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NITROCHEMIE's Serial and Future Sensitivity reduced Nitrocellulose- based Propelling Solutions



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SERIAL PROPELLANTS

⇒ Artillery ⇒ Tank Gun ⇒ Medium Caliber

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⇒ Artillery ⇒ Tank Gun ⇒ Medium Caliber

CONCLUSIONS

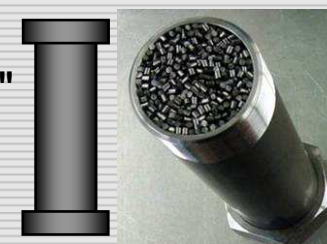
Introduction

IM Testing Methods

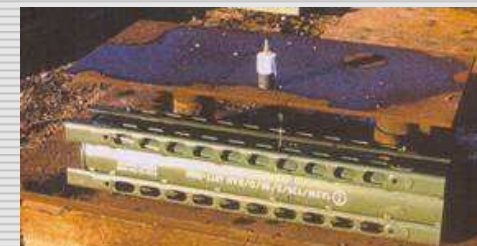
■ The following types of IM tests are used:

⇒ Comparative IM testing ("generic testing", "small-scale testing") to develop / select less sensitive (IM-improved) propellants

- ◆ Tests as referred in STANAG 4439; propellant placed in "reference cartridge" (e.g. 35 mm cartridge case)
- ◆ AASTP 2 / U.N. "Orange Book" EIDS Test Series; identical test set-up as in STANAG tests; propellant placed in "EIDS" steel cylinder with screwed caps
- ◆ Other suitable tests such as German 35 mm LSP Test



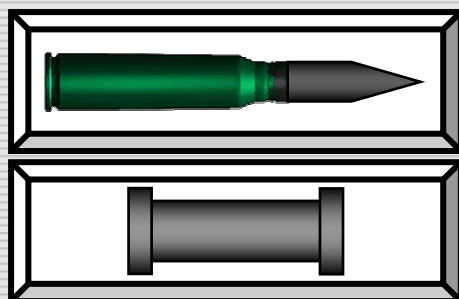
⇒ "Full-Scale Tests" of propellant in original ammunition; tests as referred in STANAG 4439



Introduction

Comparative Testing Methods used

Slow Heating SH
STANAG 4382
or U.N. "EIDS"

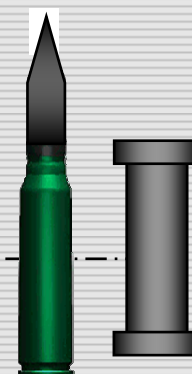


Heating Rate: 3.3°C / h

Bullet Impact BI
STANAG 4241
or U.N. "EIDS"

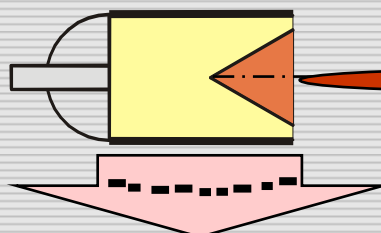
12.7 mm M2 AP

850 m/s



German 35 mm LSP Test

Bomblet
DM 1385
Cal. 42.3 mm
43.5 g Comp. A5



"Hot Fragments" Impact



Shaped Charge Jet Impact SCJI



Assessment of Fragment Pattern According to STANAG 4439 / AOP-39 / German LSP Test



V "Burning"



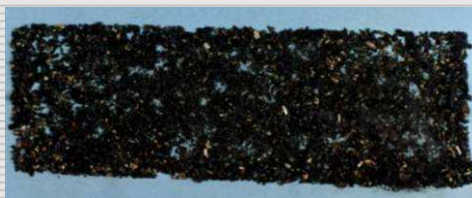
IV "Deflagration"



III "Explosion"



II "Partial Detonation"



I "Detonation"

NITROCHEMIE's IM Strategy

Conventional Propellants

~~Conventional Propellants~~

- Many of the conventional nitrocellulose-based propellants (in particular if they contain NG or DNT) are extremely sensitive (detonation after scji !!)
 - ⇒ these propellants are not suitable for modern applications

