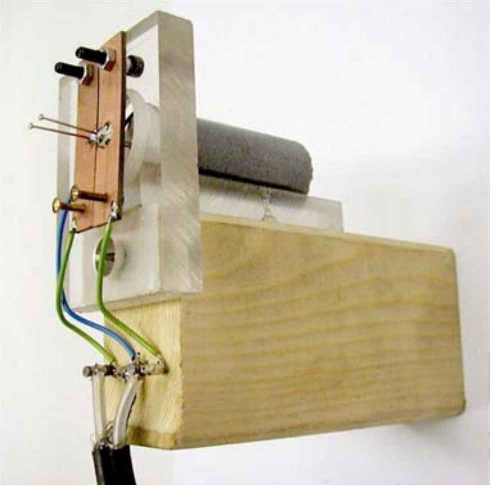


figure 1: Experimental Set Up for measuring
free surface velocity

For comparison the same measurements were performed with TNT, RDX/WAX (95/5) and HMX/WAX (97/3). Dimension and density of the samples were the same as FOX 7.

3 Results

3.1 Characterisation

The grain size distribution is shown in the following table.

Size [µm]	Percentage
0>50	15.96
50>100	9.40
100>200	25.94
200>400	41.40
400>800	7.30

The figures 2 and 3 show microscopic and SEM photographs of FOX 7 grains. As can be seen from these figures the crystal shapes can still be optimised.

