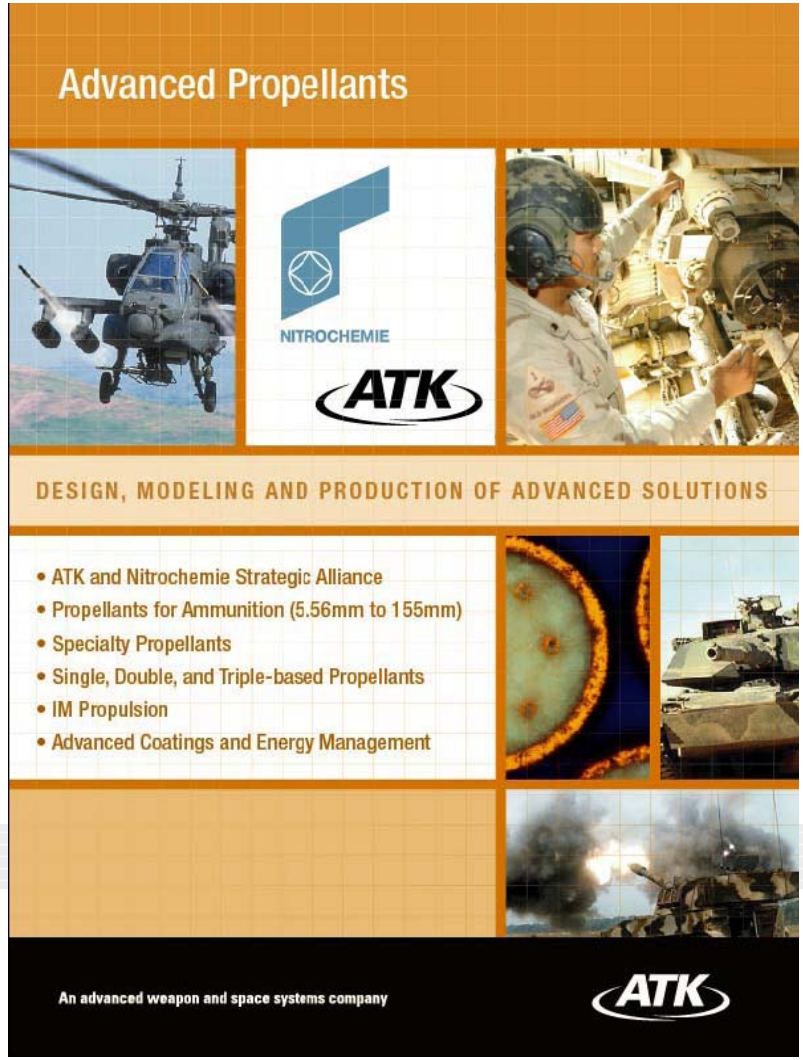
Enhanced Ammunition Performance with ECL® Technology



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- Introduction – Why Choose ECL Propellant?
- Results
  - 30 mm APFSDS-T Mk258
  - LW 30 mm M788 TP
- Conclusions

Evolution of Small / Medium Caliber and Mortar Propellants

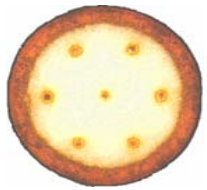
Single Base
Since 1885
Force: 950 J/g
T_{ex}: 2'500 K

- Limited performance potential; still suitable for:
  - Many small caliber applications (7.62mm, 12.7mm)
  - conventional medium calibre applications

Common Technology

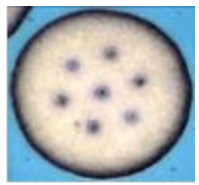
Nitrochemie Technology

EI® Extruded-Impregnated
Since 1990
Force: 1020 J/g
T_{ex}: 3'000 K



- Significantly improved performance !
  - High performance small caliber (5.56mm)
  - Medium caliber with KE projectiles
  - Mortar charges (solves migration problem, better precision)

