



RDECOM



81mm HE Mortar Cartridges (M889A1, M889A2, and M821A12) Harmonized IM/FHC Testing Results

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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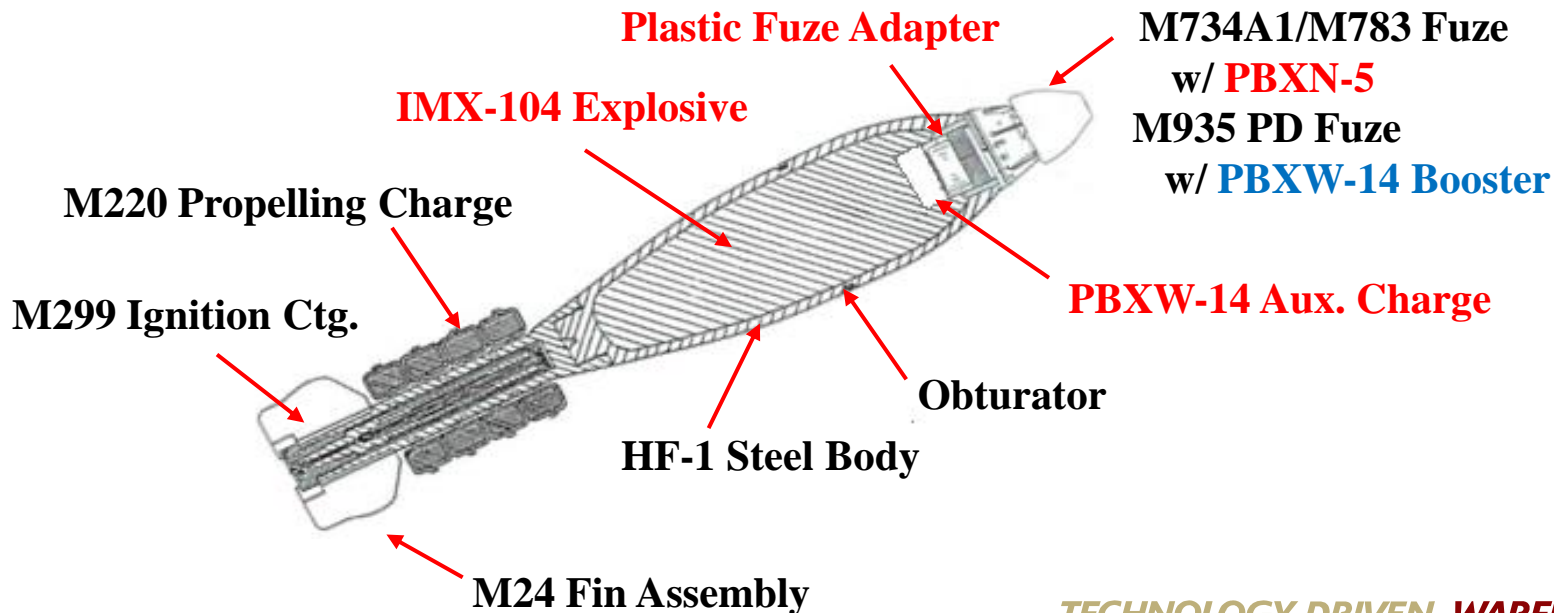
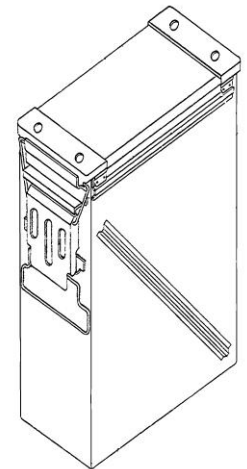
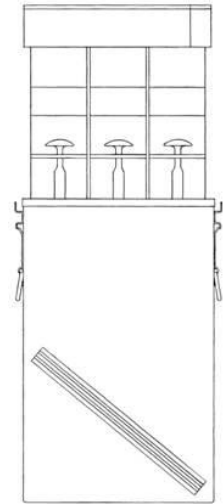
Reference #13857

