Characterization and IM Testing of DLE-C054 in 120MM Mortars

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Outline

Background

DLE-C054 Formulation Features

DLE-C054 Subscale IM Testing

IM Testing of DLE-C054 in Full-Scale 120mm Mortars

- Bullet Impact
- Fragment Impact
- Slow Cook-off
- Sympathetic Detonation

Background

A replacement explosive for Comp B must meet the following objectives:

- Low Cost
- High Performance
- Good processing characteristics
- Respond well to IM threats of impact, cook-off, and sympathetic detonation

Potential advantages of cast cure versus melt pour formulations:

- Problems with volume changes due to phase changes avoided
- Rubbery nature of binder provides damage resistance and improves response to impact events
- Cast cure charges usually contain low numbers of defects that can increase shock sensitivity
- Proven IM capabilities demonstrated with similar formulations
  - PBXN-110 (HMX) and PBXN-109 (RDX and aluminum)
  - DLE-C038 (CL-20), DLE-C050 (HMX and aluminum), and DLE-C051 (HMX)

DLE-C054 Formulation and Processing

Formulation

- Inert binder system
- 88% Solids
  - Coarse NTO (3-nitro-1,2,4-triazal-5-one)
  - Coarse RDX
  - Fine RDX

Excellent Processing

- Viscosity minimized by adjusting ratio of coarse and fine RDX
- Excellent processing with end-of-mix viscosities from 7-12 kp
- Material flows easily through slit or hole plate when casting

Excellent small scale sensitivity (ESD, friction, impact, thermal)

DLE-C054 Scale Up

- Made in ¼ pint, pint, 1-gallon, and 5-gallon mix sizes
- Scale up was straightforward with just slightly longer mix times at larger mix sizes
- End-of-mix viscosity and processing was identical at each mix size
- Expected to scale easily to production 600-gallon mixers
- ATK Aerospace Group has mix facilities capable of producing millions of pounds per year

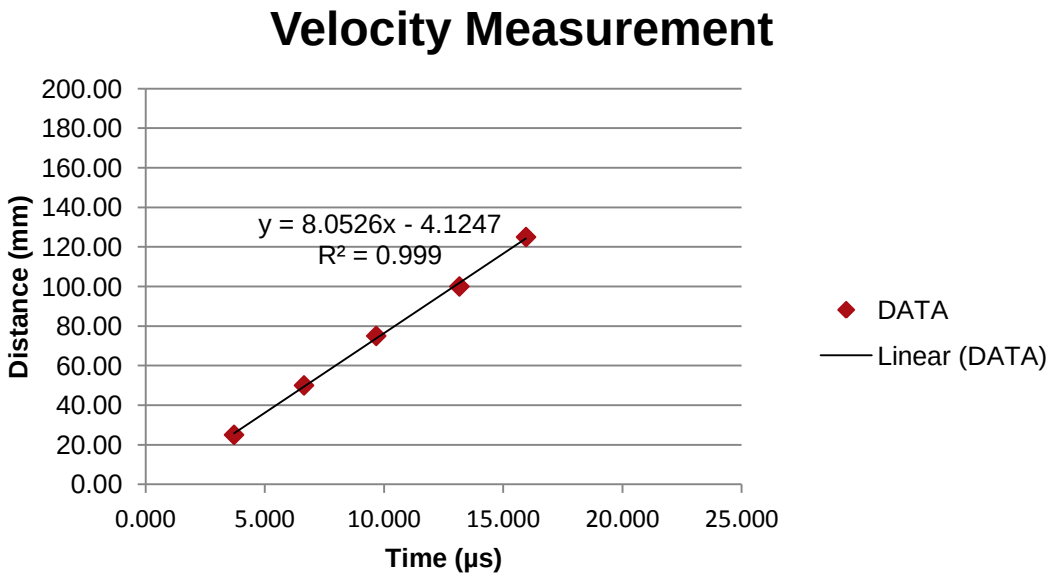
DLE-C054 Dent/Rate Tests

Two dent/rate tests performed

- LSGT Hardware (13.97 cm long by 3.65 cm diameter charge)

Excellent performance

- Detonation velocity = 8.0 km/s (Comp B = 7.9 km/s)