ECL®
Since 2006
Force: 1050 J/g
T_{ex}: 2'850 K

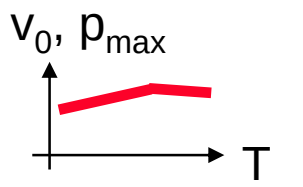


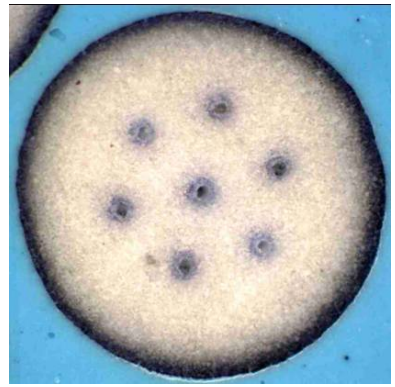
- Further improved performance !
- Nitroglycerine-free
  - Highest performance medium caliber applications (e.g. KE and airburst projectiles)
  - Special mortar applications

What are the Advantages of ECL® ?

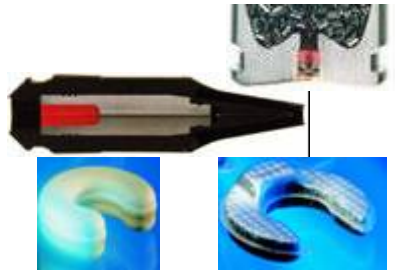
Advantages of ECL® propellants, in comparison to nitroglycerine-containing propellants, are:

- **Equal or higher ballistic performance due to:**
  - **very high thermal efficiency (up to 10% higher)**
  - **very flat, tunable temperature characteristics**
  - **reduced and uniform ignition delay**
- **Lower erosivity due to lower flame temperature**
- **IM-improved; increased cook-off resistance**
- **NG-free / non-toxic "green" formulation**
- **No problems with nitroglycerine migration**
- **At least 3 times longer service life in A1 climatic zones due to:**
  - **much better chemical stability**
  - **much better ballistic stability**
  - **much better compatibility**





Shelf life of ECL® is increased by at least factor 3 compared to nitroglycerine-containing propellants !



