



ECL[®] Propellant Demonstration for Extended Range in 120mm Mortar combined with Ballistic and Chemical Stability Equals Win for the Warfighter

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NDIA Conference

44th Annual Gun & Missile System Conference

Kansas City, 7th April 2009

“Approved for Public Release; Distribution Unlimited”

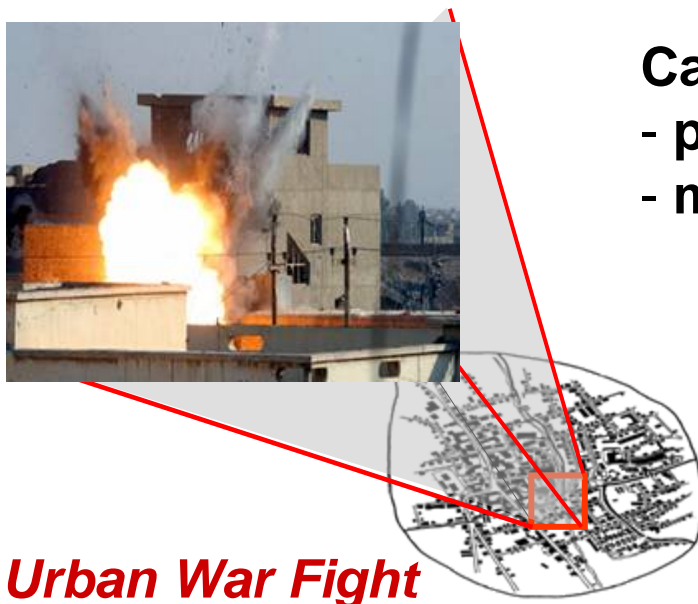
General Requirements for Future Close Fight

Main Goals

- New “hit target” precise rounds
Suppression → *Destruction*
- Compensation for heavier or high drag precision optimized projectiles
use current firing tables
- Potential for extension of battle space ranges
- Reducing number of rounds fired and time to fire those rounds
- Reducing risks of collateral damage to civilians and valued infrastructure

Propulsion System = decisive element in a chain of different system approaches for fulfillment of future requirements

General Requirements for Future Close Fight

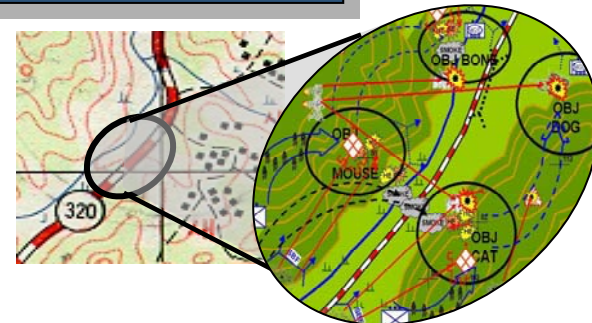


Urban War Fight

- Capability: urban clutter, rubble terrain**
- precision engagements (collateral damage)
 - mobility and survivability

- Propulsion specific requirements:**
- shelf life (extreme loads)
 - safety, reliability, consistency
 - energy density for range improvements

- Capability: complex terrain and vegetation**
- extended range (battle space)
 - precision optimized



Range Requirement



Prospective Path for Future Close Fight

	Today	2010 - 2012	20xx
Munition	Current HE	Precision Optimized	Precision Optimized
Lethality	Area fire*	Destruction (protected troops in bunkers, urban structures or vehicles)	Destruction
Range	7.2 km	7.2 - 10 km	10 – 12 km**

* Suppression of enemy troops

** Depending on system approach

New advanced propulsion technology is available for offering significant benefits for such future system solutions!