Dent Depth (DLE-C054)	Dent Depth (Comp B)	Percentage of Comp B
0.398”	0.433”	92%

DLE-C054 Subscale IM Testing

NOL Large Scale Gap Testing Performed (8 tests)

- 140 cards (44 kbar) - compared to 201 cards (20.5 kbar) for Comp B
- Significant reduction in shock sensitivity compared to Comp B

Variable Confinement Cook-off Testing Performed

- Heat rate = 6°F/hr
- VCCT at heavy 0.12 inch confinement
  - steel sleeve in one piece
  - no fragmentation

IM Testing in 120mm Mortars

M934A1 120-mm mortars tested by NTS

- Approximately 6.6 lbs of explosive fill
- Live fuze with PBXN-5 booster
- Bullet impact, fragment impact, slow cook-off, and sympathetic detonation

Bullet Impact Testing of 120mm Mortars

Two tests with a single 7.62 mm armor piercing round.

Test Monitoring

- **Over pressure gages**
- **High speed digital video**
- **Standard video**
- **Witness plates**
- **Velocity screens**

Projectile Velocity (ft/s)	Gage Pressure Readings	Side Witness Plate Markings	Bottom Witness Plate Markings	Pieces thrown >50 ft	Result
3090	0 psi	none	Slight indentation	Fuze and thread adapter	Type IV (deflagration)
3093	0 psi	none	Slight indentation	Un-reacted explosive	Type IV (deflagration)

Bullet Impact Testing of 120mm Mortars

Bullet entered on target and did not exit

Fuze and/or un-reacted explosive thrown more than 50 ft

- General behavior of this round in bullet impact with the least sensitive formulations

No damage to mortar body

Type IV (deflagration)

Fragment Impact Testing of 120mm Mortars

Two tests with a single conical mild steel projectile

Test Monitoring

- Over pressure gages
- High speed digital video
- Standard video
- Witness plates
- Velocity screens

Projectile Velocity (ft/s)	Gage Pressure Readings	Side Witness Plate Markings	Bottom Witness Plate Markings	Pieces thrown >50 ft	Result
5968	0 psi	none	Slight ring indentation	none	Type V (burn)
5930	0 psi	none	Slight ring indentation	none	Type V (burn)

Fragment Impact Testing of 120mm Mortars

Fragment entered on target and did not exit

- One article emitted smoke for 30 minutes
- One article burned for 15 minutes

No material thrown more than 50 ft

A crack in body created from impact – but mortar otherwise intact

Type V (burn)

Slow Cook-off Testing of 120mm Mortars

Two tests at 50 ºF/hour heating rate

Test Monitoring

- **Over pressure gages**
- **Standard video**
- **Witness plates**

Reaction Temperature (ºF)	Gage Pressure Readings	Side Witness Plate Markings	Bottom Witness Plate Markings	Pieces thrown >50 ft	Result
373	0 psi	none	none	none	Type V (burn)
375	0 psi	none	none	none	Type V (burn)