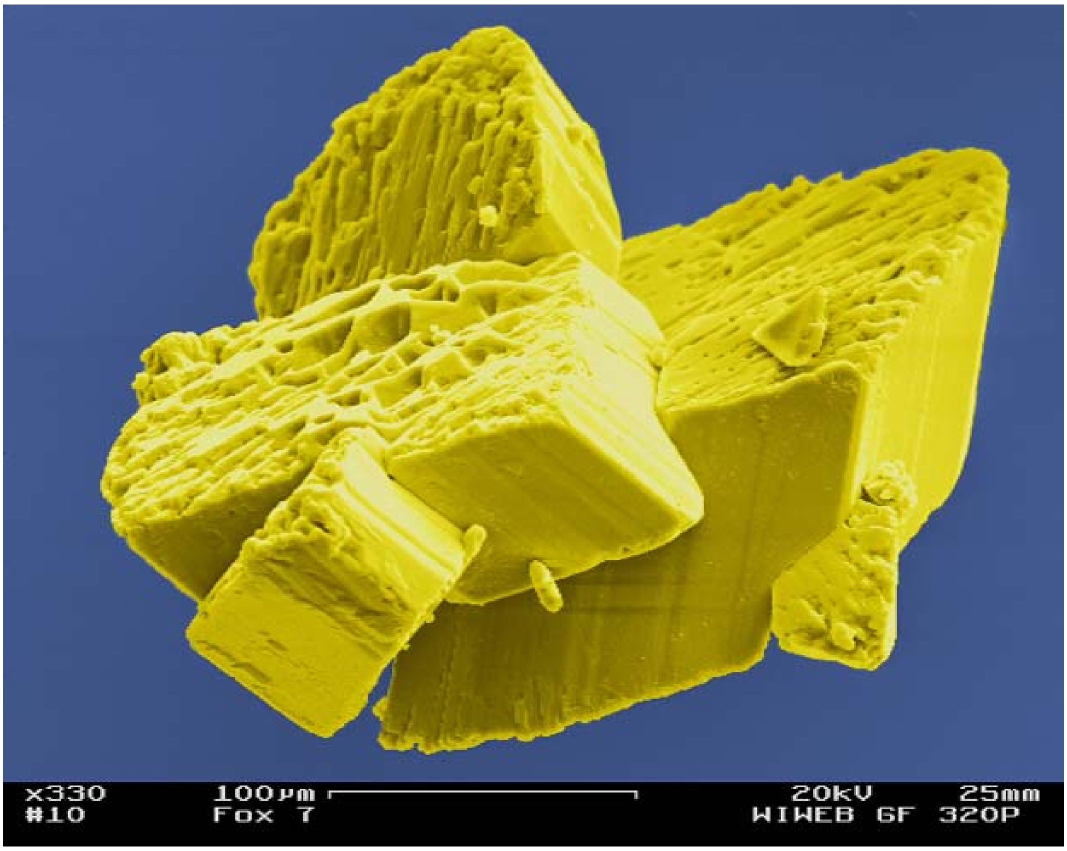


figure 2: SEM photograph of FOX 7 grain

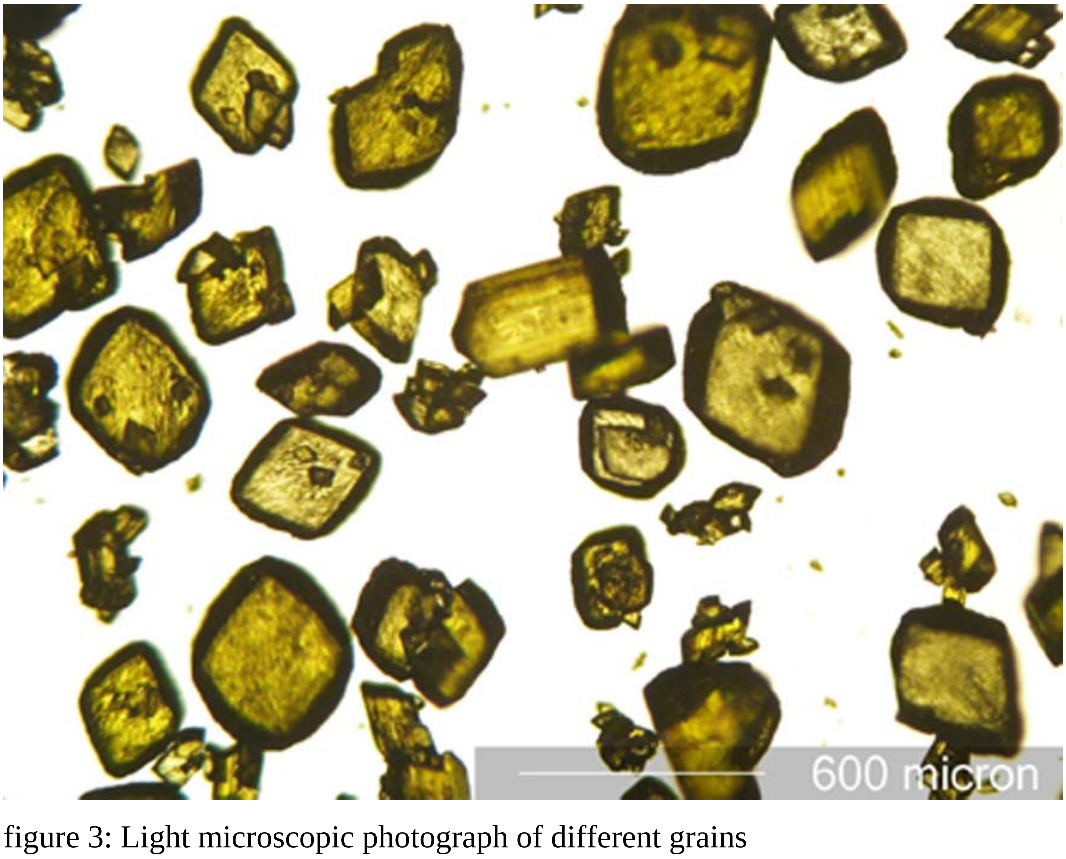
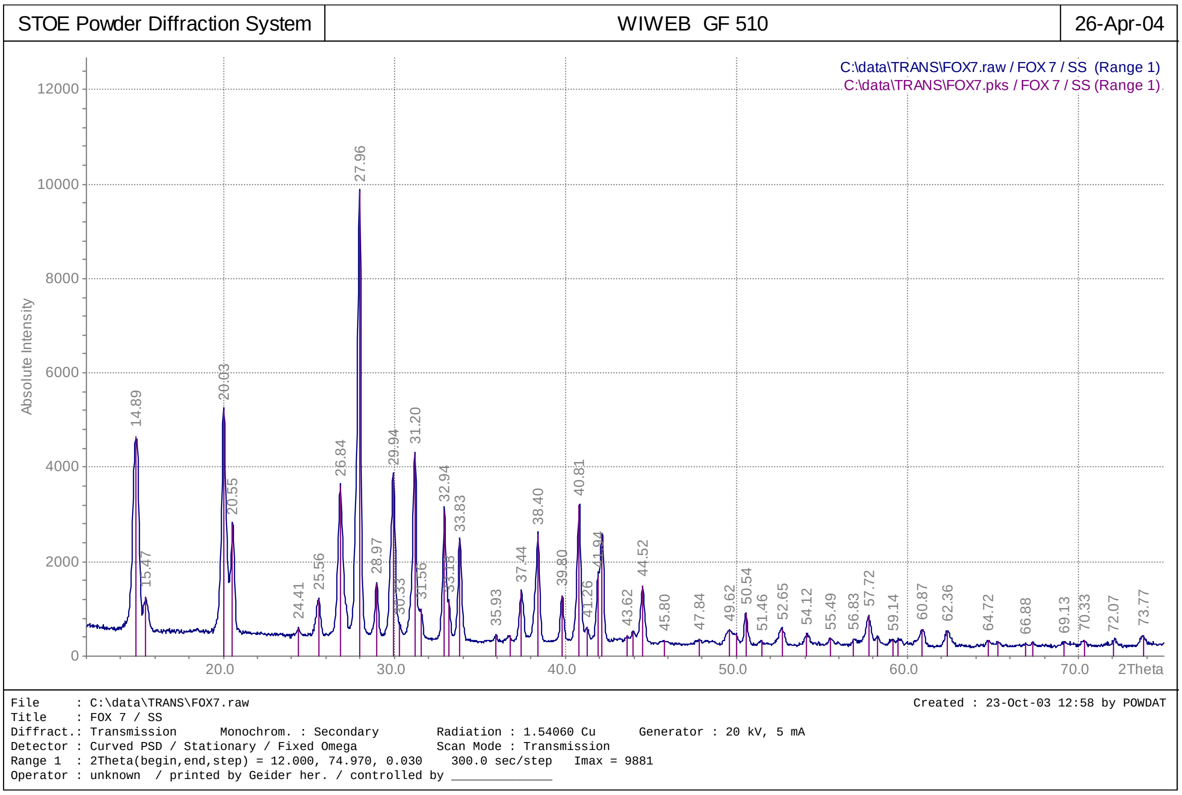