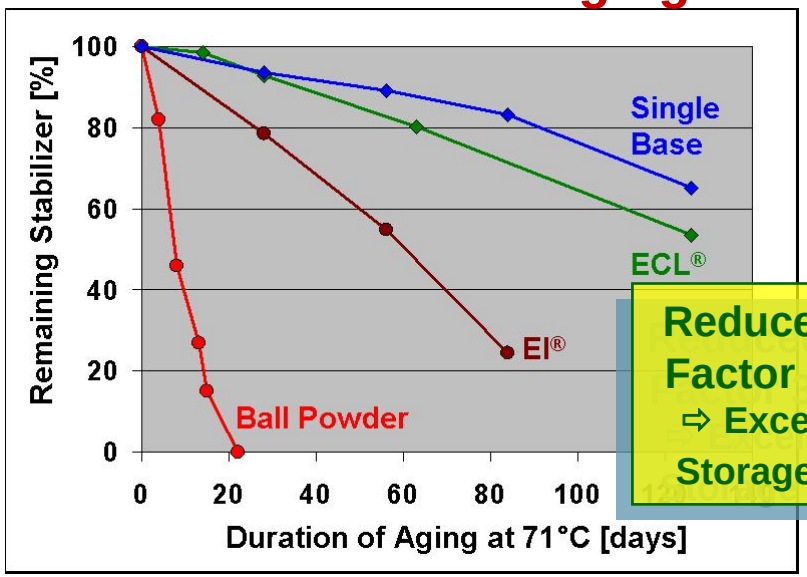
Chemical Incompatibility

Reduced by Factor 10
⇨ No Incompatibility Problems

Migration of NG / plasticizers

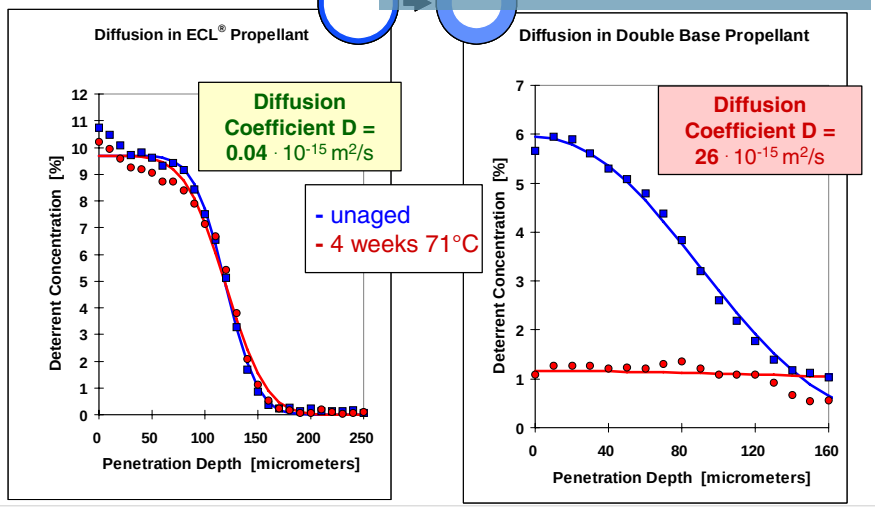
Reduced by Factor > 10
⇨ No Problems with Mobile Plasticizers

Chemical Aging



Reduced by Factor 3 – 4
⇨ Excellent Storage Life

Diffusion of Deterrents



Reduced by Factor 10 to 100
⇨ Excellent Ballistic Life

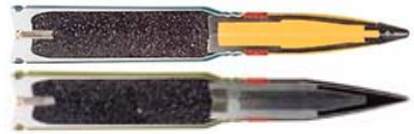
Current US Medium Caliber Applications Investigating Use of ECL® Technology

- 30 mm APFSDS-T Mk 258

- 20mm ELC Phalanx

- 30mm ABM

- 30mm Ballistic Match (PGU 13/14)



