



U.S. Army Research, Development and Engineering Command

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The logo for the Army Research Laboratory (ARL). The letters "ARL" are rendered in a large, bold, black font. Each letter has a yellow triangular shape at the top, pointing downwards, which creates a stylized, modern look.

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

DEMN-based IM Formulations for the 120mm Mortar

2012 IMEMTS 14-18 May 2012

Approved for public release; distribution unlimited.

➤ **Objective – IM Compliance**

- ❑ Develop melt cast insensitive explosives to replace TNT-based fills which currently fail most (or all) IM tests
- ❑ IM demonstration for Army artillery and mortars
- ❑ Maintain (or improve) performance requirements of TNT-based fills

➤ **Co-solidified nitrate salt eutectic system (DEMNS)**

- ❑ Nitrate salts
 - 🌱 Easily manufactured in high yield
 - 🌱 Nitrate salts available at low cost
- ❑ Added particulate energetic materials
 - 🌱 Tailor sensitivity
 - 🌱 Increase Performance
- ❑ Low melt for steam processing
 - 🌱 Compatible with existing LAP facilities
 - 🌱 Reduced loading and processing cost



120 mm HE
(M933, M934)



155 mm HE
(M107)



155 mm HE
(M795)

➤ DEMN-III J (IMX-103)

- ❑ Characterized for performance (D_v , Gurney energy, initiability, fragmentation) & sensitivity
- ❑ PM-CAS downselected DEMN-III J as backup candidate for M795 transition
- ❑ Significant IM gains demonstrated in M795 155 mm projectile successful
 - ✓ Passes 4 of 6 Tests
 - ✓ First formulation to pass sympathetic detonation in 155 mm M795 artillery projectile WITHOUT a barrier!
- ❑ Pilot Plant Loading at ARDEC (4/4 acceptable projectiles with minimal engineering controls)



IM Scorecard for the M795 artillery projectile

Explosive Fill	BI	FI	SCO	FCO	SD	SCJI
TNT	IV	IV	III	III	I	(I)
IMX-103	IV	V	V	V	III	I

➤ Build on Success of DEMN-III J

- Add sensitizing agent
- Achieve Comp B performance
- Demonstrate initiation and IM Response

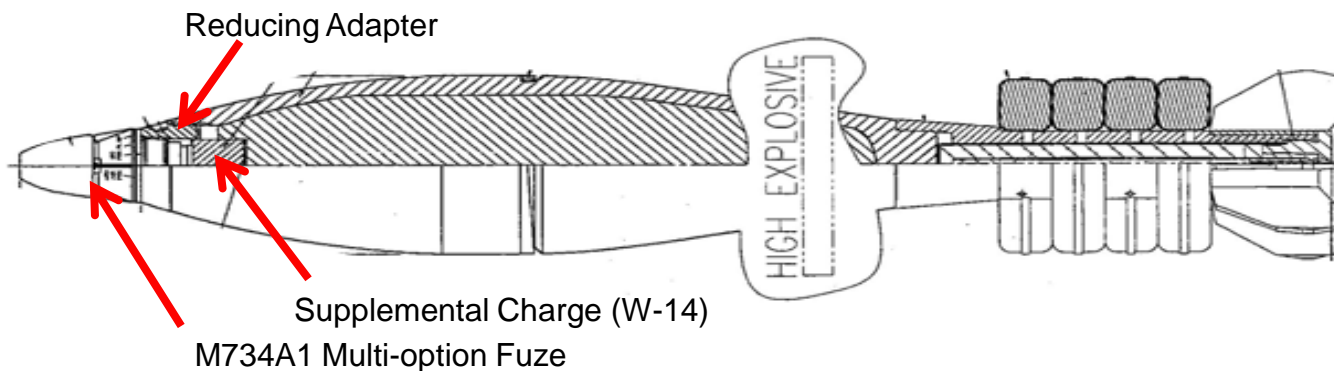
➤ M934A1 120mm Mortar (Comp B explosive fill)

- Melt cast design
- Embedded PBXW-14 supplemental charge
- Replace CH-6 with less sensitive
- 1090 mild steel body
- M734A1 Modified Multi-option Fuze (PBXW-14 fuze booster)



120 mm HE
(M933, M934)

**Comp B fails
ALL IM tests in
120 mm mortar**



High Speed Video Frame Captures



- 0.50-cal AP round into mortar warhead center of mass
- Flash on impact and exit (also seen in 0.50-cal BI test on M795 projectile)
- Mortar body breakup
- Ejection of reducing adapter/fuze
- Scattering of numerous pieces of unreacted material and 3 mortar pieces

➤ Mild response (mortar body in 3 pieces)