- 81mm HE Mortars IM testing conducted in 2011
- Harmonized with FHC testing
- IM Scores have greatly improved compared to the Comp B baseline

81mm System Description



- These cartridges are high explosive, fragmentation munitions designed for use with the 81mm M252 Mortar System
- All rounds contain identical parts, except:
 - M889A1 uses the M935 Point Detonation (PD) Fuze
 - M889A2 uses the M783 PD/Delay Fuze
 - M821A2 uses the M734A1 Multi Option Fuze for Mortars (MOFM)



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81mm Mortars IM Scores

Baseline (Comp B)						
	FCO	SCO	BI	FI	SR	SCJ
M821A2	(III)	(I)	(IV)	(I)	(F)	(F)
M889A2	(III)	(I)	(IV)	(I)	(F)	(F)
M889A1	(II)	(II)	(II)	(II)	(F)	(F)

IM Configuration (IMX-104)										
	FCO		SCO	BI		FI		SR		SCJ
	Tactical	Logistical		Tactical	Logistical	Tactical	Logistical	Unconfined	Confined	
M821A2	(V)	(V)	(V)	IV	(V)	(I)	(IV)	(Pass)	(Pass)	(F)
M889A2	V	(V)	V	IV	V	I	IV	Pass	Pass	(F)
M889A1	V	V	V	IV	V	V	V	(Pass)	(Pass)	(F)

Assessed scores in parentheses ()

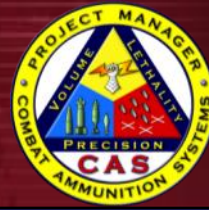
Reactions:

V – Burn
IV – Deflagration
III – Explosion
II - Partial Detonation
I - Detonation

- Scored September 2011 by AIMB
- Two test series:
 - M821A2 tested by analogy to the M889A2
 - M889A1 underwent select testing
 - Some tests for the M889A1 scored by analogy to the M889A2