(propellant with NG)



SCJ Impact:
⇒ III (Explosion)

Hot Fragments:
⇒ III (Explosion)



SCJ Impact:
⇒ I-II (Detonation)

Hot Fragments:
⇒ III (Explosion)

**M1,
M6,
M14**

(Single
Base
Propellants
with DNT)

NITROCHEMIE's IM Strategy

Polymer-bonded Nitramine-Filled Propellants

~~Conventional
Propellants~~



~~Polymer-Bonded
Propellants~~

- The only qualified / introduced polymer-bonded propellant types (XM39 / M43) show excellent cook-off properties but are brittle and thus also extremely sensitive towards more severe impact stimuli

⇒ these propellants are not suitable for modern applications

XM39

(polymer
bonded
propellant)



SCJ Impact Hot Fragments:
⇒ I (Detonation) ⇒ III (Explosion)



Fragment Impact FI
⇒ II (Partial Detonation)

XM39

(polymer
bonded
propellant)

NITROCHEMIE's IM Strategy

IM-Improved Nitrocellulose-Based Propellants



- The new generation of sensitiveness-reduced nitrocellulose-based propellants combines low sensitiveness with other superior properties (including price)
 - ⇒ these are either in serial production or to be put in service in short time

ECL

(extruded
composite
LOVA)



SCJ Impact: Hot Fragments:
⇒ V (Burning) ⇒ V (Burning)