Advantages of ECL[®] Propellants in Mortar Applications

- Main Benefits of new ECL[®] propellants compared to current nitroglycerine-containing propellant solutions:
- **Improved performance potential** due to
 - ▶ High energy density and thermal conversion
 - ▶ Tunable force level, favorable thermodynamic features
- Improved dispersion (v), consistency and repeatability (lot to lot)
- ⇒ **improved accuracy and precision**
- Direct incorporation of muzzle flash suppressants
 - ⇒ no need for added separate "salt pills"
- Higher cook-off resistance, improved IM properties
- NG-free (safety) / non-toxic "green" formulation
- **Avoidance of critical migration problems** (plasticizers)
- Much **higher service life in A1 climatic zones** due to:
 - ▶ improved chemical and ballistic stability
 - ▶ improved compatibility





ECL[®] ⇒ US Mortar Range Extension Program (8 km)

Conclusions from Firing Tests May 2008 in Yuma

- Nitrochemie Extruded Composite Low-sensitivity (ECL[®]) Propellant has demonstrated performance improvements in current 120mm mortar system
- Thermal and chemical stability improvements result in more consistent muzzle velocity over the range of temperature environments, especially at elevated temperatures
 - ➔ ***No velocity shift, consistent dispersions***
- This results in improved ballistic precision (no changes in stockpile)
- Increased energy density will compensate for heavier, higher drag projectiles
- This will eliminate the need to modify firing table and ballistic software when firing heavier or higher drag projectiles

ECL[®] propellants offer performance and safety benefits for future solutions

ECL[®] ⇒ Excellent Interior Ballistic Performance

US Mortar Range Extension Program (8 km)
Results from Firing Tests May 2008 in Yuma



145 DEG F	Wt	Range	MV	TOF	Press1	Range Std Met	Range YPG Met
	(lb)	(m)	(mps)	(sec)	(psi)	(m)	(m)
ECL [®]	30.41	8458	378.9	44.76	17072	8318	8654
70 DEG F	Wt	Range	MV	TOF	Press1	Range Std Met	Range YPG Met
	(lb)	(m)	(mps)	(sec)	(psi)	(m)	(m)
ECL [®]	30.42	8187	366.3	43.89	14416	7980	8250

Range at STD MET just reflects removing MET effects from range values

- > 8000m range target achieved with low charge density
 - ▶ >20% “head room”, potential for further improvements on serial production basis
- This demonstrates that there is ample ballistic “head room” to compensate for heavier, higher drag projectiles

ECL[®] ⇒ Prolonged Service Life; Increased Safety / Reliability

■ General Aging Factors reduced by > factor 3

- ▶ Much longer shelf life
- ▶ No danger of self-ignition of the propellant during storage (A1 zone)



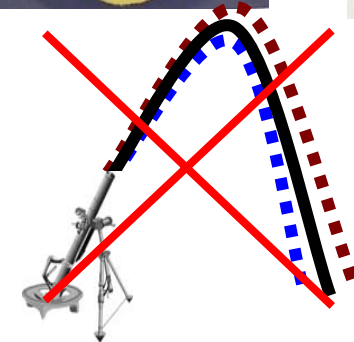
■ Problem of plasticizer migration eliminated

- ▶ No deterioration of other components of the mortar grenade due to NG uptake
- ▶ Full functionality of system maintained even after long-term storage
- ▶ ECL[®] can also be used for igniter > propelling technology for entire system



■ Essentially no changes of interior ballistic properties after aging

- ▶ Best possible precision / hit probability even after long-term storage





ECL[®] ⇒ Excellent Chemical Stability

Results from ARDEC investigations, June 2008: ECL and Ball Powder Depletion of primary stabilizer after extreme aging at 71°C for 21 days

	Chemical Stability			
	ECL Propellant		M47 Ball Powder	
	RES	RES + Daughter	RES	RES + Daughter
Baseline	1.102	1.102	1.013	1.051
21 days	0.85	1.015	0.099	0.287