Slow Cook-off Testing of 120mm Mortars

Extruding explosive dislodged fuze at about 326 ºF

Articles ignited at about 375 ºF

No material thrown more than 50 ft

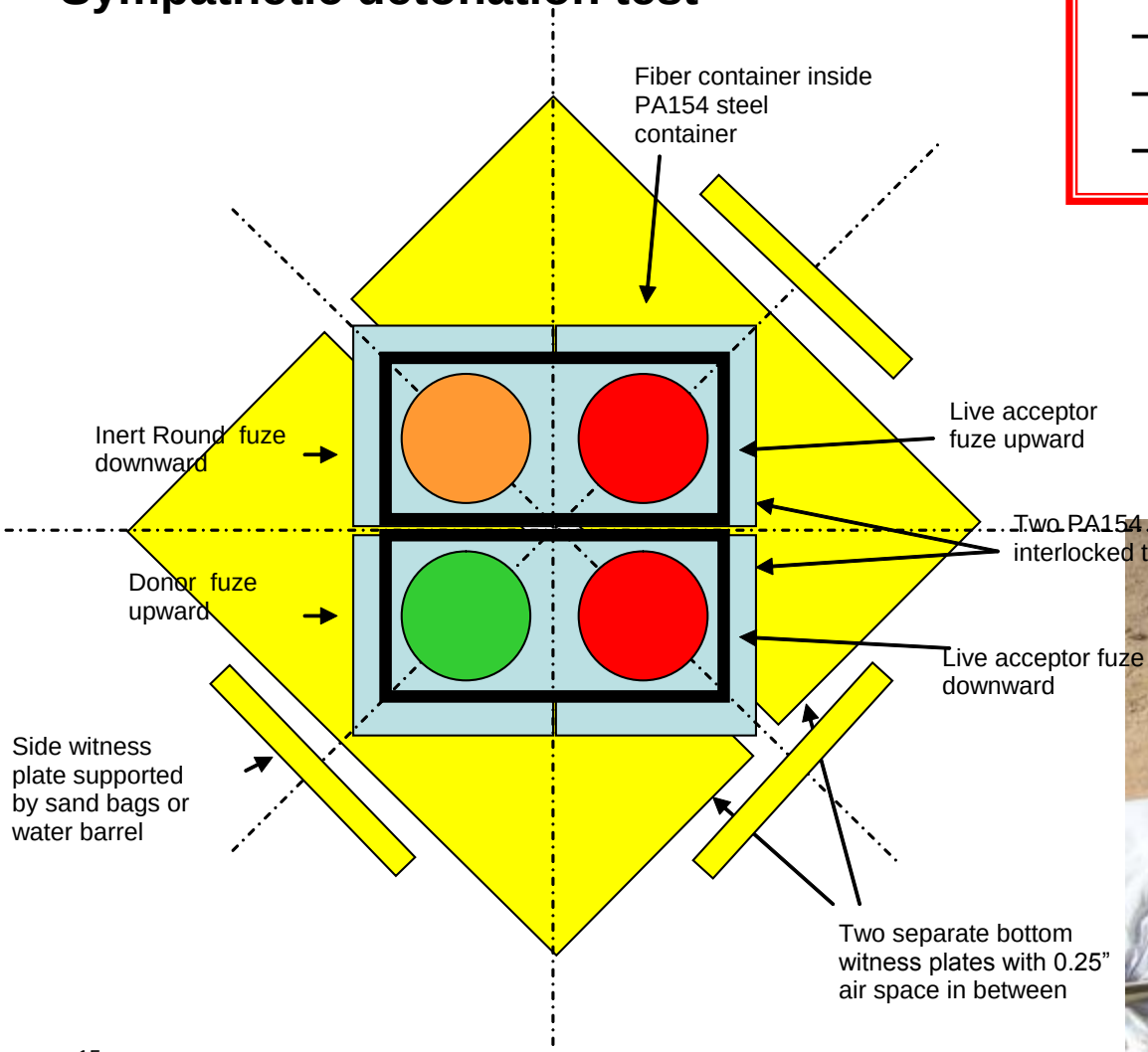
Mortar body undamaged

Type V (burn)

