New Propellant-Technologies for Small Calibre Ammunition

Beat Vogelsanger, Ulrich Schädeli, Urs von Mühlenen, and Dominik Antenen

(Conference Abstract Reference Number #15931)

© Nitrochemie 2013

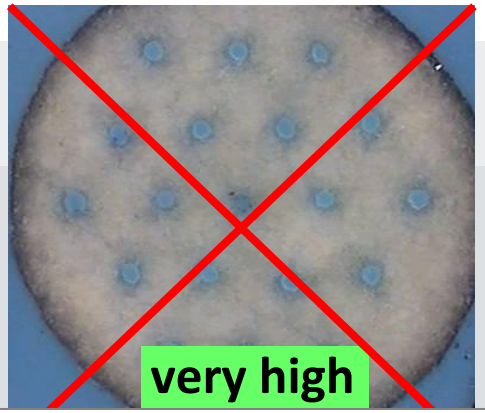
Contents

- Introduction
  - Conventional Small Calibre Propellants
  - Challenges / New Requirements
- The Solution – Nitrochemie Small-Calibre Propellants
- Examples
  - EI® Propellant for Lead-Free Ammunition
  - Improved Stability
  - C4 Propellants for Highest Performance
- Summary and Conclusions

© Nitrochemie 2013

Introduction I – Conventional Small Calibre Propellants

Propellant Geometry / Shape

	Spherical	Cylindrical 1-perforated	Cylindrical 7/19-perforated
			 
Gravim. Density:	high	low	
Progressivity:	very low	intermediate	high / very high

7-/19-perforated cylinders are not suitable for small calibre applications due to the much larger grain sizes required to match the requested burning rates

Propellant Formulation

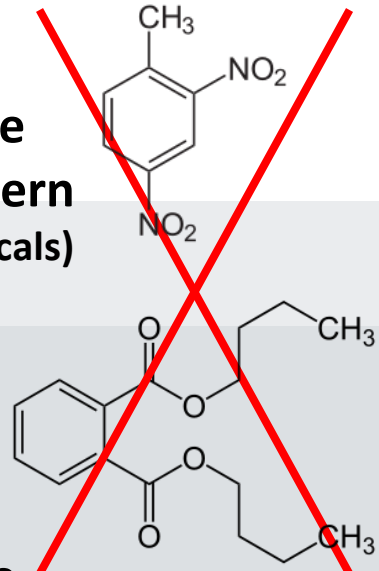
	Single Base	Double Base
Performance Potential:	low	high
Chemical/ballistic Stability:	high	low

© Nitrochemie 2013

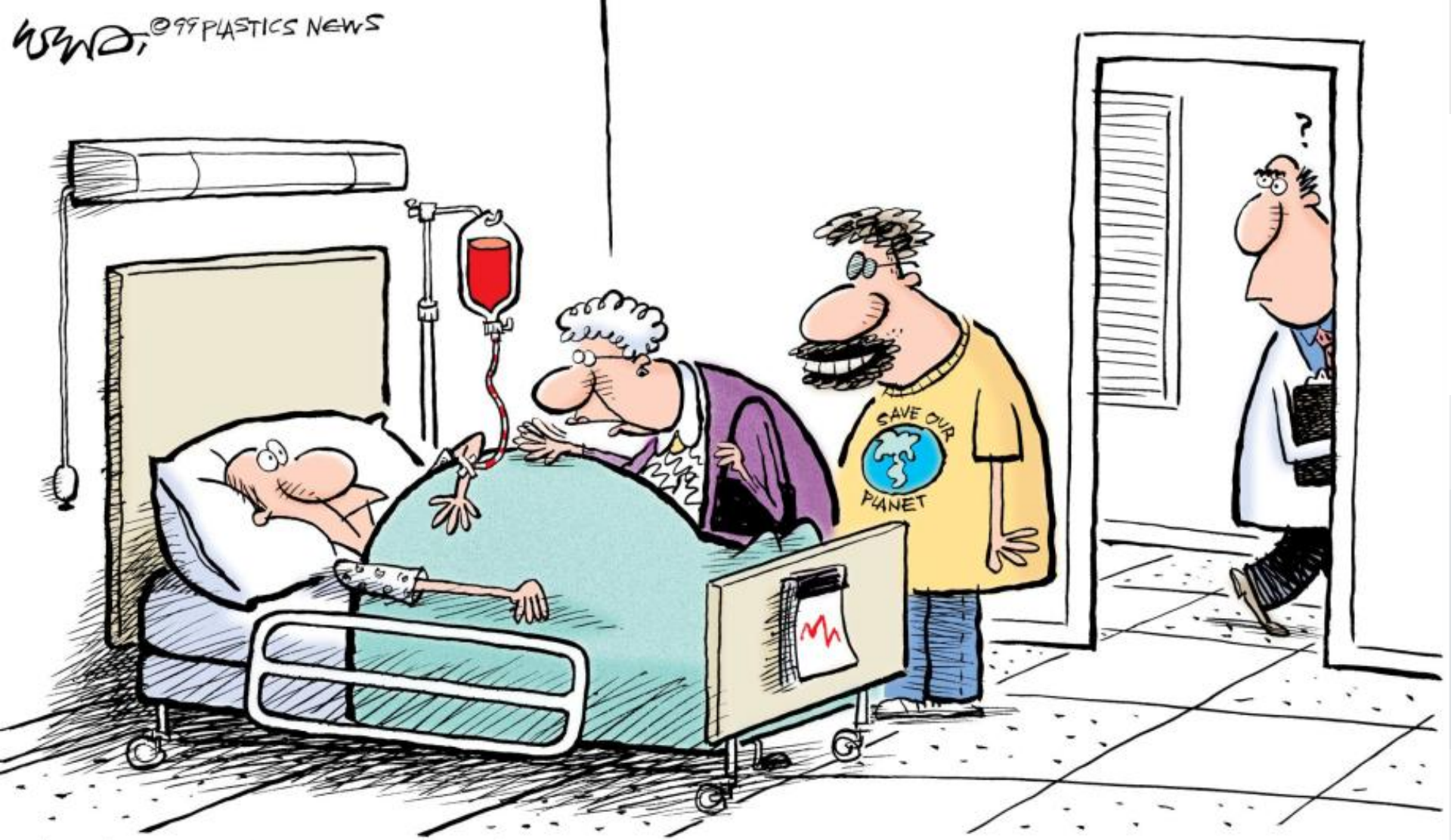
Introduction II – Challenges / New Requirements