81mm IM/FHC Test Plan



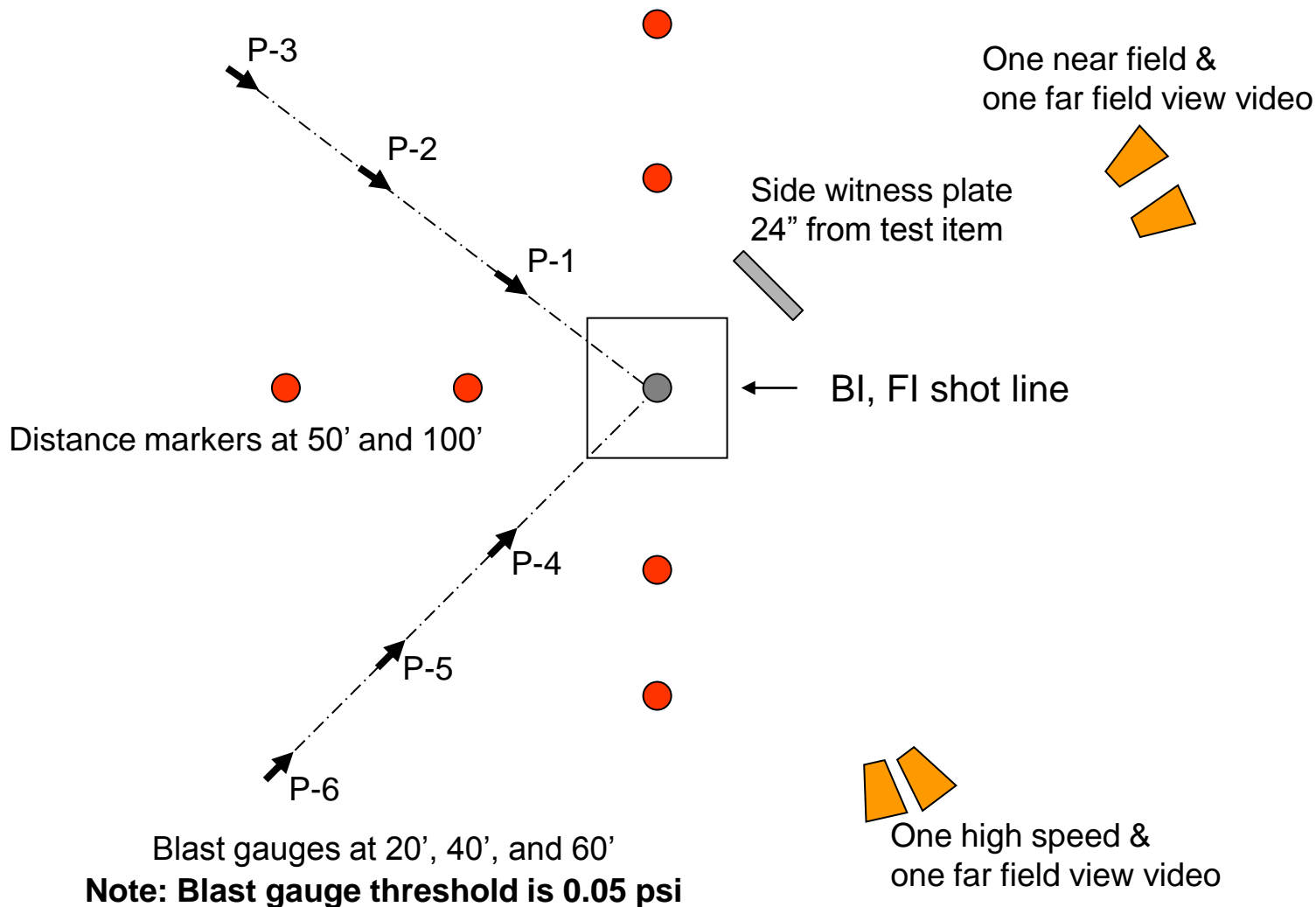
TEST	CONFIGURATION M889A2/M821A2	CONFIGURATION M889A1	PROPOSED TEST PARAMETERS
Fast Cook-Off	1 test, single round 1 test, 6 cans	1 test, single round 1 test, 6 cans	Liquid fire with a flame temperature above 1600° F
Slow Cook-Off	2 tests, 1 can each	2 tests, 1 can each	8 hour temperature soak at 122° F, 6° F per hour heating rate until T = 689° F
Bullet Impact	3 tests, single round 3 tests, single can each ▪ Shot lines through HE, booster, and propelling charge	1 test, single round 1 test, single can ▪ Through booster only	Three 0.50 caliber M2 AP bullets fired at @ 2,800 ft/s
Fragment Impact	3 tests, single round 3 tests, single can each ▪ Shot lines through main fill, booster, and propelling charge	1 test, single round 1 test, single can ▪ Through booster only	Single conical fragment at 8300 ft/s:
Sympathetic Detonation	2 test, 6 cans each	Analogy to M889A2	Initiation through donor ▪ First test unconfined ▪ Second test confined
Shaped Charge Jet Impact	No test	No test	Assessed to fail
Thermal Stability	1 test, single round	1 test, single round	In oven at 75+2° C for 48 hours
40 Foot Drop	3 tests, single can each	3 tests, single can each	40 foot free fall drop at 3 orientations

