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Common Low-cost Explosive Insensitive Munitions Program Phase 2: Explosive Replacement for Comp B

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DoD / Industry Participants

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Background: Explosive Fills for PM-CAS Items

- Baseline Explosive Fills
  - TNT (Melt-pour)
    - Baseline for all 105/155mm Artillery ***7 Projectiles***
  - Comp-B (Melt-pour)
    - Baseline for all 60/81/120mm Mortar ***6 Cartridges***
      - Also allowed for Artillery's 105mm M1 and 155mm M107

- Efforts Prior to FY07 for IM Explosive Fills
  - 60mm Mortar
    - PAX-21 (Melt-pour) --- Type-Classified & Fielded
  - 81mm Mortar
    - T.B.D. --- leveraging 60mm & 120mm Mortar efforts
  - 120mm Mortar
    - HBU-88B (Cast-cure) --- Type-Classified
  - 105mm Artillery
    - T.B.D. --- no active program
  - 155mm Artillery
    - PAX-196 (Melt-pour)

Driven to IM Solutions

Success of Phase I CLIMEX Program

- IMX-101 passed all Engineering IM Tests in the 155mm M795 Artillery Projectile
  - Met TNT lethality in M795
- IMX-101 was loaded in the 120mm M934A1 Mortar for IM and Lethality testing as part of the Common Fill evaluation
  - Performance tests proved that IMX-101 does not have enough energy to compete with Comp B in the 120mm Mortar

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

Program initiated in FY07

Primary Objective is to provide a Common IM Fill
-- or --
one common TNT replacement (Artillery)...
...and one common Comp-B replacement (Mortars)

IM Test Results
Mortar Baseline

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

IM Test:	FCO	SCO	BI	FI	SD	SCJI
Passing Criteria	V	V	V	V	III	III
60mm (Comp-B/PAX-21)	II / V**	III / II**	V	III	(I)*	(I)*
81mm (Comp-B)	(II)*	(II)*	(III)*	(III)*	(I)*	(I)*
120mm (Comp-B)	II	I	I	I	(I)*	(I)*

<- IPT Score

** with PAX-21 and Intumescent Coating

( )* Assessment -- not tested

60mm

HF1 Steel w/ PAX-21

0.8 lb Explosive Fill
[Comp-B: free]
[PAX-21: ~$15/lb]

81mm

Steel Body
HF1 Steel w/ "A1"

2.0 lb Explosive Fill
[Comp-B: free]

