Novel Manufacturing Process Development and Evaluation of the High Blast Explosive PAX-3 with BDNP A/F and R8002 Plasticizers

NDIA Insensitive Munitions & Energetic Materials Technology Symposium 2009

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Acknowledgments

- **ARDEC**
  - Patrick Dwyer
  - Stacey Yauch
- **BAE SYSTEMS, OSI**
  - Curtis Teague
  - Virgil Fung
  - Alberto Carrillo
  - Matt Hathaway
  - Kelly Guntrum

Enhanced Blast Explosives

- Deliver More Energy on Target than Traditional Explosives

- Types of Enhanced Blast Explosives
  - Metallized Explosives
  - Reactive Surround
  - Fuel Air
  - Thermobaric

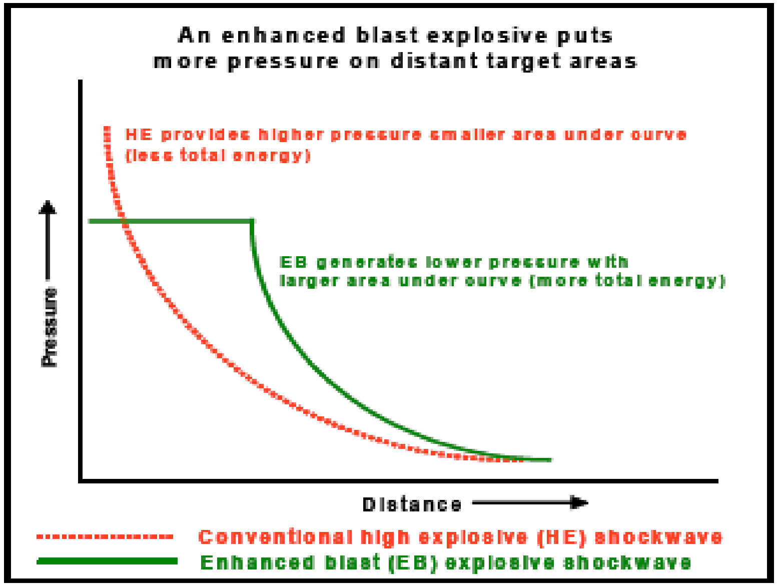


Fig. Comparison of conventional explosives and enhanced explosives.

Enhanced Blast Explosives

- Rely on Blast (Primary) and Heat (Secondary) for their Effects
- Effects Intensified in Confined Spaces (Buildings, Bunkers, Caves, Vehicles, etc.)
- Active Elements are an Explosive and a Fuel (metal)
- Vacuum or Oxygen Depletion Effect is Achieved

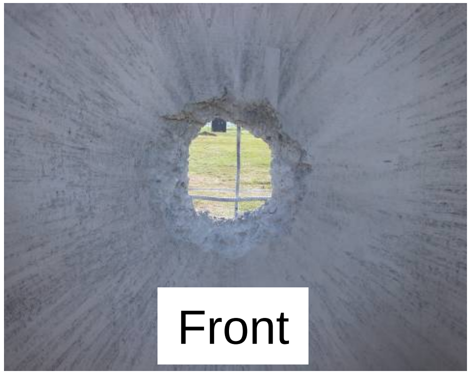
PAX-3

- Developed by ARDEC Under the Novel Energetics Science and Technology Objective (STO)
- Evaluation for the M141 Bunker Defeat Munition
- Evaluation for Line of Sight Multi-Purpose (LOS-MP)

PAX-3

- PAX-3
  - HMX
  - Cellulose Acetate Butyrate (CAB)
  - BDNPA/F plasticizer
  - Aluminum
- Replacement for Aluminized Comp. A-3

Concrete wall 10’ wide, 10’ tall 8” thick, reinforced with double steel rebar



PAX-3 INSENSITIVE MUNITION TESTING

PAX-3 3.2" Generic Shaped Charge IM Test Summary*		
IM Test	# of Tests	Reaction
Bullet Impact (50 cal 2800 ft/s)	2	Pass No Reaction Pass No Reaction
Army Fragment Impact (Cube 6000 ft/s)	2	Pass Burn Pass Burn
Slow Cook Off (50 F /hr)	2	Fail Explosion/Deflagration** Fail Explosion/Deflagration**
Fast Cook Off	2	Pass Burn Pass Burn