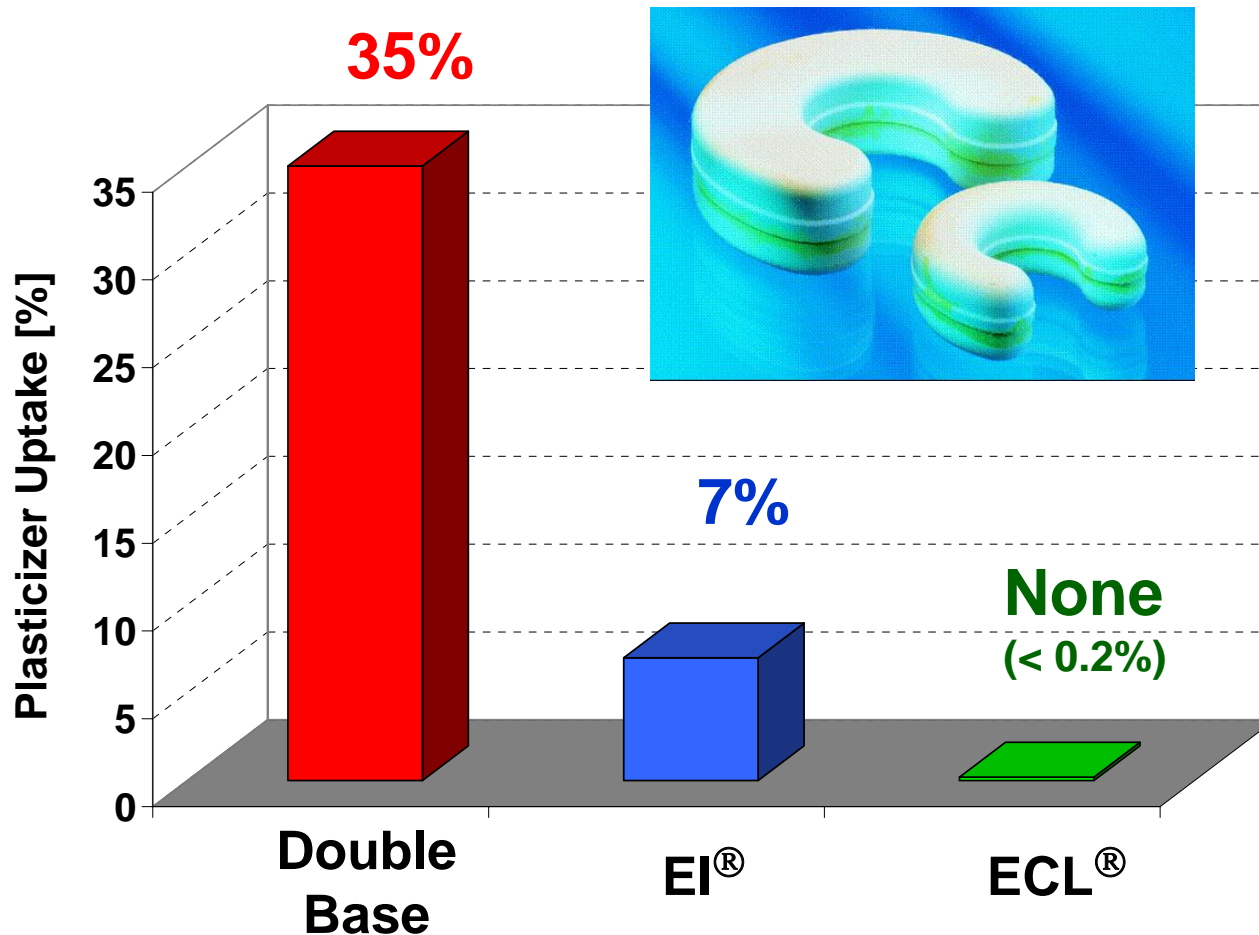
RES (Residual Effective Stabilizer) – virgin stabilizer material, full stabilizing potential

Daughter products – byproducts of stabilizer depletion, less effective at maintaining stability

- Nitrochemie ECL[®]: 77% primary stabilizer left, 92% total stabilizer left
 M47 propellant: 9% primary stabilizer left, 27% total stabilizer left
- Nitrochemie ECL[®]: improved stability with non-NG formulation
 - non-toxic stabilizer
- M47 propellant: Diphenylamine (DPA) stabilizer
 - classified "carcinogenic"

ECL[®] ⇒ Problem of Plasticizer (NG) Migration Eliminated

Equilibrium Plasticizer Uptake of Felted Fiber Container (@ 60°C)