figure 3: Light microscopic photograph of different grains

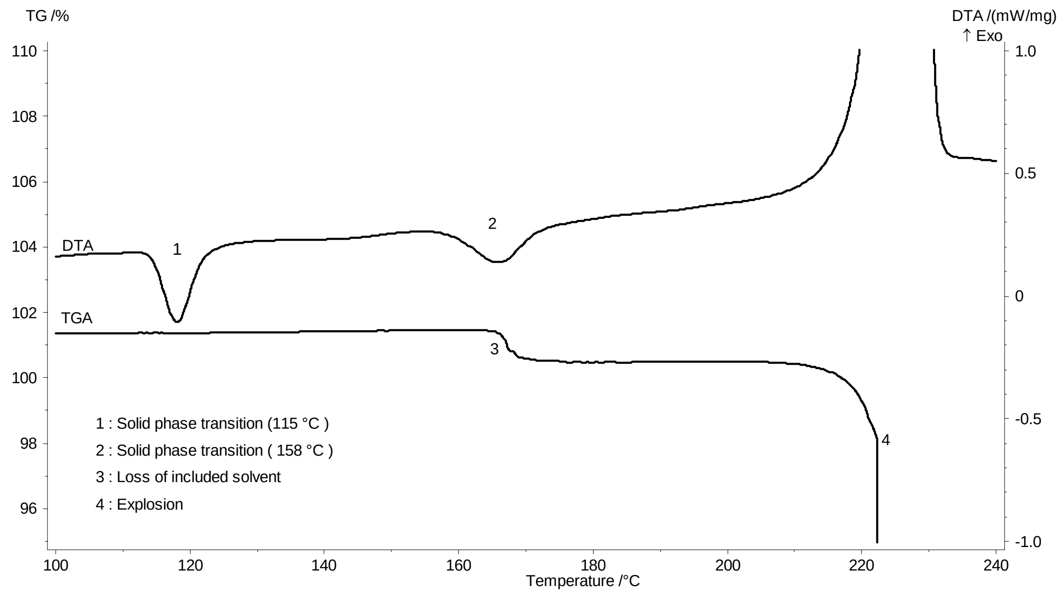
The diffraction diagram is shown in the next figure



Diffraction diagram of FOX 7

3.2 Chemical/thermal stability

The result of the DTA/TG investigation is shown in next diagram.

