Research on EFI's in relation to Insensitive Munitions
Contents

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TNO has organised its business in five core areas

- TNO Quality of Life
- TNO Defence, Security and Safety
- TNO Science and Industry
- TNO Environment and Geosciences
- TNO Information and Communication Technology
TNO Defence, Security and Safety focuses on:

- **Defence**
  - Military operations
  - Military equipment
  - Command and operational decision making
  - Threat and protection
  - Education and training

- **Security and Safety**
  - Combating crime, calamities and terrorism

- **Aerospace**
  - Improving safety

- **Maritime**
  - Shipbuilding
Exploding Foil Initiator Research

- Electrical circuit
- Exploding foil
- Velocity of the flyer
- Driver Explosive
- Secondary flyer
- Acceptor explosive
Electrical circuit

• Optimisation of the circuit
  - low loss capacitor,
  - switch,
  - transmission line
• Development of measuring techniques
• 90% efficiency of energy deposited in the exploding foil (50% other circuits)
Exploding foil

- Dimension of the foil (length, width, thickness, material)
- Shockwave impedance of the tamper
- Thickness and material of the flyer
- Length and width of the barrel
Flyer velocity measurement by F-P Interferometer

• Acceleration of the flyer influenced by:
  - thickness and material
  - exploding foil dimensions and material
  - shockwave impedance of the tamper
• Integrity of the flyer during acceleration
  - Determination of optimum barrel length
Research on Explosives I

• Recrystallisation of HNS II to HNS IV
• The crystals are more uniform (smaller distribution)
• The length to width to thickness is 10:3:2
  a further increase in specific surface area is possible
Initiation behaviour of different explosives

- Different types of explosives
  - HNS IV several brands
  - TATB several grades
  - New explosives
- Initiation energy depends on flyer thickness and velocity

![Graph showing energy vs. pressure for HNS IV and TATB explosives]
Initiation of HNS IV pellet

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Image Description</th>
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<tr>
<td>0-200 ns</td>
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<td>200-400 ns</td>
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<td>800-1000 ns</td>
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<td>1 µs streak</td>
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Numerical simulations of flyer impact

- Lee-Tarver model modified with visco-plastic pore collapse model
- Qualitatively the simulations can explain the experiments

Reacted fraction of HNS IV after initiation by 5.4 mm/µs flyer
Secondary flyer impact

- Driver explosive (HNS IV, TATB, RDX ........)
- Confinement of the explosive
- Secondary flyer material:
  - spall strength (attenuator)
  - shockwave impedance
  - size and thickness
- Initiation distance of acceptor explosive
Secondary flyer impact

Aceleration of a 0.25 mm stainless steel flyer by HNS IV
Successful initiation of TATB by
• 0.15 mm SS steel flyer
• 0.35 mm mylar flyer
• 0.3 - 0.5 mm Al flyer
Conclusions

• A very efficient electrical circuit is developed ($\eta = 90\%$)
• With “of the shelf components” small IM compliant EFI-detonators can be build (8 cm$^3$ including HV-supply)
• Combining the EFI with the electronic safety and arming unit with MEMS-technology can make a small and cost effective unit
• The use of secondary flyers makes the detonation train more reliable

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