Robust Enhanced Blast Explosive Manufacturing at Holston Army Ammunition Plant
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Virgil Fung *, Brian Alexander, Erica Lotspeich, PhD., Robyn Wilmoth
BAE Systems, Holston Army Ammunition Plant, Kingsport, Tennessee, United States
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Briefing Outline

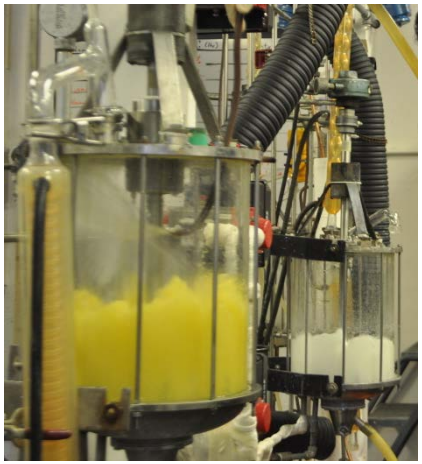
- Background
- EB Explosive Overview
- EB Explosive Process Development
- EB Explosive Manufacturing at HSAAP
- EB Explosive Manufacturing Capabilities
- Other EB Explosive Manufactured at HSAAP
- Summary
- Acknowledgements

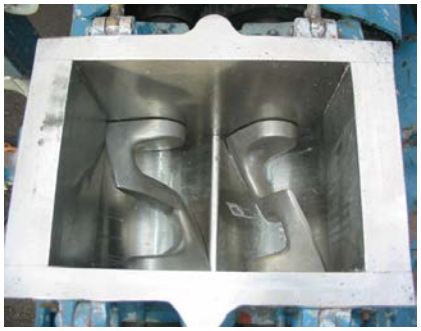
Background – Enhanced Blast Explosives Overview

- Enhanced Blast (EB) Explosives offer performance characteristics of both aluminized and non-aluminized formulations for target defeat
- The incorporation of aluminum powder achieved high shock overpressure for longer duration than non-aluminized composition
- EB Explosive is formulated to optimize the balance of detonation velocity and total mechanical energy, resulting in desirable metal pushing capability as well as high blast energy
- EB Explosives are typically selected for multi-purpose warheads in shoulder-launched weapon or direct-fire applications
- EB Explosives of interest:
  - PBXIH-18 (Aluminized HMX Based EB with inert plasticizer; ~ 30% aluminum)
  - PAX-3 (Aluminized HMX Based EB with energetic plasticizer; ~ 20% aluminum)
  - PAX-30 (Aluminized HMX Based EB with energetic plasticizer; ~ 15% aluminum)
  - PAX-42 (Aluminized RDX Based EB with energetic plasticizer; ~ 15% aluminum)

Background – EB Explosive Processing (1)

- Multiple ways to manufacture EB Explosive
  - Granulation via Aqueous Slurry Coating
    - One step process similar to standard Holston PBX manufacturing process
    - Production equipment readily available
  - Twin Screw Extrusion
    - Multi-steps process; incorporation of aluminum powder with nitramine precursor; granulator
    - Production Twin Screw Extruder not available at HSAAP
  - High Shear Mixer
    - Multi-steps process; dry or coated nitramine required
    - High Shear Mixer not available at HSAAP





Background – EB Explosive Processing (2)

- Aqueous Slurry Coating is preferred at HSAAP
  - Most efficient and cost effective process
    - Most suited for existing infrastructure without major investment
    - All processing steps conducted at HSAAP

- Choose between Water Replacement (WR) Fluid & Water
  - WR Fluid
    - Non reactive with aluminum powder
    - similar boiling point as water
    - High cost (purchase/recovery) for Production
  - Water
    - Significantly lower cost than WR Fluid
    - No special delivery or handling equipment
    - Standard aqueous source for HE manufacturing at HSAAP