Non-toxic formulation

- **Dinitrotoluene DNT + Phthalate Esters DBP, DEHP, DIBP** are on the European REACh-list of substances of very high concern
  (REACh = Registration, Evaluation, Authorisation and Restriction of Chemicals)
- They will be banned by European legislation from 2015 !
- All currently introduced ball powders and many single base propellants contain at least one of these components
- These propellants need to be re-designed and re-qualified (including re-qualification of ammunition) at least in Europe



© Nitrochemie 2013



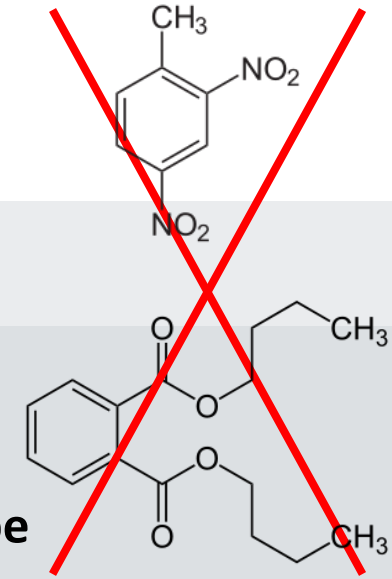
"WE'RE GOING TO ASK THE DOCTORS TO DISCONNECT YOUR LIFE SUPPORT, HOWARD. WE CERTAINLY DON'T WANT YOU ABSORBING ANY PHTHALATES..."

© Nitrochemie 2013

Introduction II – Challenges / New Requirements

Non-toxic formulation

- **Dinitrotoluene DNT + Phthalate Esters DBP, DEHP, DIBP** are on REACh-list of substances of very high concern
- They will be banned by European legislation from 2015 !
- All currently introduced ball powders and many single base propellants contain at least one of these components
- These propellants need to be re-designed and re-qualified (including re-qualification of ammunition) at least in Europe



Increased Stability / Service Life

- In Particular for out-of-area missions
- Some nitroglycerine-based formulations have caused problems such as increased peak pressure or deterioration of other functional and ballistic properties in aged ammunition

© Nitrochemie 2013

Introduction III – Challenges / New Requirements

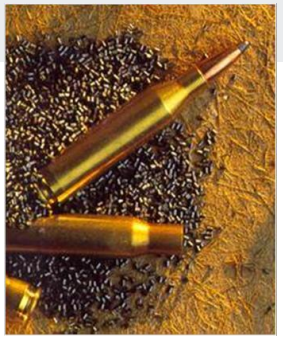
Reduced Production of Toxic Combustion Gases

- Toxic gases: Carbon monoxide CO, hydrogen cyanide HCN, ammonia NH_3
- Amount of toxic gases has caused health issues with the shooters
- Need for propellants with reduced toxic gas emission

Compatibility with "Green" Lead-Free Ammunition

- Lead-free ammunition → increased gun barrel wear and strong copper build-up in the barrel
- Side effects can be reduced by incorporating tin dioxide into propellant
- Tin dioxide is at least slightly toxic (irritant / pulmonary effects)
- Need for less toxic de-coppering and wear-reducing agents

Increased Performance



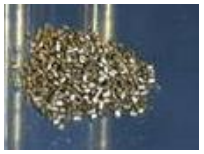
- Higher performance to increase penetration of body armour
- Need for propellant performance higher than with ball powder

© Nitrochemie 2013

RHEINMETALL NITROCHEMIE

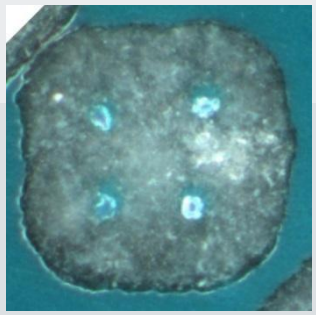
The Solution – Nitrochemie Small-Calibre Propellants

Propellant Formulations



- Single Base → intermediate performance / outstanding stability
- Extruded-Impregnated EI® → high performance / good stability