Sympathetic Detonation of 120mm Mortars

Single unit detonation calibration test

Sympathetic detonation test



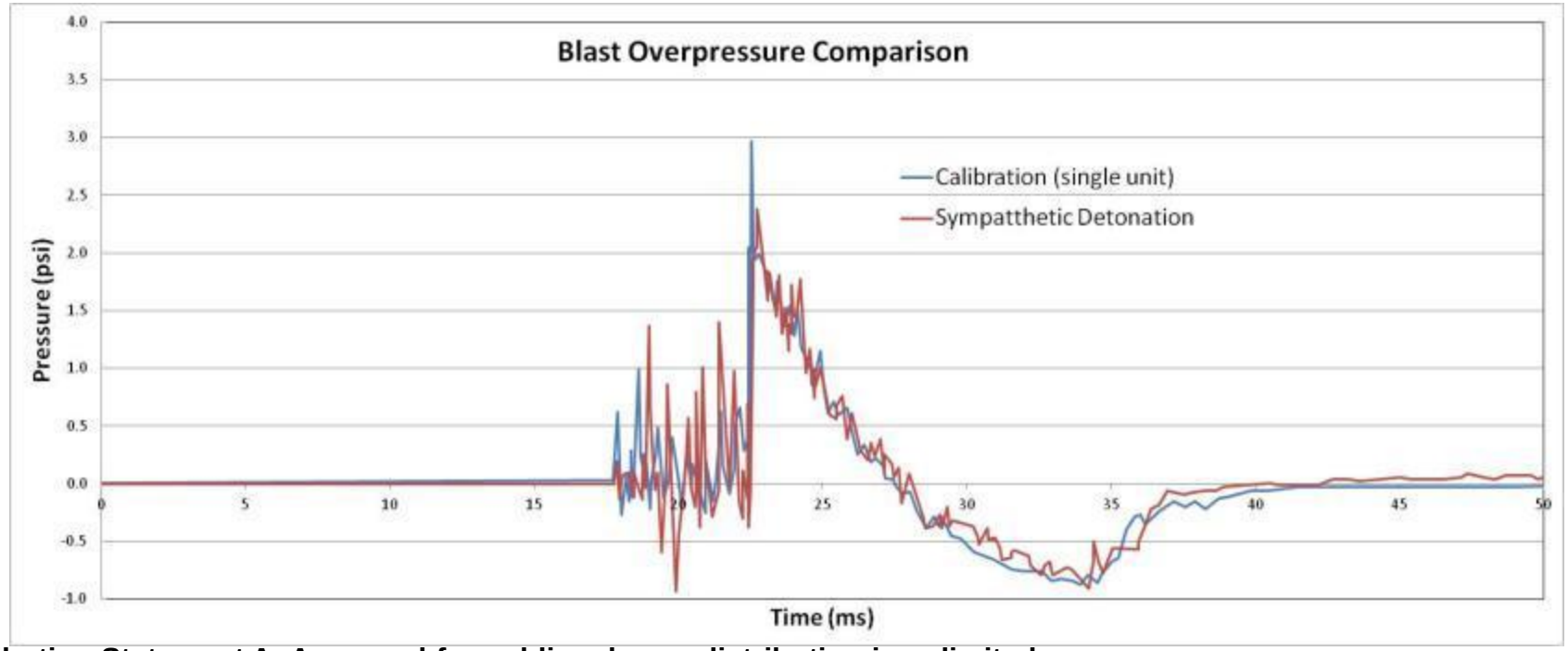
Test Monitoring

- Over pressure gages
- High speed digital video
- Standard video
- Witness plates

Sympathetic Detonation of 120mm Mortars

Acceptor charges did not contribute to measured blast overpressure!

Single Mortar Detonation Overpressure	Sympathetic Detonation Overpressure	Side Witness Plate Markings	Bottom Witness Plate Markings	Pieces thrown >50 ft	Result
5.8 psi @ 20 ft 2.45 psi @ 40 ft 1.25 @ 60 ft	**6** psi @ 20 ft 2.3 psi @ 40 ft 1.25 @ 60 ft	Bent/gouges	none	numerous	Pass



IM Comparison of Explosives in 120mm Mortars

DLE-C054 provides dramatic improvement to Comp B in IM response

Matches IMX-104 in IM response in 120mm mortars

	FCO	SCO	BI	FI	SD	SCJI
Passing Criteria	**V**	**V**	**V**	**V**	**III**	**III**
120mm Baseline (Comp B)	II	I	I	I	(I)*	(I)*
IMX-104 (Melt Cast)	Not Tested	**(V)**	**(IV)**	**(V)**	**(PASS)**	Not Tested
DLE-C054 (Cast Cure)	Not Tested	**(V)**	**(IV)**	**(V)**	**(PASS)**	Not Tested

()* - assessed, not tested

Summary and Conclusions

DLE-C054 is a promising new insensitive explosive

- Good performance
- Excellent shock sensitivity
- Good processing characteristics
- Exceptional IM response demonstrated in sub-scale and full-scale articles
- Potentially low cost

Even though DLE-C054 was not selected for the 120mm mortar, it remains an attractive candidate for other warhead applications

- The cast cure process offers high quality, defect-free charges that are stable under varying temperature conditions