- 50mm EAPS

- M789 LW 30mm HEDP

US DoD Non-NG Propellant Contract

30 mm APFSDS-T Mk 258

30 mm Medium Cal Program

System:

30 mm APFSDS-T Mk 258

Contract:

DAAB07-03-D-B011 (from 2006)

Goals of Feasibility Study:

- ⇨ NG-free Propellant ☑ **(ECL is NG-free)**
- ⇨ Performance Enhancement ☑ **(+20 m/s; better penetration)**
- ⇨ IM Improvement ☑ **(slightly milder reaction; much longer time to cook-off)**

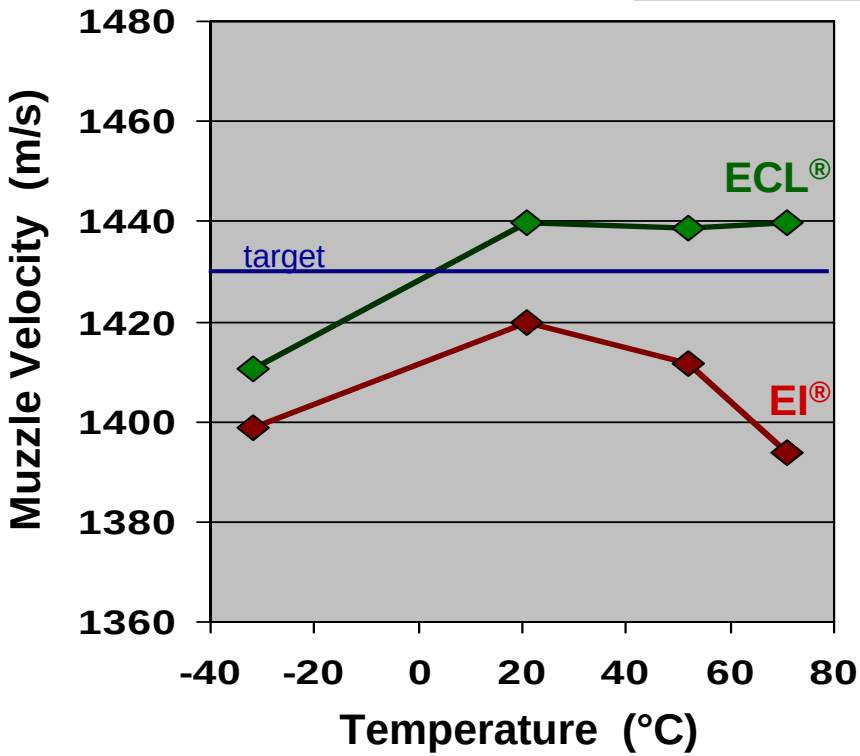
The ECL® propellant has been demonstrated for use in the Mk258 with good results but has NOT been qualified by the Army or DoD for use in the Mk258

