Improved LW30 Ammunition via Ignitability and Ballistic / Chemical Stability of ECL® (Extruded Composite Low Vulnerability) Propellant

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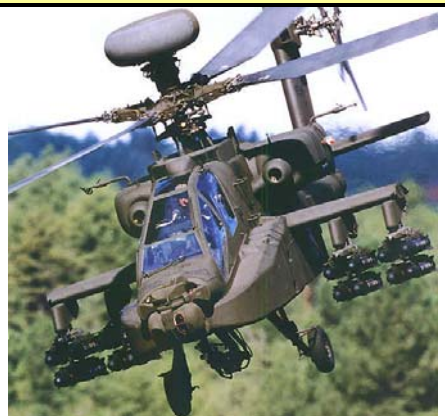
Benefits of ECL® Propellant

Improved Characteristic's of ECL	Translates to…
High energy density formulations High thermal conversion Tuneable performance and force	Improved ballsitc performance and efficiency Flat, tuneable ballistic profile across temperatures Improved dispersion, repeatability
No mobile plasticizers, non-nitrogylcerin	No migration of NG into cases Improved system compatability Improved safety during manufacture
Enhananced IM properties	Higher cook off temps - improved crew survival Less sensitive/no reaction to impact
Non-toxic, "green" formulation	Better for the environment Better for the user/manufacturer
Chemical stability Ballistic stability	Ammunition can be deployed to extreme climates with no degredation in performance Longer service life for ammunition



LW-30 Propulsion System Demands Redesign

Current LW-30 Ammunition Family

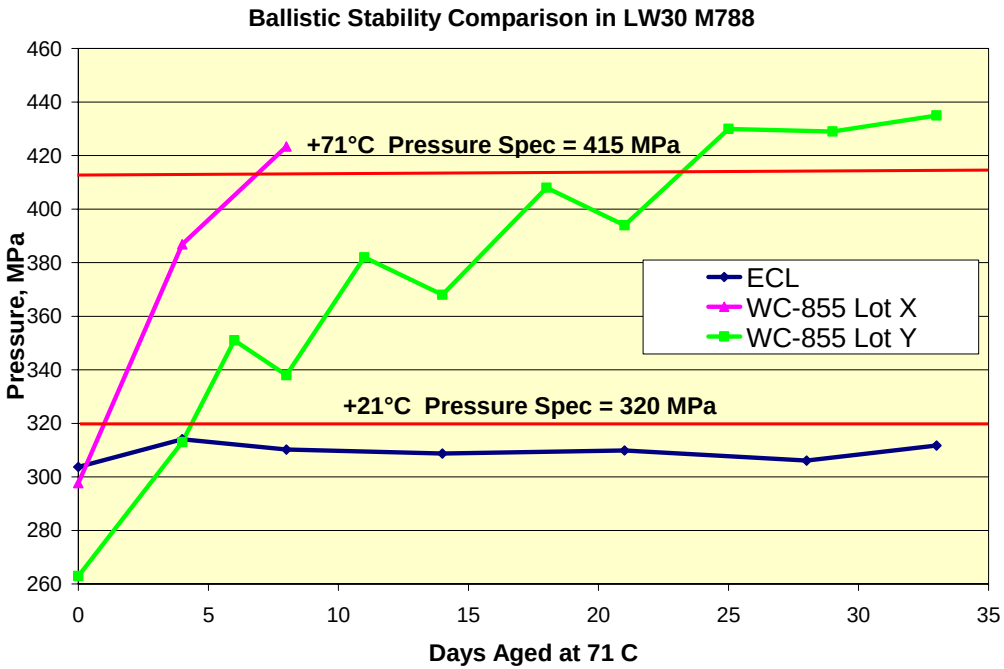
- M789 HEDP tactical round and the M788 TP practice round
- Fired from the M230 Gun System on the AH-64 Apache
- Propulsion: PA520 primer + 3 pellet flash tube + WC 855 BALL POWDER®

