Common Low-cost IM Explosive Program to Replace TNT

Joint U S Army & U S Marine Corps

October 2007
Common Low-cost IM Explosives

 ISSUE:
- TNT & Comp-B explosives have poor IM results
- HE items require IM Waiver
  - IM explosives identified under prior efforts
    - Specific to individual program requirements
    - Lacked commonality
    - Some IM improvements – still need waiver
    - NTIB Cost Impacts

 CORRECTIVE ACTION:
- Investigate new IM Explosives with intention to insert into production in near-term
Objective: Common Low-cost IM Explosive Program

New IM Explosive for Artillery and Mortar applications that are:

- **Effective**
  - Maintain Lethality with minimal or no degradation
- **Less Sensitive**
  - If not fully compliant, must show improvement over Baseline explosive
- **Affordable**
  - Artillery Cost Drivers = Steel Body Material & Explosive Fill
  - Mortar Cost Drivers = Steel Body Material, Fuze & Propelling Charges
- **Producible within the National Technology and Industrial Base (NTIB)**
  - Infrastructure
  - Raw Ingredients
  - Explosive formulation
  - Projectile Load, Assemble & Pack (LAP)
- **Other Considerations**
  - Intellectual Property Rights
  - Demilitarization
  - Environmental

Primary Objective is to provide a Common IM Fill

-- or --

one common TNT replacement (Artillery)...

...and one common Comp-B replacement (Mortars)
PM-CAS Common Low-cost IM Explosives Program

“Funnel” framework to progressively screen candidates

Munitions Fill Types

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

Pass / Fail

Filter 2 -- Insensitive Munitions
- Tier 1 IM Tests (BI, FI, SCO)
- Tier 2 IM Tests (SD)
- Tier 3 IM Tests (FCO, SCJI)

Must Show Improvement

Business Case Analysis (BCA)
- Utility
- Life-cycle Costs
- Risk Analysis

Risk analysis
- Comparable cost analysis
- Sensitivity Analysis

IM Explosive Fill for 120mm and/or 155mm

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, SCJI)

Area Test & Qualification

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

October 2007
# IM Test Results

## 155mm Artillery Baseline

### Reactions:
- **VI**: No Sustained Reaction
- **V**: Burn
- **IV**: Deflagration
- **III**: Explosion
- **II**: Partial Detonation
- **I**: Detonation

### IM Test Results Table

<table>
<thead>
<tr>
<th>IM Test</th>
<th>FCO</th>
<th>SCO</th>
<th>BI</th>
<th>FI</th>
<th>SD</th>
<th>SCJI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing Criteria</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>III</td>
<td>III</td>
</tr>
<tr>
<td>155mm M107 (TNT)</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>( I )*</td>
<td>( I )*</td>
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<tr>
<td>155mm M107 (Comp-B)</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>I</td>
<td>( I )*</td>
<td>( I )*</td>
</tr>
<tr>
<td>155mm M795 (TNT)</td>
<td>III</td>
<td>III</td>
<td>IV</td>
<td>IV</td>
<td>I</td>
<td>( I )*</td>
</tr>
</tbody>
</table>

* Assessment (not tested)

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### M107
- **Steel Body**
- **Swaged Rotating Band**
- **15.4 lb Explosive Fill [Comp-B]**

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### M795
- **Welded Rotating Band**
- **High Fragmenting (HF1) Steel Body**
- **23.8 lb Explosive Fill [TNT]**
Established IM Test Configuration for TNT-Replacement

- **155mm established as test vehicle**
  - M795 Projectile with HF1 Steel
  - Vented Nose Plug/Meltable Fuze Plug
  - Supplementary Charge of Pressed-TNT/PBXN-9

- **Palletization**
  - 8 Projectiles per Pallet, Wood (2 x 4)
  - No S.D. Barriers
Established IM Test Protocol for Artillery (155mm M795)

- **Tier 1 Tests**
  - Bullet Impact (.50 cal AP)
  - Fragment Impact (6,000 ft/s)
  - Slow Cook-off (+145°F condition, 50°F/hr rate)