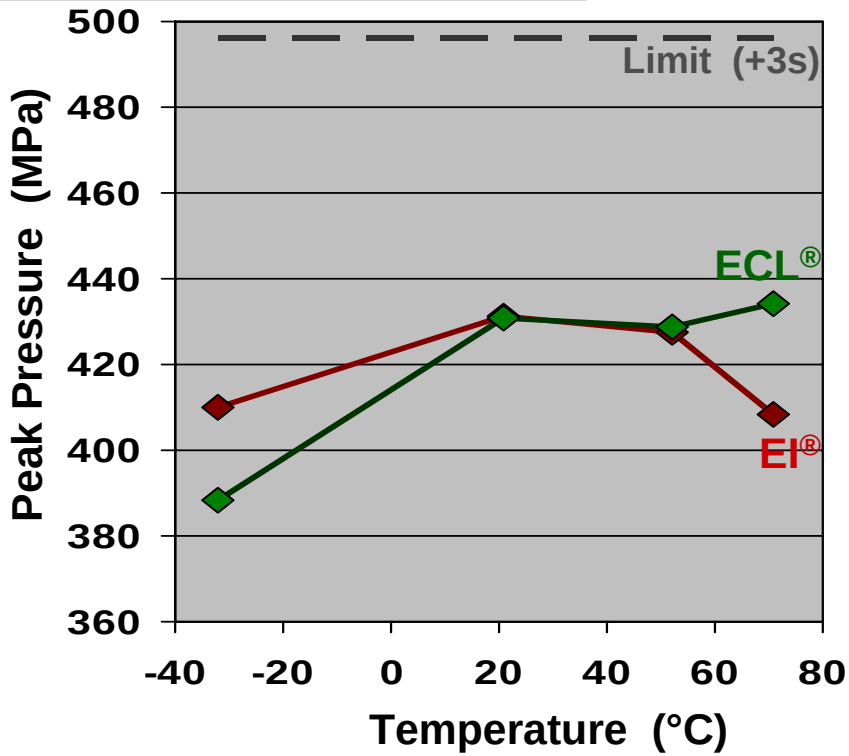
US DoD Non-NG Propellant Contract

30 mm APFSDS-T Mk 258 – Ballistic Performance

Tests performed by: Nammo NORDIC AMMUNITION COMPANY

30 mm APFSDS-T, m_p = 231g; Bushmaster II Gun

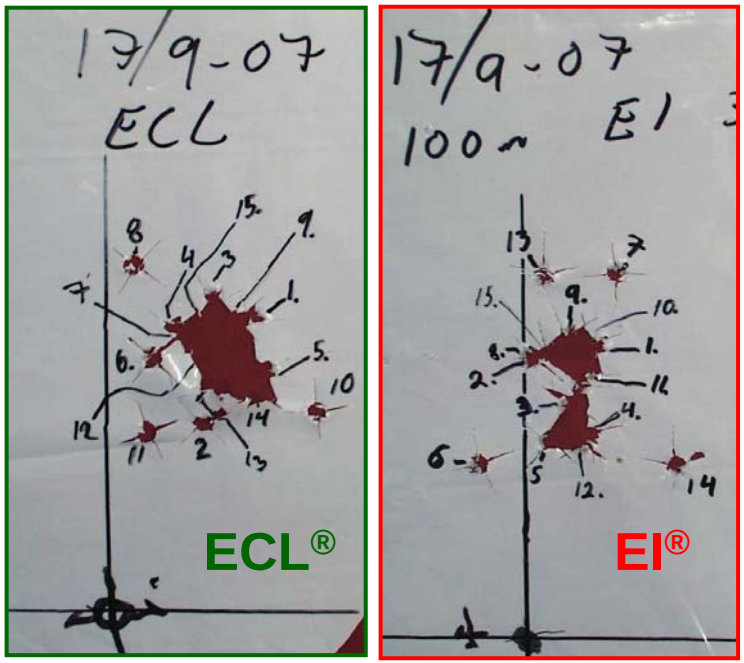




- ECL® achieves 20 m/s higher muzzle velocity than EI® at same pressure level
- Flat temperature coefficient, especially at warm / all requirements are fulfilled

US DoD Non-NG Propellant Contract

30 mm APFSDS-T Mk 258 – Dispersion and Penetration



Tests performed by:

Nammo
NORDIC AMMUNITION COMPANY

US Spec. IAW WS 33595

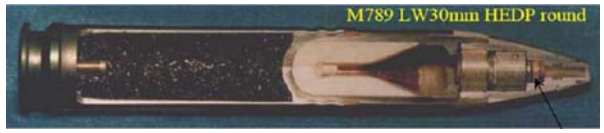
⇨ Dispersion of ECL® and baseline EI® propellants are comparable and well within limits