Test plan approved by DDESB and AIMB 2QFY11

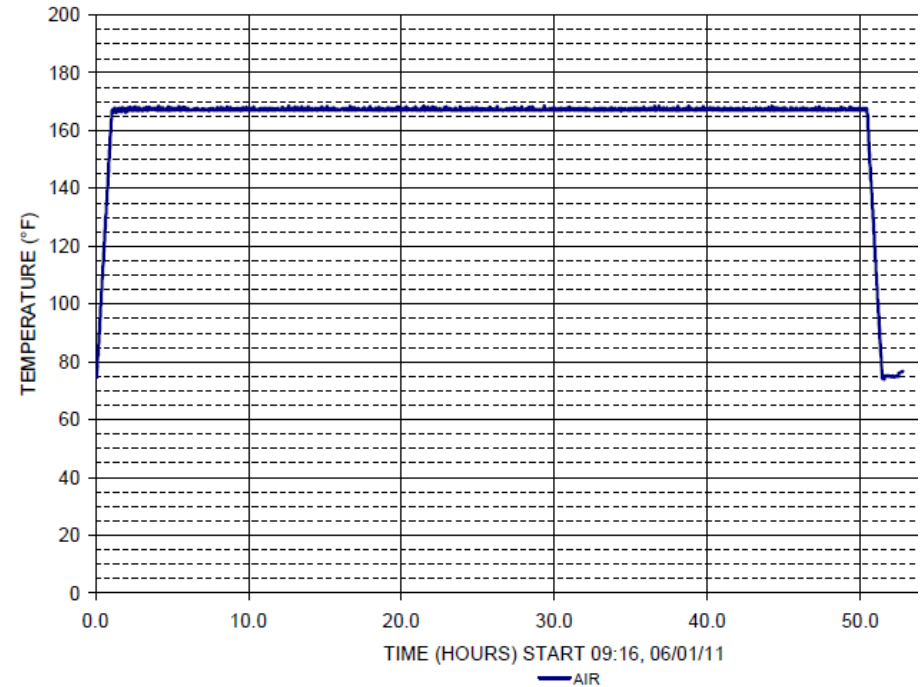
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Distribution Statement A: Approved for public release; distribution unlimited

Blast Gauge and Video Camera Arrangement

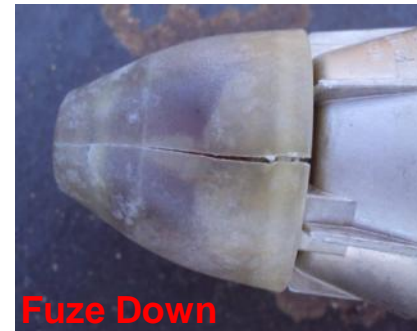


- M889A1 and M889A2 – single round each
- Conditioned at 75 C for 48 hours



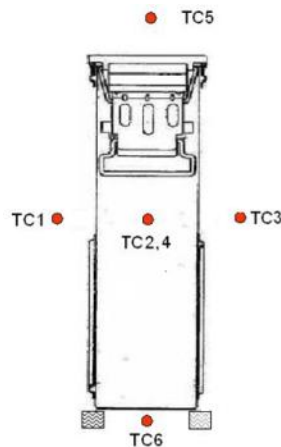
- 40 foot drop
- 3 orientations
 - Fuze up
 - Fuze down
 - Horizontal
- No reactions
- Broken parts
 - Propellant cases broken in each test
 - Damage to fiber tube and tube lids
 - Cans deformed
 - Fuze shields cracked in a couple cases

M889A2



- Two tests, single can each
 - 8 hours conditioning at 122° F
 - 6° F per hour heating rate
 - 8 inches minimum separation between oven walls and test item
 - 6 thermocouples, locations on the right
 - Testing until reaction or item temperature reaches 689° F

- Typical Results
 - Flashes and pops
 - PA156 can swelling, bowed lid
 - Melted HE
 - No damage to witness plates
 - 0 psi recorded on pressure gauges

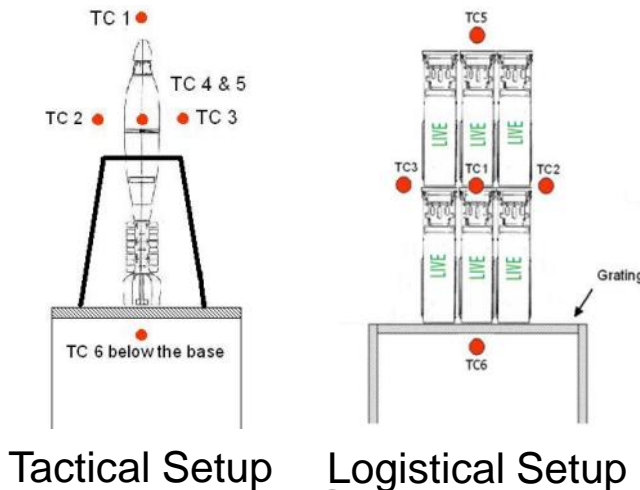


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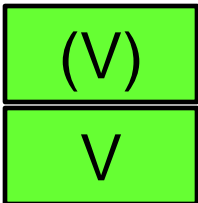
- 1st Test: tactical
 - 6 thermocouples
- 2nd Test: logistical
 - 12 thermocouples
- Sample situated on grate 18" above fuel
- 1600° F flame temperature requirement
- 1000 gallons Jet-A fuel

