Common Low-cost IM Explosive Program to Replace TNT

Joint U S Army & U S Marine Corps

The Characterization of IM Explosive Candidates for TNT Replacement

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Dr. Brian Roos
U.S. Army Research Laboratory
Attn: AMSRD-ARL-WM-TB
Aberdeen Proving Ground, MD 21005
broos@arl.army.mil

Outline

- Background/Collaboration
- Small Scale Safety Tests
- Thermal Analysis
- Performance and Shock Sensitivity
- Subscale Tests
- Initiation
- Functioning

Background

- Common Low-cost IM Explosive Program
  - ✓ Previous J. Rutkowski brief in Session 7A

- Requirements
  - ✓ Effectiveness
  - ✓ Reduced Sensitivity
  - ✓ Affordability
  - ✓ Producibility
  - ✓ Other Criteria

Collaboration

- Formulations developed by BAE-Holston, ARL, ARDEC
- Production at BAE-Holston, ARL, ARDEC
- Characterization testing at ARL, ARDEC
- Guidance from PM CAS
- Funding by PEO AMMO, PM CAS, ARDEC & ARL

BAE SYSTEMS

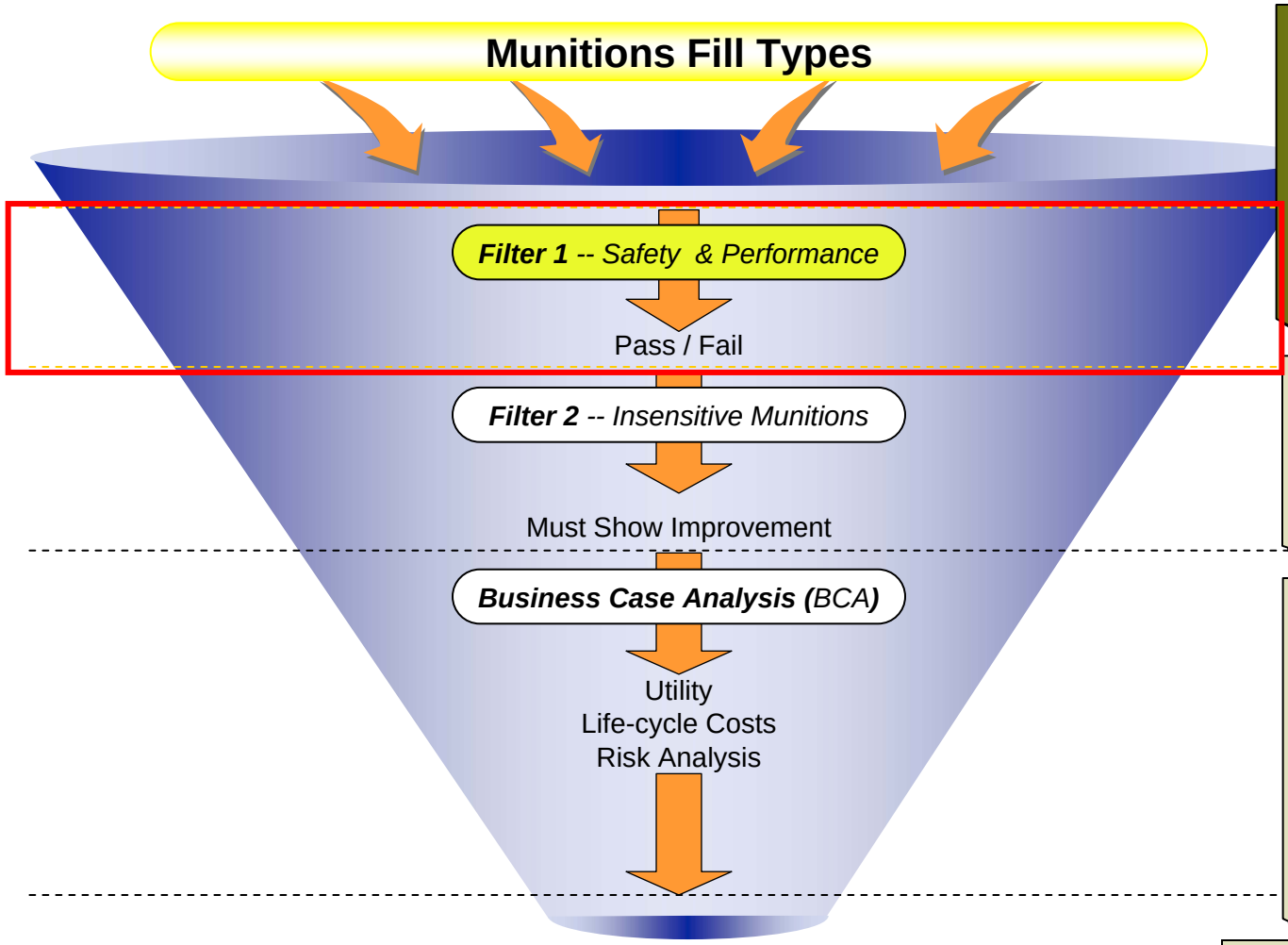
Formulations

- **Based on Non-traditional Ingredients**

Formulation	Previously Known As	Non-traditional Component	
IMX-101	OSX-CAN	DNAN, NTO	
IMX-102	MCX-8	NTO	
IMX-103	DEMN-III J	Nitrate Salt Eutectic	

