Insensitive Propulsion Systems for Large Caliber Ammunition

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Introduction – Overview Gun Propellant Types

Double Base
DEGN/(NG)

Triple Base
Rowanite
310 / 316

Double Base NG
SCDB
JA2
L1

Single Base
IMR

Small and Medium Caliber
Artillery
Tank Guns
Mortars

TP
105 mm
120 mm

Force [J/g]

Flame Temperature [K]

Small and Medium Caliber

NQ
M30
M17
R5730
MCS
M31
M15
N04
M6
M1

Rowanite
310 / 316

IMR
M10
M14
Introduction – NITROCHEMIE's Solvent-Less Gun Propellants

![Graph showing force vs. flame temperature for different propellant types.]

**Double Base**
- DEGN/(NG)

**Triple Base**
- I5420
- JA2
- L1
- SCDB / L1

**R5730**
- Type / R2
- 155 mm MCS

**L1 / SCDB®**
- 120 mm APFSDS-T

**I-Type / R2 / JA2**
- 120 mm HE / MP / TP
- 105 mm APFSDS-T
A) 155 mm MCS DM72 / DM92

155 mm Modular Charge System DM 72 / DM 92
with R5730 / R5733 Propellant
(Solvent-Less Triple Base Propellant with RDX)
A) 155 mm MCS DM72 / DM92 – Advantages

- Fully compliant with JBMoU (incl. $v_0 = 945$ ms at 21°C without exceeding 375 MPa at 63°C)
- Increased range to > 40 km (Base Bleed Ammo)
- Usability in all NATO standard weapon and ammo configurations (e.g. 39 and 52 barrel), up to 71°C
- MCS DM92 is even qualified for C2-A1 climatic zones (-52°C to +71°C) within ERO-ESCP
- Low gun barrel wear; barrel life > 2'500 rounds EFC (at 21°C)
- Bi-modular charge design for highest possible stow capacity, improved logistics, low price
- IM / LOVA requirements met (modules in packaging)
- Low toxicity (lead-free charge, no DNT)
- Well proven system; qualified and in series production since 1996; introduced in 5 NATO countries; > 1.5 million modules produced and fielded so far

Introduced:
- Germany
- Norway
- Italy
- Greece
- Netherlands

In Qualification:
- France
A) 155 mm MCS DM72 / DM92 – IM Test Results

**Bullet Impact BI (STANAG 4241)**
- Reaction Type V
- (Rupture of lid, ejection of propellant and combustible cartridge case ccc material, partly burning)

**Shaped Charge Jet Impact SCJI (STANAG 4526)**
- Reaction Type IV (RPG7) – V (Bomblet M77)
- (Rupture of packaging, non-violent pressure release, burning and ejection of propellant and ccc material)

**Liquid Fuel Fire / Fast Cook-Off FH (STANAG 4240)**
- Reaction Type V
- (Rupture of lid, ejection of propellant and ccc material, partly burning)

**Slow Cook-Off Test SH (STANAG 4382)**
- Reaction Type V
- (Burning of propellant and ccc material, ejection of lid, separation of container into 4 parts, no parts beyond 10 m, no fragmentation, blast effect <40 mbar at 5m)
A) 155 mm MCS DM72 / DM92 – Sympathetic Reaction Test

- **RPG7 Shaped Charge Jet Impact** (STANAG 4526)
  - Type IV Reaction (Deflagration of Donor)

- **Sympathetic Reaction** (STANAG 4396)
  - No Reaction
  - All four MCS acceptors recovered intact within a radius of 5 m – no ignition / no burning
  - Acceptor A1 mechanically damaged (dented)
  - Other acceptors even mechanically undamaged

- Same Test with conventional artillery propellant
  → Type I Reaction (Detonation) of Donor
A) 155 mm MCS DM72 / DM92 – Sympathetic Reaction Test
B) 120 mm APFSDS-T DM63

120 mm APFSDS-T Round DM63
with L1 / SCDB® Propellant
(Solvent-Less, Surface Coated Double Base Propellant)
B) 120 mm APFSDS-T DM63 – Advantages

- Same high performance as predecessor DM53/LKE2
- 3 times lower gun barrel wear than DM53; barrel life 400 – 600 rounds (such as DM33)
- Almost temperature-independent peak pressure, velocity, projectile acceleration, and projectile trajectory
  - Suitable for all climatic categories including A1; full function from -46°C to +63°C; save for firing up to +71°C
  - lower dispersion / higher hit probability
- Reduced peak pressure and recoil impulse
  - usable in all in-service smooth bore 120 mm guns
- Excellent IM properties due to optimized formulation and surface coating
- Qualified and in series production since 2005; introduced in Germany, Netherlands, Finland, Denmark, Austria, Canada, Turkey
B) 120 mm APFSDS-T DM63 – IM Test Results

