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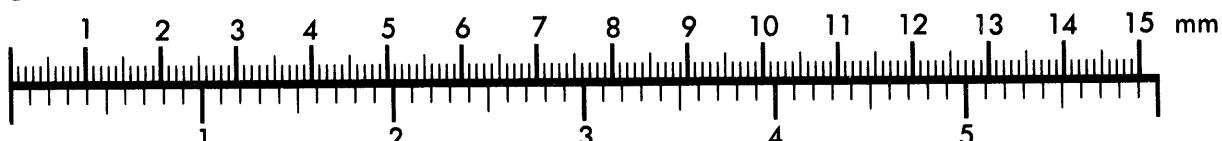
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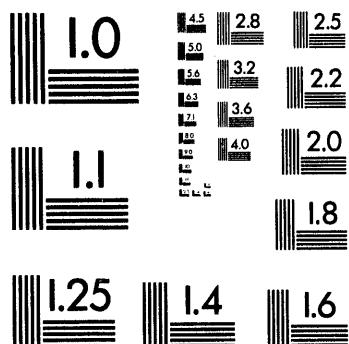
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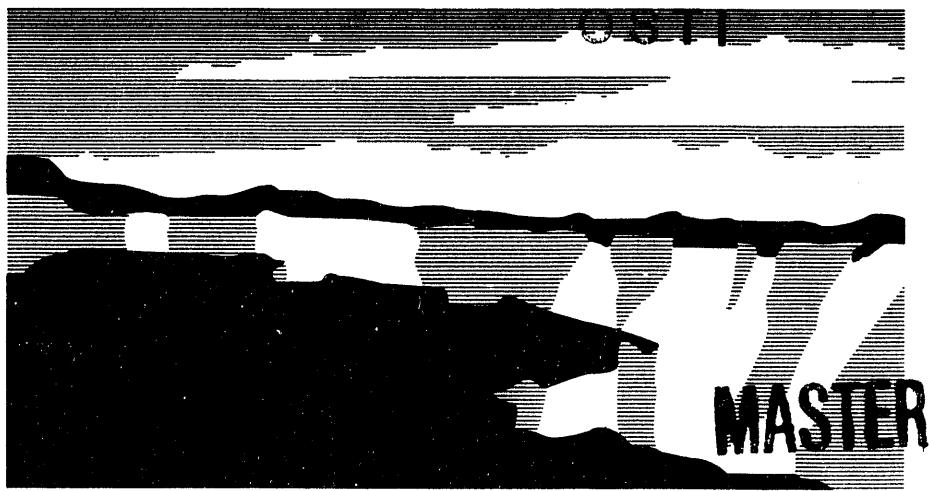
THE JOINT DoD/DOE MUNITIONS TECHNOLOGY DEVELOPMENT PROGRAM

Author(s):

Joseph V. Repa, Jr., Program Manager

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ABSTRACTS FROM THE FY93 PROGRESS REPORT FOR THE JOINT DoD/DOE MUNITIONS TECHNOLOGY DEVELOPMENT PROGRAM

Program Manager: Joseph V. Repa, Jr.

INTRODUCTION

The joint Department of Defense (DoD)/Department of Energy (DOE) Munitions Technology Development Program is a cooperative, jointly funded effort of research and development to improve nonnuclear munitions technology across all service mission areas. This program is enabled under a Memorandum of Understanding, approved in 1985 between the DoD and the DOE, that tasks the nuclear weapons laboratories of the DOE to solve problems in conventional defense. The selection of the technical areas to be investigated is based on their importance to the military services, the needs that are common to the conventional and nuclear weapons programs, the expertise of the performing organization, and the perceived benefit to the overall national defense efforts. The research benefits both DoD and DOE programs; therefore, funding, planning, and monitoring are joint activities.

Technology Coordination Groups (TCGs), organized by topical areas, serve as technology liaisons between the DoD and DOE for the exchange of information. The members of the TCGs are technical experts who meet semiannually in an informal workshop format to coordinate multiagency requirements, establish project plans, monitor technical activity, and develop classification guidance. A technical advisory committee of senior DoD and DOE managers administers the program and provides guidance on policy and strategy.