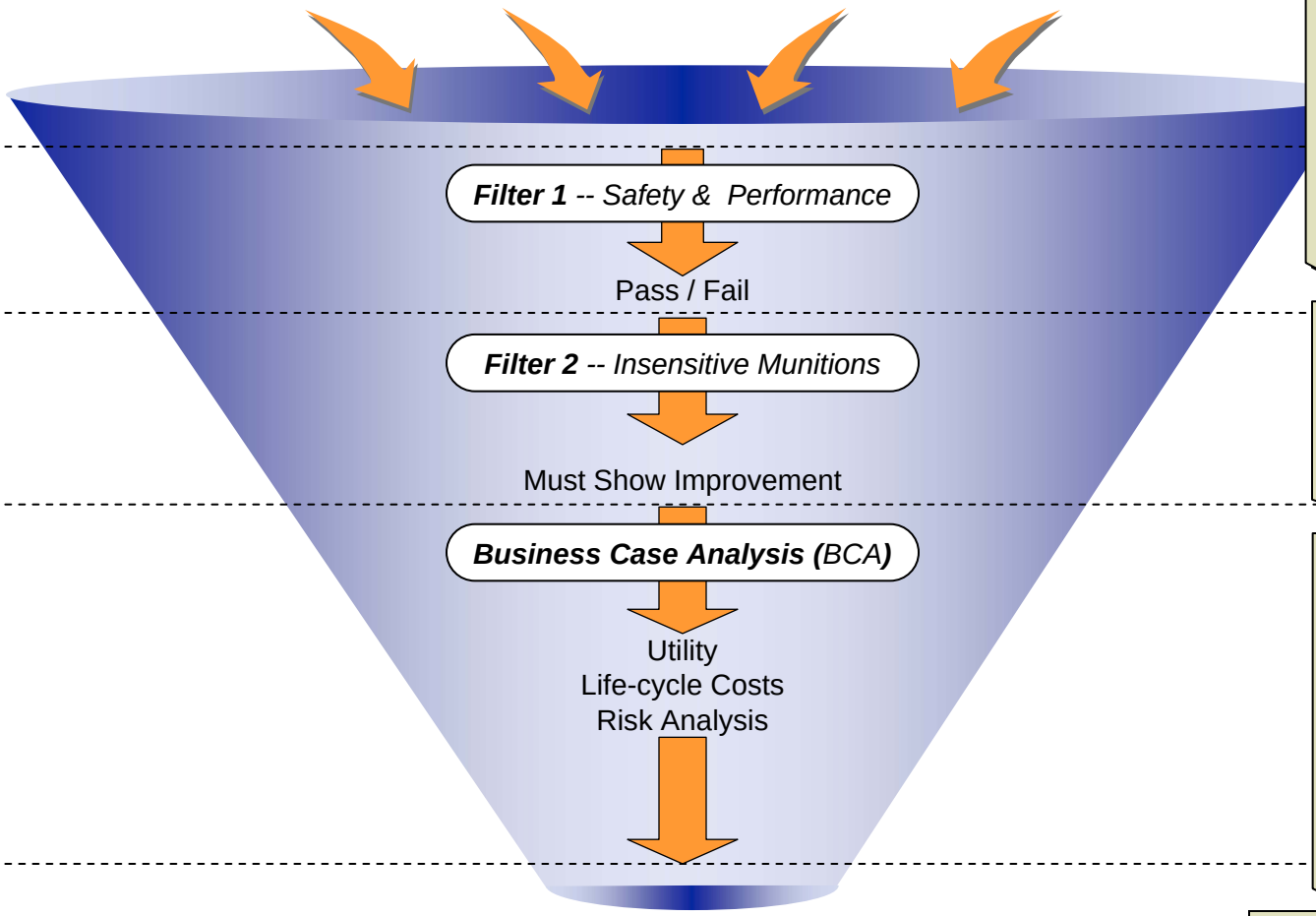
120mm

Steel Body

6.6 lb Explosive Fill
[Comp-B: free]

Common Low-cost IM Explosive Program

- "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, SD)
- Tier 2 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

IM Formulations

- Sources:
  - Historical / Government / Industry / Foreign
  - QFD conducted by ARDEC
  - PEO-AMMO IM Thrust Programs
  - Navy and Air Force Explosives
  - Industry efforts
  - Phase I CLIMEX Program

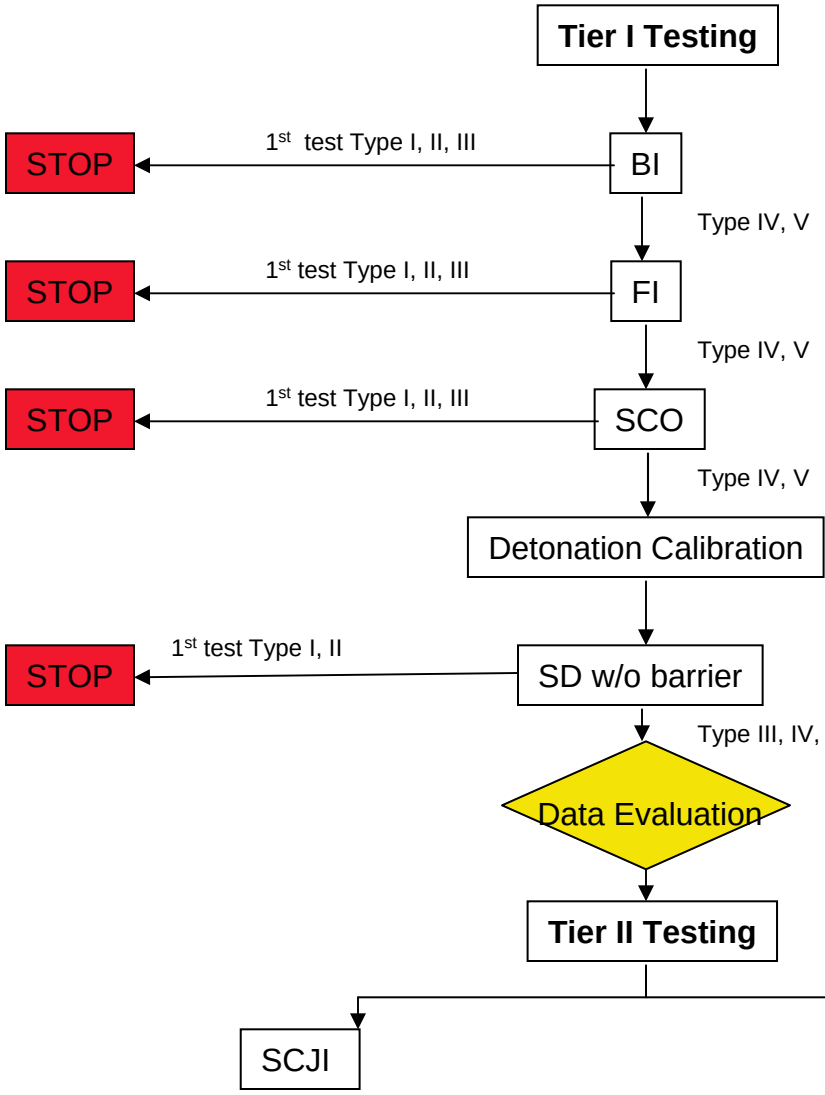
Candidate Explosive Fills

- Melt-pour
  - Traditional Ingredients
    - RDX
    - HMX
  - Less Sensitive Explosive Filler
    - NTO
    - NQ
  - Less Sensitive Energetic binder
    - DNAN
    - Nitrate Salts
  - Reduced Nitramines (Aluminized)