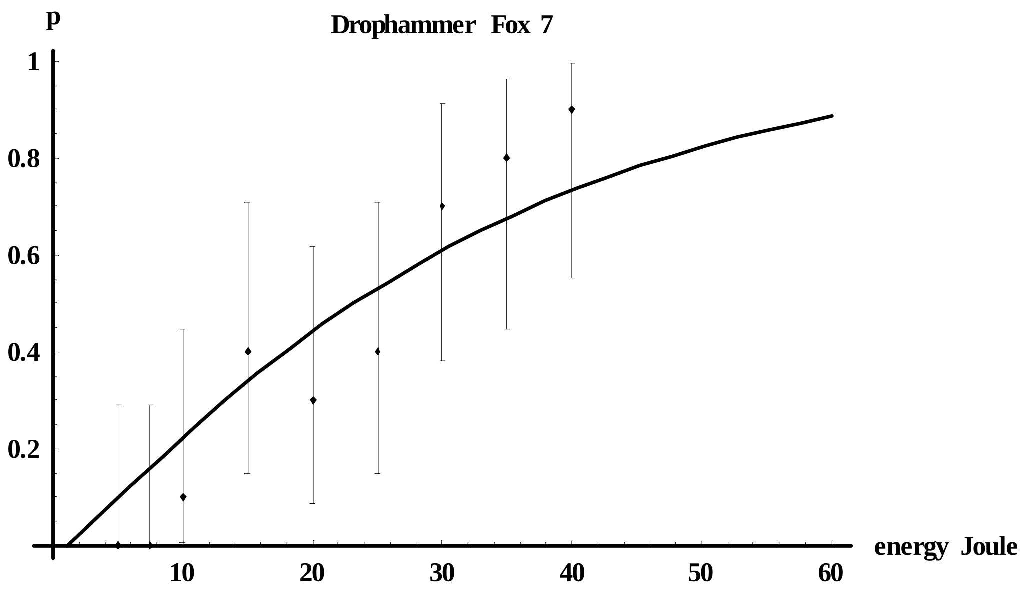


As can be seen, FOX 7 is a very stable substance, the decomposition reaction starts (explosion) at approx. 210 °C. More detailed information about the thermal behaviour of FOX 7 is available in the paper of Ticmanis et al. [2].

3.3 Impact and Friction Sensitivity

Friction Sensitivity At a load of 360 N five reactions occurred out of six trials. Compared to TNT and tetryl, which are not sensitive to friction, FOX 7 is somewhat more sensitive than those two substances but 360 N is the highest load which is tested in BAM Friction Test. Therefore FOX 7 can be regarded as insensitive to friction.

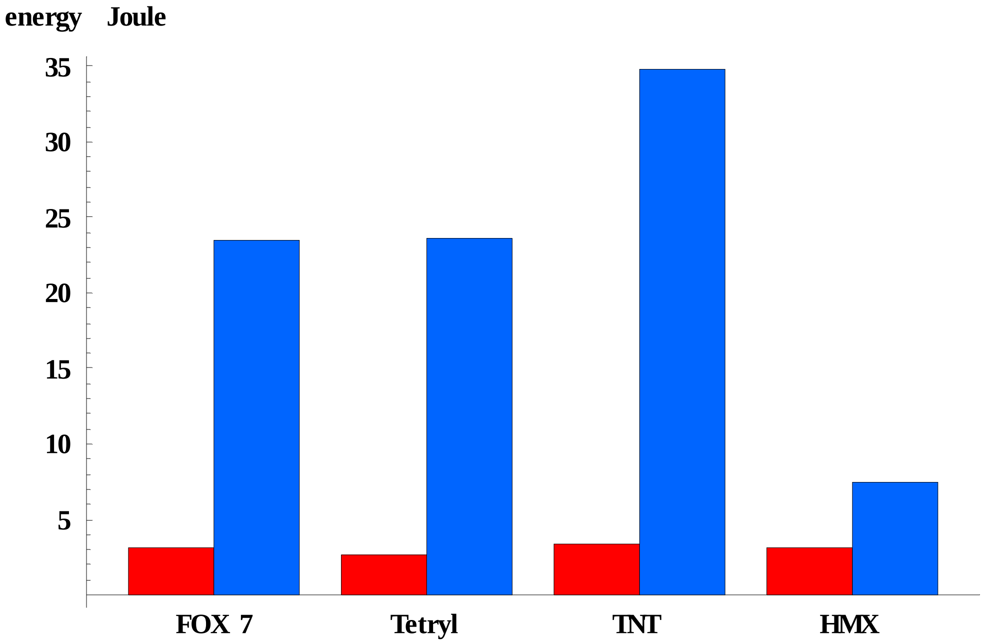
Impact Sensitivity The results are shown in the next diagram.



From this diagram one can read the probability for reaction as function of energy level.In the next table the impact energies for 5 % and 50 % reaction probabilities are listed.