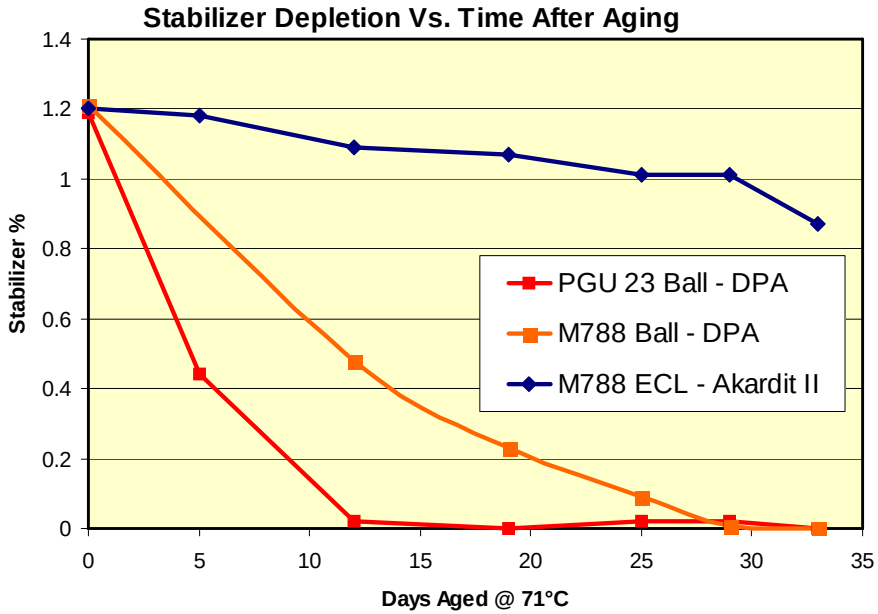
Due to In-bore detonations and hang fires resulting in weapon system failures in the field, an investigation team was established to identify root cause.

Investigation identified propulsion system weaknesses as one root cause for hang fire signature

- Propellant – current propellant found to be chemically and ballistically unstable after exposure to hot conditions
- Ignition System – nitrocellulose lacquer seal failure

ECL® Propellant Superior Stability Response





- **Large variation in ballistic stability response for WC-855 after hot temp storage**
- **Propellant lot 'X' reaches upper spec limit for pressure after 7 days at 71°C**

- **Ball propellant analyzed 0% stabilizer after 18 days at 71°C**
- **ECL propellant analyzed 1.1% stabilizer after 18 days at 71°C**

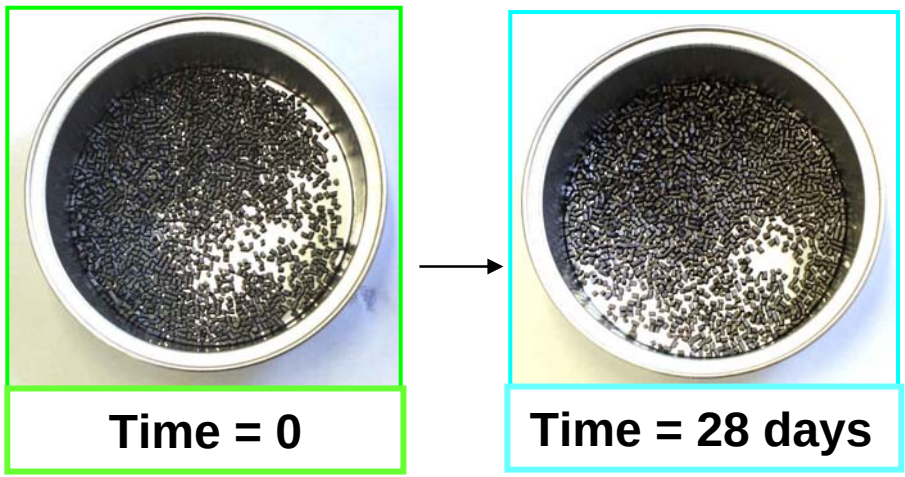
Safety Concern for User!

