

## SPACE-TIME CHARACTERISTICS OF PRE-DETONATION LUMINESCENCE ORIGIN IN HEAVY METAL AZIDES

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### Abstract:

*The topography of the origin and propagation of pre-explosive luminescence in  $AgN_3$  has been investigated for the first time. The origin of the explosive chain reaction was found to be of hot spot nature. The propagation rate of the chain reaction was  $1500 \pm 300$  m/s, leading to the conclusion that propagation results from hole diffusion.*

NTREM, PARDUBICE, 2003 page 12-17

## SYNTHESIS AND REACTIVITY OF $(CF_3)_2PN_3$ , $(CF_3)_2AsN_3$ , $CF_3AsClN_3$ AND $CF_3As(N_3)_2$ AZIDES

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### Abstract

*The trifluoromethyl-phosphinous and -arsinous azides, namely  $(CF_3)_2PN_3$ ,  $(CF_3)_2AsN_3$ ,  $CF_3As(N_3)_2$ , and  $CF_3AsCl(N_3)$ , have been synthesized readily and safely with sodium azide reagent. Their distinct reactivity can be attributed to the presence of electronegative trifluoromethyl substituents. The reactions of the  $CF_3$ -arsinous azides with reagents such as hydrogen chloride and  $(CF_3)_2NO$  radical will also be discussed. The Staudinger reactions of  $(CF_3)_2MN_3$  ( $M = P$  and  $As$ ) with tertiary phosphines yield phosphazene and the arsenic analogue, which display unusual structures and bonding modes. Chain propagation behaviour of the diphosphazene ligand has been shown to be possible.*

NTREM, PARDUBICE, 2003 page 18-29

## PRE-DETONATION PHENOMENA IN HEAVY METAL AZIDES

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### Abstract:

*A possible model for initiation of heavy metal azides (HMAs) is described, considering reaction centers as associations of cationic and anionic vacancies. Premises for the model suggested and its physical groundwork and mathematical apparatus are presented. From the analysis of the model it has been shown that the available wealth of experimental data is qualitatively described by the model suggested.*

NTREM, PARDUBICE, 2003 page 30-35

## SIMPLE METHOD OF SYNTHESIS AND CHARACTERIZATION OF SOME NITROCYANAMIDE SALTS

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### Abstract:

*A simple method has been offered to obtain alkali salts of nitrocyanimide ( $N\equiv C-NHNO_2$ ) by means of interaction between potassium (or sodium) hydroxide and S-methyl-N-nitroisothiourea. Ammonium salt of nitrocyanimide can be obtained with quantitative yield through the exchange reaction between potassium salt of nitrocyanimide and ammonium sulphate. UV-, FTIR-spectroscopy, X-ray powder diffraction and thermal characterization are all used to characterize the salts obtained.*

NTREM, PARDUBICE, 2003 page 36-44

## **INFLUENCE OF AMMONIUM NITRATE PRILLS' POROSITY AND DIMENSIONS ON DETONATION VELOCITY OF ANFO EXPLOSIVES**

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### **Abstract:**

*Prilled/granulated ammonium nitrate is commonly used as a fertiliser and basic ingredients of industrial explosives, especially ANFO. One of the important factor affects on explosive properties of ANFO explosives, is prills'/granules' porosity. In this paper an attempt of such steering of ammonium nitrate characteristics, that manufactured ANFO has high detonation properties, is presented. The method of manufacturing of porous ammonium nitrate, which has high oil absorption, has been elaborated. Relations between porosity and granulometric distribution of ammonium nitrate versus detonation velocity of ANFO have been examined. It has been investigated, that detonation velocity of ANFO significantly increases, if increases porosity and decreases dimensions of ammonium nitrate prills/granules.*

NTREM, PARDUBICE, 2003 page 45-51

## **DETO2D - THE COMPUTER CODE FOR SIMULATIONS OF GASEOUS DETONATIONS IN COMPLEX GEOMETRIES**

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### **Abstract**

*Mathematical model and two-dimensional computer code were developed for simulations of propagation of detonation waves in tubes, channels and complex geometry. The code is based on FCT numerical algorithm. It includes detailed schemes for chemistry. The code is still under development. It is currently used for simulations of detonation propagation, quenching and reinitiation in detonation arresters.*

NTREM, PARDUBICE, 2003 page 52-62

## **EMULSIONS EXPLOSIVES ELMULEX AND ELMULEXAL**

Technical characteristics - testing and standards

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### **Abstract:**

*If the ammonium nitrate ( $NH_4NO_3$ ) we sensitive with the supplement of flammable substance (put and alloy powdered, mineral oils, waxen, etc.) in quantities sufficient during attaining the equal balance of oxygen, we will get explosive which will be simple in the making, low price, sure by the handling and very brizant (for example brizant of mixtures 94,5%  $NH_4NO_3$  and 5,5% of the mineral oil, which is measured with the ballistic pendulum swinger, amounts 120% brizant of TNT).*

*Other kind of explosives on the base of the ammonium nitrate presents ammonium nitrate sensitized*

with detonation sensitize (5-12% of the TNT or the larger percentage of the DNT or 4-6% of glycerin nitrate beside the supplement of flammable substances for example the coal powder) in quantities which are necessary during attaining the equal balance of oxygen.

The third kind of ammonium nitrate explosive are called emulsions or mushy explosives which introduce suspension of non-dissolution nitrate, organic fuel and insoluble sensitive factors in the saturated mixture of ammonium nitrate and sodium nitrate. Water in emulsions explosives (11-20%) diminishes warmth of the explosion, what is compensated with the larger volume of developed gases and large density of fillings. Emulsions explosives have been developed with the aim of enlargement of efficiency up to then the known explosive beside the simultaneous decrease their sensitivity this attaining ideal technical characteristics.

In the emulsions explosive it is possible to achieve very large contact surface between the ammonium nitrate and emulsions factor and a very short distance between the oxidant and reducer, then it is therefore possible make the explosive with technical characteristics of brizant explosive and with the minimal sensitivity, in other words the large safety by the handling and uses.

We can say that the emulsion explosives unite characteristics of nitroglycerine explosives and ammonium nitrate explosives (the sensitivity, brizant, reliability and efficiency in the use) in a rate which is necessary, in other words in a rate which manufacturer has reaped. By the emulsion explosives, how forward is quoted, it is possible to achieve different technical characteristics (the ideal relation of consumption of explosive, quantity of executed work on the drilling of mine bores and expected respective given effects of mining - quantities and granulation of mined material, areas of throwing about of material, air striking and seismic waves as a result the activation of explosive charge).