Propellant Geometry



- 1-perforated Cylinders → intermediate progressivity
- 4-perforated Cubic "C4" (absolutely new grain geometry)
  → high progressivity + high gravimetric density

Non-toxic Formulation

- All formulations are already REACh-compatible (no DNT, DBP, ….)
- Also other toxic components have been replaced (e.g. DPA)

Non-Toxic De-coppering Agent for Lead-Free Ammunition

- New / patented de-coppering concept based on bismuth compounds
  → more effective + ten times less toxic than tin dioxide

© Nitrochemie 2013

Example 1: EI® Propellant for Small Calibre Applications

Solving the Toxicity / Health Problems of Small Cal Ammunition

- First generation of lead-free ammunition (with ball powder) caused <u>severe health issues</u> (Norwegian Defence Forces)
  - Irritated airways, coughing, fever, could sweats, head-ache, nausea and body pain (in not acceptable extent)
  - At indoor <u>and outdoor</u> shooting ranges
  - Filled headlines in Norwegian media (spring 2009)
  - Assumed cause is combination of <u>metal particles</u> (copper Cu, zinc Zn, tin Sn) and <u>combustion gases</u> (carbon monoxide CO, ammonia NH_3, hydrogen cyanide HCN)
  - Armed Forces Chief stopped use of this lead-free ammunition

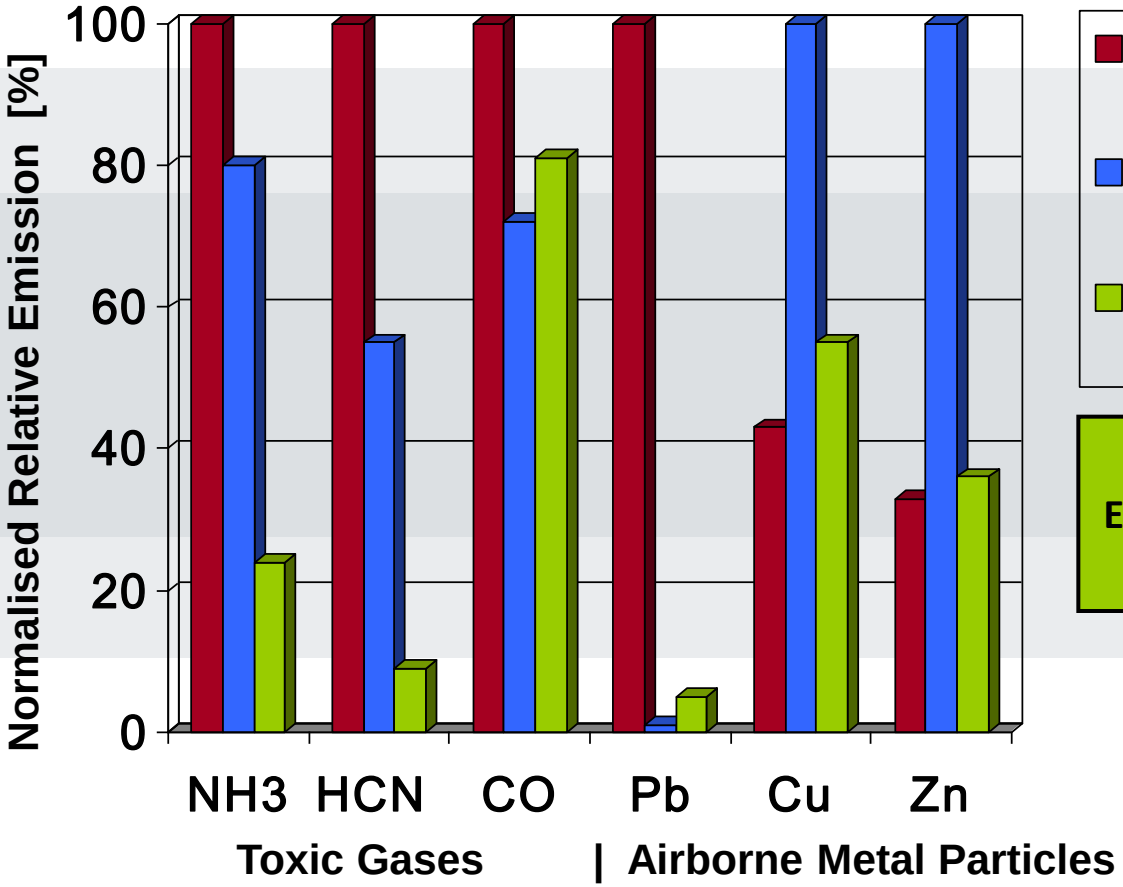
- Second generation lead-free ammo (with EI®-Type propellant + bismuth agent)
  - strongly reduced emission of toxic gases and metal particles
  - **no health issues have been reported** whilst firing this new ammo
  - Norwegian Defence Forces are now procuring this ammo !

