Gun Propellants For The 27 mm Cal. Gun Eurofighter Jet

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Content

♦ Introduction

♦ DNDA - Propellants
  ● Thermodynamic Characteristics
  ● Temperature Behaviour of LTC Propellant in Closed Vessel
  ● Performance, Safety Test Results
  ● Sensitivity Data DNDA - Propellants
  ● Shaped Charge Tests
  ● Erosivity

♦ Gun Firing
  ● 75 mm cal. Propellant Charges (2 LTC Propellants)
  ● 27 mm cal. Eurofighter (EF) Propellant Charges

♦ EF Propellant 27 mm cal. for PELE Ammunition

♦ PELE Ammunition Concept

♦ Results & Conclusion
Introduction

Since approx. 100 years are known the Nitrocellulose Propellants

  Self - Ignition Temperature  ~ 175 °C

Also the Multi Base Propellants like SCDB and EI, ECL Propellants are
giving the Self - Ignition at  ~ 175 °C

Nitrocellulose Propellants based on DNDA and RDX the
LTC Propellants are showing

- First Generation
  Self - Ignition Temperature  200 - 210 °C

- Second Generation
  Self - Ignition Temperature  > 220 °C ( Eurofighter Propellant etc. )
DNDA Gun Propellants

- RDX
- Binder, Nitrocellulose
- DNDA Plasticizer

* Plasticizer mixed into the Propellant - Dough

**NO SURFACE COATING**

- energy density adaptable
- flame temperature approx. 500 K lower compared to NC Propellants

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Impetus (J/g)</th>
<th>Flame Temp (K)</th>
<th>Mw (g/mole)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1080</td>
<td>2540</td>
<td>19.4</td>
</tr>
<tr>
<td>B</td>
<td>1180</td>
<td>2910</td>
<td>20.8</td>
</tr>
<tr>
<td>C</td>
<td>1300</td>
<td>3390</td>
<td>21.6</td>
</tr>
</tbody>
</table>
Closed Vessel Behaviour of LTC Propellants

Vivacity of Gun Propellant based on DNDA

Range -40 °C till +70 °C

LOS 190705 - Firing at different temperatures $\Delta=0.2g/ml$ in $V_b=310ml$
Linear burning rate of LTC Propellants at different pressures
### Performance, Safety Test Results

#### Performance data

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Impetus (J/g)</th>
<th>$T_f$ (K)</th>
<th>$\bar{M}_w$ (g/mole)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1080</td>
<td>2540</td>
<td>19.4</td>
</tr>
<tr>
<td>2</td>
<td>1180</td>
<td>2910</td>
<td>20.8</td>
</tr>
<tr>
<td>3</td>
<td>1300</td>
<td>3990</td>
<td>21.6</td>
</tr>
</tbody>
</table>

#### Safety data

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of weight after 18 days</td>
<td>&lt; 1.10 %</td>
</tr>
<tr>
<td>Loss of weight after 30 days</td>
<td>&lt; 1.65 %</td>
</tr>
<tr>
<td>Sensitivity to friction</td>
<td>160 N</td>
</tr>
<tr>
<td>Sensitivity to impact</td>
<td>4 J</td>
</tr>
<tr>
<td>Self - Ignition temperature</td>
<td>&gt; 220 °C</td>
</tr>
<tr>
<td>Fast cook - off test</td>
<td>burning</td>
</tr>
<tr>
<td>Shaped charge impact test</td>
<td>Class A</td>
</tr>
</tbody>
</table>
## Sensitivity Data of different DNDA - Propellants

<table>
<thead>
<tr>
<th></th>
<th>RDX - Prop. ICT 1</th>
<th>i-RDX - Prop. ICT 20</th>
<th>RDX - Prop. mod. DNDA ICT 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reaktion Class</strong></td>
<td>A</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td><strong>Shaped Charge Test</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cal. 35 mm</td>
<td></td>
<td></td>
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<tr>
<td><strong>Friction Sensitivity</strong></td>
<td>288</td>
<td>240</td>
<td>240</td>
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<tr>
<td>[ N ]</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Impact Sensitivity</strong></td>
<td>6,0</td>
<td>6,0</td>
<td>5,0</td>
</tr>
<tr>
<td>[ Nm ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ignition Temperature</strong></td>
<td>&gt; 220</td>
<td>&gt; 216</td>
<td>&gt; 219</td>
</tr>
<tr>
<td>[ °C ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1&quot; Detonation - Tube</td>
<td></td>
<td>no Detonation</td>
<td></td>
</tr>
<tr>
<td><strong>MG cal.50 / 12.7 mm</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>WIWEB Results</strong></td>
<td></td>
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</tr>
</tbody>
</table>
Shaped Charge Tests,
DNDA - Propellant ICT 1 ( RDX ), ICT 20 ( i-RDX )
Shaped Charge Test,
DNDA - Propellant ICT 3, Class B Test Result
Erosivity of LTC Propellants and Conventional Propellants