Review of Filter 1 Data for 3 Downselected 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, SCJI)

BCA Criteria

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

Arena Test & Qualification

Small Scale Sensitivity

	Impact (cm)	Friction (N)	ESD (J)
	ERL/Bruceton	BAM	
IMX-101	> 100	242	> 0.25
IMX-102	> 100	212	> 0.25
IMX-103	> 150	122	> 0.25
RDX	25.4	110	> 0.25

- All 3 IMX formulations determined to be safe for handling

Thermal Analysis

	DSC Melt Onset STANAG 4515	DSC Decomposition STANAG 4515	Vacuum Thermal Stability <2 cc/g STANAG 4556
IMX-101	94°C	228°C	Pass
IMX-102	77°C	275°C	Pass
IMX-103	99°C	235°C	Pass
TNT	77°C	300°C	Pass

- Thermal analysis shows acceptable melt temperatures for existing facilities and suitable thermal stability for melt processing operations

Performance and Shock Sensitivity

	Density TMD (g/cc)	Detonation Velocity (% of TNT)	Detonation Pressure (% of TNT)	Gap Thickness[1] (cards)	Gap Pressure[1] (kbar)
IMX-101	1.70	100	102[2]	< 100	> 57
IMX-102	1.79	104	114[2]	< 100	> 57
IMX-103	1.66	107	122[2]	< 100	> 57
TNT	1.65	100	100	153	30
Comp B	1.74	114	140	200	21

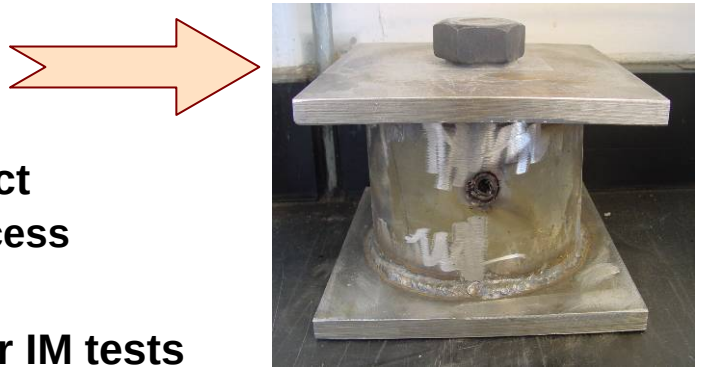
[1] NOL LSGT, STANAG 4488

[2] Cheetah 3.0 Thermochemical Equilibrium Code

- Testing indicates that IMX formulations meet TNT performance with reduced shock sensitivity

Subscale IM Testing

- **Previously investigated IM explosive**
  - ✓ **Plan was to conduct Sub-scale Tests, then IM Tests followed by Performance Tests**
    - Sub-scale IM test results
      - Projectile section between welded plates
      - Exhibited mild response to thermal/impact
        - » Indicated high probability of pass/success
    - IM Tests of All-Up Rounds (155mm M795)
      - FCO and BI were performed prior to other IM tests
      - Failed both FCO and multiple BI tests
    - Sub-scale results did not correlate completely with Full-scale Tests
  - ✓ **Use of modeling and sub-scale tests require further advances or improvements to test fixtures**
    - Configuration (common, correct, applicable)
    - Modeling Efforts (ongoing, but needs more time and data)



- **Full Scale Testing is Necessary**

Initiation Tests

- Static detonation
- M795 ogive section
- Supplemental charge
- Side and bottom witness plates

- Supplemental Charge
  - ✓ Originally pressed TNT
  - ✓ Insensitive fill require enhanced power supplemental charge
  - ✓ PBXN-9 selected for performance and IM

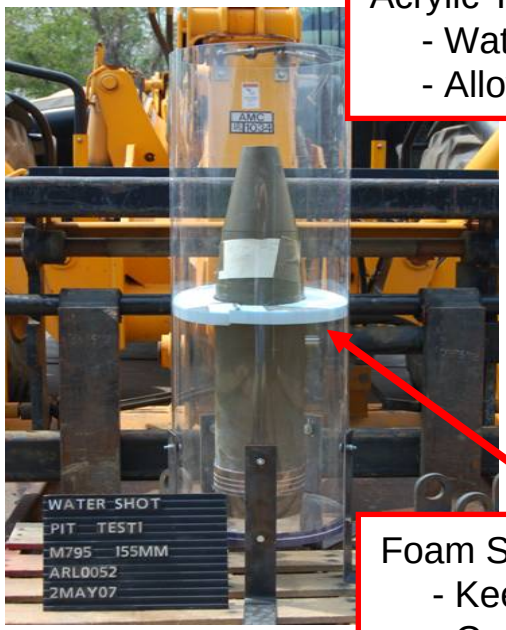
Initiation Results

- **PBXN-9 supplementary charge used to successfully initiate IMX fills**
  - ✓ **Good quality dents on bottom witness plates**
  - ✓ **Fragment pattern observed on side witness plates**