Probability [%]	Impact Energy [N]
5	3.1
50	23.8

For comparison the impact energies for TNT, tetryl and HMX, determined by the same procedures, are presented in the following bar chart (the left bars stand for 5%, the right ones for 50%).



This chart shows, that impact sensitivity of FOX 7 is within range of the standard high explosives, i.e. FOX 7 is rather insensitive to impact. According to STANAG 4170 it meets the requirements, even unphlegmatized, for main charges.

3.3 Performance

The free surface velocity of the aluminium disc, the shock pressure induced in the aluminium and detonation velocity , together with the data of the other substances are summarised in the following table.

	FOX 7	TNT	RDX/WAX	HMX/WAX
Detonation Velocity [mm/µs]	8.0	6.8	8.3	8.3
Free surface velocity [mm/µs]	1.3	0.94	1.3	1.4
Shock pressure [GPa]	≈ 26	≈17	≈ 26	≈ 28

As can be seen, FOX 7 performs better than TNT and similar to HMX and RDX.

By means of the formula[3]:

$$p_D = \frac{p_{Al}}{2} * (1 + \frac{v_D * \rho_E}{v_{Al} * \rho_{Al}})$$

with

p_D detonation pressure

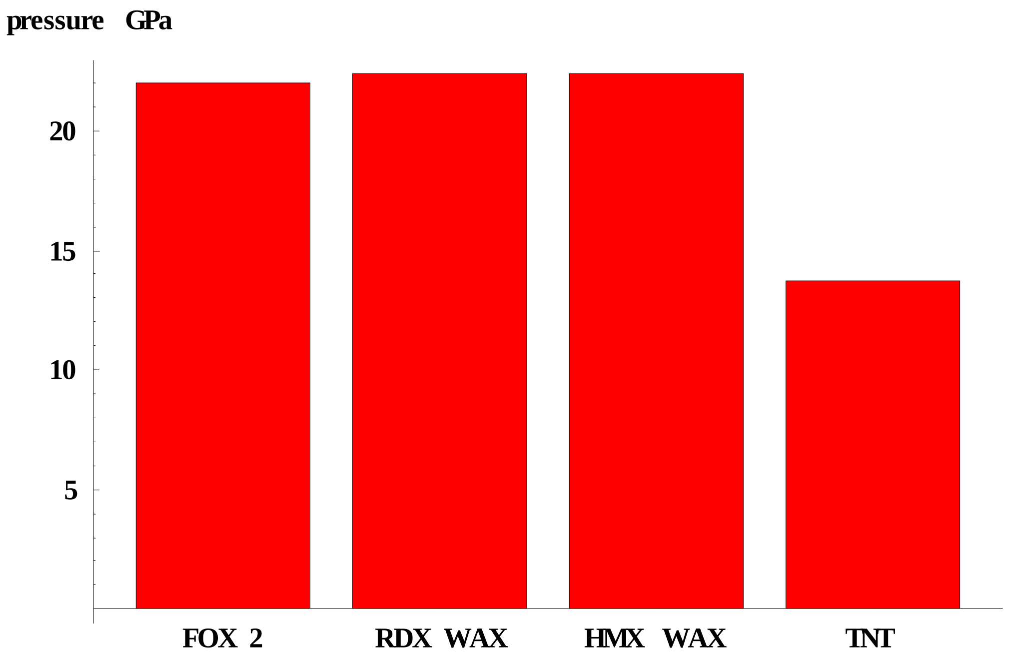
p_{Al} shock pressure in aluminium

$v_{D/Al}$ detonation velocity resp. Shockwave velocity in Al

$\rho_{E/Al}$ density of the explosive resp. Aluminium

the detonation pressure can be estimated.

The results are shown in the next bar chart.



4 Summary

The rather new high explosive FOX 7 was assessed by German test methods. FOX 7 proved to be a rather insensitive material. The performance is better than TNT and similar to HMX and RDX. As can be seen from SEM pictures crystal shapes can still be optimised, which may further reduce the sensitivity.

FOX 7 has certainly the potential to substitute the standard high explosives which are in use today.

Literature:

[1] R. Wild, E. von Collani, Modelling of explosive sensitivity Part 2: The Weibull Model
Economic Quality Control, Vol 17 (2002), No 2, 195-220

[2] U. Ticmanis et al., Product Qulaity and Decomposition Kinetics of FOX 7
Annual ICT Meeting 2004

[3] Encyclopedia of Explosives and related Items, Picatinny Arsenal, Dover New Jersey, 1960