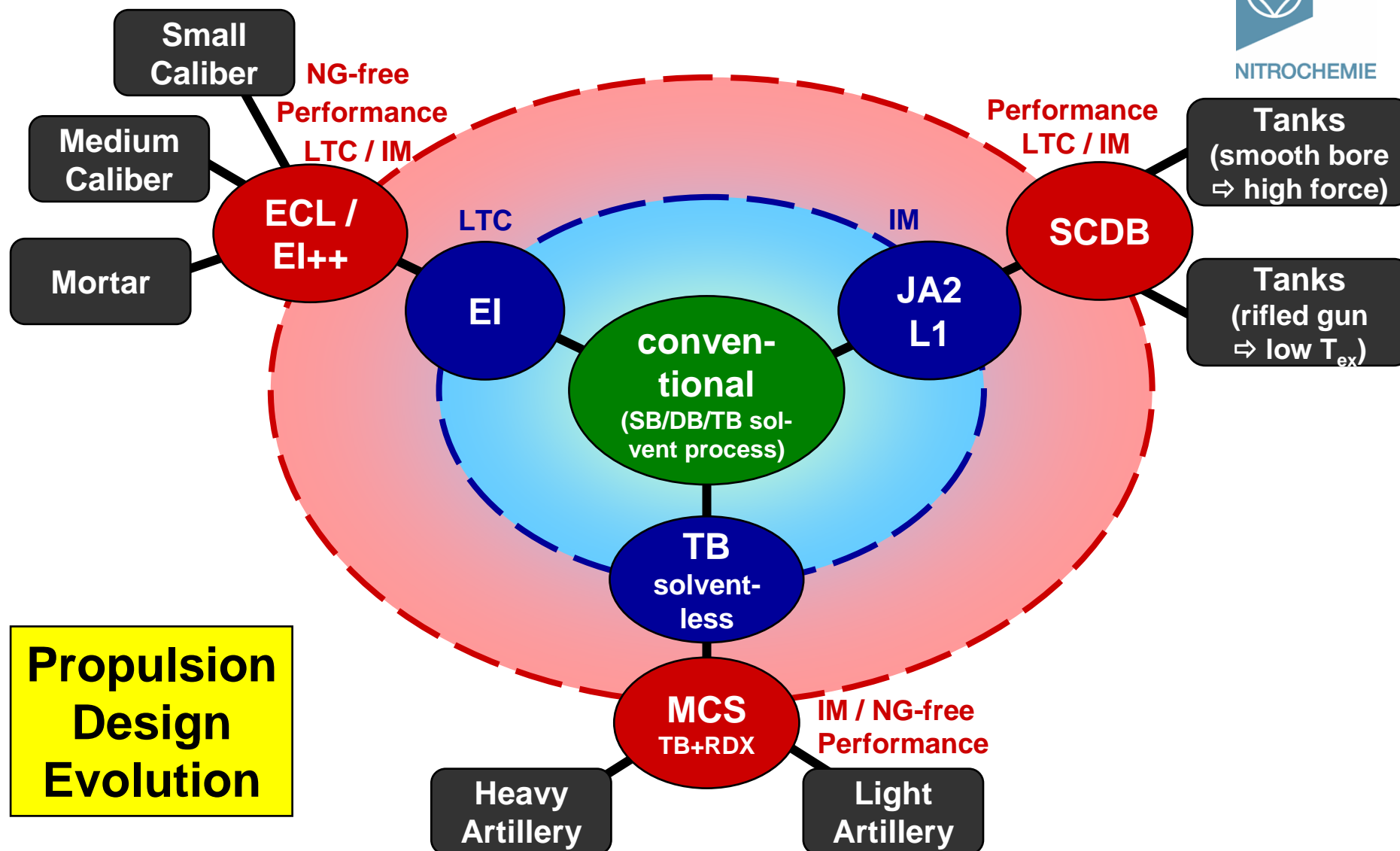


SCJ Impact: Hot Fragments:
⇒ V (Burning) ⇒ V (Burning)

N-SCDB[®]

(next
generation
SCDB)

NITROCHEMIE's Advanced Propellant Technologies



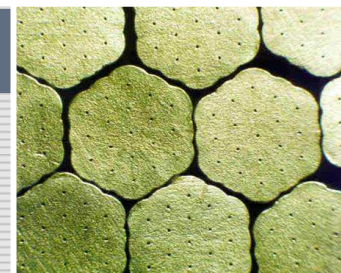
Serial Propellants - Artillery

New Generation of Triple Base Artillery Propellants (155 mm)



Triple Base with RDX: R5730 / "MCS-Propellant"

- **"Green"** and **"less sensitive"** propellant: "GUDOL modified" R5730 (Triple Base with RDX; developed in the early 90ies)
- **No toxic / carcinogenic** components
- Even NG is replaced by the less toxic DEGN (**"NG-free"**)
- Reacts with **non-violent burning (V)** if initiated by scji or hot fragments
- Is qualified for the 155 mm Modular Charge System MCS and in service in several nations for almost a decade



SCJ Impact:
V (Burning)

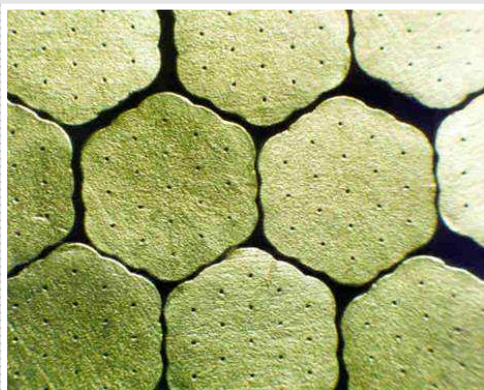
Hot Fragments:
V (Burning)

Serial Propellants - Artillery

Insensitive Artillery Charge (Modular Charge System DM 72)



155 mm Modular Charge System MCS DM 72



**Less Sensitive
Propellant
(Triple Base +
RDX; R5730)**

+

**Combustible
Cartridge**
(= less sensitive than
metal cases)

+

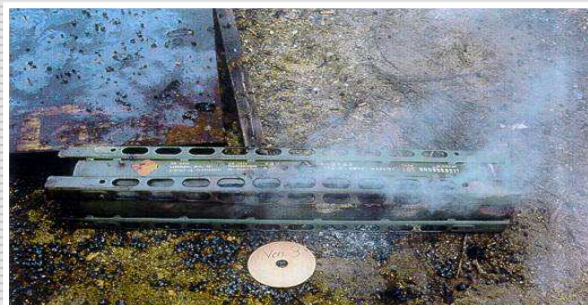
Optimised Packaging
("vented packaging
design")