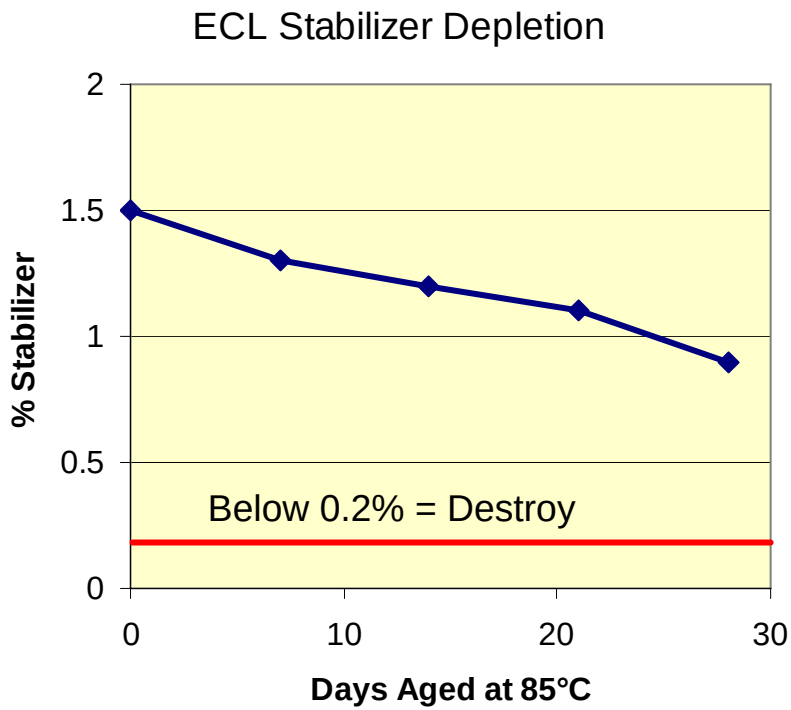
No change in ballistic performance of ECL after 33 days at 71°C!

After 33 days, ECL analyzed with 83% primary stabilizer

Excellent Chemical Stability

In anticipation of more stringent aging requirements, ECL propellant was subjected to 85°C for 28 days