⇨ Baseline EI® propellant: Projectile penetrates target at 100% and 120%, but not at 140% of specification

⇨ ECL®: Projectile penetrates target at 100%, 120%, and 140% of specification → 20% more distance !

Medium Caliber Propellants for US Programs / Ammunitions

Improved LW30 Propulsion System



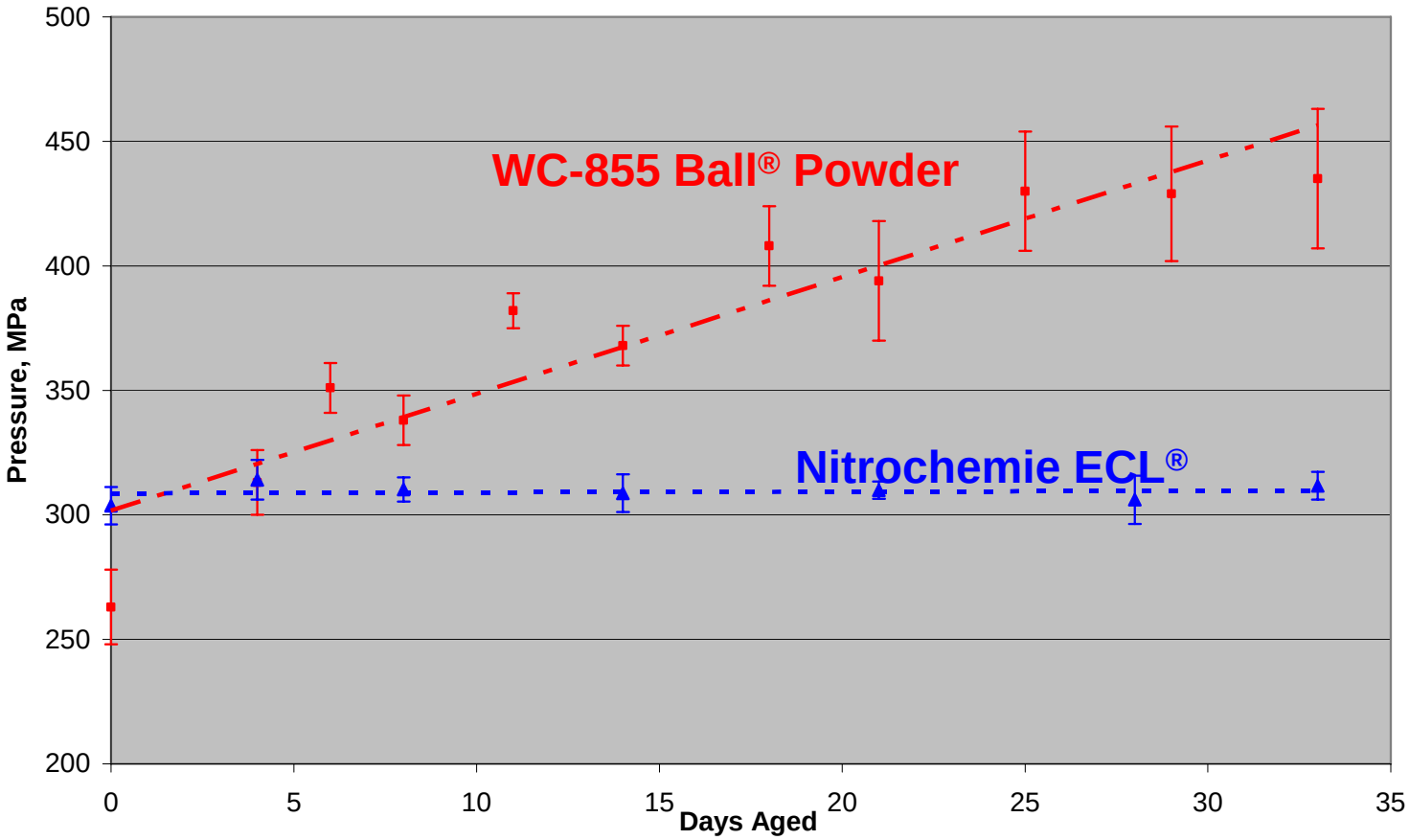
- **Actual M789 LW30mm HEDP (Light Weight / High Explosive Dual Purpose) cartridges for APACHE helicopter have caused serious problems:** (Source: J. Hirlinger; ARDEC; 42nd Armament Conference; Charlotte, NC; 2007)
  - **Hangfire:** Interior ballistics delayed; weapon systems destroyed
  - **Inbore detonation:** Premature initiation in the barrel; barrel destroyed

