

Novel Manufacturing Process for the Thermobaric Explosive PBXIH-18

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Objective

- Develop a safe, cost effective manufacturing process for Thermobaric Explosives using water slurry technology developed at BAE Systems Holston Army Ammunition Plant (HSAAP).

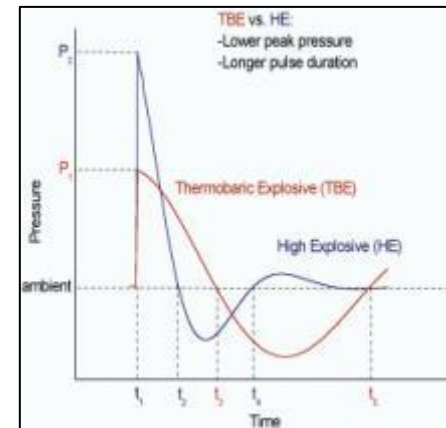
Briefing Outline

- Background
- Prior Effort
- Investigation
- Aluminum Concerns
- Laboratory Processing
- Conclusion
- Acknowledgements



Background

- Thermobaric Explosive (TBE)
 - Principles of unconfined vapor cloud explosion (UVCE)
 - Produces blast wave of long duration
 - Higher sustained blast overpressures
- Increased lethality in confined spaces
- Mechanism
 1. Primary detonation of explosive charge
 2. Combustion of fuel particles not consumed in primary detonation
 3. Flame front accelerates to a large volume producing pressure fronts with fuel/oxidant mixture and surrounding air



HSAAP Explosive Processing

- Solvent-Lacquering Technique
 - Explosive intermediates slurried in water
 - Polymer / plasticizer dispersed in organic solvent (Lacquer)
 - Lacquer gravity feed into slurry
 - Coating precipitates onto explosive intermediates
 - Recovery of organic solvent
- Production Operations at HSAAP
 - 500 Gallon (Vacuum Stills)
 - 4,000 Gallon (7A Stills)



Prior Effort

- 2003-2004 timeframe
 - NSWC Indian Head, Yorktown Detachment approached BAE Systems, OSI for implementation of full rate manufacture prove out at the Holston Army Ammunition Plant
- Coating Technique
 - Traditional Solvent-Lacquering coating system
 - Incompatible with Thermobaric processing
 - Aluminum powder oxidized by water
 - Safety hazard due to aluminum powder interaction with water forming Hydrogen gas
 - Elimination of water from coating system
 - Water replacement fluid (perfluorocarbon compound)
 - Non reactive with metal powders
 - Similar boiling point as water

2005 Production

- 300 pound pilot scale manufacture
- Product met MIL Detail Specification



	<u>Press Density</u> (g/cc)	<u>H2O %</u>	<u>VTS</u> (ml/mg) 48 hrs	<u>Coff. Of Friction</u>	<u>Granulation % Passing</u>				<u>Impact, cm</u>	
					<u>6</u>	<u>8</u>	<u>40</u>	<u>70</u>	<u>PBXIH-18</u>	<u>Std.</u>
PBXIH-18-1	1.92	0.03	0.06	150	100	100	5	2	30.04	15

Lessons Learned

- 2005 Production
 - Impact data shows a reduction in sensitivity using a HMX/DOA Premix
 - All attributes of the product meet previous laboratory produced materials
- Perfluorocarbon
 - Manufactured by 3M
 - Fluid is cost prohibitive for large scale full rate production
 - Special delivery and handling equipment
 - Multiple decants to filter PF
 - PBXIH-18 Cost is dependant of recovery and re-use
 - Recovered >97% of PF from production run
 - Loss mostly contributed from liquid barrier seals in processing equipment
- 3M discontinued manufacture of specific perfluorocarbon fluid
 - Several new products offered with identical properties

