Manufacture of Triaminotrinitrobenzene (TATB) by the Benziger Method at Holston Army Ammunition Plant

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Briefing Outline

• Review of Benziger TATB Synthesis Process
• Needs and Recent History on TATB Requirements & Manufacture
• TATB Program Overview
• Qualification of TATB and PBX Formulations from Holston Army Ammunition Plant (HSAAP)
• TATB Facilitization and Qualification Schedule
• Conclusions and Way Forward
• Acknowledgements
Review Benziger Synthesis for TATB

First Step - Nitrate TCB to TCTNB

- **1,3,5-**Trichlorobenzene (TCB) is used as the starting material for both Wet-aminated and Dry-aminated TATB

- TCB is nitrated in an Oleum / Nitric Acid solution to yield **1,3,5-Trichloro-2,4,6-trinitrobenzene** (TCTNB)
Review Benziger Synthesis for TATB

Second Step - Aminate TCTNB to TATB

• TCTNB is aminated with ammonia gas to yield 1,3,5-triamino-2,4,6-trinitrobenzene (TATB)

• The Type of TATB depends on amination conditions (i.e. whether water and/or an emulsifier is present in the reaction)

• TATB physical attributes influenced in amination step (i.e. particle size, crystalline surface characteristics, etc)
Why So Much Emphasis On TATB ?!? 

- TATB is one of the least sensitive explosive materials available 
- Critical ingredient in numerous IM Fuze systems within DOD 
- Ex. applications for TATB formulations (PBXN-7 & PBXW-14):

<table>
<thead>
<tr>
<th>General Purpose Bombs</th>
<th>2.75 HE Warhead</th>
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<tbody>
<tr>
<td>Penetrator Bombs</td>
<td>Quickstrike Mine</td>
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<tr>
<td>Tactical Tomahawk</td>
<td>60mm Mortar</td>
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<tr>
<td>SLAM ER</td>
<td>81mm Mortar</td>
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<tr>
<td>JSOW FTB</td>
<td>120mm Mortar</td>
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- DOE applications are both tactical and strategic
TATB History

- 1993 - CONUS production of TATB ceased
- 1999 - DOD began OCONUS TATB procurement from UK
- 2005 - Last qualified TATB source ceased production (and closed in 2006)
- 2007 - DOD / DOE Joint Working Group established
  - Identify service requirements
  - Develop plan for US source for TATB / TATB formulations
- 2008 - NNSA / DOE TATB Study Group established
- 2010 - Lab and pilot demonstrations of Benziger TATB synthesis by BAE Systems & ATK
- 2011 - TATB facilitization contract awarded to BAE Systems at Holston AAP
Benziger TATB: Truly a “Joint” Program

- Program participation by all DOD Services, multiple DOE Agencies, and Industry
- TATB Working Group Participants:

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<th>Organization</th>
<th>Location</th>
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<tr>
<td>OUSD (AT&amp;L) / PSA / LW&amp;M</td>
<td>Rock Island Contracting Com.</td>
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<tr>
<td>NAWC China Lake</td>
<td>679th ARSS, Eglin AFB</td>
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<tr>
<td>NSWC Indian Head</td>
<td>DOE, HQ NNSA</td>
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<tr>
<td>NAWCAD Pax River</td>
<td>DOE, LANL</td>
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<td>PD Joint Services</td>
<td>DOE, LLNL</td>
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<tr>
<td>PM CAS</td>
<td>DOE, Pantex</td>
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<tr>
<td>ARDEC</td>
<td>DLA, Strategic Materials</td>
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<tr>
<td>Joint Munitions Command</td>
<td>BAE Systems, Holston AAP</td>
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Pilot Scale-up of Benziger TATB at HSAAP

- Benziger TATB Synthesis Successfully Demonstrated on Lab-scale (both dry and wet aminated)
- In 2010, Multiple Pilot Batches Generated (100-gallon scale) for Dry Aminated TATB
  
  100-gallon Pilot Reactor Used for TATB Synthesis

  500-gallon HSAAP Vacuum Still for PBX

- Fully Compliance with TATB Military Specification (WS23158) and with draft joint DOD / DOE Specification (MIL-DTL-32337)
- TATB Successfully Converted to PBXN-7 (Production-scale) and PBXW-14 (Lab-scale)
- HSAAP TATB was “drop-in” replacement for legacy product
Pilot Scale-up of Benziger TATB at HSAAP

- Synthesis Conditions Can Effect the Physical Characteristics of the TATB. Ex.

  - Dry Aminated TATB
  - Wet Aminated TATB

- The HSAAP Pilot TATB Matched Critical Attributes of the DOE (Pantex) Legacy TATB. SEM photos from LANL (20,000x mag.)

  - Holston AAP Dry Aminated TATB
  - Typical Pantex Dry Aminated TATB
Schematic of Designed TATB Facility

• TATB Facility designed to use much of the existing infrastructure in Agile Plant
• The new equipment added for TATB will enhance overall Agile Plant capabilities

Building G-10 Agile Manufacturing Plant for Energetic Materials At Holston AAP

Key:
Red – Legacy equipment used for TATB processing
Green – New equipment being installed for TATB
Details of TATB Facility Design / Construction

• Design Completed In-house by BAE Systems at HSAAP
  - Designed with separate nitration and amination trains
  - Multiple nitration and amination batches are achievable daily
  - Ability for Concurrent (24-Hour) Operations which are Consistent with Normal Plant Functionality at HSAAP

• Building G-10 Building Preparation and Demolition Tasks are Complete

• All Equipment Procurement Activities Completed

• All Equipment Installation Subcontracts Awarded

• Equipment Installation / Final Construction Activities Initiated in May 2012 (“On-Schedule”)

Equipment Staged for TATB Facility

- TATB Facilitization Started Week of May 14, 2012
- All Major Equipment Staged In Readiness at HSAAP
Planned Program Activities

- Program Construction Phase Completed by October 2012
- Facility Commissioning Initiated in October 2012
- TATB Qualification Batches Produced in Nov-Dec, 2012
- PBXN-7 and PBXW-14 Batches Produced in December, 2012
- TATB and Formulations DOD FAT and Qualification Trials to be Complete by June 2013
Conclusions / Summary

• TATB Synthesis via Traditional Benziger Process has been Effectively Demonstrated on Lab and Pilot Scale at HSAAP (Full Compliance with DOD and DOE Specifications)

• Facilitization Program for Large-Scale Manufacture of TATB in the Agile Manufacturing Plant at HSAAP is On-Schedule

• Large-Scale Manufacture of TATB Available from HSAAP by 4\textsuperscript{th} Quarter CY-2012

• DOD Qualification of TATB, PBXN-7, and PBXW-14 to be Completed by End of June 2013

• New, Jointly Developed DOD and DOE Specification for TATB (MIL-DTL-32337) to be Finalized in 2012
Acknowledgements

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• US Army, ARDEC

• US Navy: NAVAIR Weapons Division, China Lake; NAVAIR Aircraft Division; Pax River; NSWC, Indian Head Division