* Initial Assessment

* * This reaction can be potentially mitigated by adequately venting the warhead

PAX-3 SENSITIVITY AND PERFORMANCE TEST DATA			
	PAX-3	Al Comp A3	LX-14
Impact (cm)(50%)	39.5	80.4	26
LSGT (50%)	129.5	119+/- 3	199
Detonation Velocity (m/sec)	8070	8199	8680

- Performance and sensitivity data provided by ARDEC

Data Originally Presented at 2006 IMEM

PAX-3 Current Processing

- HSAAP Slurry Processing
  - Explosive intermediates slurried in water
  - Polymer / Plasticizer dispersed in solvent
  - Coating / processing cycle
  - Recovery / reuse of solvent
- Traditional Method Incompatible with Thermobaric PBX
  - Aluminum powder readily oxidized by water
  - Safety issues significant at production-scale operations
- "Water Replacement" (WR) Fluid Evaluated *
  - Not reactive with metal powders
  - Fluidizing effect of water
  - Colorless, nonflammable liquid
  - Similar boiling point range as water
- Recovery of WR Fluid Key to Controlling Product Cost

* Previously Reported in 2006 IMEM

PAX-3 Current Processing

- Issues
  - Water Replacement Fluid Expensive
  - Separation of Water Replacement Fluid from Solvent Difficult
  - Supplier Discontinued “WR” Fluid Currently Employed for Manufacture

- New Solution
  - Re-evaluate Traditional Aqueous Slurry Technology to Manufacture PAX-3
  - Known Technology
  - Minor Changes to Processing Technique
  - Significant Cost Savings to the Customer