- M889A2 / M821A2 Logistical
 - “No Test” – cans fell into fuel
 - Scored by analogy to M889A1
- Typical Results:
 - Can and lid deformation
 - Explosive consumed in fire
 - Audible “pops”
 - Small fragments (<50 grams) around test site
 - Fuze booster, tail fin, etc





Pre-test Setup

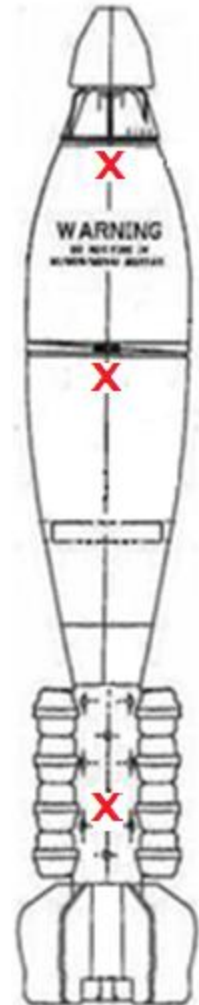


M889A1 Results



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- BI - 50 cal. AP, triple burst, 2800 ft/s
- FI - Conical fragment at 8300 ft/s
- Logistical and tactical testing of each target area
 - In the logistical test, shot line will be through the center of the middle round, otherwise the can hasp interferes
 - Bullet path through diameter of the center round
- M889A2 – shot lines through fuze booster, main fill, and prop charges
- M889A1 – shot line through fuze booster only



M889A2 BI Results Tactical – HE Shot

- First bullet broke the body apart
- Unreacted HE scattered around test site
- No damage to either witness plate
- 0 psi recorded on all pressure gauges
- Fragments found beyond 50 feet



IV

Fuze Booster Shot



V

Prop Charge Shot



IV

M889A2 BI Results Logistical – HE Shot

- Test article was knocked off test stand, container lid blown off after first impact
- Three entrance holes, one exit hole
- Test article burned and smoked for ~40 min
 - Several popping reactions
- No damage to either witness plate
- 0 psi recorded on all pressure gauges
- No fragments beyond 50 feet



Fuze Booster Shot

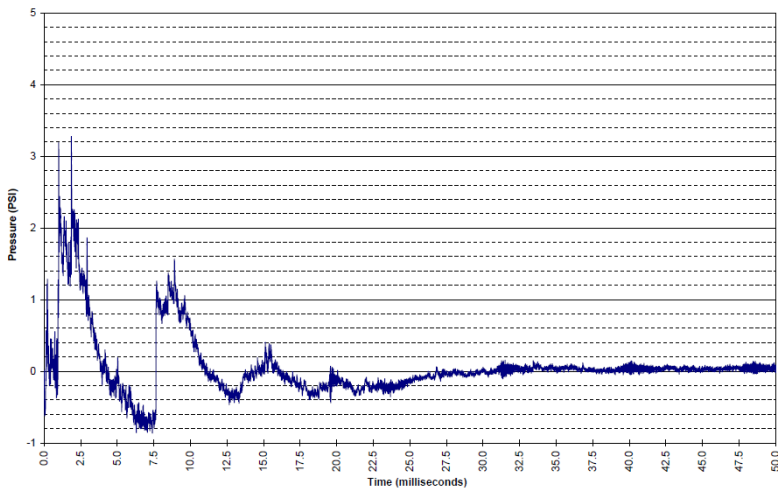


Prop Charge Shot



M889A2 FI Results Tactical – HE Shot

- Large flash upon impact
- Side witness plate thrown 20 ft
 - Heavy pitting and scarring
- Few recoverable fragments
- Peak 3.17 psi recorded on pressure gauge 4
- Fragments found beyond 50 feet