© Nitrochemie 2013

Example 1: EI® Propellant for Small Calibre Applications

Solving the Toxicity / Health Problems of Small Cal Ammunition

Emission Results of Norwegian Study (FFI / NAMMO 2011)



Improved ammo design + EI® propellant solved health problems

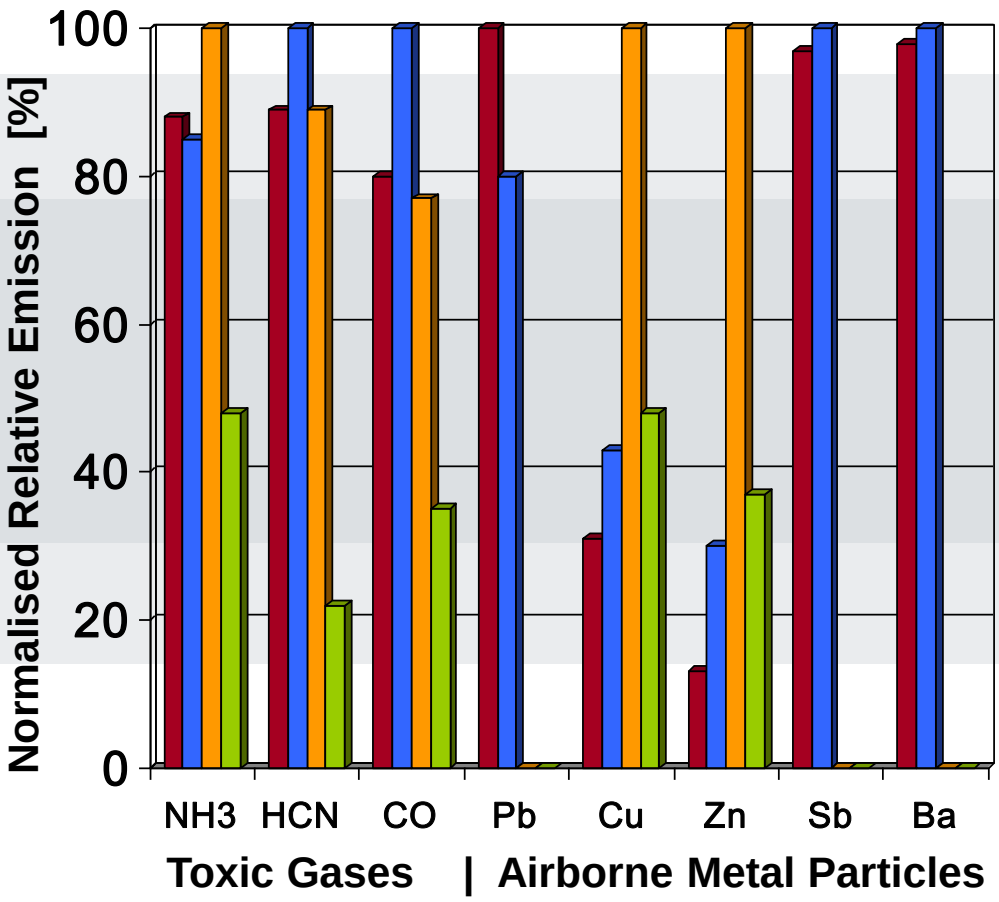
Nammo + RHEINMETALL NITROCHEMIE

© Nitrochemie 2013

Example 1: EI® Propellant for Small Calibre Applications

Solving the Toxicity / Health Problems of Small Cal Ammunition

Emission Results of Norwegian Study (FFI 2009)