PAX-3 Aqueous Development

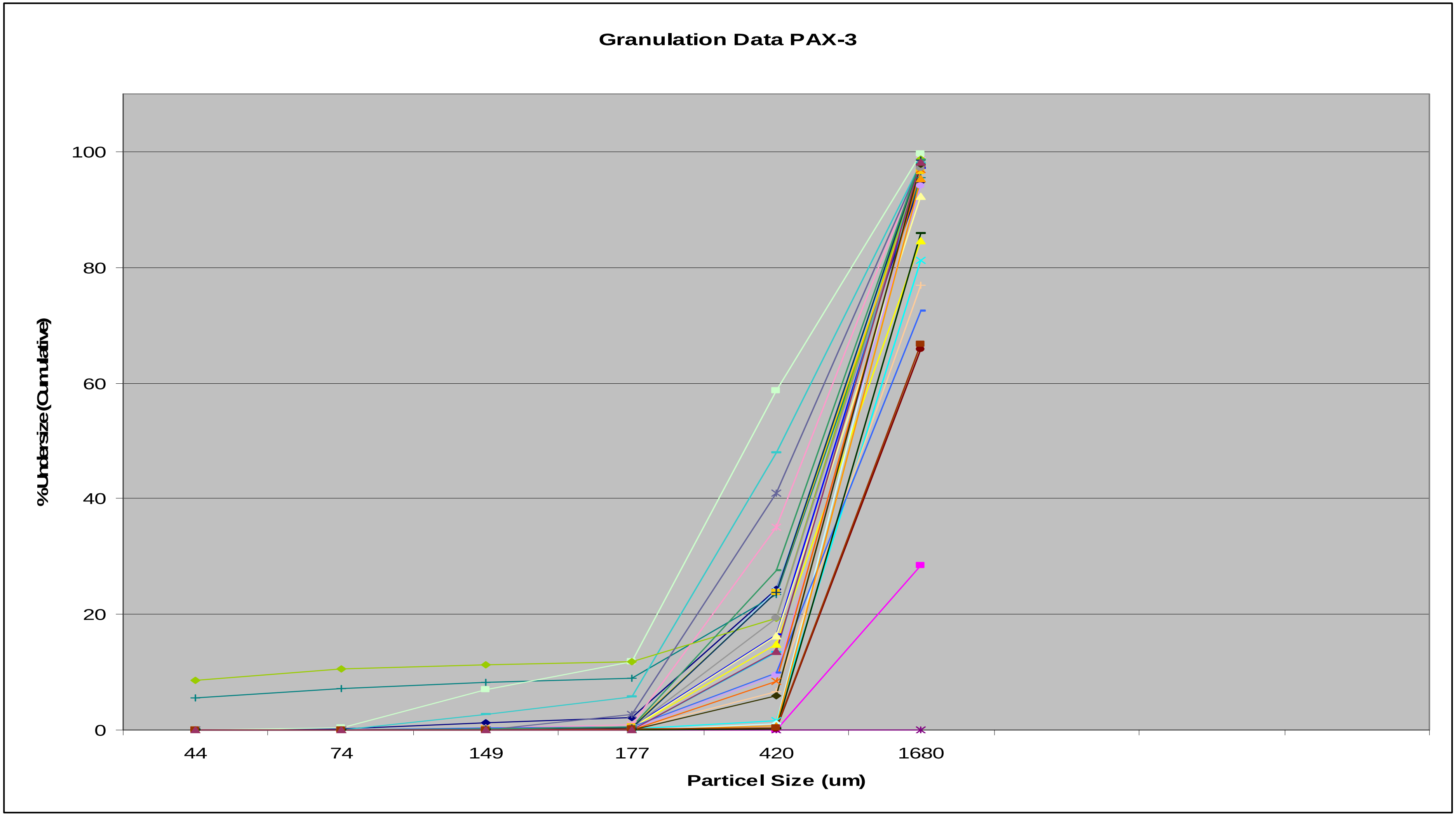
- Processing Concerns
  - Hydrogen Gas Generation During Coating Cycle
    - Time / Temperature of Aluminum Exposure in Slurry
    - pH of the Slurry Medium
- Material Evaluation
  - Explore any “Additives” that has the Potential to Impede or Delay Gas Generation

PAX-3 Aqueous Process Development

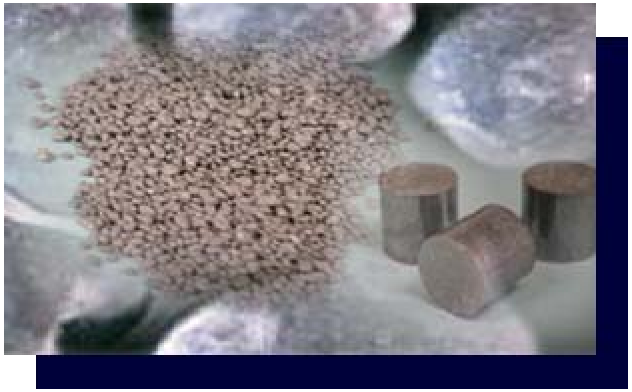
- Lab-Scale Process Development
  - Design of Experiments
    - Baseline Using “WR” Parameters
  - Systematic Evaluation of Process Parameters for PAX-3
    - Time
    - Temperature
    - Agitation
    - Addition Rates
    - Process “Additives”
  - Typical lab batch size of 1,000 grams
  - 2 “Additives” Identified and Employed for Processing
    - Gas Generation Monitored Real Time
      - H2 Scan: HY-Optima 1720 Process Monitor