Fuze Booster Shot



I

Prop Charge Shot



V

M889A2 FI Results Logistical – HE Shot



- Flash inside the can upon impact
- Test article knocked off stand
 - Smoked for ~20 min
- No damage to either witness plate
- 0 psi recorded on all pressure gauges
- No fragments beyond 50



Fuze Booster Shot



IV

Prop Charge Shot

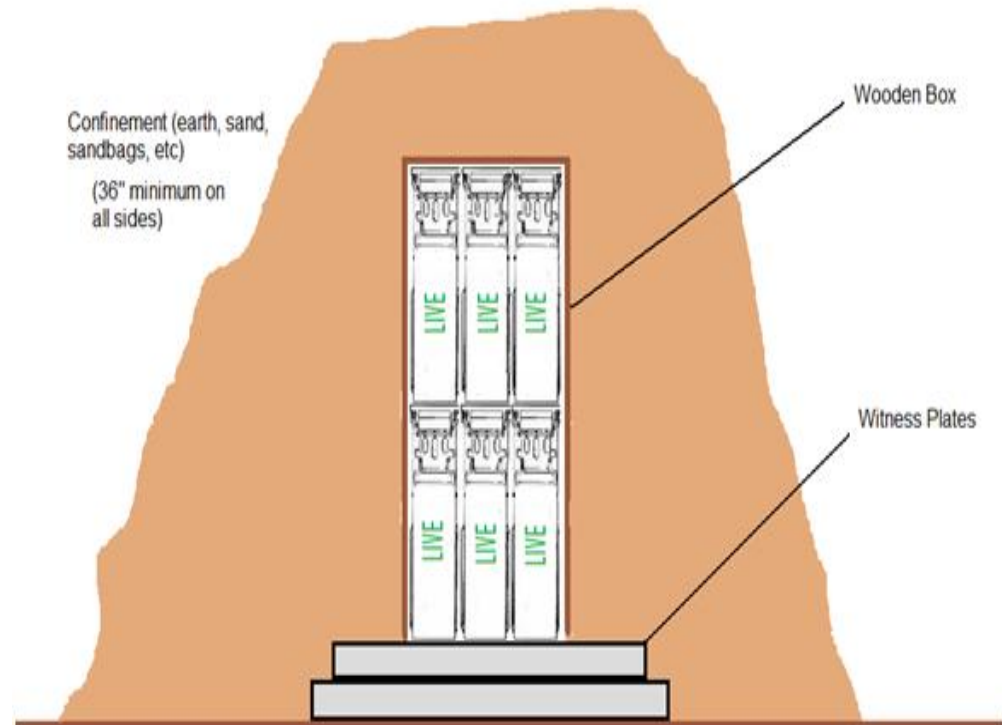


V

- 2 tests- confined and unconfined
- Donor located at center of the bottom row
- All rounds live



Pre-test Setup



M889A2 SD Results Unconfined

Adjacent
Acceptor



- Acceptor PA-156 cans ripped open
- Mortars cast out of cans
- Mortars either intact or broken at ogive
- Unconsumed HE in most rounds
- No marks on bottom witness plate

Adjacent
Acceptor



Donor
Can

PASS

M889A2 SD Results Unconfined

- Pressure readings:
 - 2.76 psi on gauge 1
 - 2.86 psi on gauge 4
 - Blast gauge pressure less than single round calibration
- Numerous large fragments beyond 50 ft