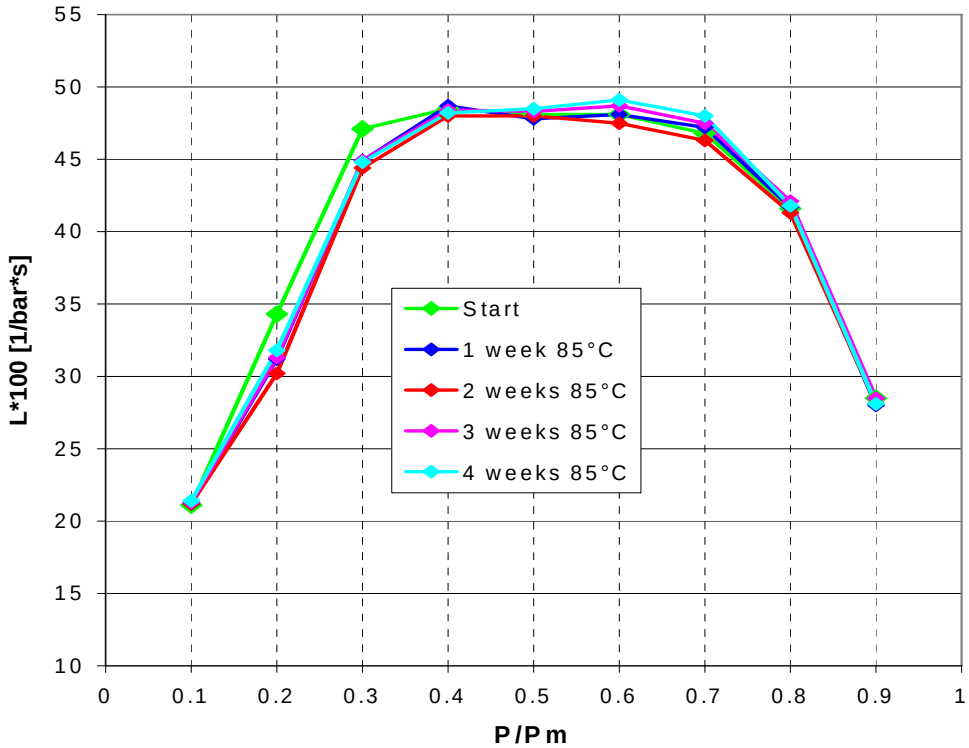


- No physical change in appearance
- No gluing or tackiness of grains
- No RDX migration to surface

- After 28 days storage at 85°C , 58% primary stabilizer analyzed in ECL propellant

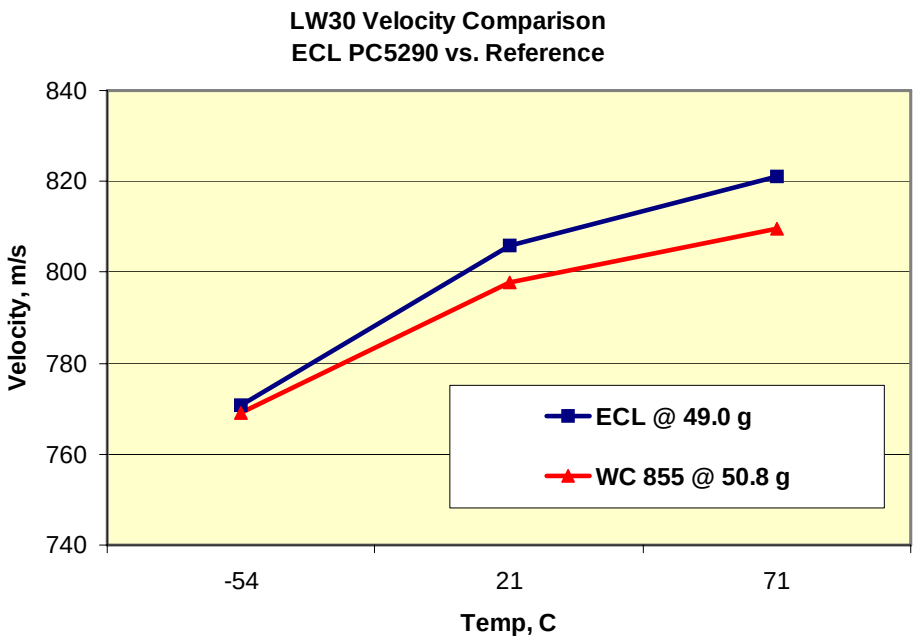
Excellent Ballistic Stability

- **Dynamic vivacity is a parameter of interest derived from closed bomb firing data**
- **Vivacity is an expression of propellant chemical composition (burn rate) and the surface area**