High Recovery

✓ 99.8% of mortar body

✓ 92.5% of unreacted explosive

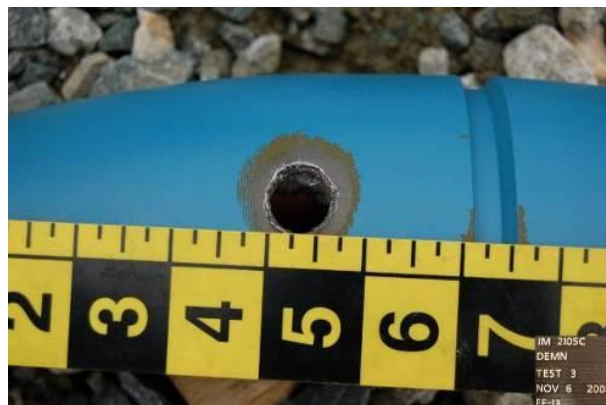
PBXW-14 Supplemental charge recovered

Fuze/adaptor recovered 52' from test stand

➤ Type IV response

Deflagration

Type I – Detonation for Comp B



ID: 0 Scene 739 Trigger START Trigger Time 08/11/03 15:13:46.274135 Time +00000.05



Nickname ef1308nov03-02 CID 1537 Rec 1000 Shutter OPEN

➤ Mortar body translation

ID: 0 Scene 739 Trigger START Trigger Time 08/11/03 15:13:46.274135 Time +00000.05

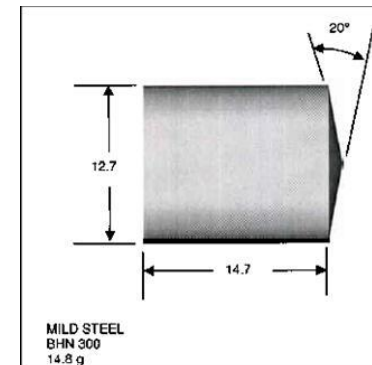


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ID: 0 Scene 739 Trigger START Trigger Time 08/11/03 15:13:46.274135 Time +00000.05



Nickname ef1308nov03-02 CID 1537 Rec 1000 Shutter OPEN



➤ Flash on impact

STANAG fragment at
6000 ft/s into mortar
warhead center of mass

➤ Ejection of fuze/adaptor



➤ Ignition of DEMN fill in mortar body

➤ Ejection and burning of W-14 supplemental charge

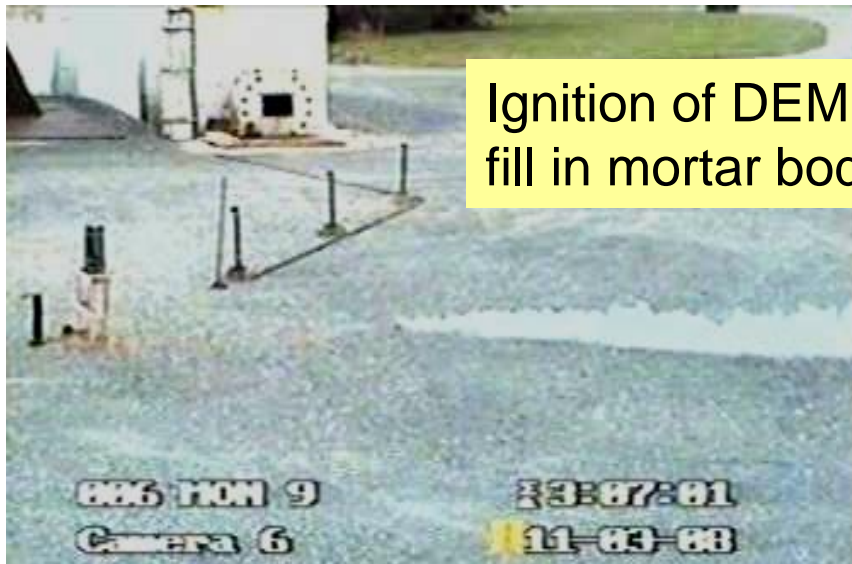


➤ Mild response

- ❑ Mortar lands 16' from table in 1 piece
- ❑ Contents burn to completion
- ❑ Remnants of PBXW-14 supplemental charge can
- ❑ Fuze/adaptor recovered 32' from test stand

➤ Type V Burn response

(Type I – Detonation for Comp B)



- Disposable sheet metal oven
 - ❑ Heater cartridges
 - ❑ Blower/circulator fan
 - ❑ Heated at 50°F/hour
- Type III Explosion response
 - ❑ Minimal pressure
 - ❑ 41.5% of mortar body recovered
 - ❑ Minimal witness plate scarring
- Better venting mechanism needed