The abstracts in this volume were collected from the technical progress report for fiscal year 1993. The annual report is organized by major technology areas. Telephone and fax numbers for the principal contacts are provided with each abstract.

INSENSITIVE HIGH-EXPLOSIVES

by

M. D. Coburn, M. Hiskey, and J. F. Kramer

Insensitive high explosives (IHEs) are of mutual interest to the Department of Energy (DOE) and the Department of Defense (DoD) for enhancing the safety, survivability, and reliability of weapon systems. Previous candidate IHEs that have been developed and characterized are dinitroglycouril (DINGU), spherical nitroguanidine (NQ), 3-nitro-1,2,4-triazol-5-one (NTO), and 3,6-diamino-1,2,4,5-tetrazine-1,4-dioxide (LAX-112). The LAX-112 explosive is shock insensitive for the measured detonation velocity and cylinder energy. Formulated batches of 2,4-dinitroimidazole (2,4-DNI) with Estane were prepared for performance and sensitivity testing. A newly developed synthesis of 1,3,3-trinitroazetidine (TNAZ) has dramatically increased yields in fewer steps and has reduced the generation of hazardous waste. Six new energetic salts, which use 3,3-dinitroazetidinium (DNAZ) as an energetic cation, have also been prepared and initially characterized. We will continue to prepare and test new energetic materials that are relatively insensitive for their explosive performance.

Point of Contact: J. F. Kramer, Phone: (505)667-8308, FAX: (505)667-0500

NONSHOCK INITIATION THRESHOLDS OF LIQUID AND SOLID ENERGETIC MATERIALS

by

D. J. Pauley-Idar, B. W. Asay, and E. N. Ferm

The initiation criterion database for nitromethane and diethylenetriamine-sensitized solutions has been extended over a confined range of jet diameters, velocities, and failure diameters. The data were normalized with the failure diameter, and they support the hypothesis that the failure diameter should be made part of the critical initiation function. The diameter of the Viper jet has been further characterized over a wide range of velocities using an optical diagnostic technique. Hydrodynamic modeling has been used successfully to predict Viper jet diameters and velocities and to investigate the effect of confinement geometry on initiation.

Point of Contact: B. W. Asay, Phone: (505)667-3266, FAX: (505)667-0500

ADVANCED INITIATION SYSTEMS

by

E. Martinez and R. Yactor

Advanced in-line initiation systems use thin finite-diameter disks traveling at high velocity to shock initiate high-density secondary explosives. The disks (commonly called flyers) are accelerated to a high velocity by an electrically exploded flat bridge foil or laser-generated plasma. The results of several threshold voltage experiments using thinner flyers and composite flyers with bridges are presented. Other innovative lower-energy bridge-flyer designs were successfully tested, and the information obtained will significantly aid the development of detonators operating at lower voltages and energies. The DoD standard small-scale gap test was performed on fine-particle PETN containing 0.25% and 0.5% binder. Multipoint initiation systems with individually etched bridges attached to a flat circuit were manufactured and tested. Several prototype multipoint ring initiation systems have been designed and tested. The SLAPPER FORTRAN program for modeling these systems has numerous improvements and was distributed to several DoD organizations and contractors.

Point of Contact: R. Yactor, Phone: (505)667-6655, FAX: (505)665-4049

DEVELOPMENT OF LONG-ROD COMPOSITE KINETIC-ENERGY PENETRATORS

by

P. S. Dunn

The uranium-tungsten composite penetrator program was established to develop increased mechanical properties and hydrodynamic performance for Department of Defense (DoD) and Department of Energy (DOE) applications. We have been successful in meeting the goals of the program through the use of composite technology. We have developed a ternary alloy based on the uranium-molybdenum-tungsten system with exceptional mechanical properties and ballistic performance. Although we were unsuccessful in fabricating full-scale rods, 1/3-scale ballistic testing of the microcomposite material shows the material performed well compared to U-0.75 Ti penetrator material. In addition, the program has made significant contributions in the understanding of penetrator deformation mechanisms during ballistic testing and composite fracture mechanics, and has shown proof-of-principle of increased ballistic performance by matrix substitution in tungsten heavy alloys.