Top
Acceptor
Directly
Above
Donor



Top
Acceptor

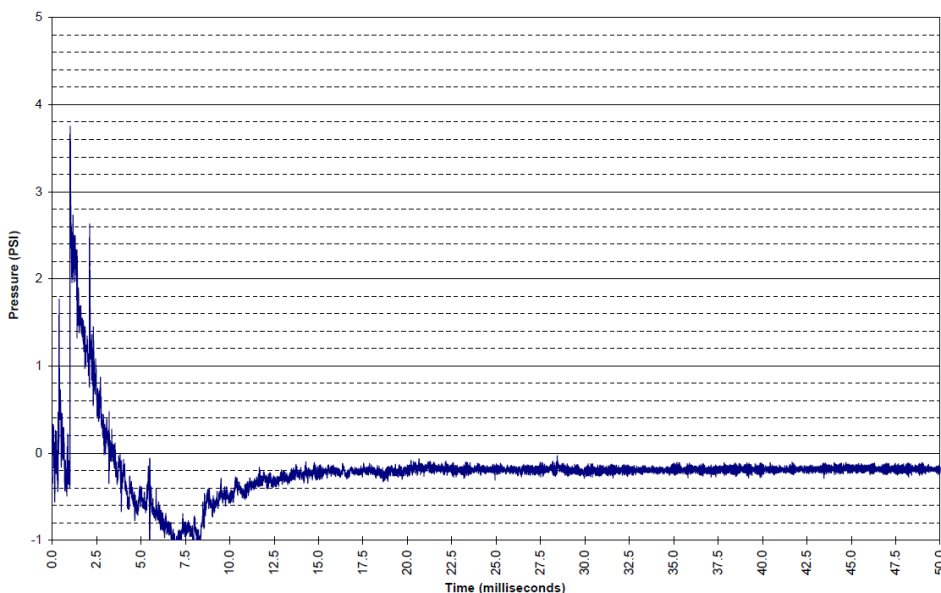


Top
Acceptor

PASS

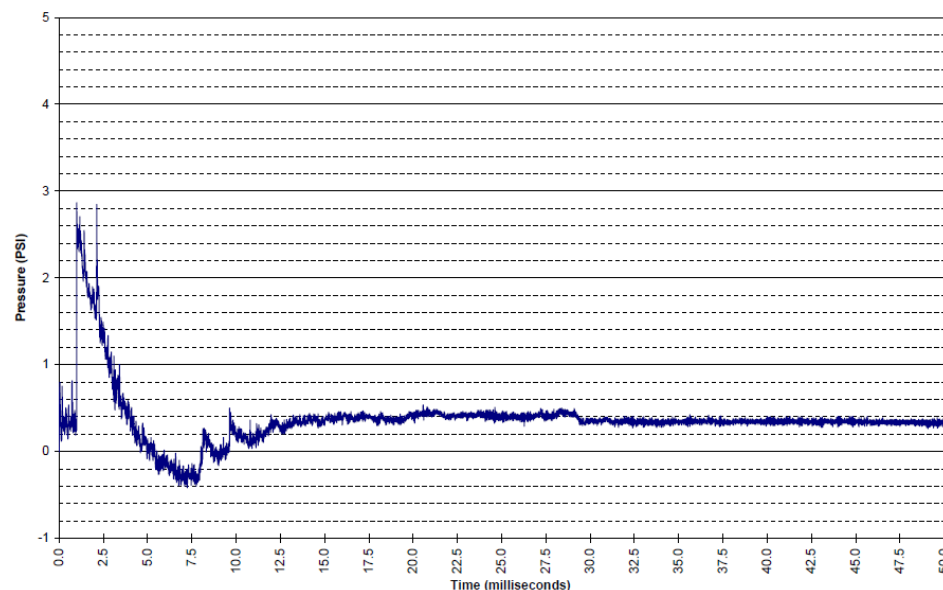
M889A2 SD Results Unconfined

Peak 3.75 psi



Calibration Test

Peak 2.86 psi



Unconfined SD Test
Peak Pressure

M889A2 SD Results Confined

Post-test
Results



Donor
Can



PASS

- Sand confinement pile opened
- Acceptors in can with donor were broken into several large pieces
- Bottom row of acceptors
 - Either intact or broken at ogive
- Top row of acceptors
 - Either intact or broken at ogive
 - Some had HE, the rest other HE had burned out
- Items smoked, then burned for ~1 hr and 45 min
- No marks on bottom witness plate
- No fragments beyond 50 feet

M889A2 SD Results Confined



Top Acceptors

Adjacent Acceptors



PASS

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Summary



- Based on SD results, data shows the rounds are not mass detonating
- Drastic improvement over the baseline response has been witnessed
- Plans exist for full harmonized IM/FHC testing of 60mm and 120mm HE mortar cartridges

