DLE-C067: A New Insensitive Cast-cure Formulation for Large Munition Use

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Prepared for:
2012 NDIA Insensitive Munitions / Energetic Materials Symposium
Las Vegas, Nevada
May 14-17, 2012

Acknowledgements

- Project team consisted of the following:
  - Program Management: Jared Olson, Bob Wardle
  - Investigators: Michael Adams, Paul Braithwaite
  - Technicians: Dean Child, Colton Potter, Marc Hall
  - Safety Testing: Josh Hill, Mindy Burnett, Lyle Merrill
  - Performance Testing: Todd Anderson, Russ Stuart, Terrel Christensen
- Formulating, mixing, casting and testing all performed at ATK facilities in Promontory, Utah

Background & Introduction

- DLE-C067 is a new cast-cure explosive
- It was developed as an IM-compliant explosive for use in large munition applications
- Large munition fills exhibit a mix of moderate brisance and high blast
- Poor IM response can be devastating based on size of munition alone
- Goals for this formulation:
  - Good performance similar to PBXN-109 and H-6
  - Combined effects
  - Low shock sensitivity and good IM response

Formulation Development – Approach

- DLE-C054 starting point
  - Cast-cure explosive with 88% solids containing RDX & NTO
  - Performance similar to Comp B
  - Demonstrated excellent IM response to all types of stimuli in subscale and full-scale testing
- Develop an aluminized version of DLE-C054
- Initial theoretical approach
  - Followed two branches of conceptual analysis approaching formulation from different directions
  - Adjusted formulations along these branches with focus on
    - Maintain total solids loading level
    - High detonation pressure
    - Good cylinder expansion energy
    - Moderate brisance

Formulation Development – Performance

- Made initial small mixes of two formulation modifications based on initial performance calculations
  - Both processed well, were castable, with good basic safety test results
- Down selected to a single formulation designated DLE-C067
  - Calculated properties, but formulation is very non-ideal so estimates are guidelines of potential relative performance only

	DLE-C067 Properties Relative to		
Calculated Property	**DLE-C054**	**PBXN-109**	**H-6**
Theoretical Max. Density	103%	102%	95%
Pressure (C-J)	113%	129%	127%
Temperature (C-J)	125%	97%	89%
Shock Velocity	97%	107%	107%
Energy at V/Vo=7.2	111%	106%	98%
Mech. Energy	120%	86%	78%

Formulation Development – Processing/Safety

- Rheological properties
  - Measured viscosity at end of mix: 6 to 10 kP
  - Casts well
- Safety test data
  - Tested according to our standard safety testing protocols
  - Safe for handling and processing
  - Compared to RDX baseline for reference

Test	Uncured	Cured	Class 5 RDX
ABL Impact (cm), TIL	26	64	1.8
ABL Friction (lbs), TIL	560 @ 8 ft/s	420 @ 8 ft/s	25 @ 6 ft/s
ABL ESD (J), TIL	1.305	No reaction	0.025
Bulk ESD (at 8 J)	---	No consumption	No mass ignition
SBAT Onset (°F)	324°F (162°C)	318°F (159°C)	378°F (192°C)

Formulation Development – Scale-up

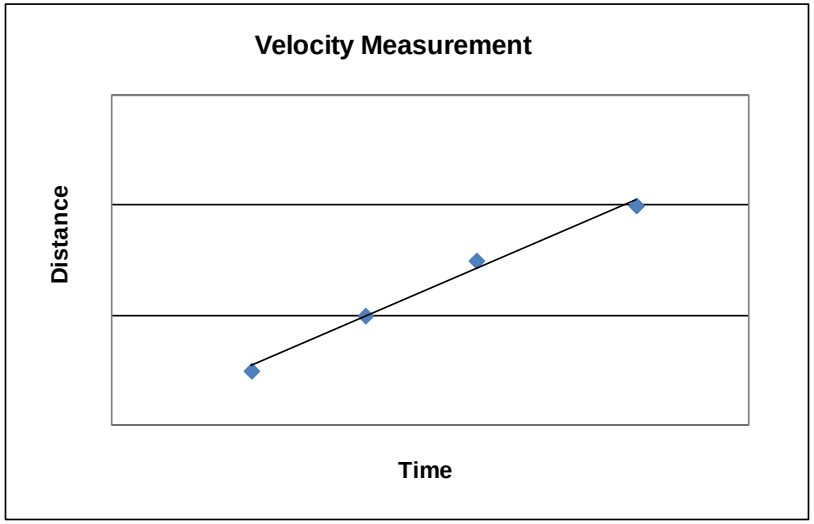
- Mixes of DLE-C067 made from less than ¼ pint to 1-gallon scale
  - Same consistency and ease of casting at each mix size
  - Similarity in family leads to good scale-up potential beyond that
  - Other formulations have scaled up well such as DLE-C054