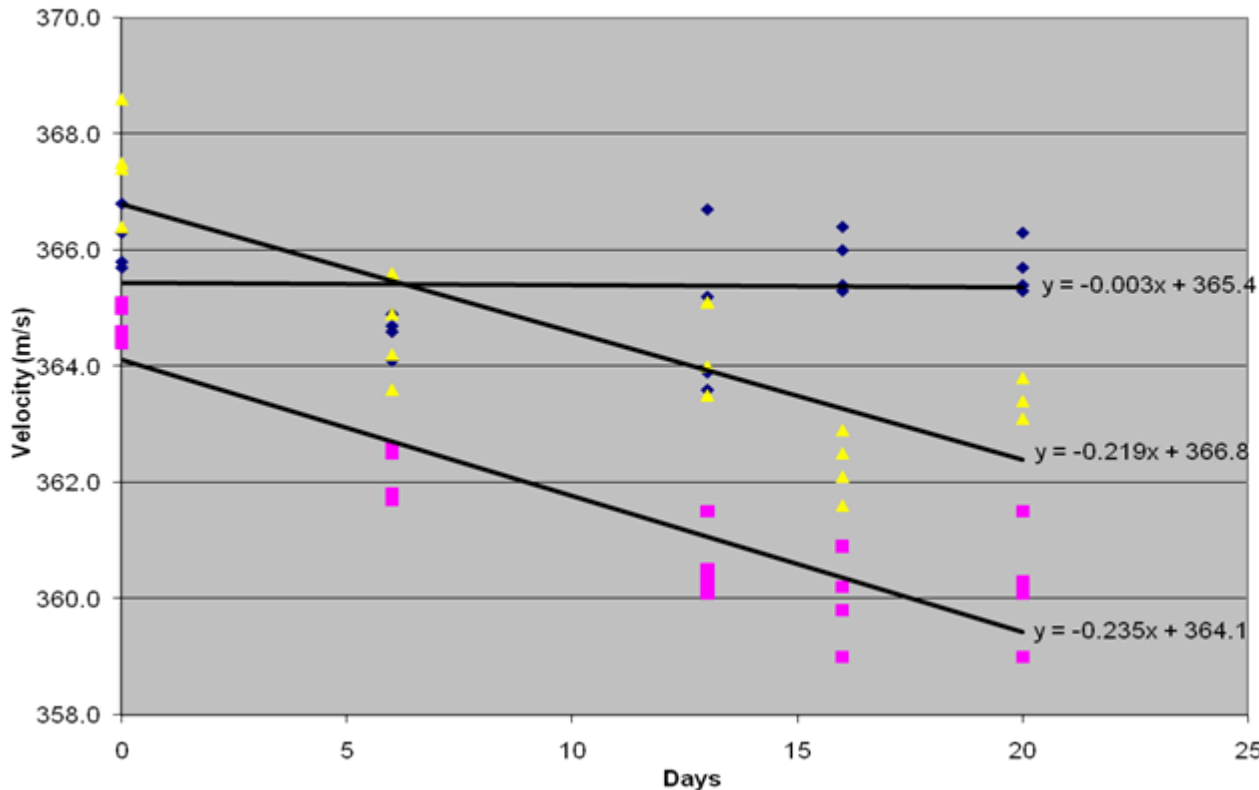
Plasticizers used in ECL[®] propellant do not migrate

⇒ unchanged mechanical properties of increment materials after long-term storage!!!

ECL[®] ⇒ Excellent Ballistic Stability

Results from Tests Yuma, June 2008

Extended Range Propellant Candidate Comparison



Conditioned at
160°F / 71°C
for 20 days

- ◆ Nitrochemie
- Linear (Nitrochemie)
- ◆ Other propellant candidates
- Linear (other candidates)