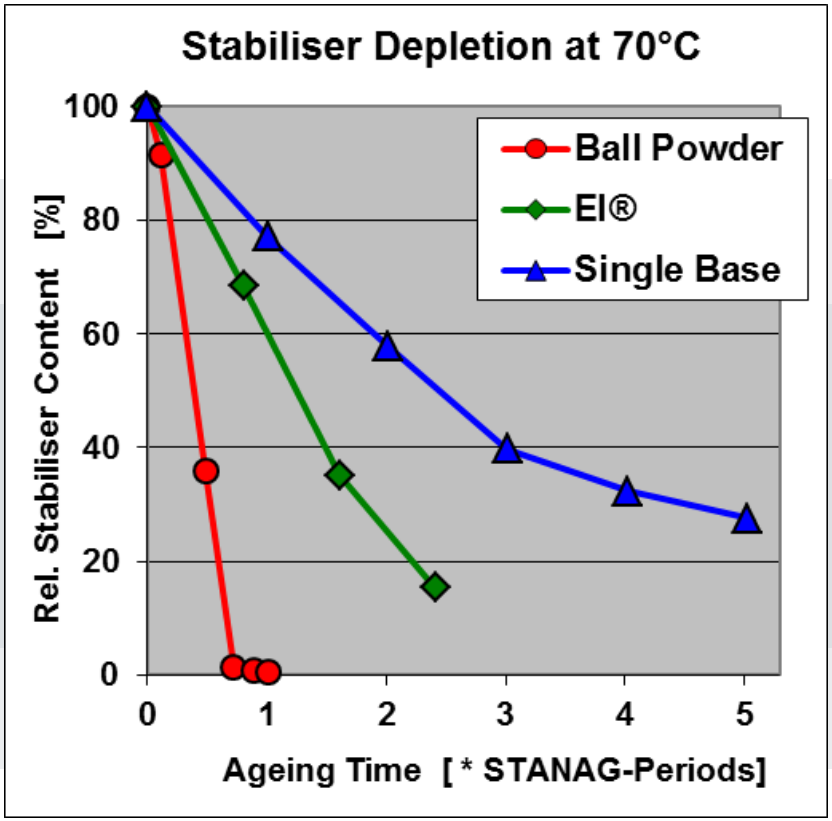


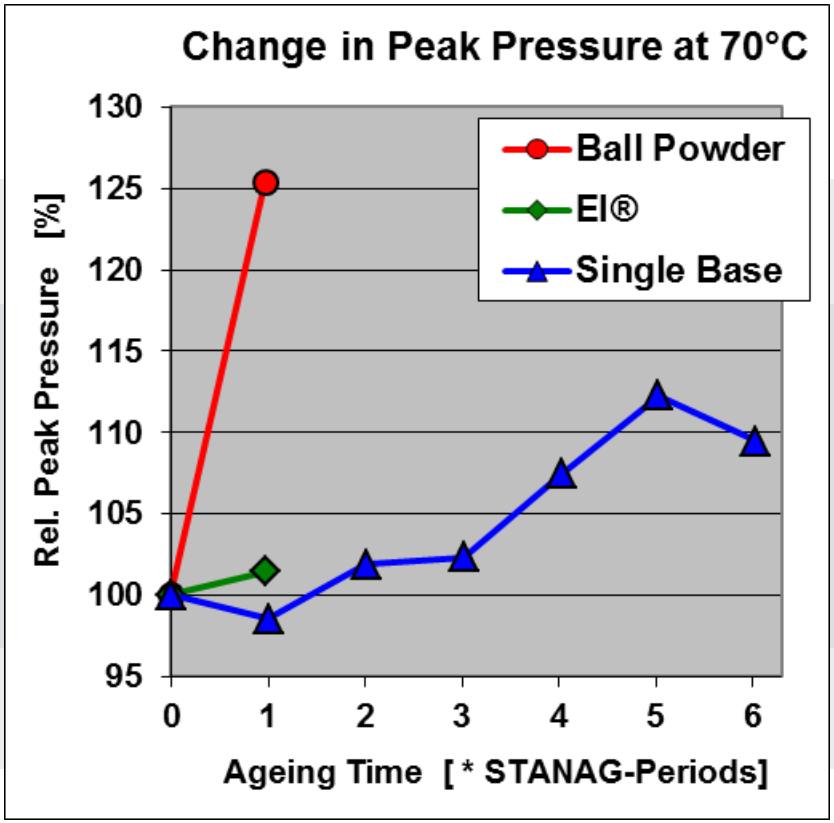
Best results obtained with RUAG SELF ammo design + EI® propellant

RUAG + RHEINMETALL NITROCHEMIE

© Nitrochemie 2013

Example 2: Improved Chemical and Ballistic Stability

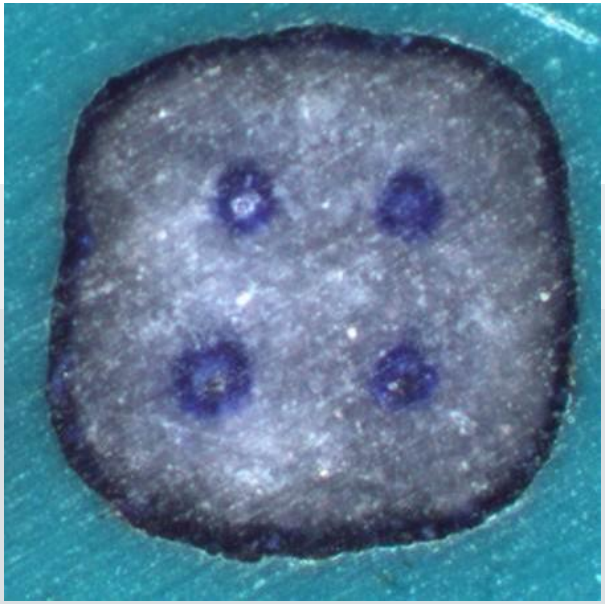




- Chemical and ballistic stability of single base propellant is (inherently) much better as for nitroglycerine containing propellants (EI®; Ball Powder)

© Nitrochemie 2013

Example 3: 4-Perforated Cubic Propellants "C4"