- From 1-gallon size mix, successfully cast subscale test items, including:
  - NOL Large Scale Gap Test (LSGT) pipes
  - Various sizes of cylindrical samples

Subscale Performance – Shock Velocity/Pressure

- Dent/rate testing performed using NOL card gap pipes with TOA pins along length of pipe
- Dent depth corresponds to 99% of PBXN-109 depth in same configuration
- Detonation velocity was higher than Comp B or PBXN-109

	DLE-C067	DLE-C054	Comp B
Det. Velocity (relative)	105%	101%	100%
Plate Dent Depth (in.)	0.369	0.398	0.433



Subscale Performance – Critical Diameter

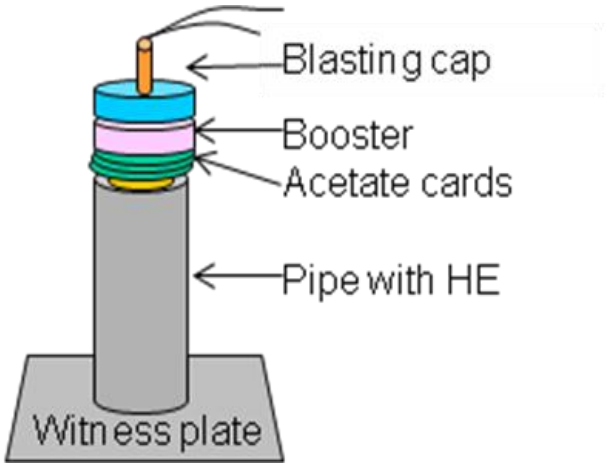
- Critical diameter measured using unconfined cylinders of various sizes lined up end to end on aluminum witness plates
  - TOA wires at end of samples to measure unconfined velocity
- Critical diameter measured between ½-inch and ¾-inch

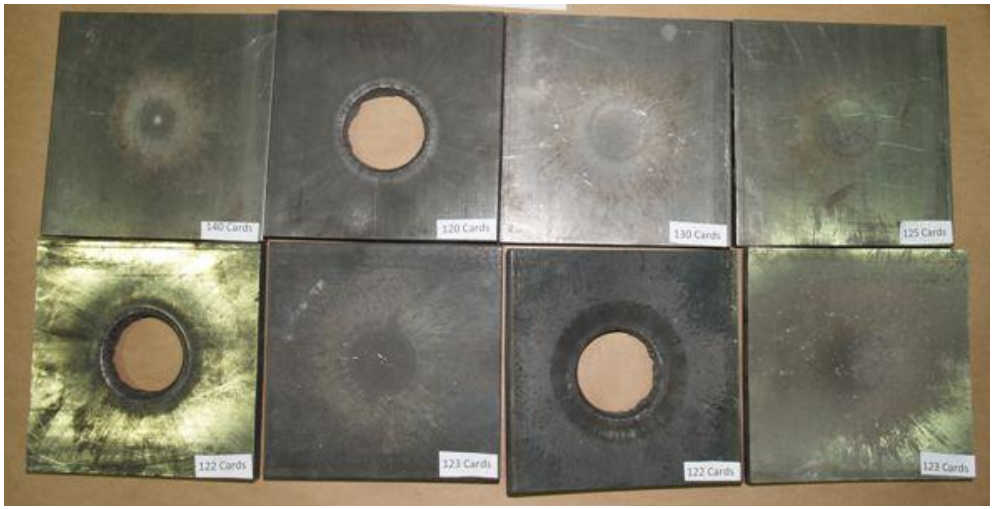
1” dia.	¾” dia.	½” dia. Dies out	¼” dia. intact

Subscale IM Performance – Shock Sensitivity

- Shock sensitivity measured by Large Scale Gap Test (LSGT)
  - Excellent shock sensitivity response, improved over DLE-C054

	DLE-C067	DLE-C054	Comp B
LSGT Gap Results (inch)	1.22	1.40	2.01
Corresponding Pressure (kbar)	49.7	44.3	20.7





Summary & Conclusions

- A promising new cast-cure explosive, DLE-C067, has been developed for use in large munitions
  - Formulation is an aluminized version of the excellent IM explosive DLE-C054
- Formulation scale-up to 1-gallon scale has been straightforward
  - Excellent safety properties and rheology
  - No differences in processing characteristics based on mix size
- Testing shows good balance of performance and low shock sensitivity
  - Measured detonation velocity > Comp B or PBXN-109
  - CJ pressure nearly identical to PBXN-109
  - Reduced shock sensitivity relative to DLE-C054 & PBXN-109
- Additional characterization in larger hardware expected to further highlight impressive properties of this newly developed formulation