Functioning Tests - Fragmentation Analysis

➢ ARL Water Pit Test

- ✓ Static detonation of M795 projectiles with TNT and IMX fills
- ✓ Soft Recovery of Fragments
- ✓ Fragmentation Analysis



Acrylic Tube
- Watertight seals
- Allows expansion to 2x CD

Foam Spacer
- Keeps projectile upright
- Centering device

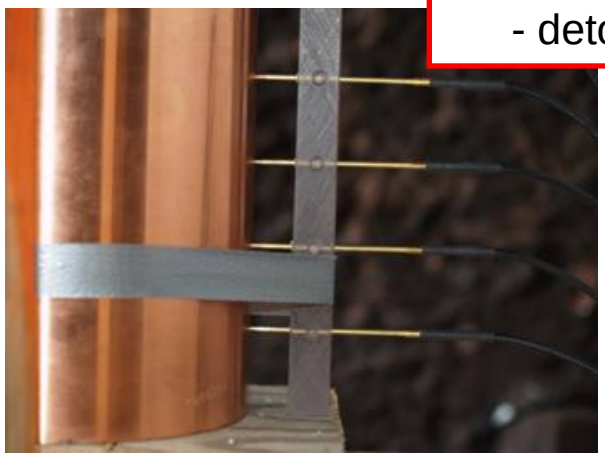
All 3 IMX fills meet or exceed TNT fragmentation performance

Additional Performance Tests - CYLEX

➢ Cylinder Expansion Test

- ✓ **Gurney energy derived from streak camera record showing wall expansion**
- ✓ **Detonation Velocity**

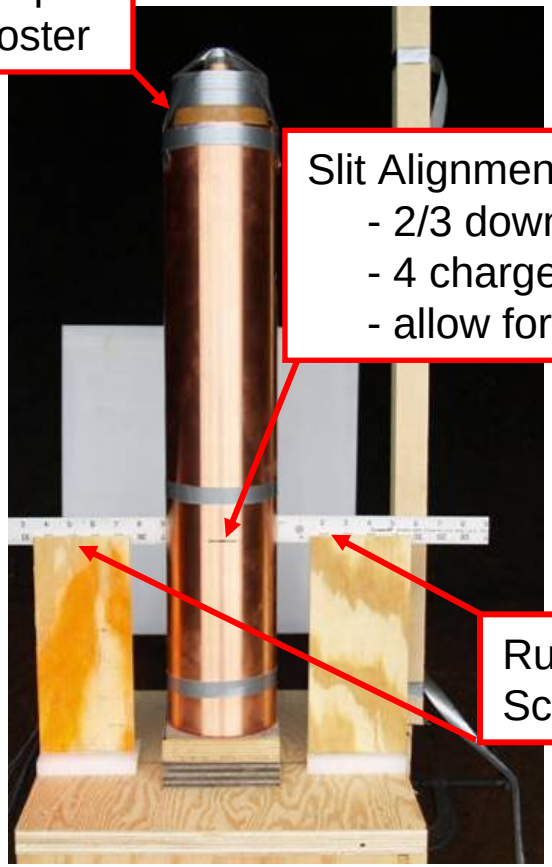
Piezoelectric pins
- on back wall
- detonation velocity



Comp B Booster

Slit Alignment
- 2/3 down cylinder
- 4 charge diameters
- allow for steady state

Rulers for Scale



All 3 IMX fills match or exceed TNT Gurney energy

Summary

- **Common Low-cost IM Explosive Program – Jim Rutkowski, PM CAS**

- **The Characterization of IM Explosive Candidates for TNT Replacement**
  - ✓ **Safe for handling and transportation**
  - ✓ **Performance equivalent or greater than TNT**
  - ✓ **Reduced sensitivity**
  - ✓ **Initiable and meets TNT lethality in the M795 projectile**

- **Manufacture of Explosive Ingredients and Compositions for the IM M795 Artillery Ammunition – Andrew Wilson, BAE Holston OSI**
- **The Application of New IM Explosive Candidates in the M795 Projectile – Sanjeev Singh, US Army ARDEC**
- **IM HE Loading of 155 mm Projectiles – Erik Boykin, US Army ARDEC**

Less Sensitive and Meets Performance Requirements