NTREM, PARDUBICE, 2003 page 63-68

## SYNTHESIS OF CERAMIC AND CARBON NANOSTRUCTURES BY SELF-SUSTAINING COMBUSTION OF MIXTURES OF HALOGENATED HYDROCARBONS WITH REDUCERS

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### Abstract:

This paper is aimed at a study of reactions of some fluoro- or chloro- hydrocarbons (like PTFE, heksachlorobenzene, heksachloroethane) with different reducers, such as Al, Mg, Zr, Ti, Zn, Cr, Si, alloys (ZrTi, FeSi) or compounds ( $\text{CaSi}_2$ ,  $\text{Al}_3\text{Mg}_4$ ,  $\text{NaN}_3$ ). Combustion process was carried out in a calorimetric bomb under argon (0.5 MPa). The released heat of reaction was measured and solid reaction products were analysed using ultimate analysis, XRD, SEM, TEM and HRTEM techniques to identify their composition and morphology. We found out that the mixtures are able to self-sustaining highly exothermic reactions (heat of reaction equals up to 8500 kJ/kg). The XRD examinations showed that in addition to turbostratic graphite the combustion products include crystalline phases of  $\text{AlF}_3$ ,  $\text{MgF}_2$ ,  $\text{ZrF}_4$ ,  $\text{TiF}_3$ ,  $\text{CrF}_3$ ,  $\text{ZnF}_4$ ,  $\text{B}_4\text{C}$ ,  $\text{B}_{13}\text{C}_2$ , Si,  $\text{Fe}_3\text{Si}$ ,  $\text{Fe}_5\text{Si}_3$ , SiC,  $\text{CaF}_2$ , and NaF depending on the starting material. The microscopic observations revealed polyaromatic carbon and carbon nanoparticles (30÷40 nm in diameter) in each sample and very interesting nanofibres in the combustion products of silicon containing mixtures. They were identified as 1D single SiC crystals covered with thin layers of amorphous carbon and  $\text{SiO}_2$ .

NTREM, PARDUBICE, 2003 page 69-75

# THE INFLUENCE OF THE TYPE AND INTENSITY OF IGNITION SOURCES ON EXPLOSION PARAMETERS OF THE GASEOUS, DUSTS AND HYBRID MIXTURES

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## Abstract

*Explosion parameters e.g. maximum explosion pressure -  $p_m$ , maximum rate of pressure rise -  $(dp/dt)_m$  and times connected with these variables:  $t_i$  - induction time (time from the ignition to the first rise of pressure),  $t_r$  - reaction time (time when  $(dp/dt)_m$  is got) and the  $t_m$  - time when  $p_m$  is got, are influenced by the type and intensity of ignition sources at the gaseous, dusts and hybrid explosions. It means that variables, which are calculated or evaluated from measured ones, e.g. flammability limits - lower flammability limit and upper flammability limit, are influenced too. Following types of ignition sources were chosen for comparison: electric fuse, Vesuvit TN and nitrocellulose. The intensity of ignition sources was varied. Attention was fixed on gaseous mixture methane - air and hybrid mixture black coal - methane - air.*  
NTREM, PARDUBICE, 2003 page 76-89

# THE INITIATION OF GASEOUS DETONATIONS IN H<sub>2</sub>-O<sub>2</sub> MIXTURES BY INCIDENT SHOCK WAVE

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## Abstract:

*Detonations are an extremely efficient means of burning a fuel-air mixtures and releasing its chemical energy content. Recently there has been renewed interest in the application of intermittent or pulsed detonation to propulsion. The application of detonations involves many difficulties in rapidly mixing the fuel and air, and initiating and sustaining a detonation in a controlled manner. One method of initiating detonation is by using a shock wave to heat the mixture to a temperature, which is above the autoignition temperature. The initiation of detonation by planar shock in constant area tubes has been studied in the past by several authors. In most of these studies the conventional single-diaphragm shock tube technique was used to initiate detonation. This method suffered from several disadvantages, notably those arising from the nonideality of the diaphragm rupture introducing very nonuniform conditions at the interface separating driver gas from the combustible test mixture. For this reason this technique was displaced by removable sliding plate method which was unfortunately also causing nonuniformity in the interface zone. The main objective of the present experiments was to perform preliminary studies of the influence of disturbances on autoignition behind planar shock and initiation of detonation in H<sub>2</sub> - O<sub>2</sub> mixture. The disturbances at the interface separating buffer gas from the test mixture were introduced by means of single wire, multiple parallel wires and wire meshes of various density.*  
NTREM, PARDUBICE, 2003 page 90-100

# DETERMINATION OF THERMAL STABILITY, RESISTANCE TO WATER AND RESISTANCE TO HYDROSTATIC PRESSURE OF ELECTRIC DETONATORS ACCORDING TO DRAFTS OF EUROPEAN STANDARD

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## Abstract:

*In the paper are presented results of testing electric detonators according to New European*

*Standards. In order to establish real, marginal values and values directed by the standard, testing have been performed on suggested devices with extreme parameters applied. Consequently, thermal stability, resistance to water and resistance to hydrostatic pressure of electrical detonators have been measured with wider range than proscribed by the standard. The results obtained by the research were used to evaluate reality of proposed values in New European Standards.*  
NTREM, PARDUBICE, 2003 page 101-108

## **FIRST EXPERIENCE WITH ANALYSIS AFTER LIQUIDATION OF SMOKELESS POWDERS**

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### **Abstract:**

*The aim of this study is an identification of products after combustion of smokeless powders. At first a sample of smokeless powder was burned on the clean sand and then an isolation of compounds from this sand was used for further identification. The accelerated solvent extraction and ultrasonication were used for the isolation of these compounds. Gas chromatography GC 17A with mass spectrometry detector QP505A was used for an identification of compounds.*  
NTREM, PARDUBICE, 2003 page 109-112

## **SYSTEMATIC STUDY OF SIMULATED MINE EXPLOSIONS USING AUTODYN**

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### **Abstract:**

*Within the mine-blast research community, there is an increasing desire to enhance the efficiency and efficacy of mine-resistant vehicles, albeit in a cost-effective way. The explosion of a surrogate mine is studied and modelled by using the GUI based nonlinear dynamics analysis software, AUTODYN. A simple model has been developed to validate numerically obtained results with accessible experimental data. The simulation setup consists of a hemispherical charge, laid on a rigid surface, with the blast waves propagating into the surrounding air. This model setting covers our focus of studying the explosion at close vicinity, which is currently not well laid out in available literature. The crucial feature is an equation of state (EOS) for materials. The surrounding air is described as an ideal gas. Two EOS of detonation products were studied, with the first one being the commonly used empirical equation of state, Jones-Wilkins-Lee (JWL). The second area of study applied the ideal gas form equation of state, often used for simplification in complicated models. The experimental data is obtained from code CONWEP. Two parameters of blast waves, namely, maximum pressure and specific impulse, are compared and evaluated. Further approaches have been proposed for modelling the explosion in air close to the charge surface.*  
NTREM, PARDUBICE, 2003 page 113-120

## **DEGRADATION, REARRANGEMENT AND REDUCTIVE ACETYLATION OF HEXABENZYLHEXAAZASOWURZITANE**

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**Abstract:**

*In the course of searching for an efficient route for reductive acylation of 1, several degradation products were characterized. For instance we have found that refluxing 1 in a solvent of the type R'COX in non-reductive conditions, a semicrystalline, functionalized, isomeric product 2 is formed. The new isomer has lost its high symmetry and turned to be highly complicated for complete NMR assignment. However, synthesis of para-Bromo derivative afforded crystals suitable for X-ray analysis. X-ray crystallography showed that the new HBIW isomer had structure 2.*  
NTREM, PARDUBICE, 2003 page 121-127

## CHEMICAL AND THERMAL STABILITY OF FLEXIBLE PBX's

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**Abstract:**

*In this paper, the flexible PBXs chemical and thermal stability are observed before, during and after their ageing. The following three flexible PBXs were observed: explosive E (RDX/polymer binder), explosive H (RDX/PENT/polymer binder) and explosive N (PETN/polymer binder). All explosives have been introduced into service of the Slovak Armed Forces.*  
NTREM, PARDUBICE, 2003 page 128-136