- Cast-cure
  - Inert binder
    - RDX
    - IRDX
    - Rounded RDX

- Press-fill
  - Inert binder with RDX (Redesign of metal parts – Not Evaluated)

IM Test Matrix



Protocol Considerations:

- Cost of Test
- Ease of Setup
- Threats for Comparison to Baseline
- Reaction Level for proceeding

Test Configuration

- IM Test Configuration for Comp-B Replacement (Mortars)
  - 120mm established as test vehicle
    - M934A1 Mortar Round with Standard Steel
    - No container for FI, BI, SCO
    - M734A1 MOFM Live Fuze
      - Reduced-thread Steel Fuze Adapter
      - PBXW-14 Booster Pellet to initiate IM fills
    - Replace CH6 Booster Pellet with PBXW-14 (if necessary)
    - Palletization configuration for SD
      - 2 rounds per PA154 Metal Container
      - One Round Up, One Round Down in Fiber Tubes
      - Wood (6 x 8)

Bullet Impact Test

MIL-STD-2105C / 7.62mm AP Bullet / Witness Plate & Pressure Gage

Results varied from Type III to Type V

Fragment Impact Test

MIL-STD-2105C / 6,000 ft/s Fragment / Witness Plate & Pressure Gage

Results varied from Type IV to Type V

Slow Cook-off Test

MIL-STD-2105C / 50F/hr / Precondition 145F / Witness Plate & Pressure Gage

Results varied from Type I to Type V

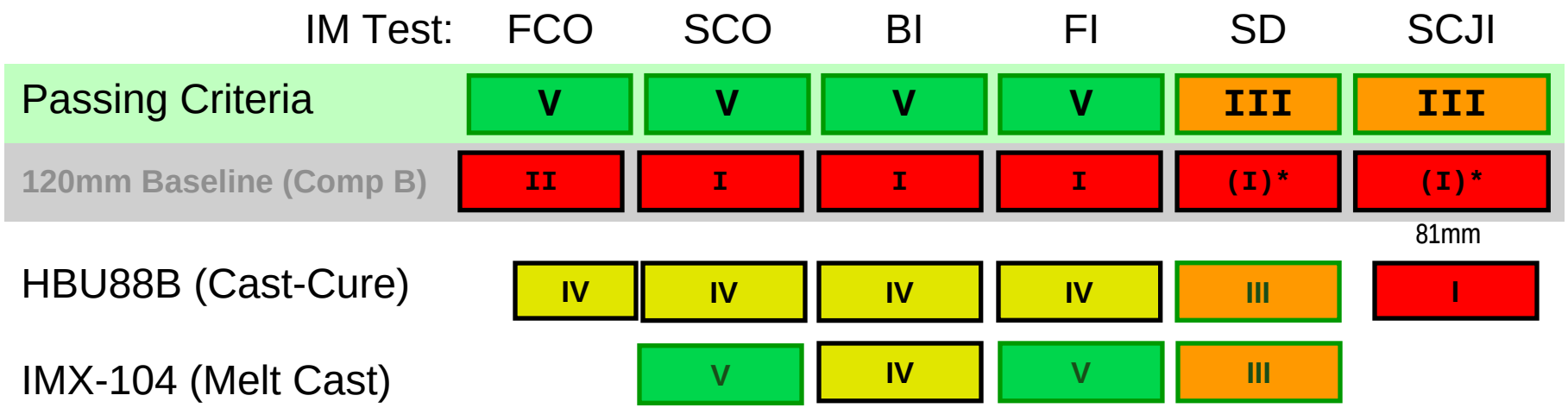
Sympathetic Detonation Test

MIL-STD-2105C, PA154 Configuration, Witness Plate & Pressure Gages

PA154 w/o Barrier

Results varied from Type I to Type III

IM Test Results



- Engineering IM Tests in the M934A1 120mm Mortar with IMX-104 show vast improvement over baseline Comp B

ARL Water Pit Test

- Static detonation of M934A1 Mortars loaded with IM formulations and Comp B Baseline
- Soft Recovery of Fragments
- Fragmentation Analysis

IMX-104 fill meets Comp B fragmentation performance

Summary

- IMX-104 down-selected as best candidate based on IM, Lethality, Life Cycle Cost, and Production Readiness

- IMX-104 qualification:
  - 81mm M821A2 Mortar for FY11
  - 60mm & 120mm Mortars in FY12

PM-CAS Common Low-cost IM Explosive Programs resulted in two successful programs in attaining IM replacement formulations:
IMX-101 as the IM replacement formulation for TNT
IMX-104 as the IM replacement formulation for Comp B