- **Tier 2 Tests** -- must show improvement in at least 1 of Tier 1 Tests
  - Sympathetic Detonation (single-rd detonation, 2x2 diagonal acceptor/donor)

- **Tier 3 Tests** – Candidates based on Tier 1 & 2 Test Results
  - Fast Cook-off
  - Shaped Charge Jet

Protocol Considerations:
- Cost of Test
- Ease of Setup
- Threats for Comparison to Baseline
- Reaction Level for proceeding
Phase 1 Summary
(Tier 1 & 2)

✓ Performed IM Tests
  • 23 Explosive candidates considered

<table>
<thead>
<tr>
<th>CANDIDATES:</th>
<th>Melt-pour</th>
<th>Cast-cure</th>
<th>Press-fill</th>
</tr>
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<tbody>
<tr>
<td>Inert Binder</td>
<td>2</td>
<td>5</td>
<td>1</td>
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<tr>
<td>Energetic Binder</td>
<td>15</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

• 9 candidates tested (melt-pour, cast-cure, pressed)
• Top 3 Candidates
  – All three are Melt-pour and each passed SD test without Barriers
    » Insufficient difference to select the go forward candidate
  – Perform Tier 3 prior to entering Qualification Testing and address
    1) Producibility
    2) High Risk Areas
    3) Lethality Assessment
Comparison to TNT

- **Water Pit Tests**
  - M795 projectiles loaded with IM formulations

- **Cylinder Expansion Tests**
  - 4” copper cylinders

All 3 formulations have fragmentation and Gurney Energy equivalent or better than TNT.
Achievements

✓ **Demonstrated IM Compliance**
  - Production Equipment
  - Product Ingredients
  - Production scale

### Passed SD
Passed SCJI

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<tr>
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<td>V</td>
<td>V</td>
<td>V</td>
<td>III</td>
<td>III</td>
</tr>
<tr>
<td>M795 Baseline (TNT)</td>
<td>FAIL</td>
<td>FAIL</td>
<td>FAIL</td>
<td>FAIL</td>
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<td>FAIL</td>
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<tr>
<td>IMX-101</td>
<td>PASS</td>
<td>PASS</td>
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<td>PASS</td>
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<tr>
<td>IMX-102</td>
<td>(PASS)</td>
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<tr>
<td>IMX-103</td>
<td>PASS</td>
<td>PASS</td>
<td>FAIL</td>
<td>PASS</td>
<td>PASS</td>
<td>FAIL</td>
</tr>
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50mm RPG
Qualification Program Schedule for TNT-Replacement

- **Phase 1 – Screening / Downselect**
  - Passed SD without Barriers

- **Phase 2 – Selection / Qualification**
  - Passed RPG SCJI
  - Equal or better lethality
  - Producible

- **Phase 3 – Transition / Qualification**
  - EMQB Certification and Gun Qualification

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TNT-Replacement

**Phase 1 “Screening”**
- Identify & Test Candidates
- Downselection

**Qualification Phase 2**
- Selection (Primary/Secondary)

**Qualification Phase 3 (IMX-101)**
- ECP into TDP

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<tbody>
<tr>
<td></td>
<td></td>
<td>Tier 1 &amp; 2 IM</td>
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<tr>
<td></td>
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<td>Tier 3 IM</td>
</tr>
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<td>EMQB Cert., Gun Qual.</td>
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Today
Summary

- Demonstrated IM Compliance
  - Results far exceeded expectations
  - Suitable Affordable & Sustainable solution

- Further details on this effort will be presented in the following presentations:
  - Characterization
    - The Characterization of IM Explosive Candidates for TNT Replacement – Brian Roos, US Army Research Lab
  - Producibility
    - Manufacture of Explosive Ingredients and Compositions for the IM M795 Artillery Ammunition – Andrew Wilson, BAE Holston OSI
  - IM Testing
  - Projectile Filling
    - IM HE Loading of 155 mm Projectiles – Paul Betts, US Army ARDEC

This technology saves lives, facilities & assets