OSI Investigations

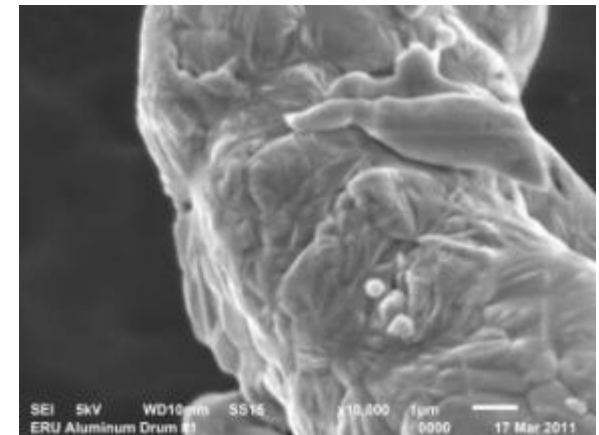
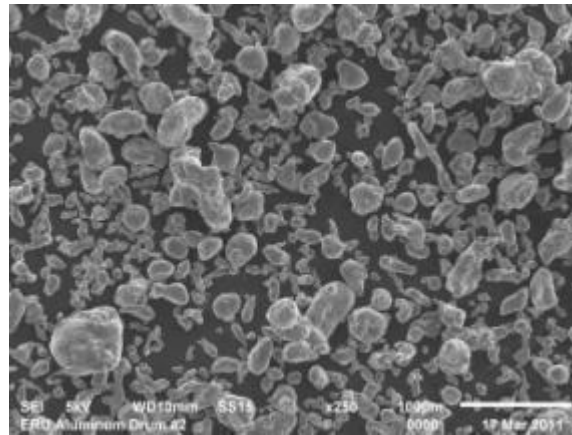
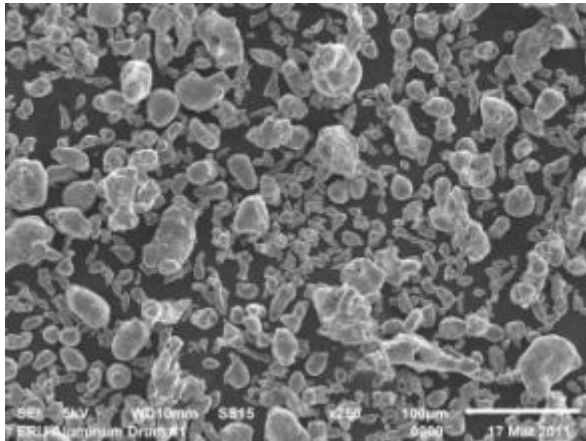
- Several customers seeking TBE pressable warheads
 - Applications: Grenades, SOCOM, Warheads...
 - Many different binder matrixes (Viton, Hytemp, CAB, etc...)
- OSI R&D to investigate cost saving measures to make affordable product
 - Perfluorocarbon fluid vs. filtered water
- Water Advantages
 - No special delivery or handling equipment
 - No targeted training for operations staff
 - Readily available
 - “Virtually” free as compared to PF
 - Standard processing at HSAAP

Experimentation

- Aluminum-Water interaction
 - Temperature
 - Time
 - pH monitoring
 - Hydrogen detection
- No Hydrogen generation observed when varying temperature with time
 - 30 min – 24 hour period
- As expected, pH change did expedite the limited oxidation reaction
 - Altering the pH of the slurry medium allowed the operation of move forward slowly
 - No Hydrogen was generated (Real time monitoring)
- Addition of explosives and binder components
 - Did not affect the reaction

Aluminum Powder

- Suppliers
 - Toyal America, Inc.
 - Alcoa Inc.
- Both suppliers products were evaluated
 - Production process for the metal powders leave product oxidized
 - Explanation for lack of Hydrogen formation over extended periods of processing



Laboratory Processing

- All experiments were conducted in the HSAAP 10L coating
 - Replicate of production equipment
 - Used to make PBXN-9, PBXN-5, Comp A-5, etc...
- Trials were conducted with production filtered water
- Standard parameter evaluation was conducted
 - Time
 - Temperature
 - Agitation Rate
 - Age Time
 - Solvent-to-water ratio
 - Distillation rate
 - Lacquer addition rate
- Key parameter for acceptable product was solvent/water ratio and temperature
- Other parameter effects were negligible on the product