⇒ No change of muzzle velocity

⇒ No deterioration of 1st hit probability / collateral damage risk with aging

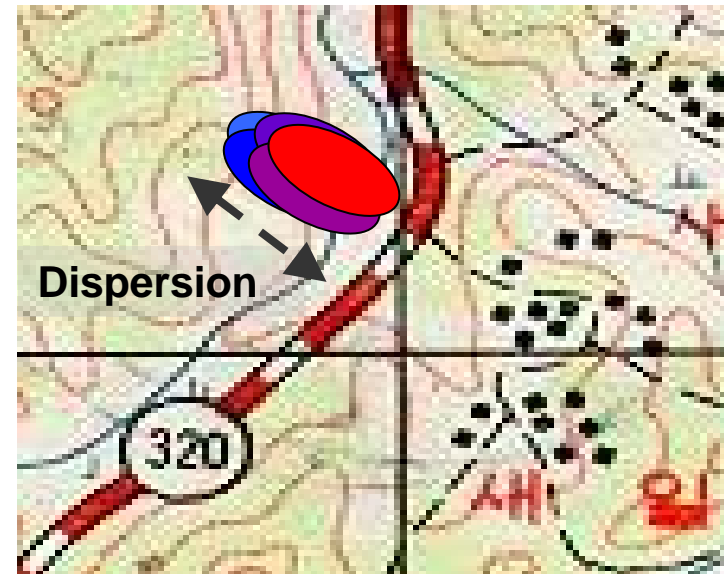
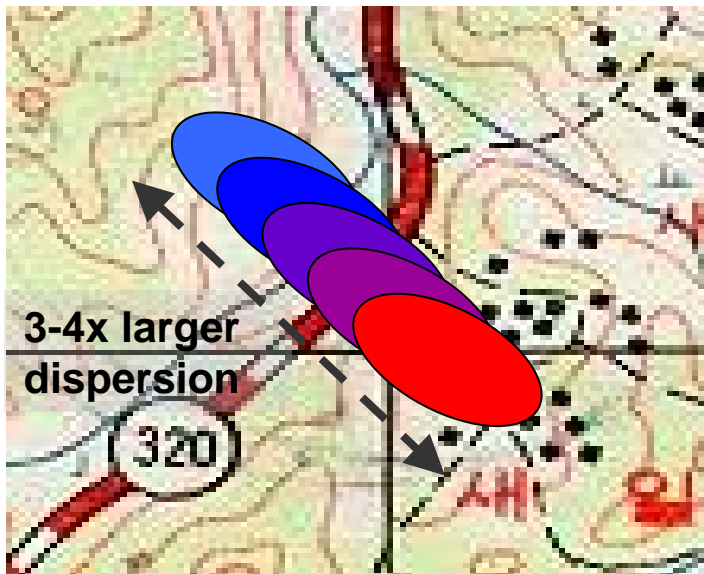
ECL[®] ⇒ Excellent Ballistic Stability

■ Current Propellant Solutions:

- ▶ Significant dispersion already for non-aged propellant / charge
- ▶ Velocity shift and thus impact on shot range due to aging
- ▶ Massively increased target area if ammo with various aging history is fired
- ▶ **High dispersion and collateral damage**

ECL[®] Propellant:

- ▶ Low dispersion for non-aged propellant / charge
- ▶ No significant change in muzzle velocity / shot distance due to aging
- ▶ Target area remains small even if ammo with various aging history is fired
- ▶ **Minimum collateral damage, reduced number of rounds**



ECL[®] ⇒ Incorporation of Muzzle Flash / Blast Suppressants

Firing Test Switzerland (January 2008)



Propellant with
low potassium
salt content



ECL[®] Propellant with
high potassium salt
content (incorporated)

ECL[®] propellant allows the incorporation of MF suppressant additives and thus avoiding need for added "salt pills"

Incorporation of sufficient salt load enhances the loading charge potential of propellant!



Conclusions

- **ECL[®] is the propellant of choice for future mortar rounds (step forward into 21st century):**
- ECL[®] Propellant is well suited for any **range extension program** (e.g. for range extension of current or future system configurations)
- ECL[®] has the **high energy density** needed to compensate for future **heavier or high drag projectiles** and still use **current firing tables**
- ECL[®] is **chemically** and **ballistically stable** during long term storage at high temperatures (current mortar propellant solutions are not). This provides
 - ▶ improved safety for our war fighters for all kind of close fights
 - ▶ superior ballistic accuracy and reduced collateral damage
 - ▶ saving of rounds and time to fire
 - ▶ longer service-life, reduced life cycle costs
- ECL[®] has proven its unique overall potential in Yuma test campaign

Acknowledgments

- **Co-workers at ARDEC, Picatinny Arsenal**
 - ▶ Bishara Elmasri, Elbert Caravaca and Brian Talley
- **Co-workers at Nitrochemie Wimmis AG**
 - ▶ Beat Vogelsanger, Peter Zoss and Heinz Jaskolka
- **Co-workers at ATK Radford Plant**
 - ▶ Steve Ritchie, Randy O'Brien and Amy Morris
- **Audience: For your Attention**