No Degredation in Ballistic Performance in ECL Propellant After 28 Days at 85°C

Superior Ballistic Performance of ECL®

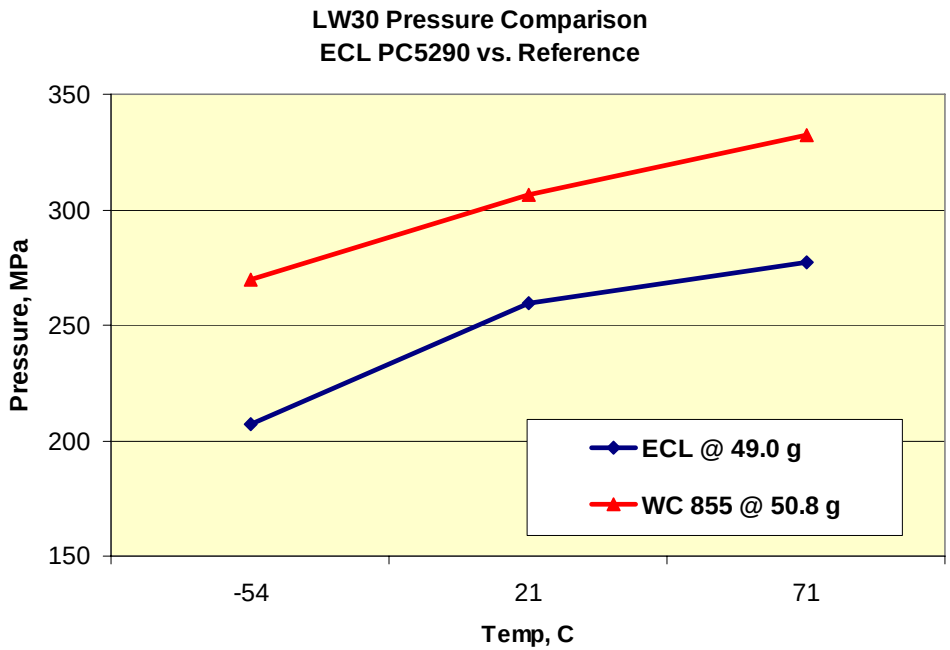


ECL Exceeds Ballistic Performance of WC 855:

- ✓ Lower Charge Weight
- ✓ Higher Velocity
- ✓ Reduced Pressure

Extra Efficiency of ECL Translates to:

- ✓ Extended Range
- ✓ Increased Lethality
- ✓ Cost Savings
- ✓ Ballistic Margin



ECL ® Propellant Offers Extended Barrel Life

Thermo-Mechanical Approach to Calculating Gun Barrel Erosion by Stein RWM

$$\text{Erosion} \sim (m_c)^{1.5} \cdot (T_{ex})^{7} \cdot (v_0)^{1.4} \cdot (p_{max})^{5}$$

m_c = Charge Mass, T_{ex} = Flame Temperature, v_0 = Muzzle Velocity, P_{max} = Peak Pressure

21°C	ECL	Ball
Charge weight, g	49.0	50.8
Flame temp, K	2880	2750
Pmax, Mpa	259.4	306.4
Erosion	6.62 E+38	1.16 E+39
Relative Erosion, %	**57**	**100**

71°C	ECL	Ball
Charge weight, g	49.0	50.8
Flame temp, K	2880	2750
Pmax, Mpa	277.4	332.4
Erosion	9.26 E+38	1.75 E+39
Relative Erosion, %	**53**	**100**

- **Relative erosivity of ECL ~ 55% of WC 855 Ball**
- **Peak gas pressure is the main driver for barrel erosion**

Ultimate LW30 : New Propellant + New Ignition

Action time critical to the LW30 M230 gun system

- **Rate of fire is 625 rounds per minute**

Propellant	Description	AT, ms
Reference	Std Ignition	2.70
LW30 ECL FM4285	Std Ignition	2.49
LW30 ECL FM4285	Standard primer, no flash tube	3.74
WC 855 L574	Standard primer, no flash tube	75.25
LW30 ECL FM4285	MIC primer, with flash tube	3.26
WC 855 L574	MIC primer, with flash tube	3.43
LW30 ECL FM4285	MIC primer, no flash tube	4.03
WC 855 L574	MIC primer, no flash tube	85.61

Conducted work share investigation with PM MAS to investigate alternate primer mix effects

- MIC primers are aluminum based primers
- Potential next generation lead-free “green” primer

Alternate ignition testing illustrates superior ignitability of ECL propellant

Conclusions

- **Nitrochemie ECL propellant offers superior ballistic performance in the LW-30 Ammunition Family**
- **ECL propellants are extremely stable: both ballistically and chemically even after hot temperature storage**
  - Excellently suited for extreme climate missions
- **ECL propellants are "GREEN" formulations, they do not contain toxic ingredients or mobile plasticizers**
- **ECL propellants exhibit improved IM characteristics**
- **ECL propellant formulation shows improved erosivity compared to currently fielded ammunition - service life of barrels will increase**
- **Superior ignition properties demonstrated with ECL propellant**

Acknowledgements and Questions

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