Point of Contact: P. S. Dunn, Phone: (505)667-4428, FAX: (505)667-5268

UNCONVENTIONALLY PROCESSED HIGH-DENSITY MATERIALS

by

G. T. Gray III, S. R. Chen, S. R. Bingert S. I. Wright, P. Maudlin, R. Castro, D. Korzekwa, H. Sheinberg, A. D. Rollett, R. Carpenter II, M. Lopez, C. Trujillo, P. Mombourquette, M. Mauro, V. Vargas, B. Roybal, and A. Kelly

Experiments and modeling have been performed on microstructure/property relationships that show how tungsten solute additions influence the mechanical properties and texture evolution in wrought plate-form tantalum. We measured the stress-strain response of the wrought tantalum and tantalum plate materials in tension and compression as a function of temperature and strain rate. The yield and flow stress levels increase with increasing tungsten alloying additions, and these alloys showed pronounced temperature and rate sensitivity.

After modeling the constitutive behavior using the Johnson-Cook, Zerilli-Armstrong, and Mechanical Threshold Stress models, we found that the Mechanical Threshold Stress model provided much superior fitting because of its physical basis. The biaxial/alternate stress path characterization technique developed for this study provides a tool for quantifying the link between bulk mechanical properties and texture measurements. Powder metallurgy processing of tantalum, including (1) screening of commercially available tantalum-powder characteristics, (2) selection of physical properties of the tantalum powder, and (3) details of the powder metallurgy consolidation and forming studies, are in progress.

Point of Contact: G. T. Gray III, Phone: (505)667-5452, FAX: (505)667-8021

REACTIVE MUNITIONS

by

W. C. Danen

The objective of the Reactive Munitions project is to understand and optimize the effect of munitions that couple energy to the target by processes other than blast and fragment impact. The goal is to incorporate the necessary special features into a hydrodynamics code that will help to provide critical understanding of the mechanism of action of reactive munitions and to assist in quantifying the lethality of such munitions. The MESA-2D and the PAGOSA-3D hydrocodes were chosen as the codes in which to implement these capabilities. During FY93, significant progress was made in the calculations of reactive munitions. The implementation of a fracture model into the currently modified version of MESA was an important milestone. We are now able to model in an elementary fashion the entire reactive munitions event. We have conducted rather extensive parameter variations to determine the relative importance of various physical variables and have compared calculations with experiments for model validation purposes. Laboratory-scale experiments are planned during FY94 that will address several remaining obstacles to understanding the reactive munitions process.

Point of Contact: W. C. Danen, Phone: (505)667-4686, FAX: (505)665-4631

METASTABLE INTERSTITIAL COMPOSITES

by

J. A. Martin

A new class of energetic materials, metastable interstitial composites (MICs), is being developed. MIC materials are specially designed mixtures of exothermically reactive species that exhibit widely variable energy release characteristics. The MIC energy release rate is continuously tunable from the low value associated with standard thermite to that approaching conventional explosives. Ignition sensitivity is independently tunable. Performance tunability in MIC materials centers on controlling the morphology of thermite-like reactants in ultrafine grain form. The new MIC materials may replace conventional energetic materials in a variety of applications by providing more effective performance through a uniquely tunable set of energy release characteristics.

Point of Contact: J. A. Martin, Phone: (505)667-4377, FAX: (505)665-2992

WARHEAD DESIGN AND ANALYSIS

by

L. A. Schwalbe

This year the warhead design and analysis project has initiated two major start-up activities involving (1) interactions of munitions with large and complex targets and (2) development and evaluation of new hydrodynamic codes. In the first area, we addressed specific problems related to improving and upgrading the Patriot warhead, benchmarked the MESA code against experimental data obtained from fragment and rod impacts into fluid-filled containers, and studied mesh convergence issues. In the second start-up activity, we are in the process of developing and evaluating new hydrodynamic codes using the smooth particle hydrodynamics (SPH) technique.

In addition to these new endeavors, we have continued work on some more traditional tasks. In the area of model implementation and testing, we have included additional equation-of-state, strength, and fracture models into the MESA and PAGOSA codes. We have implemented programmed burn into the SPHINX code, and we have begun autotasking MESA-3D. Our research in chemical and kinetic-energy warhead technology continues with wave interaction experiments and studies of the effects of varying high explosives (HEs) and liner materials in an adaptable warhead.

