Large Scale Manufacturing of Insensitive Explosive IMX-104 at Holston Army Ammunition Plant

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Briefing Outline

- IMX-104 Explosive Overview
- Recent Manufacturing Achievement
- IMX-104 Manufacturing Technology (MANTECH) Program Overview
- Modernized Melt-Cast Explosive Manufacturing Facility at HSAAP
- Concluding Remarks
- Acknowledgements
IMX-104 Explosive Overview

- An insensitive melt-pour explosive to replace Composition B for Mortar Applications
- IMX-104 and all starting ingredients manufactured at Holston Army Ammunition Plant
- Exhibited superior IM properties and comparable performance over Composition B in 81mm Mortar HE
- IMX-104 qualified as an main fill explosive in June, 2011
- Type qualification on-going for 81mm Mortar HE (60mm and 120mm to follow)

<table>
<thead>
<tr>
<th>IM Test:</th>
<th>Fast Heating</th>
<th>Slow Heating</th>
<th>Bullet Impact</th>
<th>Fragment Impact</th>
<th>Sympathetic Reaction</th>
<th>Shaped Charge Jet Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>81mm M889A1 (Comp-B)</td>
<td>(II)</td>
<td>(II)</td>
<td>(II)</td>
<td>(II)</td>
<td>(FAIL)</td>
<td>(FAIL)</td>
</tr>
<tr>
<td>81mm M889A1 (IMX-104)*</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>(PASS)**</td>
<td>(FAIL)</td>
</tr>
</tbody>
</table>

Assessed score in parentheses ( ).

* Logistical configuration with full packaging

** Result obtained from M889A2
IMX-104 – Superior IM Performance

Bullet Impact (TYPE V)  
Fragment Impact (TYPE V)  
Fast Heating (TYPE V)  

Donor  
Sympathetic Detonation (PASS – no mass detonation)  
Acceptor  

Slow Heating (TYPE V)

Photos courtesy of PM-CAS
## A Family of Insensitive Melt Cast Explosive Formulations

Insensitive Melt Cast Explosives manufactured at Holston Army Ammunition Plant

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Key Ingredients</th>
<th>Purpose</th>
<th>Qualification Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMX-101</td>
<td>DNAN + NTO + NQ</td>
<td>TNT replacement (for Artillery and other large caliber munitions)</td>
<td>Material qualified; Type qualified for 155mm M795, on-going for 155mm M1122 and 105mm projectiles</td>
</tr>
<tr>
<td>IMX-104</td>
<td>DNAN + NTO + RDX</td>
<td>Comp B replacement (for mortar applications)</td>
<td>Material qualified; Type qualification on-going for 81mm mortar, 60mm &amp; 120mm to follow</td>
</tr>
<tr>
<td>PAX-48</td>
<td>DNAN + NTO + HMX</td>
<td>Comp B replacement (for mortar &amp; tank ammunition)</td>
<td>Material qualified; Type qualification achieved for 120mm IM HE-T tracer round (NAMMO)</td>
</tr>
<tr>
<td>OSX-12</td>
<td>DNAN + NTO + RDX + Al</td>
<td>PAX-28 replacement (high blast applications)</td>
<td>Material under evaluation</td>
</tr>
<tr>
<td>PAX-21</td>
<td>DNAN + RDX + AP + MNA</td>
<td>Main fill for the 60mm M768 Mortar Rounds</td>
<td>Currently in-use in theater</td>
</tr>
<tr>
<td>PAX-41</td>
<td>DNAN + RDX + MNA</td>
<td>Main fill for the Spider Grenade</td>
<td>Currently in-use in theater</td>
</tr>
</tbody>
</table>
Recent Manufacturing Achievements

- Current batch size over 1300 lb. (1500 lb. possible)
- Over 90,000 lb. manufactured at HSAAP to date
- IMX-104 supplied to support US ARMY Mortar Loading Trial and Qualification
- Utilize existing equipment in the melt-pour explosive facility
- Robust and repeatable processes established for IMX-104, and the raw ingredients (DNAN, NTO, RDX FEM)
- Optimization opportunities identified to reduce process cycle time & to improve process efficiency
IMX-104 MANTECH Program Overview

• Objective: To maximize the manufacturing process efficiency of IMX-104 in order to lower unit cost while maintaining the desirable properties

• Funded by US ARMY Research, Development and Engineering Command (RDECOM)

• Program Management and Producibility Support from RDECOM-ARDEC Munitions Engineering & Technology Center (METC)