10 L Coating Still

PAX-3 Laboratory Granulation



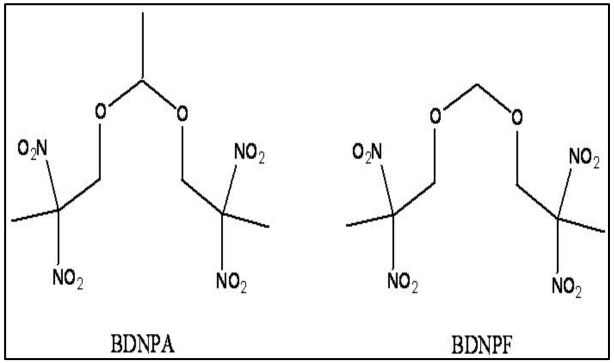
Process Development Conclusion

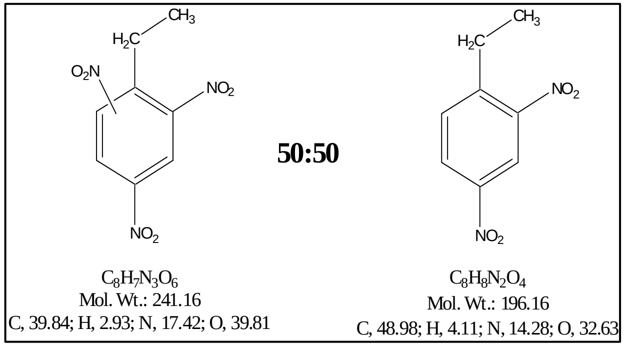


- Key Variables
  - Time
    - Resonance Time – Coating Process
  - Solvent Concentration
    - Very Tight Tolerance
      - No Growth of Granules
      - Excessive, Rapid Growth into Agglomerations-Undesired Product
- Hydrogen Gas
  - Negligible Level Detected at Lab Scale Evaluation
- Production Scale Batch
  - FMEA Completed
  - Industrial Hydrogen Gas Detector Purchased/Commissioned
  - Process Parameters Established Based on Lab Scale Development Efforts
  - 2 x 500 lb Batches Scheduled for Week of April 27th

Plasticizers

- BDNP A/F
  - Energetic Plasticizer
    - 50% bis(2,2-dinitropropyl)acetal (BDNPA)
    - 50% bis(2,2-dinitropropyl) formal (BDNPF)
  - Initially Developed in 1950's for Polaris Program
  - First Manufactured by U.S. Navy (Indian Head) and Aerojet in the 1960's
  - Later Manufactured by Thiokol in the 1990's
  - Used Today in Various Formulations
    - LOVA Propellants
    - Navy PBX 106 Formulation
    - IM Explosives (PBXN-106, PAX-2A and PAX-3)
- R8002
  - 50% Dinitroethylbenzene (DNEB)
  - 50% Trinitroethylbenzene (TNEB)
  - Similar to K10 (65:35 DNEB:TNEB)
  - Used Internationally as an Energetic Plasticizer in Experimental Applications



