Common Low-cost IM Explosive Program to Replace TNT

Joint U S Army & U S Marine Corps

Explosive Ingredients and Compositions for the IM M795 Artillery Ammunition
Briefing Outline

- Background and Introduction to IMX-101, -102 and -103
- Manufacturing Overview
  - Non-traditional Ingredients
    - Large Scale Manufacture
      - DNAN, NTO
    - Lab Scale Manufacture
      - Nitrate Salt Eutectic
  - Compositions
    - Large Scale Manufacture - IMX-101, IMX-102
    - Lab Scale – IMX-103
- Strategic Supply Capability
  - Current Capacity
  - Pricing and Availability
Background and Introduction

- PM-CAS Common Low-cost IM Explosives Program
- Seeking IM Explosives that are:
  - Effective
  - Less sensitive
  - Affordable
  - Producible
  - Life-cycle compliant
- Phased Evaluation Program
- Led to 3 Primary Candidates
  - IMX-101, -102, and -103
- Undergoing Qualification Testing (Phase 3)
- Formulations & Ingredients:
Formulations

- Largely composed of “non-traditional” ingredients:

<table>
<thead>
<tr>
<th>Formulation</th>
<th>AKA</th>
<th>Non-traditional Ingredient(s)</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMX-101</td>
<td>OSX-CAN</td>
<td>DNAN, NTO</td>
<td>DNAN</td>
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<tr>
<td>IMX-102</td>
<td>MCX-8</td>
<td>NTO</td>
<td>NTO</td>
</tr>
<tr>
<td>IMX-103</td>
<td>DEMN-III J</td>
<td>Nitrate Salt Eutectic</td>
<td>Eutectic</td>
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</tbody>
</table>
Review of Business Case of Down-selected Candidates

“Funnel” framework to progressively screen candidates

- **Filter 1 Criteria**
  - Cheetah Calculations
  - Standard Safety Tests
  - Electrostatic
  - Friction Impact
  - Sensitivity
  - Vacuum Thermal
  - Stability
  - Differential scanning
  - Critical Diameter

- **Filter 2 Criteria**
  - Tier 1 IM Tests (BI, FI, SCO)
  - Tier 2 IM Tests (SD)
  - Tier 3 IM Tests (FCO, SCJ)

- **BCA Criteria**
  - IM Tests, Lethality, Logistics, Safety, Platform
  - Performance of the alternatives against weighted factors
  - Risk analysis
  - Comparable cost analysis
  - Sensitivity Analysis

- **Munitions Fill Types**
  - Filter 1 -- Safety & Performance
    - Pass / Fail
    - Must Show Improvement
  - Filter 2 -- Insensitive Munitions
  - Business Case Analysis (BCA)
    - Utility
    - Life-cycle Costs
    - Risk Analysis

- **IM Explosive Fill**
  - for 120mm and/or 155mm

- **Review of Business Case of Down-selected Candidates**
  - “Funnel” framework to progressively screen candidates

- **Focus on Ingredient and Composition Producibility**
Manufacturing Producibility
Non-Traditional Ingredients

- **Cost of ingredients:**
  - DNAN
  - NTO
  - Nitrate salts

- **Strategic Synthesis Capability**
  - Current, active manufacturing capacity at HSAAP (as of 2007)
  - Ingredients synthesized in the HSAAP Agile Plant
    - Combined DNAN/NTO capacity is ≈2-3m LB / year
      - Using existing facilities and infrastructure
Agile Plant Manufacture Overview

- Reported at Prior IM EM Conferences
- Established in CY2001
  - 2,000 Gallon Reactor at Heart of Facility
  - Installed in a facility designed to be flexible in operation
    - Rapidly reconfigurable
    - Multi-purpose chemistry capability
    - Extensive infrastructure support
    - Expandable
- Presently used for the LARGE SCALE manufacture of:
  - DNAN
  - NTO
  - DMDNB
  - Special grades of PETN, RDX
  - TATB
  - R8002 (short-term future production)
Product Collection: Nutsche De-watering

Pfaudler 2,000 Gallon Reactor

Process Control – SIEMENS PCS-7
2,4-Dinitro anisole (DNAN)

- Batch-Manufacture
- A Good Melt-phase Insensitive Substitute for TNT
  - A critical component of IMX-101
- Two Synthetic Routes Demonstrated on Production Scale
- Multiple raw-material sources (U.S., international)
- Qualified in U.S. Weapon Systems
  - PAX-21 (60mm Mortar)
  - PAX-41 (SPIDER)
HSAAP DNAN – INDICATIVE PRICING

Single-shift Batch Operation

Single-shift Multi-batch Operation

24/5 to 24/7 Continuous Operation

Note: Prices subject to formal RFQ review.

ITAR Approved
Nitrotriazolone (NTO)

- **Batch Manufacture**
  - Synthesis based upon published route
  - Modified to improve safety and productivity
  - Multiple raw-ingredient sources

- **Used as an insensitive RDX Replacement**
  - Critical for achievement of adequate product functioning
    - Performance and sensitivity
  - Available in various particle sizes
    - Key to achieving desired processability
HSAAP NTO – INDICATIVE PRICING

Note: NTO pricing is influenced by a key raw-ingredient index, linked to oil prices. Prices subject to formal RFQ review.
Nitrate Salt Eutectic

- Manufactured on Lab-Scale only to Date
- Elegant Salt Manufacturing Method
  - Water-based synthesis
  - Acid-base neutralization
- Robust Salt Eutectic
  - Insensitive to composition variation (+/-2% tested)
Melt-Pour Explosive Manufacture

- **Traditional Melt-Pour Technology**
  - Melt-phase ingredient (TNT, DNAN, Wax etc.)
  - Fillers (RDX, NTO, etc.)
  - Low-shear incorporation
  - Flaking
  - Quality control / assurance, final packaging

- **Industrial Capacity**
  - Current active capacity: 6m LB / year
    - Surge capacity >25m LB / year

- **Life-cycle Management**
  - IMX-101, -102 and -103 are melt-pour explosives
  - Existing Demil technology base applies to IMX products

Test Quantities of IMX-101 and IMX-102 Manufactured on FULL PRODUCTION SCALE at HSAAP in support of PM-CAS Common Explosive Program (1,500 LB nominal batch size)
Concluding Remarks

IMX-101, -102 and -103 Candidates for 155mm Artillery Projectile

- Contain “non-traditional” ingredients
  - NTO, and/or DNAN, or nitrate-salt eutectic
- NTO and DNAN produced on full production scale
- Nitrate-salt eutectic producible on same scale (not yet demonstrated)
- Raw ingredients available CONUS and OCONUS
- IMX-101 and -102 Manufactured on full production scale

Demonstrated IM Compliance
Results far exceeded expectations
Safe, Suitable & Sustainable
Acknowledgements

- ARL
- ARDEC
- BAE Systems
- PM-CAS
- DZI (Kansas)
- NTS
Briefing Session Summary

- Common Low-cost IM Explosive Program – Jim Rutkowski, PM CAS
- The Characterization of IM Explosive Candidates for TNT Replacement
- Manufacture of Explosive Ingredients and Compositions for the IM M795 Artillery Ammunition – Andrew Wilson, BAE Holston OSI
- IM HE Loading of 155 mm Projectiles – Erik Boykin, US Army ARDEC