INSENSITIVE GUN PROPELLANTS
WITH LOW TEMPERATURE COEFFICIENT BASED ON DNDA

Dr. Dietmar Mueller
Fraunhofer Institut Chemische Technologie (ICT), D-76327 Pfinztal, Germany
mue@ict.fhg.de

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INSENSITIVE GUN PROPELLANTS

Content

♦ Processing Technology
♦ Low Temperature Coefficient (LTC) Propellants
  ● Temperature Behaviour
  ● Characteristics of the Propellant Components
  ● Performance, Safety & Sensitivity Datas
  ● Shaped Charge Tests
  ● Closed Bomb Tests
  ● Gun Firing
  ● Erosivity

♦ Results & Conclusion
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Processing Technology for Inensitive Gun Propellants based on DNDA

**Continuous Process**
- Shear Roll Mill
- Twin Screw Extruder (TSE) ZSK 58 E

**Batch Process**
- Kneader / Mixer
- Rampress
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Shear Roll Mill (Continuous Process)
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Corotating intermeshing Twin - Screw Extruder ZSK 58 E
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Twin - Screw Extruder Process

- Remote Controlled Refilling Equipment
- Solid loss-in-weight Feeder
- Solvent Pump System
- Gear Box Hydraulic Drive
- Dewatering
- Die with Die Lift-Off-System (Safety Device)
- Conveyer
- Cutter
- Conveyer (swivel)
- Conveyer (wide)
- Strands Cutter

TSE 58 E
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Temperature behaviour of gun propellants
Max. gas pressure vs propellant temperature

- LTC Propellant
- DNDA Propellant
- Conventional Propellant

△P_m

maximum gas pressure
propellant temperature (°C)
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ARC measurement of several Nitrocellulose (NC) types
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Lightmicroscope pictures of different NC types

NC M30       NC CP2       NC 53
ARC measurement of RDX, FOX-12 and DNDA
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ARC
DNDA-5,7 compared with NENA
Microcalorimeter Result of DNDA-5,7
Endothermic Behaviour

Heat - Development at 89°C

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- DNDA 120401WH

- DNDA 120401 WH Q

- Time (Days)

- dQ/dt (µW/g)

- Q (J/g)
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**Performance Data of LTC Propellants**

<table>
<thead>
<tr>
<th>RDX / FOX-12</th>
<th>x</th>
<th>x</th>
<th>x</th>
<th>x</th>
<th>x</th>
<th>x</th>
<th>x</th>
<th>x</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>DNDA-5,7</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Stab., Additives</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>T [K]</strong></td>
<td>2540</td>
<td>2913</td>
<td>3118</td>
<td>3160</td>
<td>3264</td>
<td>3335</td>
<td>3390</td>
<td></td>
</tr>
<tr>
<td><strong>Force [J/g]</strong></td>
<td>1080</td>
<td>1182</td>
<td>1212</td>
<td>1229</td>
<td>1250</td>
<td>1263</td>
<td>1300</td>
<td></td>
</tr>
<tr>
<td><strong>Q_{ex} [J/g]</strong></td>
<td>4000</td>
<td>4204</td>
<td>4347</td>
<td>4411</td>
<td>4519</td>
<td>4594</td>
<td>4730</td>
<td></td>
</tr>
<tr>
<td><strong>Mw [g/mole]</strong></td>
<td>19,4</td>
<td>20,8</td>
<td>21,4</td>
<td>21,4</td>
<td>21,7</td>
<td>21,9</td>
<td>22,1</td>
<td></td>
</tr>
</tbody>
</table>

Reaction gas

| Reaction gas | 19,4 | 20,8 | 21,4 | 21,4 | 21,7 | 21,9 | 22,1 |

**Note:** till max. 59 Wt. - %
## INSENSITIVE GUN PROPELLANTS

### Safety Data of selected LTC Propellants

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass - Loss weight after 18 days, 90 °C</td>
<td>0.50 till 0.70 %</td>
</tr>
<tr>
<td>Mass - Loss weight after 30 days (no autocatalytic effects)</td>
<td>1.10 till 1.40 %</td>
</tr>
<tr>
<td>Ignition temperature</td>
<td>&gt; 215 °C</td>
</tr>
<tr>
<td>Cook - off temperature approx.</td>
<td>&gt; 210 °C</td>
</tr>
</tbody>
</table>
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### Sensitivity Data of different DNDA - Propellants