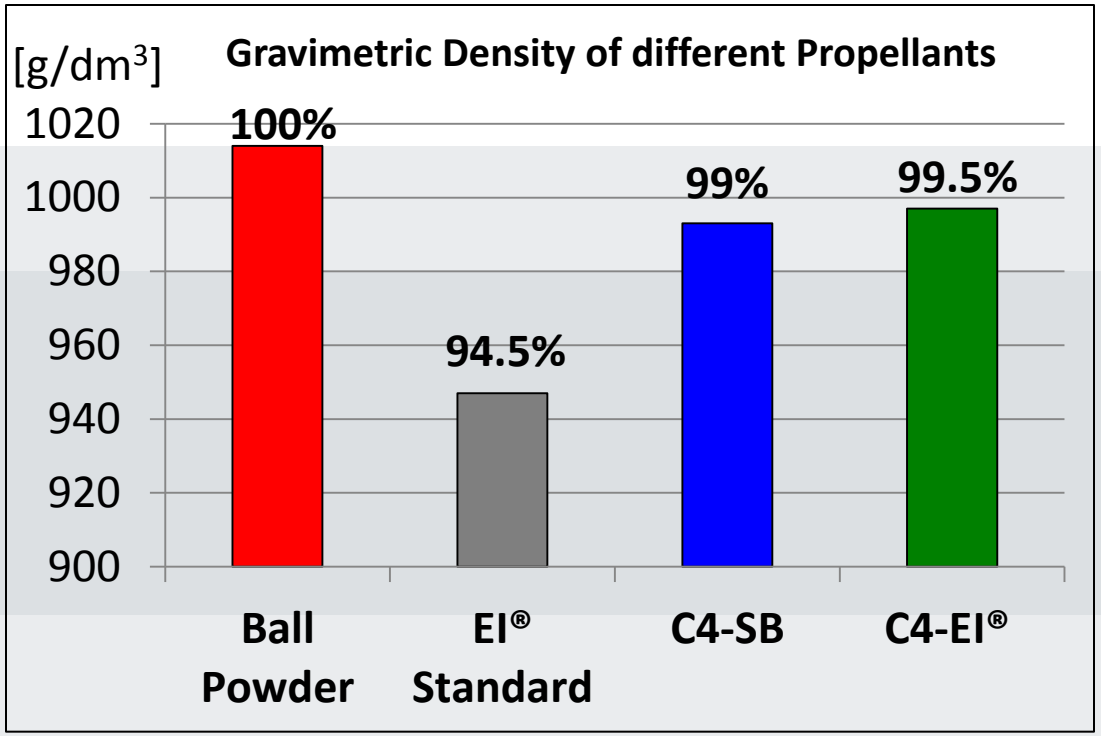


- **Single Base "C4-SB"**
  - NG-free → outstanding stability
  - Improved progressivity ("C4")
  - Performance in range of ball powder / EI® 1-perforated
- **EI® Extruded Impr. "C4-EI®"**
  - Contains NG; good stability
  - Boost in performance
  - V_0 increase of 30 – 50 m/s at same pressure against ball powder

© Nitrochemie 2013

Example 3: 4-Perforated Cubic Propellants "C4"

Increased Gravimetric Density / Bullet Charge Weight

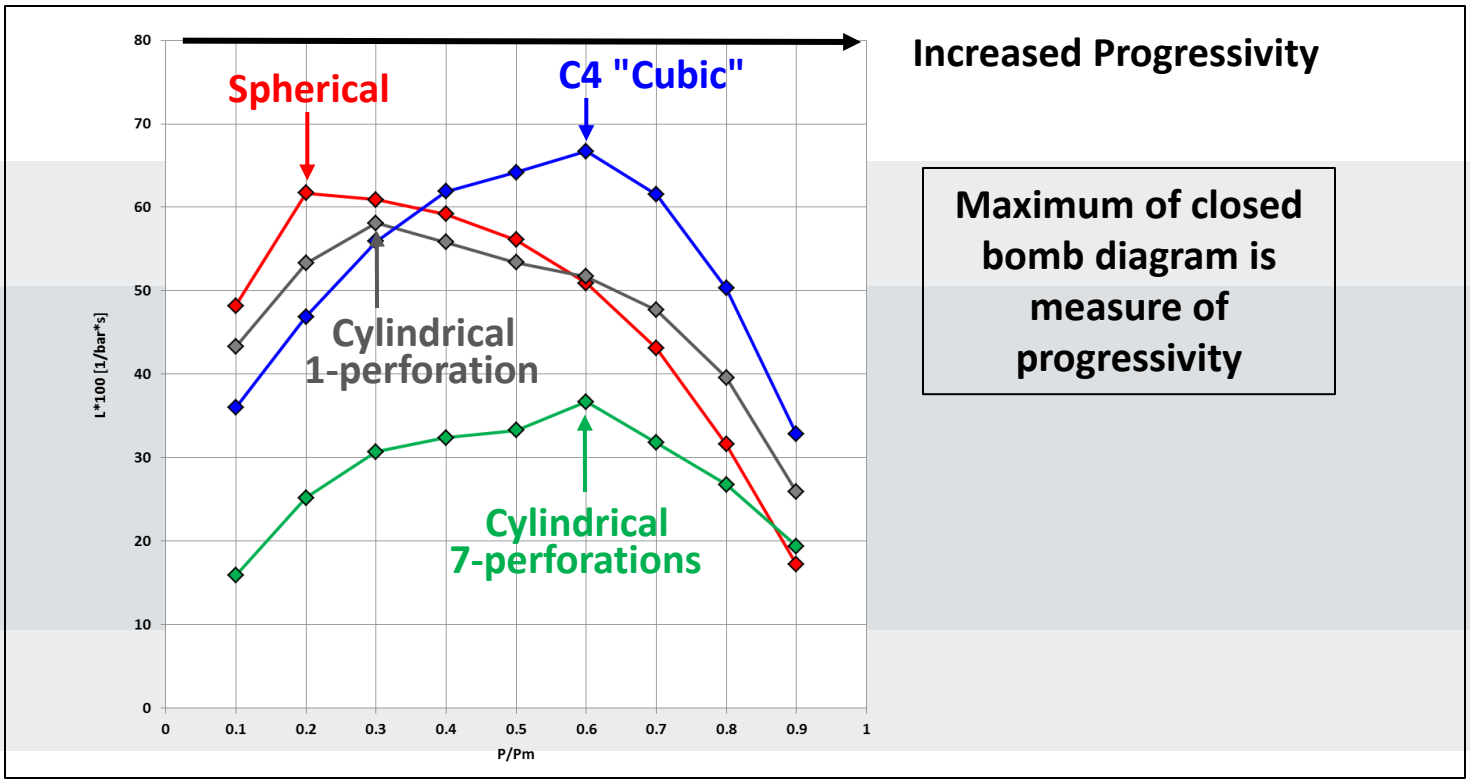


- Gravimetric density and thus maximum charge weight in the bullet for cubic propellants C4-SB and C4-EI® is much higher than for standard EI® (cylinder 1-perforated); and almost equal as for Ball Powder