• Program executed by the Research & Development and Operations Department at BAE Systems Holston Army Ammunition Plant
IMX-104 MANTECH Program Technical Approach

• Test Plan Development
  • Design of Experiments (DOE) technique utilized
• Laboratory Scale Evaluation
  • Effect of ingredient variation on processability
• Laboratory Analytical Method Development
  • Alternate analytical method to evaluate processability
• Production Scale Evaluation
  • Alternate vessel to pre-melt DNAN
  • Steam supply modification at discharge valve
• Manufacture of Design of Experiment (DOE) batches
• Manufacture of Confirmation Batches
• Validation of IMX-104 via
  • First Article Testing
  • Loading Study
## IMX-104 MANTECH Design of Experiments

<table>
<thead>
<tr>
<th>Variables</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>1,325 lb batch</td>
</tr>
<tr>
<td></td>
<td>Ingredient addition temp @ 105°C</td>
</tr>
<tr>
<td></td>
<td>Final mixing time &amp; temp 90 minutes @ 100°C</td>
</tr>
<tr>
<td>DNAN Pre-Melter</td>
<td>Various loading methods of DNAN</td>
</tr>
<tr>
<td></td>
<td>Various steam supply levels</td>
</tr>
<tr>
<td>Process Temperature</td>
<td>Elevated ingredient addition and processing temperature</td>
</tr>
<tr>
<td>Ingredients Addition Rate</td>
<td>Fastest possible addition rate without compromise on product temp in kettle</td>
</tr>
<tr>
<td>Final Mixing Time &amp; Temperature</td>
<td>Reduced mixing time combined with higher mixing temperature</td>
</tr>
<tr>
<td>Batch Size</td>
<td>High and low (1,500 lb / 700 lb)</td>
</tr>
</tbody>
</table>

### Diagram

```
DNAN & Ingredients
Pre-Melter
Incorporation Kettle
Hold-Up Kettle
Pellet Pot
Casting Belt (water cool)
Nutsche
```
IMX-104 MANTECH Program Status and Schedule

- Lab Scale Ingredient Evaluation Completed
- DNAN Pre-melter received, awaiting installation
- DNAN Pre-melter proof out scheduled for June 2012
- IMX-104 DOE and confirmation batches scheduled for Q3/4 2012
- First Article Testing and Loading Trial scheduled for Q1 2013
Modernized Melt-Cast Explosive Manufacturing Facility

- Current Melt-Cast Facility (Bldg. L-4) at HSAAP will not meet future requirements of IM explosives
  - IMX-101, IMX-104, PAX-48, PAX-21, PAX-41
- MANTECH Programs will improve currently process efficiency at L-4
- Modernization of the Melt-Cast Facility will satisfy future production requirements
  - New design & technologies featured to further improve process efficiency
- Funded by the US Army Project Director for Joint Services (PD-JS)
- Construction started: May 2011
- Scheduled completion date: Oct 2012
Modernized Melt-Cast Explosive Manufacturing Facility

Benefits / Improvements

- Annual production capacity increase > 250% (3.9M lb.)
  - DNAN Pre-melter concept to streamline process
  - Growth opportunity with other IM products
- Replacing aging equipment with state-of-the-art systems
  - New flaker belt design eliminates water exposure
  - New discharge valve with better flow control
  - New loss-in-weight feeder (accurate discharge rate)
- Better control of temperature profile in melt kettle
  - Improve process and product consistency
- Accurate material balance resulting in consistent product composition
  - Load cell in kettle to ensure accurate ingredient increment
Modernized Melt-Cast Explosive Manufacturing Facility

- Building Layout
Modernized Melt-Cast Explosive Manufacturing Facility

- Equipment Layout
Modernized Melt-Cast Explosive Manufacturing Facility

• Ingredient Incorporation

• Product Casting
Concluding Remarks

- A NEW FAMILY of IM melt-pour explosives now available at HSAAP
  - IMX-104 demonstrated excellent IM properties over Composition B
  - IMX-104 material qualified by U.S. Army – qualification for 60 and 81mm Mortar HE in progress, and 120mm planned
- Robust large scale manufacturing process for IMX-104
- Process efficiency shall further improve after MANTECH program
- Modernized Melt-Cast Explosive Manufacturing Facility shall further enhance HSAAP capability and capacity as the center of excellence in IM explosive manufacturing
  - Improved product quality
  - Improved process efficiency
Acknowledgement

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