## AGEING INFLUENCE ON PLASTIC EXPLOSIVES ON THE BASE OF RDX

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**Abstract:**

*This paper presents results of testing of plastic explosives on base RDX during eight months ageing. 5 kind of PBX (plastic bonded explosive) with RDX as their base were investigated. It was discovered one from them (E) is chemically unstable already after 2 months of ageing. The other tested plastic explosives are chemically and heat stable.*  
NTREM, PARDUBICE, 2003 page 137-145

## COORDINATION COMPLEXES AS INORGANIC PRIMARY EXPLOSIVES

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**Abstract:**

*The report deals with the synthesis of coordination compounds in the series of perchlorates of d-metals containing polynitrogen heterocyclic ligands. Considerable attention is also devoted to the characterization of the compounds obtained and their applications in safe electric and laser detonators.*  
NTREM, PARDUBICE, 2003 page 146-152

## 1-(3',5'-DINITROPHENYL),-3,3-DINITROAZETIDINE: A NEW ENERGETIC MATERIALS

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**Abstract:**

Strained polynitro cyclic compounds are at the forefront of the search for more powerful and less sensitive energetic materials. Examples in this regard are polynitrobicyclooctane, polynitrocubanes, polynitropolycyclododecane, and various polynitromono- and polycyclicpolyazanitramines. Such materials are potentially useful as explosives, propellants, fuels, and oxidizers in applications requiring substances which combining high energy, high density and reduced sensitivity properties. An important new member of this class of energetic materials is 1,3,3-Trinitroazetidene. Based on this analogy, we have synthesized 1-(3',5'-Dinitrophenyl), 3,3-dinitroazetidene and fully characterized the new derivative. The thermal, safety and explosive properties of the new compound compared with TNAZ., shows the new derivatives having acceptable energetic performance.  
NTREM, PARDUBICE, 2003 page 153-159

## CRYSTALLIZATION OF HEXANITROSTILBENE

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**Abstract:**

A literature survey of methods for hexanitrostilbene (HNS) crystallization is presented. Crystallization of HNS from N-methylpyrrolidinone, cyclohexanone, dimethylformamide and nitric acid are part of the experimental section. Cyclic heating-cooling crystallization from dimethylformamide produces HNS with bulk density 0,28 g/cm<sup>3</sup>. Crystallization from nitric acid produced HNS with bulk density 0,56 g/cm<sup>3</sup> and acidity 0,028% and 0,083%. resp. with dependence on the acidity method determination.  
NTREM, PARDUBICE, 2003 page 160-165

## STUDY OF DECOMPOSITION OF TNT BY HEAT AND SHOCK

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**Abstract:**

Samples of technical TNT exposed to heat or to shock have been analysed chromatographically (HPLC). It was found that the main decomposition products are identical in the two cases. It has been stated that the chemical micro-mechanism of the primary fragmentations of shocked TNT molecules should be the same as in the case of their low-temperature thermal decomposition  
NTREM, PARDUBICE, 2003 page 166-172

## EXPLOSION HAZARD OF SOME ORGANIC PEROXIDES

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**Abstract:**

The ultimate objective of our work was to investigate the ability to heat explosion, burning and detonation of some organic peroxides. The main attention was paid to investigation of cumene hydroperoxide, but some properties of benzoyl peroxide and were collected and analyzed too. For the first time the law of burning rate of CH) and temperature of burning were measured at p=24-36 MPa, and low velocity detonation was fixed in steel tubes by the mean of photorecording method. The explanation of the investigation results focused on identifying the most probable occurring chemical reactions at decomposition, heat explosion, and burning of CH and on reaction thermochemistry data.  
NTREM, PARDUBICE, 2003 page 173-182

# INVESTIGATION OF THE WETTABILITY OF AMMONIUM NITRATE PRILLS

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## Abstract:

*The wettability of various types of ammonium nitrate (AN) prills were compared using capillary penetration measurements where the penetration rates of various alkanes and fuel oil into packed columns of AN samples were determined. Complementary characterization studies using scanning electron microscopy (SEM) and thermogravimetry (TG) were performed to rationalise the observed differences in wettability. The wettability of AN was found to be affected by several factors, including surface tension, viscosity, density, purity, polarity and/or polarizability of liquid used, as well as surface composition, porosity, bulk density, particle size and moisture content of the AN samples.*

*High-resolution TG (HR-TG) was used to study the thermodesorption of octane from the various AN prills. The samples were wetted by immersing in octane. Multiple steps were obtained from the measured mass-loss curves, and they reflect the evaporation of the excess liquid, as well as the thermodesorption of octane from the pores and the surface of the AN prills. The quantity of octane desorbed in these steps was correlated to the volume in the pores and the amount adsorbed on the surface, and it was used to estimate the porosity and surface area of AN prills.*

*NTREM, PARDUBICE, 2003 page 183-197*

# DETERMINATION OF THE POWER OUTPUT OF DETONATORS

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## Abstract:

*The need to assess the power of detonators led recently to the development of new European standard tests to determine their initiating capability. In an effort to standardize the methods, European Union experts have selected an underwater explosion test to determine the basic power of detonators and a witness plate test to assess the influence of the ambient temperature on their performance. The underwater explosion test method, commonly used to calculate the explosive performances, is used to evaluate the initiation power of electric detonators. The investigation of the influence of selected parameters (distance detonator/pressure gauge, integration limit in the post-processing procedure, relative position of the detonator, the type of sensor, sampling rate of data acquisition...) made possible to draw up a satisfactory standard experimental procedure according to the EU-directive 93/15.*

*NTREM, PARDUBICE, 2003 page 198-204*

# INFLUENCE OF DEMILITARIZED DOUBLE BASE PROPELLANTS ON DETONATION PARAMETERS OF AMMONALS

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## \*\*Abstract:

*The incorporation of double base propellants into mining blasting agents offers an optimal method of disposing military propellants. The influence of double base propellants on detonation velocity of ammonals - mixtures containing ammonium nitrate and aluminum powder - was investigated. Initial results suggest that double base rocket propellants used as ingredients of ammonals can increase their detonation parameters.*

*NTREM, PARDUBICE, 2003 page 205-211*



# METHODOLOGY OF TESTS OF SENSITIVITY OF ENERGETIC MATERIALS TO ELECTROSTATIC DISCHARGE

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## **Abstract:**

*The literature describes concepts of test devices designed for evaluation of sensitivity of energetic materials (EM) to spark discharge. However, mutual comparability of the resulting activation energies is relatively low, which among others is due to differences in construction of the respective devices, type of the test electrodes and container, differences in the amount of sample exposed, sometimes differences in interpretation of the sample activation symptoms, a wide variety of the activation symptoms found in the whole large palette of EM.*

*The aim of this communication is to describe the tests performed on a self-constructed electrostatic device (ESZ) and to suggest a unique approach to evaluation of the activation measure of EM. Acceptance of the regulations suggested could reduce the personal view of the test course and the resulting condition of the sample tested. The apparatus works at the conditions of both oscillation and damped discharge of a condenser charge into a circuit containing besides parasitic members also the spark gap (JZ) where the sample of EM is exposed.*