EB Explosive Process Development

- Hydrogen Generation from Aluminum/Water Interaction

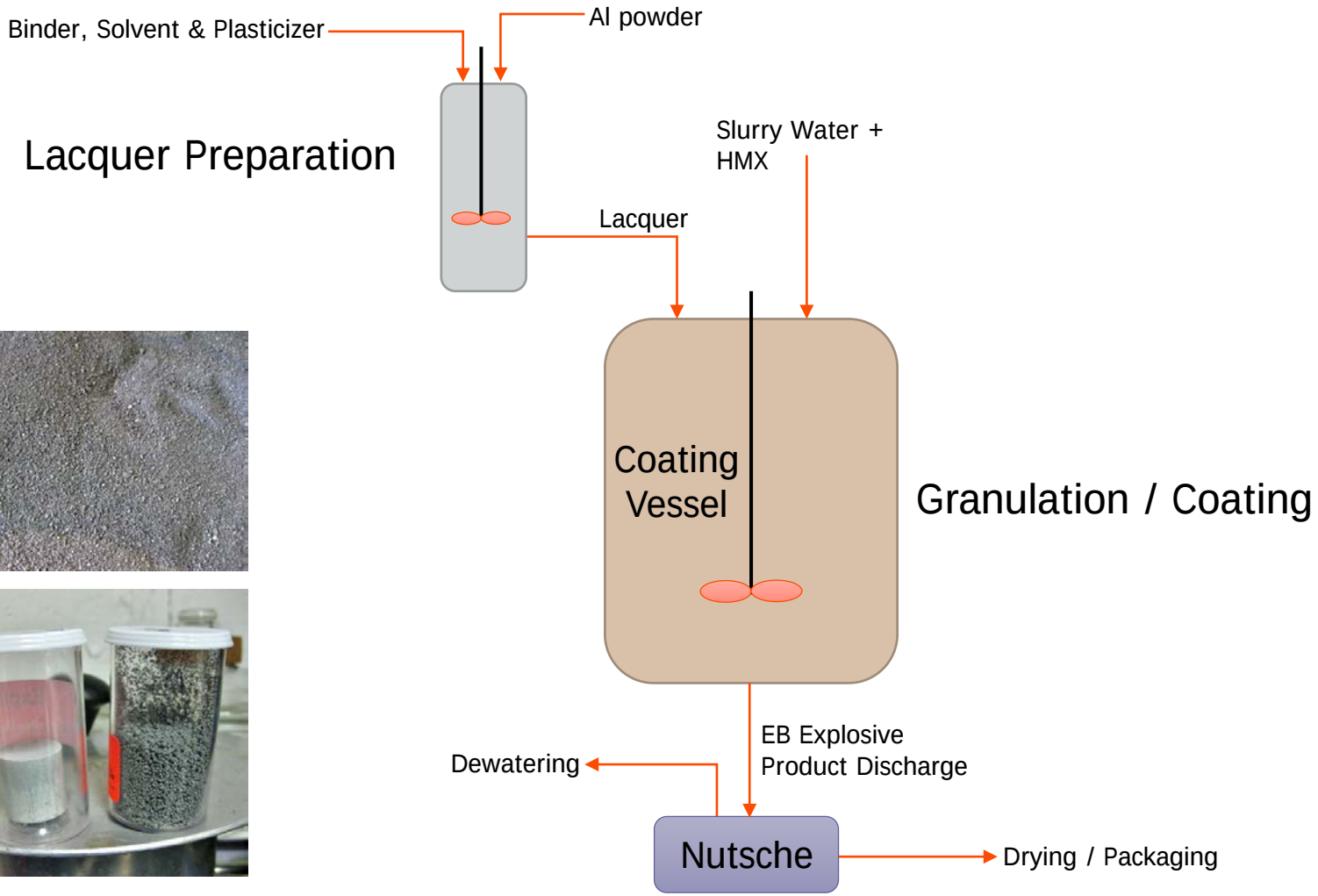
$$2Al + 6H_2O = 2Al(OH)_3 + 3H_2 \quad (1)$$
$$2Al + 4H_2O = 2AlO(OH) + 3H_2 \quad (2)$$
$$2Al + 3H_2O = Al_2O_3 + 3H_2 \quad (3)$$

- BAE Systems developed a water slurry coating process to encounter potential Hydrogen generation via
  - Suitable additives
  - Specific temperature during key stages of the process (granulation & distillation)
  - Process Configuration Changes (e.g. solvent removal / lacquer preparation)

- Hydrogen monitoring conducted at various stages of the process (coating / dewatering / drying) and none was recorded, suggesting no hydrogen generation was detected throughout the process

- The new EB Explosive Water Slurry Process was successfully scaled from Lab (5 lbs.) to Production (300 – 350 lbs.)

EB Explosive Water Slurry Process - Overview



EB Explosive Manufactured in Production at HSAAP (1)

- PAX-3
  - Developed & Qualified by US ARMY ARDEC
  - HMX based EB with aluminum and energetic plasticizer (BDNPA/F)
  - Previously manufactured at HSAAP via Slurry Coating with WR Fluid
  - Produced PAX-2 (precursor without Aluminum) for Twin Screw Extrusion (3rd party facility) in 2011
  - Robust Process for Slurry Coating with Water developed in 2015
  - Over **5,500 lbs.** manufactured in Production to date
  - PAX-3 fielded in shoulder launched weapon and under evaluation in the 120mm Advanced Multi-Purpose (AMP), XM1147 Tank Cartridge

EB Explosive Manufactured in Production at HSAAP (2)