- **Hangfire signature duplicated with WC855 Ball® Powder that had been subjected to 71°C for 33 days**
  - **WC855 Ball® Powder exhibits chemical and ballistic degradation after hot temperature storage – Pressures in excess of 480 MPa when shot at ambient.**
  - **Propellant gases vented from the chamber area can damage the operating system and receiver.**
  - **Damage created in testing similar to that seen in HE-Inbore events, except no barrel bulge and generally no Blast Suppressor damage.**

ECL® propellant is excellently suited to solve these problems. ECL ® propellant combines high interior ballistic performance with excellent chemical and ballistic stability

ECL® for LW30mm – Consistent Ballistics After Hot Storage

M788 Ball Powder and Nitrochemie ECL Propellant Aged at 71°C for 33 Days
Test Vehicle LW30 M788

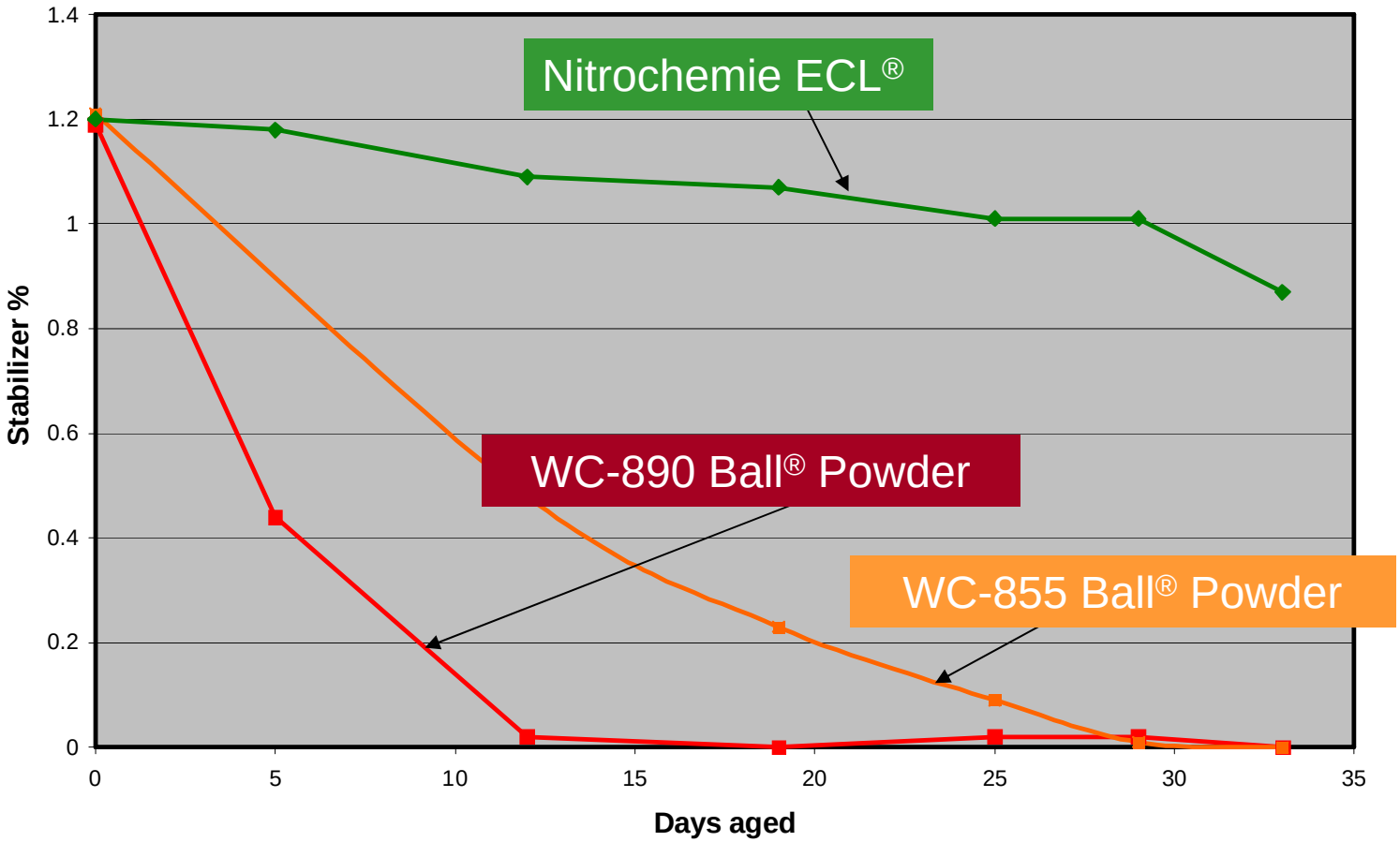


⇨ **Increase of peak pressure by 50% (or 150 MPa) with WC855 Ball® Powder**

⇨ **No change of peak pressure with ECL® propellant after 33 days at 71°C**

ECL® for LW30mm – Exhibits Superior Chemical Stability

Stabilizer Depletion Vs. Time After Aging at 71°C



⇨ 100% of primary stabilizer, DPA, depleted in Ball® samples after 33 days at 71°C

⇨ ECL® shows only 25% depletion of Akardite-2 after 33 days at 71°C

Summary and Conclusions

ECL® propellant are state-of-the-art formulations with superior performance characteristics:

- **Improved ballistic performance – high thermal efficiency**
- **Flat, tunable temperature characteristics**
- **No carcinogenic ingredients**
- **Improved IM properties**

ECL® propellants demonstrate superior chemical and ballistic stability when compared to single base, double base and EI propellant formulations.

SERVICE LIFE OF AMMO EXTENDED BY FACTOR OF 3

IMPROVED SAFETY FOR THE WARFIGHTER

Acknowledgements

- **Co-workers at ARDEC, Picatinny Arsenal**
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  - **Steve Ritchie, Jim Wedwick, Randy O'Brien and Amy Morris**
- **Audience: For your Attention**