=

Insensitive Ammunition

Serial Propellants - Artillery

Insensitive Artillery Charge (Modular Charge System DM 72)



Bullet Impact Test (STANAG 4241)

⇒ Reaction Type V

(rupture of lid, ejection of propellant and combustible cartridge material, partly burning)



Shaped Charge Jet Impact Test (MIL 2105B 5.2.6)

⇒ Reaction Type IV – V

(rupture of packaging, non-violent pressure release, burning and ejection of propellant and combustible cartridge material)



Liquid Fuel Fire Test (STANAG 4240)

⇒ Reaction Type V

(Rupture of lid, ejection of propellant and combustible cartridge material, partly burning)

Serial Propellants - Tank Gun

New Tank Gun Propellants (105 / 120 mm APFSDS)

SCDB® (Surface Coated Double Base) Propellant

- Qualified in Germany (DM63)
- No carcinogenic components; environmental friendly solvent-less production process ("**green**" propellant)
- **Good vulnerability characteristics**
- **Non-violent reaction** after impact of shaped charge jet or hot fragments (V burning / IV deflagration)
- **SCDB® reacts only with "normal combustion" ("burning") to shaped charge jet impact, thereby being the most insensitive one amongst the tested propellants**, even slightly less sensitive than the RDX / HTPB sample (result of study performed at Ernst Mach Institute)



SCJ Impact:
V (Burning)

Hot Fragments:
IV (Deflagration)

Serial Propellants - Tank Gun

New Tank Gun Propellants (105 / 120 mm APFSDS)

Results of Tests Performed by US Army Research Lab. Aberdeen

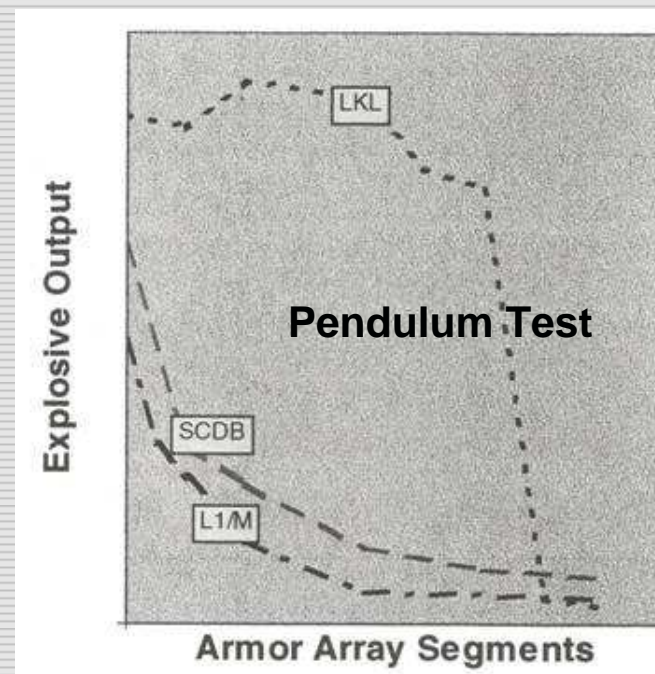


- Ballistic Pendulum Test and 8-Round Compartment Test (simulation of an M1A1 Abrams ammunition compartment with 8 rounds containing SCDB[®] propellant); impact of ballistic munition

→ no tendency to explode

→ minimal damage to compartment

8-Rounds
Compartment
Test



Serial Propellants - Tank Gun

SCDB® Propellant in DM 63



Results of Tests Performed by WTD91, Meppen, Germany



■ Tests performed on packed DM 63 rounds



Bullet Impact Test (STANAG 4241)

⇒ Reaction Type V

(rupture of casing in area of bullet exit, burning of propellant and combustible cartridge material, no blast, no fragments)