<table>
<thead>
<tr>
<th></th>
<th>FOX - Prop. ICT 8</th>
<th>FOX - Prop. ICT 7</th>
<th>RDX - Prop. ICT 1</th>
<th>i-RDX - Prop. ICT 2</th>
<th>RDX - Prop. mod. DNDA ICT 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reaktion Class</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shaped Charge Test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>cal. 35 mm</strong></td>
<td>O</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td><strong>Friction Sensitivity</strong></td>
<td>[N] 240</td>
<td>252</td>
<td>288</td>
<td>240</td>
<td>240</td>
</tr>
<tr>
<td><strong>Impact Sensitivity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>[ Nm ]</strong></td>
<td>6,0</td>
<td>7,5</td>
<td>6,0</td>
<td>6,0</td>
<td>5,0</td>
</tr>
<tr>
<td><strong>Ignition Temperature</strong></td>
<td>[ °C ] ~ 200</td>
<td>~ 200</td>
<td>~ 220</td>
<td>~ 216</td>
<td>~ 219</td>
</tr>
<tr>
<td><strong>1&quot; Detonationtube</strong></td>
<td></td>
<td></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>
<td>IM Reaktiontype 5 ( MIL – STD 2105B )</td>
<td></td>
</tr>
</tbody>
</table>

WIWEB Results
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Shaped Charge Tests, FOX Propellant ICT 8 and RDX Propellant ICT 1
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Longtherm - Storage Stability at 90 °C
Mass - Loss over Time

ML [%]

DNDA Propellant
90°C

ML average

Days [d]
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Longtherm - Storage Stability at 90 °C
Mass - Loss over Time

ML [%]

DNDA Propellant
90°C

ML average

Days [d]
ARC
Accelerating Rate Investigations of DNDA - Propellants compared with CAB-Lova, M30, Single Base and Double Base
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Batch Process Mixer compared with Shear Roll Mill

vivacity of the propellants

Los 250199/W

Los 180705

Los 190705

$\Delta=0.2g/ml$ in $V_b=310ml$

0.2g/ml in $V_b=310ml$

$\Delta=0.2g/ml$ in $V_b=310ml$

Low Friction

High Friction

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Batch Process Mixer compared with Shear Roll Mill Process

vivacity of the propellants

Los 250199/W - 1  \( \Delta=0.2 \text{g/ml in V_b=310 ml} \)

Los 180705  \( \Delta=0.2 \text{g/ml in V_b=310 ml} \)

Los 190705  \( \Delta=0.2 \text{g/ml in V_b=310 ml} \)

Gas pressure of the propellants

Gas pressure in the Gun
LOS 250199

Gas pressure in the Gun
LOS 180705

Gas pressure in the Gun
LOS 190705

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Linear burning rate of LTC Propellants at different pressures

![Graph showing linear burning rate of LTC Propellants at different pressures. The graph plots linear burning rate (m/s) against propellant temperature (°C) for pressures of 3000, 2500, 2000, and 1500 bar. The burning rate decreases with increasing pressure and is highest at 3000 bar.](image-url)
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40 mm Gun Firing Tests of 3 LTC Propellants based on DNDA, NC, RDX

![Graph showing the relationship between propellant temperature and maximum gas pressure for different propellants.](image-url)
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75 mm Scale model gun derived from cal. 120 mm 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.

![Graph showing gas pressure (P_m) vs temperature (T) for JA 2 and LTC Prop.](image)
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Test Firing in 75 mm cal. Model Gun (Diehl BGT)

Optimized propellant for firing at 21°C
Muzzle velocity vs temp.
Muzzle velocity of LTC propellant same at 21°C like JA 2

\[ V_o \text{ vs } T \]

\begin{center}
\begin{tabular}{c|c|c|c|c|c|c|c}
\hline
\textbf{Temp. [°C]} & -40 & +21 & +50 \\
\hline
\textbf{\( V_o \) [m/s]} & 1500 & 1550 & 1600 & 1650 & 1700 & 1750 \\
\hline
\end{tabular}
\end{center}
Erosivity of LTC - Propellants and Conventional Propellants
Results from Diehl BGT
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Results & Conclusion

♦ LTC Propellants based on DNDA 5,7 for a wide Caliber - Range
♦ Excellent Shaped Charge Test results (Reaktion Class 0 or A)
♦ High Ignition Temperature > 215 °C
♦Insensitive, Reactiontype 5 (MIL - STD 2105 B)
  Shaped Charge Test
  MG cal. 12.7 mm firing on Steeltube with propellant
♦ Excellent Longtherm Stability
♦ Low Combustion Temperature at High Force
♦ Low Gun Tube Erosion
♦ Pilot Lot for Eurofighter - Gun, Mauser cal. 27 mm