The graph illustrates the relationship between force (J/g) and mass loss (%) for different types of propellants:

- **Double base**
- **Triple base**
- **Single base**

The graph also includes data points for LTC 1, LTC 2, LTC 3, LTC 4, and LTC 5.
75 mm Scale model gun derived from 120 mm cal. tank gun (Diehl BGT)

- based on interior ballistic similarity laws
- less cost (combustible paper case, less propellant mass)
Test Firing in 75 mm cal. Model Gun (Diehl BGT)

Optimized propellant for firing at 21°C

gas pressure vs temp.

muzzle velocity vs temp.
Test Firing in 75 mm cal. Model Gun (Diehl BGT)
Performance optimized propellant

gas pressure vs temp.

muzzle velocity vs temp.

LTC-Prop. 2

JA2
EF Propellant

Gun Firing 27 mm cal. Eurofighter

pressure vs temperature

propellant temperature (°C)

max. pressure (bar)
EF Propellant

Gun Firing 27 mm cal. Eurofighter

muzzle velocity vs temperature

propellant temperature (°C)
muzzle velocity (m/s)
EF Propellant

Aged propellant compared with non aged propellant

muzzle velocity vs temperature

- non-aged
- aged: 8d @ 70°C
EF Propellant 27 mm cal. Eurofighter PELE Cartridge

Combustion Temperature  2900 K       Gun Erosion like Single Base Propellant
Force                   1140 J/g
Ignition Temperature    > 220 °C

Cook - off Cartridge 27 mm cal.
27 mm Gun Tube Mauser, MATE ( Mauser )
Q 5560 ( Ref. Prop. )   125 °C   3,5 h   Ignition
EF Propellant           125 °C   8,5 h.   No Ignition
Cook - Off Test in Gun Tube 27 mm cal. ( MATE )
Gun Test Tube
PELE Cartridge 27 mm cal.

PELE = Penetrator with Enhanced Lateral Efficiency

EF DNDA
gun propellant

PELE® projectile DM 83 and DM 93 (with tracer)
Eurofighter BK 27
27 mm cal.
Diehl PELE Ammunition Concept

- PELE Projectiles
  → Highly effective against all targets

- New type of LTC propellant
  with low flame temperature (reduced erosion), high cook-off temperature
  - high shot precision within the temperature range
  - high internal ballistic safety
  No $v_o$ correction necessary

high density material for tube
l.e. tungsten, steel

low density material for inner core
l.e. plastic or aluminum
Part I: Erosion by penetration

Part II: Fragments by PELE effect (Adjustable between 30% and 100%)

Part III: Penetration and/or PELE effect in next plates (Adjustable between 0% and 70%)

high density material for tube
I.e. tungsten, steel

low density material for inner core
I.e. plastic or aluminum

Pressure distribution on penetrator

kbar
4.8
1.6
-1.6
-4.8

t = 17µs
t = 27µs
Results & Conclusion

♦ LTC Propellants based on DNDA 5,7 and RDX for a wide Caliber - Range
♦ Excellent Shaped Charge Testresults ( Reaktion Class A )
♦ High Self - Ignition Temperature > 220 °C
♦ Insensitive, Reaction Type 5 ( MIL - STD 2105 B )
  IM Characteristic
  MG 12.7 mm cal. firing on Steeltube with propellant
♦ Excellent Long - Term Stability
♦ Low Combustion Temperature at High Force and Low Gun Tube Erosion
♦ Less Sensitive in Hot Gun Tube ( MATE )
♦ Propellant Charge for Eurofighter Gun, 27 mm cal. PELE Cartridge