*NTREM, PARDUBICE, 2003 page 212-220*

# ANALYSIS OF THE DEFORMATION AND STRENGTH PROPERTIES OF ENERGY POLYMERIC COMPOSITES (EPC)

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## **Abstract:**

*This study covers one of the most important problems of the physicochemical mechanics of polymeric materials, i.e., the problem of "kinetic" and "critical" approaches to the evaluation of the mechanical destruction of polymeric composites. It follows the studies presented at the previous (5<sup>th</sup>) Seminar held in 2002 in Pardubice. This study is meant to check the adequacy of the method we are developing for calculation of kinetic parameters of mechanical destruction of energy polymeric composites (EPC) based on tests performed using standard tensile testing machines at constant deformation rates ( $\dot{\epsilon}=\text{const}$ ). In this study, the nominal deformation and strength characteristics of a number of standard compositions of double-base powder and high-filled energy composites are analyzed using interrelated formulas obtained previously. The results of this analysis show that the method we are developing is adequate and can be used successfully, not only to predict the kinetics of destruction of newly developed compositions but also to reach their technological perfection.*

*NTREM, PARDUBICE, 2003 page 221-228*

# A FAST NON-SELFCONSISTENT ELECTRONEGATIVITY EQUALIZATION METHOD WITH APPLICATIONS IN THE FIELD OF ENERGETIC MATERIALS

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## **Abstract:**

*The needs for simple models of electron distribution in energetic materials and molecules are pointed out. The derivation of linear equations for atomic charges from the electronegativity*

*equalization principle is outlined, with an emphasis on the assumptions and limitations of such schemes. Then, a simple non-selfconsistent model involving a minimum number of empirical parameters is presented and parameterized against charges derived from first-principles calculations. It is found that Mulliken charges are more amenable to a description in terms of electronegativity equalization than potential-derived or even Hirshfeld atomic charges. This result suggests that charges that reproduce electrostatic potentials satisfactorily while remaining close to Mulliken values - such as those defined by Levy and Enescu - would be especially useful to describe electrostatic interactions without resorting to quantum computations. Finally, applications to the derivation of materials properties - such as sublimation enthalpies - are presented.*

NTREM, PARDUBICE, 2003 page 229-240

## **CHEMICAL DECOMPOSITION OF TRIACETONE TRIPEROXIDE AND HEXAMETHYLENETRIPEROXIDEDIAMIDE**

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**Abstract:**

*Triacetone triperoxide (TATP) and hexamethylenetriperoxidodiamine (HMTD) are well known primary explosives often called improvised that are frequently prepared in improvised conditions. These organic peroxides are very often components of pyrotechnist's findings. This paper summarizes experimental results of chemical decompositions of these peroxides.*

NTREM, PARDUBICE, 2003 page 241-247

## **QUANTITATIVE ANALYSIS OF SOME TECHNOLOGICAL COMPONENTS USED IN INHIBITED HOMOGENEOUS ROCKET PROPELLANTS BY MEANS OF THIN LAYER CHROMATOGRAPHY**

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7, Str., 05-220 Zielonka, POLAND

**Abstract:**

*In this paper new original methods of thin layer chromatography (TLC) analysis for quantitation of plasticizers, energetic additives and stabilizers being components of inhibited double-base propellants used in rocket motors assigned for launching of explosive long line charges to clearance of minefields are presented. Analytically measured substances were as follows: nitroglycerine (NG), dibutylphthalate (DBP), 2,4-dinitrotoluene (2,4-DNT), 2,4,6-trinitrotoluene (TNT), ethylcentralite (EC) and 4-nitro-ethylcentralite (4-NO<sub>2</sub>-EC). Above mentioned substances were separated by TLC and next they were quantitatively measured with use of UV/VIS spectral densitometry. On the basis of TLC some migration and nitration processes of analyzed substances were observed in the propellant and in its inhibitor.*

NTREM, PARDUBICE, 2003 page 248-254

## **BIODEGRADATION OF TNT BY IN VITRO CULTIVATED PLANTS: A MODEL SYSTEM FOR STUDY OF DEGRADATION PROCESSES**

**Aleš Nepovím\*, Anja Hebner\*\*, Andre Gerth\*\*, Hartmut Thomas\*\*\* and Tomáš**

**Vaněk\***

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\*\*\* Wasag Decon GmbH, Werkstraße 111, 45721 Haltern, GE

**Abstract:**

*Removing of explosives and nitroaromatic compounds from contaminated soil and ground water belongs to one of the most important environmental tasks. Phytoremediation appears to be a promising technique for treatment of water or soil contaminated by low concentration of these compounds.*

*We have used in vitro cultivated water plants - halophytes for removing of TNT from cultivation medium. The efficiency of four selected plant species of reed (*Phragmites australis*), rush (*Juncus glucus*), reed mace (*Typha latifolia*) and sedge (*Carex gracillis*) were compared. The highest efficiency in removing of TNT in initial concentration of 100 mg/l was reached by reed and reed mace. Reed showed as well as high tolerance to TNT, however, more tolerant of TNT was sedge, which showed induction of growth in comparison to untreated plants.*

*NTREM, PARDUBICE, 2003 page 255-258*

## **DETERMINATION OF SENSITIVITY OF PLASTIC EXPLOSIVE CONTAINING NTO**

**Andrzej Orzechowski\*, Andrzej Maranda\*\*, Dorota Powała\* and Jacek Borkowski\*\*\***

\* Institute of Industrial Organic Chemistry, 6 Annopol St, 03-236 Warszawa, PL

\*\* Military University of Technology, 2 Kaliskiego St, 00-908 Warszawa 49, PL

\*\*\* Military Institute of Armament Technology, 7 Wyszyńskiego St, 05-220 Zielonka, PL

**Abstract:**

*We tried to obtain insensitive high explosive. We investigated plastic explosive based on hexogen, octogen.. As an additive we used NTO. We researched sensitivity to impact and friction. This additive generated the decrease of sensitivity without worsening another parameters.*

*NTREM, PARDUBICE, 2003 page 259-265*

## **A COMPARATIVE ANALYSIS OF BLAST WAVES PARAMETERS GENERATED BY EXPLOSION OF EMULSION EXPLOSIVES AND DYNAMITES**

**Józef Paszula\*, Andrzej Maranda\*, Andrzej Papliński\*, Barbara Gołabek\* and Johann Kasperski \*\***

\* Military University of Technology, 00-908 Warszawa, ul. Kaliskiego 2, Poland

\*\* Blastexpol, 59-145 Duninów, Poland

**Abstract:**

*In the paper results of experimental investigations as well as numerical analyses of blast waves parameters generated by explosion of water-in-oil emulsion explosives and dynamites is presented. In the experiments the overpressure magnitude in transient shock wave generated by explosion of investigated explosive charges was measured. Also numerical evaluation of blast field in the space surrounding the explosive charge is performed. Comparison of the blast wave intensity generated by various kinds of explosives is performed. It is concluded, that the blast wave overpressure can be considered as an optional characteristic of the explosive performance, likewise detonation velocity, detonation (explosion) energy.*

*NTREM, PARDUBICE, 2003 page 266-273*

## **CLASSICAL MOLECULAR DYNAMICS SIMULATIONS OF RDX DECOMPOSITION UNDER HIGH PRESSURE**

**Miroslav Pospíšil\*, Pavla Čapková\*, Pavel Vávra\*\* and Svatopluk Zeman\*\***

\* Department of Chemical Physics and Optics, Faculty of Mathematics and Physics, Charles University Prague, Ke Karlovu 3, 12116 Prague 2, Czech Republic.