Fast Heating Test (STANAG 4240)

⇒ Reaction Type V

(Rupture of lid, burning of propellant and combustible cartridge material, no blast, no fragments)

Serial Propellants – Medium calibre Deterred single base propellants

Deterred single base propellants

- Qualified and in service in various nations (e.g. GE, GB, N, E, CH) for TPDS-T and APFSDS-T (low cost)
- **Excellent performance** and **low-temperature coefficients** due to coating process
- **Good to excellent vulnerability characteristics**
- **Medium to non-violent reactions** after impact of shaped charge jet and hot fragments; assesment is V burning (scji) and III explosion (hfi)
- **Non violent reaction** after initiation with 12.7 mm bullet; fragmentation pattern is V / burning



Bullet Impact
V (Burning)



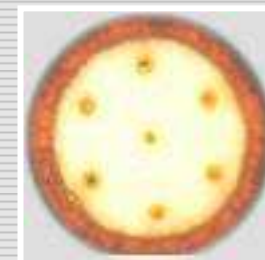
SCJ Impact:
V (Burning)

Hot Fragments:
III (Explosion)

Serial Propellants – Medium calibre EI[®] propellant for highest performance ammunition

EI[®] (Extruded Impregnated) Propellant

- Qualified and in service in various nations (e.g. GE, BE, A, US, N, FI, PO, CH) for FAPDS-T, APFSDS-T and full calibre
- **Excellent performance and low-temperature coefficients** due to application-specific EI-process
- Combat proven in hot climates (A1)
- **Acceptable vulnerability characteristics**
- **Medium to non-violent reactions** after impact of shaped charge jet and hot fragments; assesment is III explosion (scji) and IV deflagration (hfi)



SCJ Impact: **Hot Fragments:**
III (Explosion) **IV (Deflagration)**

Future Propellants

Strategy / Ways to Further Reduce Sensitiveness

- The next generation of IM improved propellants is under development
- Totally new formulations (but still basing on NC binder) and / or improved manufacturing processes are applied
 - ⇒ Replacement of NG by less sensitive energetic plasticizers (e.g. NENA)
 - ⇒ Replacement of RDX by less sensitive energetic solids (e.g. NTO, TATB)
 - ⇒ Improved solvent-less extrusion process to yield softer, elastic and thus less sensitive propellants
- These propellant react, if at all, very mildly



SCJ Impact:
V (burning)

Hot Fragments:
V (burning)

Future Propellants - Artillery

Improved Formulation and Production Process

Conventional Formulation Solvent-Free Process

- R5730 with DEGN is already insensitive



SCJ Impact: Hot Fragments:
V (Burning) **V (Burning)**

Improved Formulation Improved Solvent-Free Process

- Propellant (NC / NIGU / NENA) becomes soft / elastic and thus less sensitive



SCJ Impact: Hot Fragments:
V (Burning) **V (Burning)**

IM Improvement

Future Propellants – Tank Gun Improved Formulation

Conventional Process (Solvent Process)

- Propellant (NC / RDX / NENA) is very brittle and thus sensitive



SCJ Impact: Hot Fragments:
I (Detonation) IV (Deflagration)

New Process (Improved Solvent-Free Process)

- Propellant (NC / RDX / NENA) significantly less sensitive



SCJ Impact: Hot Fragments:
V (Burning) V (Burning)