IM Configuration (IMX-104)										
	FCO		SCO	BI		FI		SR		SCJ
	Tactical	Logistical		Tactical	Logistical	Tactical	Logistical	Unconfined	Confined	
M821A2	(V)	(V)	(V)	IV	(V)	(I)	(IV)	(Pass)	(Pass)	(F)
M889A2	V	(V)	V	IV	V	I	IV	Pass	Pass	(F)
M889A1	V	V	V	IV	V	(I)	V	(Pass)	(Pass)	(F)

Assessed scores in parentheses ()

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BACK UP CHARTS

81mm IM Tech Approach



- Explosive Replacement

- IMX-104 identified as best main fill candidate after PM CAS CLIMEx effort
- Inclusion of PBXW-14 auxiliary charge
 - Risk mitigation effort using pressed IMX-104

	NOL (cards)	Pressure (kbar)	DV (km/s)	Gurney (km/s)
IMX-104	109	208	7.38	2.536
Comp B	200-220	278	7.98	2.756
PBXW-14	175	318.4	8.13	2.869
PBXN-5	206	375	8.76	2.909

- Fuze Booster Design

- PBXN-5 for the M734A1 and M783 fuzes
- PBXW-14 booster charge and PBXN-5 lead pellet for M935 fuze

- Venting Technology

- Use of a threaded fuze adapter to allow fuze venting during cook-off situations

Explosive Comparison



Explosive	TMD (g/cc)	D _c	T _c (° C)	ERL (cm)	BAM	ESD
IMX 104	1.78	0.745"	164	>100	Reaction at 168 N, None at 160 N	0 out of 10 at 0.25 J
Comp B	1.728	0.169"	190	33.9	Reaction at 318 N, None at 282 N	0 out of 10 at 0.25 J
PBXW-14	1.9	0.125"	216	38	> 980 lbf on ABL	0 out of 10 at 0.25 J
N-5	1.817	< 0.2"	223	20	No reaction at 250 N	0 out of 10 at 0.25 J

Full IM Scoring (by individual test)



IM Test Result Summary for the 81mm Mortar						
Item/Test Configuration	FCO	SCO	BI	FI	SR	SCJI
FCO: M889A2-logistical	(V)*					
FCO: M889A2-tactical	V					
FCO: M889A1-logistical	V					
FCO: M889A1-tactical	V					
BI :M889A2-tactical-main bulk fill			IV			
BI: M889A2-tactical-fuze			V			
BI: M889A2-tactical-prop charge			IV			
BI: M889A2-logistical-main bulk fill			V			
BI: M889A2-logistical-fuze			V			
BI: M889A2-logistical-prop charge			V			
BI: M889A1-tactical-fuze			IV			
BI: M889A1-logistical-fuze			V			
SCO: M889A1-Test #1		V				
SCO: M889A1-Test #2		V				
FI: M889A2-tactical-main bulk fill				I		
FI: M889A2-tactical-fuze				I		
FI: M889A2-tactical-prop charge				V		
FI: M889A2-logistical-main bulk fill				V		
FI: M889A2-logistical-fuze				IV		
FI: M889A2-logistical-prop charge				V		
FI: M889A1-tactical-fuze				V		
FI: M889A1-logistical-fuze				V		
SR: M889A2-unconfined					Pass	
SR: M889A2-confined					Pass	
SCJ: M889A1						(Fail)
SCJ:M889A2						(Fail)
Notes:					Key:	
Assessed scores in parentheses ()					FCO: Fast Cook-off	
1. Test article fell into the fuel, and the temperature requirements were not met due to wind. The AIMB assesses this reaction as a Type (V), by analogy to the M889A1 and the reaction resulting from this test.					SCO: Slow Cook-off	
					BI: Bullet Impact	
					FI: Fragment Impact	
					SR: Sympathetic Reaction	
					SCJ: Shaped Charge Jet	
					Type VI: No Reaction	
					Type V: Burn	
					Type IV: Deflagration	
					Type III: Explosion	
					Type I/II: Detonation/ Partial Detonation	