\*\* Department of Theory and Technology of Explosives, University of Pardubice, 53210 Pardubice, Czech Republic.

**Abstract:**

*Classical molecular dynamics simulations in NPT ensemble have been performed to investigate the decomposition of cyclotrimethylene-trinitramine  $C_3H_6N_6O_6$ , more commonly known as RDX, under high pressure. Dynamics simulations were carried out in 3D periodic systems of RDX crystal at 300 K under the high hydrostatic pressure. Dynamic trajectories were calculated for a series of hydrostatic pressure in the range 46 - 500 GPa. The detailed analysis of dynamic trajectories revealed the mechanism and kinetics of decomposition under high pressure. Increase of the hydrostatic pressure changes the course of dynamic trajectory and results in increase of the kinetic energy and decrease of the time corresponding to the rupture of the first N-NO<sub>2</sub> bond.*

*NTREM, PARDUBICE, 2003 page 274-283*

## **THE CHEMICAL KINETIC AT DETONATION OF NITROESTERS SOLUTIONS**

**Vlada M. Raikova, Georgy D. Kozak and Evgeny A. Likholatov**

Mendeleev University of Chemical Technology, Miusskaya sq. 9, Moscow A-47, Russia

**Abstract:**

*The main objective of this work is measurement of failure diameters ( $df$ ) of some nitroesters (NE) solutions and estimation of overall kinetic parameters of reactions in detonation wave. The dependencies  $df$  vs. content of components were measured for mixtures on a base of nitroglycol (NGL) and nitroglycerin (NG) with diethyleneglycoldinitrate (DGDN) propylnitrate (PN), methanol and acetone. A minimum of  $df$  is fixed at a small quantity of additive. Failure and reinitiating of a chemical reaction at detonation in the reaction zone according to the Failure diameter theory by Dremin were chosen to be the base for calculation of temperature ( $T_3$ ) and pressure ( $p_3$ ) in this zone. According to our calculations maximum of  $T_3$  values was fixed at the concentrations of the additives corresponding to the minimum of  $df$ . It was proposed, that detonation wave decomposition of NE solutions includes only monomolecular decomposition of a nitrocompound. The results of the calculations revealed that values of  $E=140-160$  kJ/mol and  $\lg k_0= 13,5-14,5$  ( $s^{-1}$ ) at detonation of the systems based on nitroesters is closed to the data obtained previously in the course of investigation of slow decomposition of these substances.*

*NTREM, PARDUBICE, 2003 page 284-294*

## **SOME REGARDS ABOUT COLD POWDERS PLASTICIZERS**

**Traian Rotariu and Octavian Orban**

Military Technical Academy, Department of Ammunitions, Missiles and Explosives, 81-83 George Cosbuc Boulevard, Bucharest, RO

**Abstract:**

*This article presents experimental tests results done by authors in order to determine explosive and ballistic properties of spherical gunpowder modified by adding a cooling agent, a plasticizer like glycidylazide polymer, having a low molecular mass. Assuming that by adding such a "gas generator" the combustion temperature of the powder can be lowered, by keeping the same ballistic properties, the authors developed a laboratory technology for the doped powder manufacture and they made a series of tests in order to characterize it.*

*NTREM, PARDUBICE, 2003 page 295-299*

## **IMPROVED INSENSITIVE HYTEMP/DOA BONDED HMX AND RDX MIXTURES BY PASTE PROCESS**

**Karl P. Rudolf**

## 1. INTRODUCTION:

*A study on miniaturized electric detonators and insensitive booster high explosives showing two initiation shock levels for No-Go in the BICT-Small Scale Gap Test (SSGT)*

- 26 kbar (TL 1376-800) and
- 42,2 kbar (STANAG 4170)

*In addition passing of Fast Cook Off and Bullet Impact Tests with 12,7 mm mild core munition at reaction level type IV is mandatory.*

*The intended use of an European made PBXW11 and PBXN11 at that time failed already showing already to low sensitivity at SSGT, however an additional treatment in a Jahnke and Kunkel high shear mixer could improve the shock insensitivity to the threshold of TL 1376-800 as we expected on our experience on HTPB bonded castable insensitive high explosives.*

*Above mentioned experiences led to the decision to develop pressable IHE s using standard RDX and HMX crystals quality A and a solvent paste process suitable for a DRAIS vertical and High-Shear Mixers.*

*NTREM, PARDUBICE, 2003 page 300-308*

## CHANGES IN SENSITIVENESS OF FLEGMATIZED HIGH EXPLOSIVES AFTER ARTIFICIAL AGING

**Jakub Šelešovský\*, Jiří Pachmáň\* and Marcel Hanus\*\***

\* Department of Theory and Technology of Explosives, University of Pardubice, 532 10 Pardubice, Czech Republic

\*\* Military Institute for Weapon and Ammunition Technology, Dlouhá 300, 763 21 Slavičín, Czech Republic

### **Abstract:**

*An isothermal heating of four samples of wax flegmatized high explosives at 70°C for 113 days was performed to simulate artificial aging. This research was done as apart of an extensive program dealing with characterization of aging process of military explosives. Changes in sensitiveness to impact, friction and electrostatic discharge due to artificial aging were evaluated. Sensitiveness increase to all stimuli was observed despite the thermal characteristics (from DTA, VST) remained same. The tests were as well performed on pure RDX, PETN and PETN/TNT (90/100) for comparison. The changes in sensitiveness were not observed in case of these samples.*

*NTREM, PARDUBICE, 2003 page 309-321*

## THERMOLYSIS OF KETO-RDX AND ITS PLASTIC BONDED EXPLOSIVES WITH FLUORO POLYMERS

**Gurdip Singh and S. Prem Felix,**

Chemistry Department, DDU Gorakhpur University, Gorakhpur-273 009

### **Abstract:**

*Thermolysis of keto-RDX and its plastic bonded explosives (PBXs) containing Kel F and Viton A was studied using various thermo-analytical techniques. The PBXs decompose at slightly lower temperatures and with higher heat release than K-6. Kinetic analysis of isothermal data was made using a model free isoconversional method. The activation energy is dependent on extent of conversion and different values were obtained for thermolysis of K-6 and the PBXs. Thus even thermally stable, inert binders such as Viton A and Kel F, alter the thermochemistry of K-6 in their PBXs.*

*NTREM, PARDUBICE, 2003 page 322-328*



# THERMOLYSIS AND KINETICS OF SOME BIS(PROPYLENEDIAMINE) METAL NITRATE COMPLEXES

Gurdip Singh\* and Durgesh Kumar Pandey

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## Abstract:

Five bis(propylenediamine)metal nitrate (BPMN) complexes like  $[M(pn)_2](NO_3)_2$  (where  $M = Cr, Mn, Ni, Cu, Zn$  and  $pn =$  propylenediamine) have been prepared and characterized. Thermal decomposition studies have been done using TG-DTA in an inert atmosphere of nitrogen. TG and DTA studies have also been carried out separately in air atmosphere to examine the effect of the atmosphere change on thermolysis trend of these complexes. Several measurable changes were recorded on decomposition mode of all these complexes when atmosphere was changed. However, as indicated by thermoanalytical techniques, thermal stability of all these complexes decreases in the order

$[Cr(pn)_2](NO_3)_2 > [Mn(pn)_2](NO_3)_2 > [Zn(pn)_2](NO_3)_2 > [Ni(pn)_2](NO_3)_2 > [Cu(pn)_2](NO_3)_2$  Isothermal TG, over the temperature range of deamination (a step corresponding to the loss of amine ligand) of all the complexes, has been done. An analysis for kinetics of deamination of these complexes was made on the basis of isoconversional method.