© Nitrochemie 2013

Example 3: 4-Perforated Cubic Propellants "C4"

Increased Progressivity of Propellant Burning



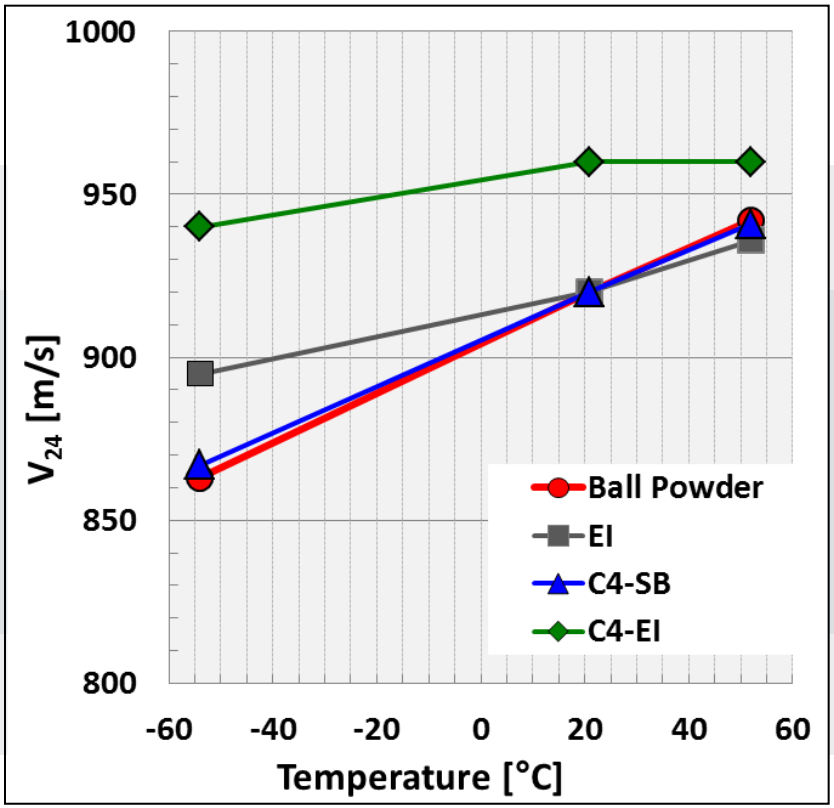
Maximum of closed bomb diagram is measure of progressivity

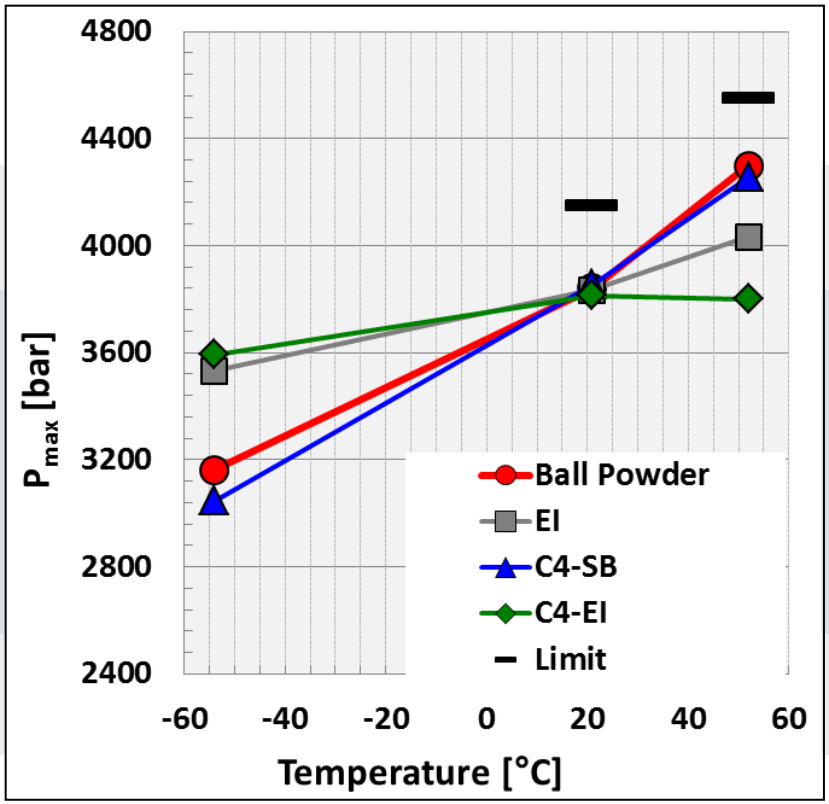
- Closed bomb testing confirms that progressivity of C4-propellant is in same range as for 7-perforated propellants and thus much higher than for cylindrical 1-perforated and for spherical propellants