- Two shipping containers
 - ❑ Each holds 2 mortars in fiber tube
 - ❑ 1 up, 1 down
- Donor (yellow, nose up) - functional initiation
- Adjacent Acceptor (pink, nose down)
- Diagonal Acceptor (green, nose up)
- Inert (unpainted, sand-filled)



- Initiation train
 - ❑ RP-87 detonator
 - ❑ M734A1 Fuze modified W-14 booster in reducing adapter
 - ❑ W-14 supplemental charge in crimped aluminum can
- Witness plate
 - ❑ Scarring demonstrates detonation in donor round
 - ❑ Obturator groove markings (lack of)



➤ Adjacent mortar body

- ❑ Several pieces recovered (40-120')
- ❑ Tail fin, supplemental charge, fuze/adapter
- ❑ Scarring on half of witness plate



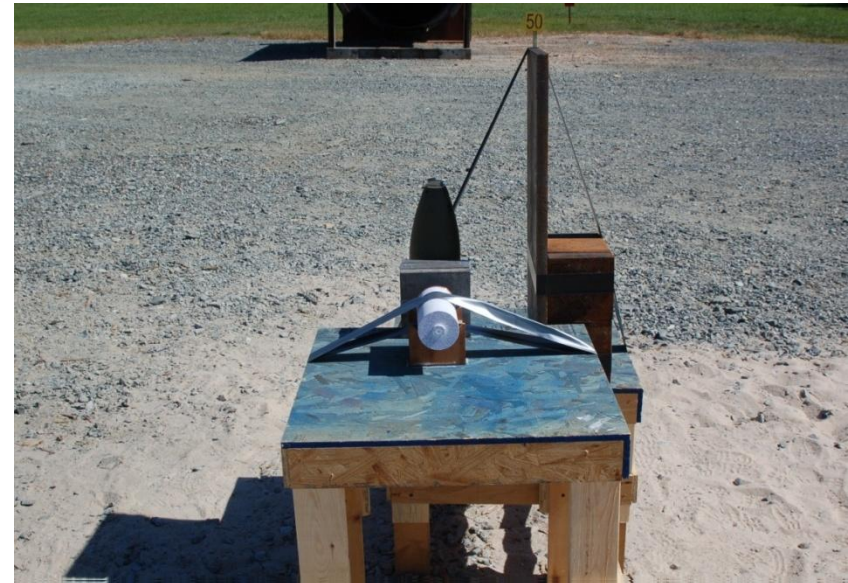
➤ Diagonal Mortar body

- ❑ Split at thin-walled obturator groove
- ❑ Each half filled with unreacted explosive
- ❑ Minimal scarring on side witness plate



➤ Standard SCJI Test

- ❑ RPG surrogate
- ❑ Impact along centerline at center of mass
- ❑ Witness plates below and adjacent to projectile



- Witness plates
 - ❑ Mild scarring on side witness
 - ❑ Vastly different from that of SD donor
 - ❑ No markings on bottom witness
- Recovery
 - ❑ Only recovered fragment was threaded for attaching tail
 - ❑ Only damage tail recovered from SD donor
- Pressure
 - ❑ Minimal pressure above baseline from shaped charge
 - ❑ Not indicative of detonation
- Passing non-detonative response



Passing responses

- Fragment impact – Type V burn
- Sympathetic detonation – non-detonative passing response
- Shaped charge jet impact– non-detonative passing response

First Comp B type fill to pass SCJI

Bullet Impact

- Type IV w/ 0.50-cal bullet (fuze >50 feet)
- Still significant improvement over Comp B

Slow Cookoff

- Type III Response
- Need to address currently insufficient venting design

- Fast cookoff – TBD; Likely to fail without venting

IM Results for M934A1 120mm Mortars

Explosive Fill	BI	FI	SCO	FCO	SCJI	SD
DEMN-IX H	(IV)	(V)	(III)*	TBD	(P)	(P)
Comp B	I	I	I	II	I	I

➤ NERF Processing

- Roy Maulbetsch, Dawnn Saunders, Terry Piatt, Lori Pridgeon
- Bill Gault, Kevin Bare, Chris Inmon, Ian Cochrane, Chris Miller

➤ Detonation Science Team

- Debbie Pilarski, Richard Benjamin, Gene Summers
- Ronnie Thompson, Will Sickels, Ray Sparks

➤ IM Testing Team

- Benjamin Showalter, Travis Payne
- Rachel Ehlers

➤ Funding

- Project Manager Combat Ammunition Systems (PM-CAS) through Common Low Cost IM Explosive (CLIMEx)
- ARL Mission Funds
- Office of the Secretary of Defense's Joint IM Technical Program (OSD JIMTP)