NTREM, PARDUBICE, 2003 page 329-338

# HOPKINSON BAR STUDIES ON POLYMER BONDED EXPLOSIVES

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PCS Group, Cavendish Laboratory, Cambridge CB3 0HE, UK

## Abstract:

This paper describes the Split Hopkinson Pressure Bar (SHPB) method for obtaining mechanical properties at high strain rate, and its applicability to Polymer Bonded Explosives (PBXs). The advantages and abilities of the technique are discussed, as are the difficulties of testing soft materials. Recent results are presented to demonstrate typical properties of PBXs in these experiments.

NTREM, PARDUBICE, 2003 page 339-349

# PROCESSES IN THE VESSEL DURING BLEVE EFFECT

Radovan Skacel, Bretislav Janovsky, and Jaroslav Svihovsky

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## Abstract

In the last fifty years, more than twenty great accidents with storage tanks, rail tank cars and road tankers filled with pressurized gases with death toll more than one hundred people, passed there. BLEVE - boiling liquid expanding vapour explosion - is a type of this incident, when containment (the cover of pressurized gas) is loosed. The paper contains results of literature recherche, which displays some important findings about recent research of BLEVE: 1) Now it is known that there are several types of accidents, which are very different in consequences and magnitude of claims in dependence on circumstances before rupture of the vessel like temperature and pressure, degree of filling, rigidity of cover and creation of leak or hole before rupturing. 2) However, the mechanism of last processes before rupture passes inside the vessel is not still exactly clear. This process was summarized and specified on grounds of literary sources. In the text, there is a suggestion of a possible scenario of the processes proceeding in the vessel and its description. Definition of this mechanism is important for explanation and prediction of blast and pressure effects in different starting conditions. For contribution to resolve this problem, a special apparatus was designed that can measure liquid behaviour in conditions of high pressures and temperatures similar to those in real propane and butane vessels engulfed in fire, and can visualize the processes inside the vessel with the help of endoscope-camera system.

NTREM, PARDUBICE, 2003 page 350-361

## GEMINAL TRINITROCOMPOUNDS THERMAL DECOMPOSITION UNDER NON-ISOTHERMIC CONDITIONS

Rudolf S. Stepanov, Ludmila A. Kruglyakova and Alexander M. Astachov  
Siberian State Technological University 660049, Krasnoyarsk, prosp.Mira, 82, Russia

### Abstract:

*The influence of chemical structure on thermostability of the polyfunctional geminal trinitrocompounds is shown. Characteristic temperatures and activation parameters of thermal decomposition are determined. It is shown that compound's thermostability may change by more than two orders of magnitude depending on the compound's structure. This is caused not only by the influence of substituents, but also by difference in the mechanism of final decomposition stage.*

NTREM, PARDUBICE, 2003 page 362-366

## ELIMINATION OF LEAD AND LEAD CONTAMINANTS IN THE MK 141 MOD 0 DIVERSIONARY CHARGE

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### Abstract:

*The Charge, Diversionary, MK 141 Mod 0 is a pyrotechnic device used for diversionary purposes. The device is used and operated like a hand grenade without its lethal effects. The fuze system contains a pyrotechnic delay column intended to delay the function of the item until after a user has thrown it. This delay is crucial for mission effectiveness and user safety. The original design contained a lead-sheathed delay column where a boron-barium chromate delay composition was compacted in a lead tube through a progressive rolling/swaging process. The Naval Surface Warfare Center Crane Division sought replacement of lead in the delay holder during early production of the MK 141 Diversionary Charge. A first attempt, in the early 1990's, was incomplete due to exhaustion of funding. In 1999, the Naval Surface Warfare Center Crane Division and the prime contractor, Pyrotechnics Specialties, Incorporated (PSI), Byron, GA, began a limited product improvement teaming effort to improve environmental impact and producibility of the boron-barium chromate pyrotechnic delay design by using an aluminum housing to replace the lead sheath of the existing design. The change also included the incorporation of a pressed boron-barium chromate delay column. The change resulted in environmental improvements at all stages of the life cycle of the item, while generating a recurring manufacturing cost savings, with no adverse effects on performance or reliability. The end result was that lead was removed from manufacturing, usage, and disposal aspects of the item's life cycle. This mitigated expensive environmental problems on test and training ranges. Savings achieved were both tangible and intangible.*

NTREM, PARDUBICE, 2003 page 367-373

## DETERMINATION OF ARRHENIUS KINETIC CONSTANTS FOR DOUBLE BASE PROPELLANTS BY NON-ISOTHERMAL DSC MEASUREMENTS. INFLUENCE OF SAMPLE SELF-HEATING.

Muhamed Sućeska, Sanja Matečić Mušanić and Maša Rajić

Brodarski Institute, Av. V. Holjevca 20, 10000 Zagreb, Croatia

### Abstract:

*In order to predict with required accuracy the shelf-life and thermal hazard potential of an explosive material a true decomposition mechanism and true kinetic constants should be known. Various experimental techniques and experimental conditions, various kinetic approaches and data treatments procedures have been applied in order to evaluate Arrhenius' kinetic constants from experimental data as accurately as possible. Consequently, the kinetic constants for an energetic material*

reported in literature may be in considerable disagreement.

In this paper we studied the influence of propellant sample self-heating degree on the values of Arrhenius kinetic constants, using non-isothermal DSC measurements and the isoconversional kinetic approach described by Ozawa, and Flynn and Wall. The results have shown that Ozawa method is capable of producing valid results for double base propellants, provided that self-heating is minimised by adjustment of the experimental conditions.

The activation energy was calculated to be ~173 kJ/mol in the case when sample self-heating has been avoided, while in the case of samples self-heating existence the activation energy was calculated to be ~140 kJ/mol.

NTREM, PARDUBICE, 2003 page 374-391

## APPLICATION OF DSC IN STABILITY STUDIES OF DOUBLE BASE PROPELLANTS

Muhamed Sućeska, Maša Rajić, Sanja Matečić Mušanić, Sanko Bakija\*, Ružica Čuljak\*, Vladimir Jagušić\* and Slavko Đurak\*

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\* Ministarstvo obrane RH, Bauerova 33, 10000 Zagreb, Croatia

### Abstract:

Thermal decomposition of propellants limits their safe and reliable service life. Under certain conditions propellants decomposition may become autocatalytic and can lead to the well-known phenomena of self-ignition. It is therefore of great importance to determine accurately propellant stability at a given moment of storage time, as well as to predict with sufficient accuracy whether or not a propellant will ignite under given conditions.

Decomposition causes decrease of relevant propellants' properties: decrease of nitrocellulose molar mass, decrease of stabiliser content, decrease of specimen mass, change of mechanical and ballistic performances, etc. Thus, the quality of propellants, i.e. their stability, may be quantified and judged by measuring the changes of these properties.