Point of Contact: L. A. Schwalbe, Phone: (505)667-0325, FAX: (505)665-5553

DYNAMIC PROPERTIES OF MATERIALS

by

**F. L. Alderssio, J. B. Aidun, J. K. Dienes, P. S. Follansbee,
J. N. Johnson, D. A. Hunter, N. L. Marusak, P. J. Maudlin,
M. S. Sahota, S. K. Schiferl, C. M. Snell, R. P. Swift, D. L. Tonks,
and A. K. Zurek**

During the preceding year, several research studies have been brought to a logical conclusion including the study of steady shock-wave profiles and the investigation of release waves in shocked metals. The major conclusions from these two studies are (1) that face-centered cubic metals show a clear transition from thermal activation to viscous drag whereas body-centered cubic metals do not and (2) that release-wave speeds measured in face-centered cubic metals may not give correct values of the elastic moduli in the shock-compressed state and those in body-centered cubic metals always do. The latter effect is a consequence of the normally large value of the Peierls stress in body-centered cubic metals.

The major new effort undertaken during the current year is the study of composite materials behavior under dynamic loading conditions. The emphasis has been a systematic investigation of possible ways that common dispersive behavior in real, heterogeneous composites can be represented as pseudo-dissipation in homogeneous materials and what this means in terms of thermodynamic-like considerations. The benefit of this kind of representation is that existing codes and existing constitutive models can be used to describe composite material behavior in a simple, rational way without excessive attention to detailed wave interactions. This work is being carried out in conjunction with an institutionally supported research and development program that provides experimental data on model composite materials. The main thrust of the composite modeling effort is the examination of ways in which existing continuum theories can be used to represent the essential aspects of dynamic composite material behavior from an average standpoint. This study includes representation of small-scale wave interactions as well as the more familiar long-wavelength, average moduli response.

A twinning evolution model has been developed and implemented into a finite-element analysis, allowing a more realistic modeling of hexagonal-close-packed and body-centered cubic materials. The anisotropic plasticity model with experimental data has been compared, and a more robust texture evolution algorithm was developed, which resulted in favorable computational times.

Development of failure and fracture models continues. In this report we review the loss of a length scale in the equations governing rate-independent softening and the resulting computational mesh sensitivity and present a method for restoring a length scale to the governing equations. The theory for the T-crack has been documented. Furthermore, the T-crack formulation has been verified for limiting cases, and two-dimensional fracture simulations have been conducted to study void coalescence and fracture. A Voronoi tessellation for analyzing three-dimensional fracture problems has been developed and macroscopic averaging techniques have been explored.

A version of the Lagrangian, finite-element code EPIC has been developed for the parallel Connection Machine. The version excluding the slide-line algorithm has shown an impressive savings in computer time. Currently, the eroding slide-line algorithm is being developed for the parallel architecture.

Using a simple Drucker-Praeger constitutive model, we applied numerical simulations to the Hopkinson Bar experiments for the study on comminuted ceramics. Following an initial validation procedure, the effects of the containment material were studied. Experiment and computational simulations were used to explore the penetration process for U/Ti as compared to W-Ni-Fe alloys. The improved characteristics of the uranium alloys have been attributed to a lower melting temperature and a phase-transition-induced, low-temperature softening behavior.

The SMC codes were improved to facilitate the geophysical studies. The improvements include the addition of a velocity damping initialization scheme and a slid-line algorithm. Constitutive models continue to be developed and validated for geologic materials. Applications efforts include the calculation of momentum coupling from buried high-explosive detonations.

Point of Contact: F. L. Addessio, Phone: (505)667-9098, FAX: (505)665-5926

FLUID-STRUCTURE INTERACTION MODELING

by

M. W. Lewis and B. A. Kashiwa

A method of coupling structural Lagrangian finite element programs to finite difference arbitrary Lagrangian-Eulerian fluid dynamics programs was implemented in two dimensions. The method was then tested against experimental results and an analytical solution for underwater problems. It was also used to model a fictive two-dimensional air blast problem. Based on the success of the coupled two-dimensional program, a three-dimensional coupled program is now being tested.

Point of Contact: M. W. Lewis, Phone: (505)665-2497, FAX: (505)665-2137

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