© Nitrochemie 2013

Example 3: 4-Perforated Cubic Propellants "C4"

Interior Ballistic Performance of C4-Propellants (5.56mm NATO)



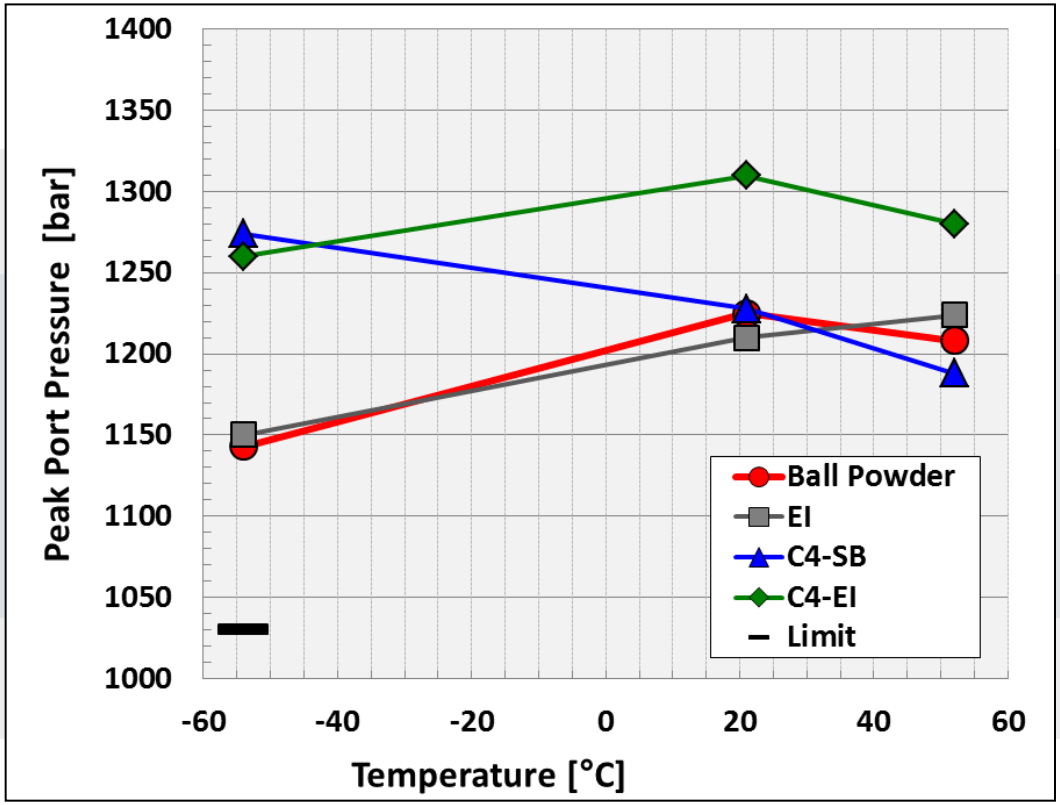


- Single Base C4-SB achieves equal performance as NG-containing ball powder !
- C4-EI® achieves 40 m/s higher velocity as ball powder → significant gain !

© Nitrochemie 2013

Example 3: 4-Perforated Cubic Propellants "C4"

Interior Ballistics / Peak Port Pressure (5.56mm NATO)



- Reaching the required peak port pressures (ppp) is often difficult, in particular at cold – this is no problem with C4-propellants; they show high ppp

© Nitrochemie 2013

Example 3: 4-Perforated Cubic Propellants "C4"

On-going Projects / Partnerships

- First C4 samples shipped to main customers in January 2013 for testing
  - Limited testing has yielded excellent results in several weapon / ammunition systems
  - High performance at low pressure levels could be confirmed
  - Good loadability; good functionality
  - No unusual erosion; no fouling; low dispersion

Customer	C4-SB	C4-EI®
Switzerland	308 Win	
Germany	(5.56mm)	
UK		5.56mm
Scandinavia		5.56mm
USA		7.62mm + Commercial

C4 Cubic wins the Game !

© Nitrochemie 2013

RHEINMETALL NITROCHEMIE

Summary and Conclusions

- The small calibre ammunition industry faces several propellant-related challenges in the near future:
  - DBP and DNT will be banned in Europe from 2015; other nations follow
  - Adjustments in propellant industry
  - Many small calibre propellants need to be re-designed and re-qualified
- A good opportunity to change to Nitrochemie propellants !
  - Choice of different propellant types (single base / EI® in 1- and 4-perforated grains, even 7-perforated ECL® for 12.7mm systems)
  - All propellants have already non-toxic formulations ("REACh compatible")
  - Well established propellants for all major ammunition/weapon systems available (already qualified and in service in several NATO/PfP nations)
  - New propellant types with outstanding properties
    - C4-SB allows for the first time to fulfil all NATO 5.56mm requirements with a nitroglycerine-free propellant
    - C4-EI® boosts performance into a region not accessible before

© Nitrochemie 2013

Thanks very much for your attention !

NITROCHEMIE WIMMIS AG, CH-3752 Wimmis, Switzerland
Tel: +41 (0) 33 228 13 00 Fax: +41 (0) 33 228 13 30
Email: beat.vogelsanger@nitrochemie.com

© Nitrochemie 2013