In this paper we have studied thermal properties of several stable and unstable double base propellants in order to see if there are such changes in thermal properties that can be used in propellants stability assessment. Thermal properties were studied applying the non-isothermal differential scanning calorimetry (DSC) measurements. It was found out that DSC curves of stable and unstable double base propellants, obtained under the same experimental conditions, differ considerable. Also, it was found out that the information obtained from DSC measurements are in reasonable agreement with the results obtained by some other tests for propellants' stability determination -the heat test at 100 °C and the stabiliser concentration determination test. These suggest that DSC results can help in propellants stability judgment.

NTREM, PARDUBICE, 2003 page 392-404

## MEASURING OF THE BLEVE INTERNAL PROCESSES

Jaroslav Švihovský, Břetislav Janovský and Radovan Skácel

Department of Theory & Technology of Explosives, University of Pardubice, CZ-532 10 Pardubice, Czech Republic

### Abstract:

In the present context, the term BLEVE is used for a sudden release of liquid with temperature higher than its boiling point from the container at the failure time, with a total collapse of the container. Most theories about the formation of BLEVE are based on evaporation dynamics and pressure changes inside the container. In the available theories, however, there is a gap in clarifying the initiatory process mechanism, which is going on during and immediately after the collapse of the container. The upcoming experimental works are conducted with the intention to unify the notions of this initiatory process. In the text of this contribution are described apparatuses, which were used during researches on BLEVE problems and which became a basis for the proposed apparatus. The proposed apparatus, together with the matrix of the experiment, is mentioned at the end of this contribution.

NTREM, PARDUBICE, 2003 page 405-410

# FLAME AND DETONATION ARRESTERS - EUROPEAN NORMATIVE STANDARD FOR TESTING

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\*\*Centre for Explosion Studies, University of Wales, Aberystwyth, Ceredigion, UK SY23 3BZ

## Abstract:

*This paper describes the European normative standard developed on flame and explosion protection devices destined for use in the European community. The new standard covers the design, constructional and performance aspects, test methods and limits of use of flame and explosion arrester devices. In the present paper, to illustrate why a range of tests are required under such a standard, the various stages of explosion pressure events that can arise in pipelines containing potentially explosive mixtures are first summarized. This is followed by a discussion of the tests included in the standard to ensure that an explosion arrester protection device is 'fit for purpose', with particular attention paid to detonation testing. A brief comparison with other existing national standards is also presented.*

NTREM, PARDUBICE, 2003 page 411-419

# PREDICTION THE THEORETICAL INTERIOR BALLISTIC PROPERTIES OF SOLID PROPELLANT ROCKET MOTORS

Jasmin Terzic, Alija Lekic and Berko Zecevic

Mechanical Engineering Faculty, Defense Technologies Department, Vilsonovo setaliste 9, 71000 Sarajevo, Bosnia and Herzegovina

## Abstract

*Process for prediction the interior ballistic properties of solid propellant rocket motors is based on identification and quantitative estimation of idealized performances deviations. Solid propellants combustion and expansion of combustion gases within a rocket motor and nozzle represent a complex problem, which includes influences of chemical reactions, erosive burning, transport phenomena etc. The computer program TCPSP (Thermo-Chemical Properties Solid Propellant), which ensures calculation the equilibrium contents of combustion gases, transport properties of combustion gases and theoretical performances of rocket motors with specified propellant grains, has been developed. Comparative analyses of results from the TCPSP computer code with referring codes Ophelie and CEA have been carried out. A very good agreement has obtained.*

NTREM, PARDUBICE, 2003 page 420-435

# DETONATION CHARACTERISTICS OF LOW-SENSITIVITY NTO-BASED EXPLOSIVES

W. A. Trzciński, L. Szymańczyk, and S. Cudziło

Military University of Technology, Kaliskiego 2, 00 980 Warsaw, Poland

## Abstract:

*Detonating performances of new explosive compositions containing NTO, TNT and RDX are investigated in this work. Detonation velocity, pressure and energy of the mixtures tested and acceleration ability and equation of state of their detonation products are determined. Shock and impact sensitivity is evaluated in the gap test and heavy hammer test.*

*The compositions investigated can be considered as a suitable insensitive explosive to replace TNT/RDX mixtures in munitions applications.*

NTREM, PARDUBICE, 2003 page 436-444



# UTILIZATION OF NUMERICAL SIMULATION METHODS TO STUDY POSSIBLE INFLUENCE OF INITIATION ON THE PERFORMANCE OF LINEAR SHAPED CHARGES

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Department of Theory and Technology of Explosives, University of Pardubice, 532 10 Pardubice, Czech Republic

## Abstract:

*There was realised an analysis of problems studying a possible influence of initiation on performance of linear shaped charges without cumulative liner. A model system was designed to study this type of charge. The behaviour of designed system was examined by three different ways of initiation by means of numerical simulation using method of final elements. There was discovered a significant improvement of observed performance parameters of model system at the application of anticipated initiatory source on the back of the charge.*

NTREM, PARDUBICE, 2003 page 445-461

# TRACE ANALYSIS OF POST EXPLOSION RESIDUES OF INDUSTRIAL EXPLOSIVES BY MEANS OF GC-ECD AND IC

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\*\* Institute of Forensic Science of the Slovak Police Corps, Sklabinská 1, Bratislava 812 72, Slovak Republic

## Abstract:

*The paper deals with possible applications of GC-ECD and IC to specification of post explosion residues of secondary explosives. Technical TNT and dynamite Danubit 2 have been used as real secondary explosives: at present they are the most frequently abused explosives on the territory of the Slovak Republic and Czech Republic. It has been shown that distilled water is a good medium for collecting the post explosion traces of nitro compounds (TNT and DNT) in testing ground. The separation, purification and simultaneous concentrating of aqueous extracts of post explosion residues was realised by means of SPE (the extraction discs type C18). The procedure is simple and allows obtaining extracts for organic and inorganic analyses in a single operation, at a considerably preconcentration the traces of organic explosives. The ECD detector was shown to be highly selective and its combination with GC makes it an efficient tool in trace analysis of organic components of post explosion residues. Similarly, also ion chromatography (IC), thanks to its sufficient sensitivity, is well applicable to trace analysis of inorganic components in these residues.*

NTREM, PARDUBICE, 2003 page 462-473

# EFFECT OF INTERMOLECULAR FORCES ON SOME PROPERTIES OF EXPLOSIVES II: INFLUENCE OF NON-COVALENT HYDROGEN BOND

Pavel Vávra\* and Miroslav Pospíšil\*\*

\* Department of Theory and Technology of Explosives, Faculty of Chemical Technology, University of Pardubice, 53210 Pardubice, Czech Republic

\*\* Department of Chemical Physics and Optics, Faculty of Mathematics and Physics, Charles University, 12116 Prague, Czech Republic

## Abstract

*On the basis of known structural data, the values of total energy of crystals have been calculated for a selected set of explosives, and their non-negligible effect on sensitivity parameters, melting temperatures and densities has been found. The presence of non-covalent hydrogen bonds and/or van der Waals forces in crystalline individual explosives distinctly lowers the impact sensitivity, increases their melting temperatures and contributes—together with other factors—to their enhanced density. Possibility of prediction of these parameters for proposed structures of new explosives is*