IM Improvement

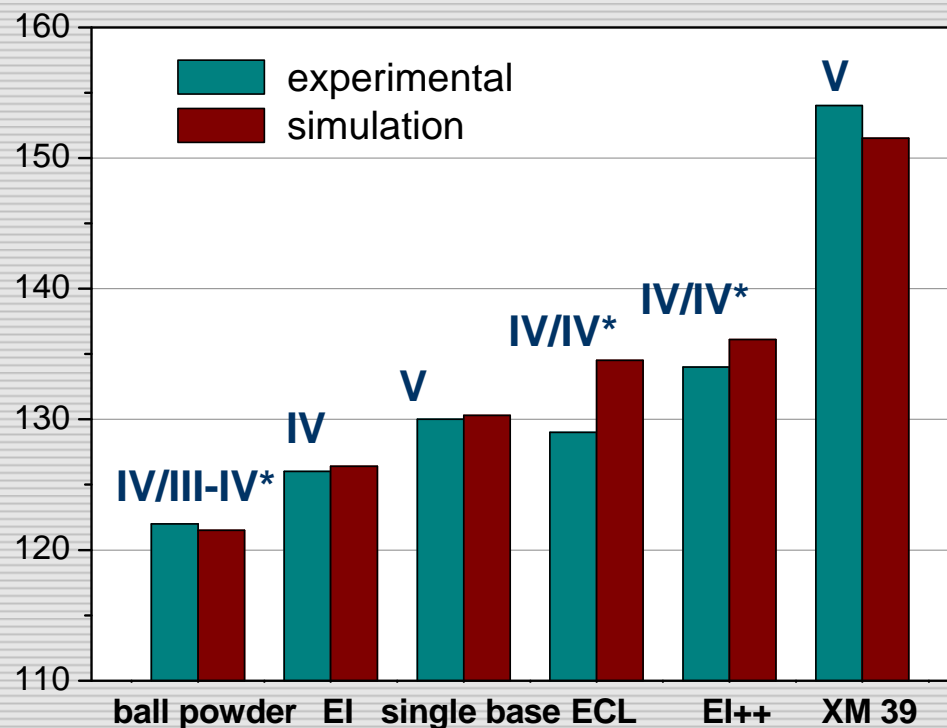
Future Propellants – Medium caliber

Improved Formulations – effect on cook-off behavior

- ECL and EI++ exhibit high cook-off resistance, e.g. increase of 10-15 °C compared to ball powder
- **Non-violent reaction** in slow cook-off experiment ; fragment pattern varies from IV (Deflagration) to V (Burning) in UN steel cylinder
- ECL and EI++ also react in 35 mm cartridge case as IV (Deflagration)



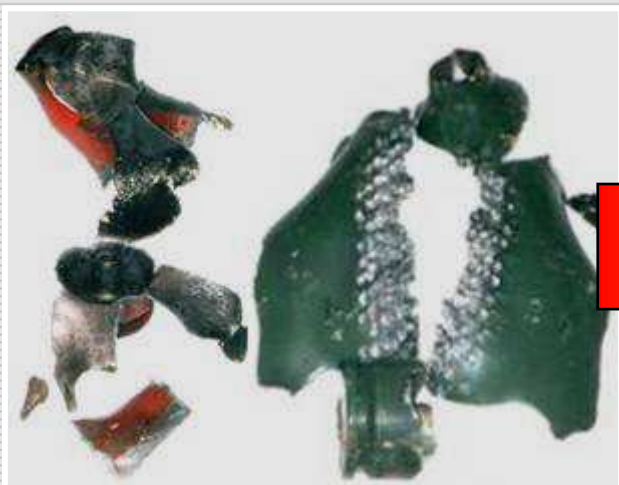
IV-V (Deflagration)



Future Propellants – Medium calibre Improved Formulation

Conventional Impregnation (nitrocellulose grain)

- Propellant (NC / NG) is sensitive due to NG impregnation



SCJ Impact: Hot Fragments:
III (Explosion) IV (Deflagration)

Alternative Impregnation (composite grain)

- Propellant (NC / RDX / Plasticizer) is NG free



SCJ Impact: Hot Fragments:
V (Burning) V (Burning)

IM Improvement

Conclusions

Polymer-Bonded Propellants

Qualified + In-Service



IM-Improved NC-Based Propellants

Qualified + In-Service



Experimental



Strategic Alliance for North-American Market



- **NITROCHEMIE and ATK have a strategic alliance in order to easier market NITROCHEMIE's IM- and performance improved propellants in North-America**

Acknowledgement



coworkers at company sites and elsewhere