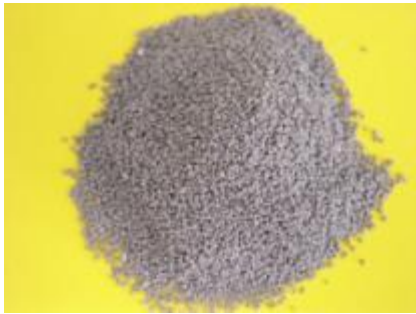


Assessment

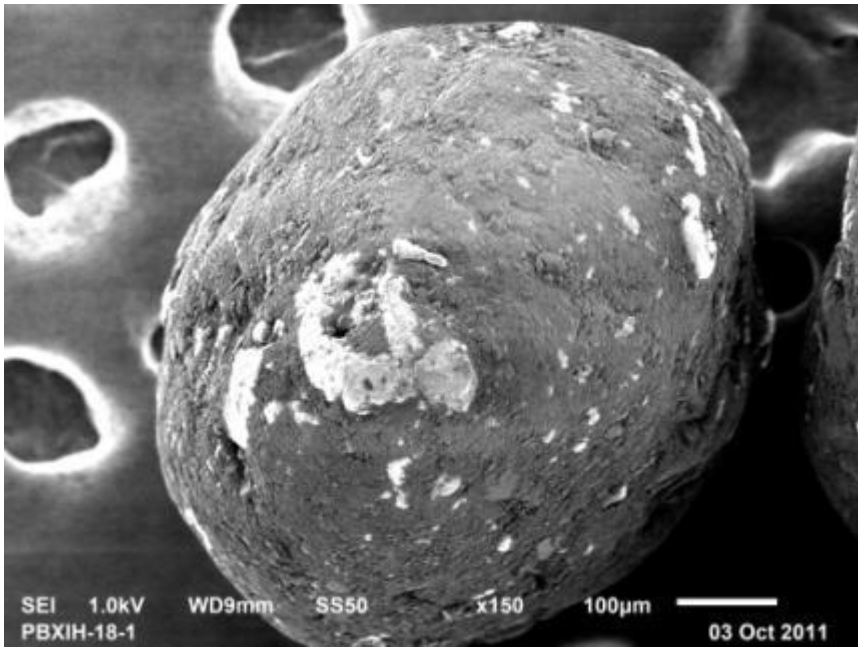
- Water Slurry Process Results
 - Achieved >30% reduction in solvent usage
 - Reduced process cycle time by 67%
 - Product batches met the MIL Detail (MIL-DTL-32156 REV A)

- Analysis Comparison

	<u>Press Density</u> <u>(g/cc)</u>	<u>H2O %</u>	<u>VTS</u> <u>(ml/mg)</u> <u>48 hrs</u>	<u>Coff. Of</u> <u>Friction</u>	<u>Granulation, % Passing</u>				<u>ERL Impact, cm</u>	
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PBXIH-18-1	1.92	0.03	0.06	150	100	100	5	2	30.04	15
1099-43	1.93	0.02	0.09	161	100	99.9	0.3	0.1	73.56	15