*discussed.*

NTREM, PARDUBICE, 2003 page 474-482

## EVALUATION OF THE EFFICIENCY OF IGNITION PROCESSES BY COMBUSTION UNDER DIFFERENT PRESSURES

**Fred Volk, Helmut Bathelt, Richard Jakob and Dietmar Mueller**

Fraunhofer Institut Chemische Technologie (ICT), Joseph-von Fraunhofer-Str. 7, 76327 Pfinztal-Berghausen, Germany

### **Abstract:**

*For the optimization of ignition materials a better insight into the burning behavior is necessary. Especially incomplete and none-equilibrium reactions accompanying the combustion process must be found out. This could be achieved by the analysis of reaction products as well of propellants as of the igniter materials as a function of pressure or loading density. It was found that it is important for an excellent ignition process that the combustion of the igniter material is as far as possible independent of the pressure. In this case the full exothermic reaction heat of the igniter can be transferred to the propellant bed. Very good results were recorded with high energetic ignition materials such as boron /potassium nitrate, B/KNO<sub>3</sub>, and zirconium/barium nitrate, Zr/Ba(NO<sub>3</sub>)<sub>2</sub>, containing ignition charges or benite strands.*

NTREM, PARDUBICE, 2003 page 483-496

## LONGTERM BEHAVIOUR OF THE HARDNESS MEASURED ON CURE CAST SAMPLES

**Richard Wild**

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### **Abstract:**

*Shore A measurement of PBX cure cast samples is usually used as a method to discover the polymerisation conditions of the resin. Other applications for hardness measurements are material selection, material comparison and quality control. When the test specimen are stored under higher temperature conditions for a longer time, hardness can also be one of the data to predict aging.*

NTREM, PARDUBICE, 2003 page 497-506

## STABILITY ANALYSES OF POROUS PROPELLANTS

**Stephan Wilker, Gabriele Pantel and Lutz Stottmeister**

WIWEB ASt Heimerzheim, Großes Cent, 53913 Swisttal (DE)

### **Abstract**

*Porous propellants are used in some special applications. Their main feature is a high surface to volume ratio. This affects mainly their burning behaviour. But this feature has a negative impact on the chemical stability. As the oxidation of nitrocellulose is an elementary part of the decomposition process of all propellants and starts on the surface the chemical stability of porous propellants is markedly lower than in comparable solid propellant blocks of the same chemical composition. This can be easily demonstrated by microcalorimetry. Whereas standard single base propellants do not show any autocatalysis at 89°C within 60 or 80 days, a porous single base DPA stabilized propellant has a strong autocatalysis after 10-11 days.*

*The paper also describes in detail the decomposition of the stabilizer DPA into its daughter products and shows the difference between this reaction in porous and in solid propellants (there is a completely different distribution of daughter products in dependence of the available oxygen in the ageing vessel). However, the time to autocatalysis changes independently of a pre-ageing of the porous propellant, demonstrating that other effects (probably mainly the composition of the atmosphere in the ampoule) play the decisive role.*

Finally, a concept to determine the low temperature (40-30°C) activation energy and including first results of this study on two single base propellants is presented. The determination of the activation energy at these temperatures is extremely important to correctly extrapolate results from high temperature ageing tests to ambient temperature.

NTREM, PARDUBICE, 2003 page 507-524

## OVERPRESSURE GENERATED BY DETONATIONS OF ELONGATED GAS CLOUDS

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\*\* Military University of Technology, Kaliskiego 2, 00-908 Warsaw, Poland;

\*\*\* Warsaw University of Technology, ITC, Nowowiejska 25, 00-665 Warsaw, Poland

### Abstract:

Experiments were performed to study overpressure generated in air by detonations of acetylene-air mixtures in a form of elongated clouds. In the first series of experiments the influence of cloud diameter on overpressures was studied. Next, the series of experiments were performed with the clouds of the same volume but different diameter to length ratio. To examine the influence of ignition location on blast wave intensity the experiments were performed for five different locations along main axis of cylindrical cloud. Experimental results were compared with the predictions of Dorofeev's empirical formula for spherical clouds and TNT equivalent. The results were used for formulating the expressions, which describe overpressure along two main directions.

NTREM, PARDUBICE, 2003 page 525-534

## PHYSICOCHEMICAL PROPERTIES OF NITROCELLULOSE MIXTURES WITH LOW MOLECULAR COMPOUNDS IN THE SHAPE OF FOILS AND IN WATER SUSPENSIONS

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### Abstract:

Samples of nitrocellulose mixed with the low molecular compounds, prepared as foils and water suspensions were stored and the long - term changes were observed. Some their parameters were determined - the glass transition temperatures and the difference between the maximum of DSC peak due to  $\beta$  relaxation effect. The analysis of DSC curves after different storage time showed that the migration undergoes into the nitrocellulose structure. For the samples prepared as a foil thermal effects of phase changes were very low. It proves that low molecular component is fully bonded with nitrocellulose chains.

NTREM, PARDUBICE, 2003 page 535-543

## SYNTHESIS OF N-ACETYL-3,3-DINITROAZETIDINE \*

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### Abstract:

N-Acetyl-3,3-dinitroazetidine(ADNAZ) has such advantages as low melting point, insensitive to detonation on impact and forming a eutectic with TNAZ which has many applications in melt-cast explosive production. ADNAZ was synthesized by a five-step reaction, using nitromethane, paraformaldehyde and tert-butylamine etc. as starting materials with overall yield of 42.8%. The factors affecting the preparation were discussed in detail. Structures of intermediates and ADNAZ were confirmed by FTIR, HNMR, CNMR and MS.

## INFLUENCE OF THE SOLID PROPELLANT GRAINS PROCESSING ON BURNING RATE OF DOUBLE BASE ROCKET PROPELLANTS

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### **Abstract**

*Besides a basic value of burning rate measured in standard test rocket motors, actual burning rate within a real rocket motor includes other influences as rocket motor dimensions, combustion gases flow within the chamber, chamber pressure, environmental temperature, angular acceleration, processing technology etc. The basic burning rate of solid rocket propellants is measured by standard ballistic test motor and is expressed by Saint Robert's law in form of  $n p a r \cdot =$ . Actual burning rate can be greater or less than the basic burning rate. Determination of different impacts on the actual burning rate is a complex task, which includes introduction of several assumptions in order to estimate an influence of each factor on the total burning rate. Impacts of geometric shape of propellant grains (star grain and hollow cylindrical grain with interior burning surface) and grain processing technology on variance of the basic burning law have been considered. Propellant grains, which were used in this research, had been manufactured by pressing and extrusion. Significant deviation between burning rate measured in standard ballistic test rocket motors and the actual burning rate within the real rocket motors has been observed.*

NTREM, PARDUBICE, 2003 page 548-559

## THE INFLUENCE OF MEASUREMENT METHODE ON THE INITIATION TIME MEASUREMENT NECESSARY FOR PRIMER MIXTURE INITIATION OF ELECTRICAL DETONATOR

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### **Abstract:**

*This paper considers the differences in measurement of time necessary for primer mixture initiation of electrical detonator when measured with two different methods. First method is electro-optical where time measurement is electrically triggered but stopped by light of primer mixture flame. Second method is electrical and measures time of current flow through bridge wire. There was significant difference in attained results. Reasons, as well as the influence on application are discussed in this paper.*

NTREM, PARDUBICE, 2003 page 560-569