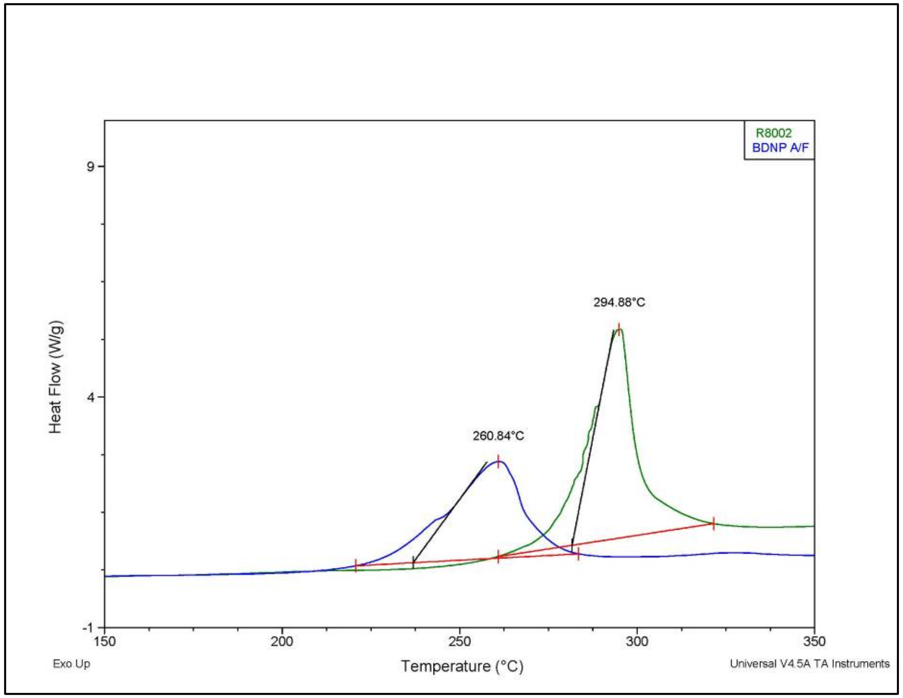


PAX-3 w/ R8002

- Processing
  - Drop in Replacement with Current Aqueous Procedure
  - No Observable Change in Processing Steps

- Observations
  - Binder Lacquer system is less viscous than BDNP A/F
  - Binder Components Readily Mix with Little Mechanical Input
  - PAX-3 Product Using R8002 Generates a Higher Bulk Density Under Same Process Conditions
  - No Compatibility Issues

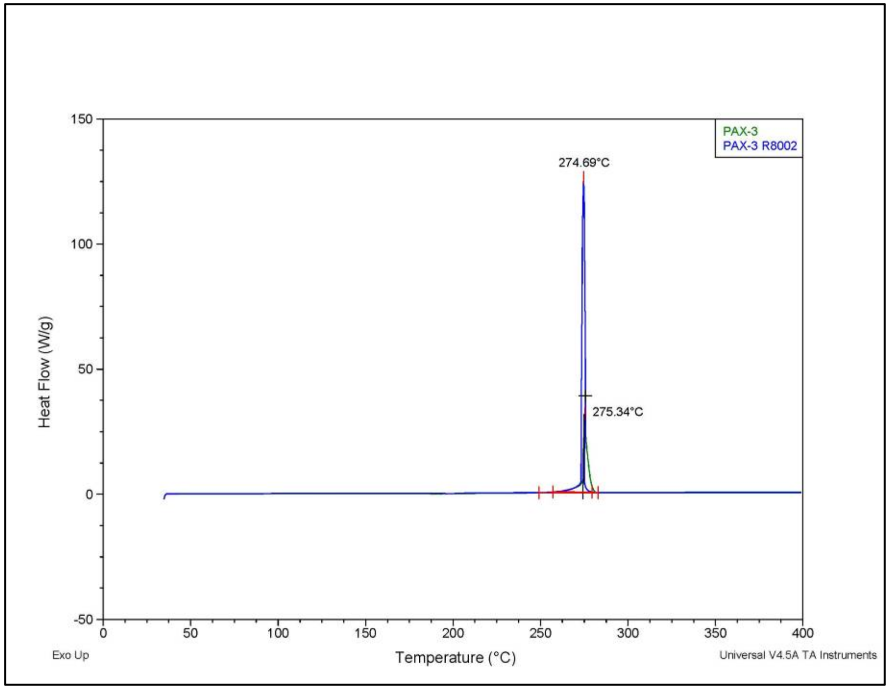
DSC Analysis



Plasticizers

BDNP A/F vs. R8002

Ramp 5°C/min



PAX-3

BDNP A/F vs. R8002

Ramp 5°C/min

PAX-3 Analysis

Batch #	PAX-3 Plasticizer	DSC Exothermic Peak °C	VTS Evolved Gas g/cc	Press Density g/ml	ERL Impact cm
1069-88C	BDNP A/F	275.34	0.266	1.73	36.14
1069-114	R8002	274.69	0.132	1.80	41.40

Conclusion

- The Aqueous Coating Method Provides Spec. Product
- Method Conforms to HSAAP Infrastructure
  - No Specialized Pumps, Seal, or Handling Equipment as with “WR” Method
- Product to Be Scaled to 500 lb Batch Size for Pilot Production Trial
- The R8002 Plasticizer Showed No Processing or Compatibility Concerns
  - Drop in Replacement for BDNPA/F

IT ALL STARTS HERE!!