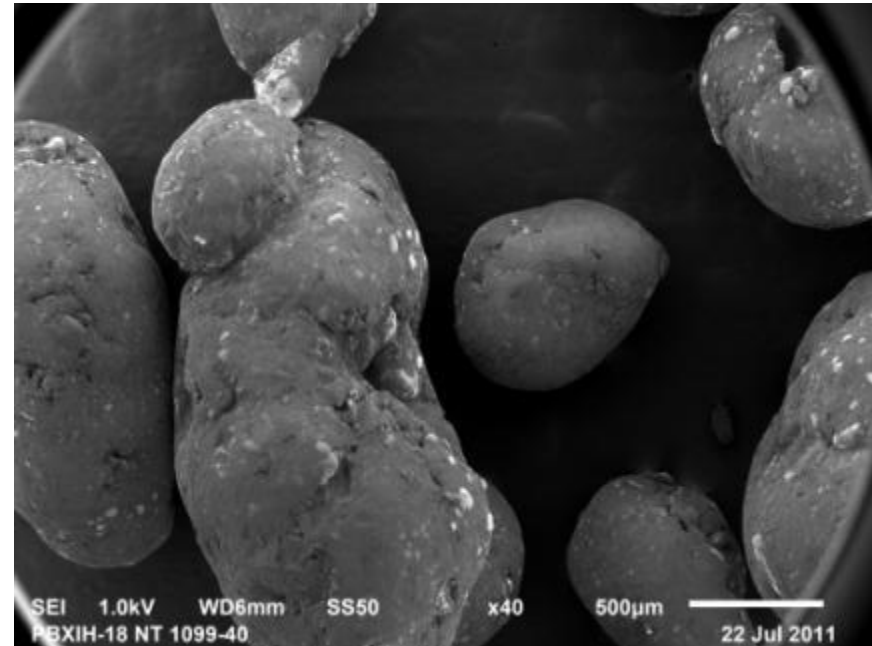


Scanning Electron Microscope



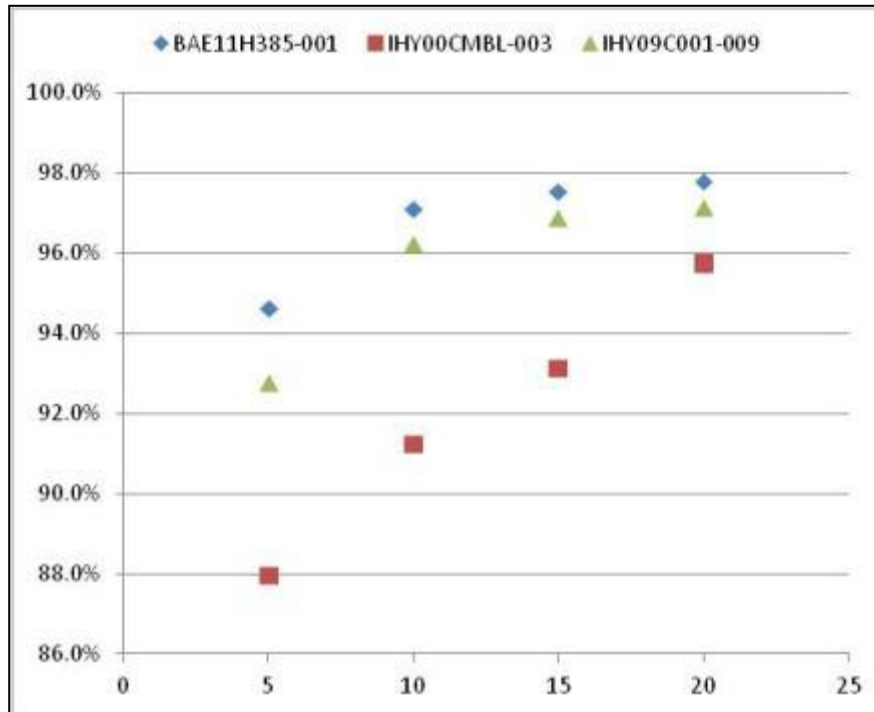
PBXIH-18-1

PBXIH-18-1099-40



Product Evaluation

- OSI partnered with Nammo Talley for pressing studies and calorimeter testing
 - Supplied 20 pounds of PBXIH-18 manufactured from the water slurry processing
- Pressing Study
 - OSI and NSWC materials evaluated at 5 ksi, 10 ksi, 15 ksi and 20 ksi



Product Evaluation

- Calorimeter Testing
- Average of 2-15.00g pellets; booster 5.00g C-4; RP-80 detonator



Material	%TMD	Energy of Det. (cal/g)
Holston	98.5	-1826
NSWC	98.6	-1774

Conclusion

- Implementing water as the slurry medium showed no adverse effects to the Thermobaric Explosive product
- Process Improvements
 - Achieved significant reductions in processing times and raw material usage
 - Significant saving in raw material cost, utilizing water instead of PF
- Testing conducted by Nammo Talley show that the OSI and NSWC materials are comparable
 - Both materials had comparable results from pressing and calorimetric testing
- OSI has successfully developed and demonstrated a repeatable water slurry method for manufacture of PBXIH-18

Acknowledgement

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