- PAX-3 (from 2017 Production Campaign)

EB Explosive Manufactured in Production at HSAAP (3)

- PAX-3 vs. PBXN-9

EB Explosive Manufactured in Production HSAAP (4)

- PBXIH-18
  - Developed & Qualified by US NAVY Indian Head
  - HMX based EB with aluminum and inert plasticizer (DOA)
  - Previously manufactured at HSAAP via Slurry Coating with WR Fluid
  - Current process involved Twin Screw Extrusion (3rd party facility) of precursor (e.g. PBXN-9)
  - Robust Process for Slurry Coating with Water developed in 2016
  - Over **2,100 lbs.** manufactured in Production to date
  - BAE Systems water slurry material performed identically to WR slurry material (presented at IMEMTS 2016)

EB Explosive Manufactured in Production HSAAP (5)

- PBXIH-18 (from 2017 Production Campaign)

EB Explosive Manufacturing Capability at HSAAP (1)

- Manufacturing Equipment – R&D Pilot Plant

Lacquer Preparation Vessel

Coating/Granulation Vessel (Small)
~ 50-100 lbs.

Coating/Granulation Vessel (Large)
~ 300 lbs. or more

EB Explosive Manufacturing Capability at HSAAP (2)

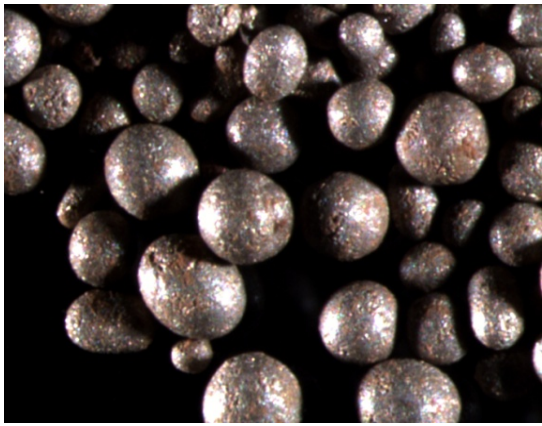
- Manufacturing Equipment – Production Facility

Lacquer Preparation Vessel

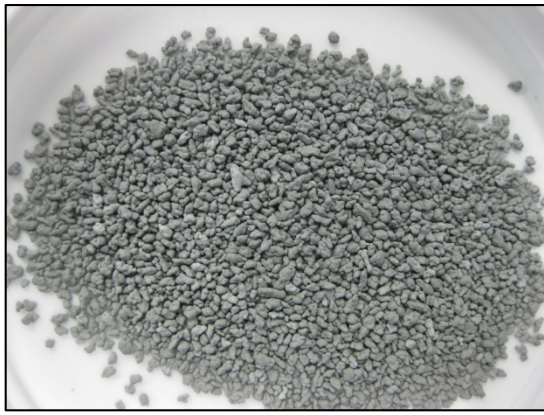
Coating/Granulation Vessel (Large) ~ 300 lbs. or more

Other EB Explosive Manufactured at HSAAP

- PAX-3 with alternate Energetic Plasticizer (R8002)
  - ~ 2,000 lbs. manufactured with water slurry coating production process
  - R8002 plasticizer replacing BDNPA/F in order to address limited supply issue
  - R8002 readily available (HSAAP product)
- PAX-30
  - High HMX Content (>75%) EB Explosive
  - BAE Systems developed lab-scale coating process for both energetic plasticizer (BDNPA/F & R8002)
    - 2 lbs. batch size (Scale-Up Ready)
    - Samples under end-use evaluation
- PAX-42
  - High RDX Content (>75%) EB Explosive using BDNPA/F
  - Robust lab scale process developed under IRAD effort
    - 2 lbs. batch size (Scale-Up Ready)



PAX-3 w R8002 (Production)



PAX-42 (Laboratory)

Summary

- BAE Systems had developed a **ROBUST**, **SAFE** & **COST EFFECTIVE** one-step water slurry coating process to manufacture aluminized EB Explosive at HSAAP
- Water-Replacement Fluid is no longer needed to mitigate the risk of Hydrogen Generation
- PAX-3 (**5,500 lbs.**), PBXIH-18 (**2,100 lbs.**) and PAX-3 w R8002 (**2,000 lbs.**) have been successfully manufactured with Production Equipment
- Both PAX-3 and PBXIH-18 made in this process are qualification-ready
  - PAX-3 will be subjected to explosive qualification later this year
- No difference in material characteristics between Water and WR Fluid
- R&D Pilot Scale Coating Vessel available for Process Development and Optimization with current and new EB Explosives
- Other pressable EB Explosives such as PAX-30 and PAX-42 ready to “Scale-Up”

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