- Tests performed on packed DM63 rounds during DM 63 Qualification

**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 (< 0.09 bar), no fragments, no propulsion of parts)

**Fast Heating Test** (STANAG 4240) ⇒ **Reaction Type V**
(Rupture of lid, burning of propellant and combustible cartridge material, no blast (< 0.09 bar), no fragments, no propulsion of parts >15 m)

Assessment: The 120mm x 570 DM63 round fulfils the level V criteria of STANAG 4439 and can be classified according to UN Code as 1.3 C
B) 120 mm APFSDS-T DM63 – Sympathetic Reaction Test

- **RPG7 Shaped Charge Jet Impact** (STANAG 4526)
  - Type IV Reaction (Deflagration of Donor)
- **Sympathetic Reaction** (STANAG 4396)
  - No Reaction
    - All three acceptors recovered intact within a radius of 5 m – no ignition / no burning
    - Acceptor A1 mechanically damaged (dented)
    - Other acceptors even mechanically undamaged

Test performed by Rheinmetall
B) 120 mm APFSDS-T DM63 – Sympathetic Reaction Test
C) 120 mm TPDS-T with I- / R-Type Propellants

Solvent-Less Produced I-Type and R2 Propellants for 120 mm TP-, HE- and MP- Cartridges and for 105 mm APFSDS-T Applications
C) 120 mm TPDS-T with I- / R-Type Propellants – Advantages

- The solvent-less produced I-Type and R2 propellants are excellently suited for 120 mm TP-, TPDS-, HE- and MP-cartridges and for 105 mm APFSDS-T applications.

- Main advantage is that these propellants are much less brittle thus showing better IM properties than the M14, M26 and M30 propellants often used in these applications.

- I-Type formulation (I5420; double base with DEGN)
  - Well established and fielded for 30 years in 120 mm ammunition (MP: DM11; APFSDS-T: DM48).
  - Propellant production process was recently optimized regarding IM properties and production costs.
  - Chosen for the new Rheinmetall 120 mm HE round.
  - Chosen for the European version of the 120 mm M865 round where the sensitive and toxic M14 propellant is replaced (→ M865C1; qualified, production commencing 2008).

- R2 formulation (triple base with RDX/NIGU)
  - Recently developed for maximum performance at low erosion level.
  - Performance and IM properties somewhat better than I-Type propellant.
  - Slightly more expensive than I-Type propellants.
C) 120 mm TPDS-T M865C1 with I-Type Propellant – Sympathetic Reaction Test

- **RPG7 Shaped Charge Jet Impact** (STANAG 4526)
  - Type IV Reaction (Deflagration / Propelling of Donor)

- **Sympathetic Reaction** (STANAG 4396)
  - No Reaction
  - Acceptor A1 mechanically damaged
  - Acceptor A3 not even damaged
  - Acceptor A2 was accidentally hit by RPG7 fragments and was ignited / reacted with burning

Test performed by Rheinmetall
C) 120 mm TPDS-T M865C1 with R2 Propellant – Sympathetic Reaction Test

- **RPG7 Shaped Charge Jet Impact** (STANAG 4526)
  - Type IV Reaction (Deflagration / Propelling of Donor)

- **Sympathetic Reaction** (STANAG 4396)
  - No Reaction
  - All 3 Acceptors recovered within 3 m
  - Acceptor A1 mechanically damaged
  - Acceptor A3 not damaged
  - Acceptor A2 (case and ccc) punctured by RPG7 fragments but not ignited

Test performed by Rheinmetall
Conclusions

- The new generation of NITROCHEMIE's large caliber gun propellants combines outstanding performance with excellent IM-properties.

- The excellent IM properties are achieved by a combination of:
  - optimized formulation,
  - improved and carefully operated solvent-less propellant production process,
  - and, in case of the SCDB® propellant, the addition of the surface coating step.

- Upgrade of the solvent-less propellant factory with new and automated equipment assisted IM improvements and reduced costs.

- NITROCHEMIE's strategy to optimize IM properties of nitrocellulose-based propellants rather than searching for exotic polymer-bonded formulations has proven successful again.
Last year's winner of the MSIAC Award is not resting on its laurels but searching for further improvements!
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