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THE DEVELOPMENT OF A CLEAN FAST COOK-OFF TEST IN THE NETHERLANDS

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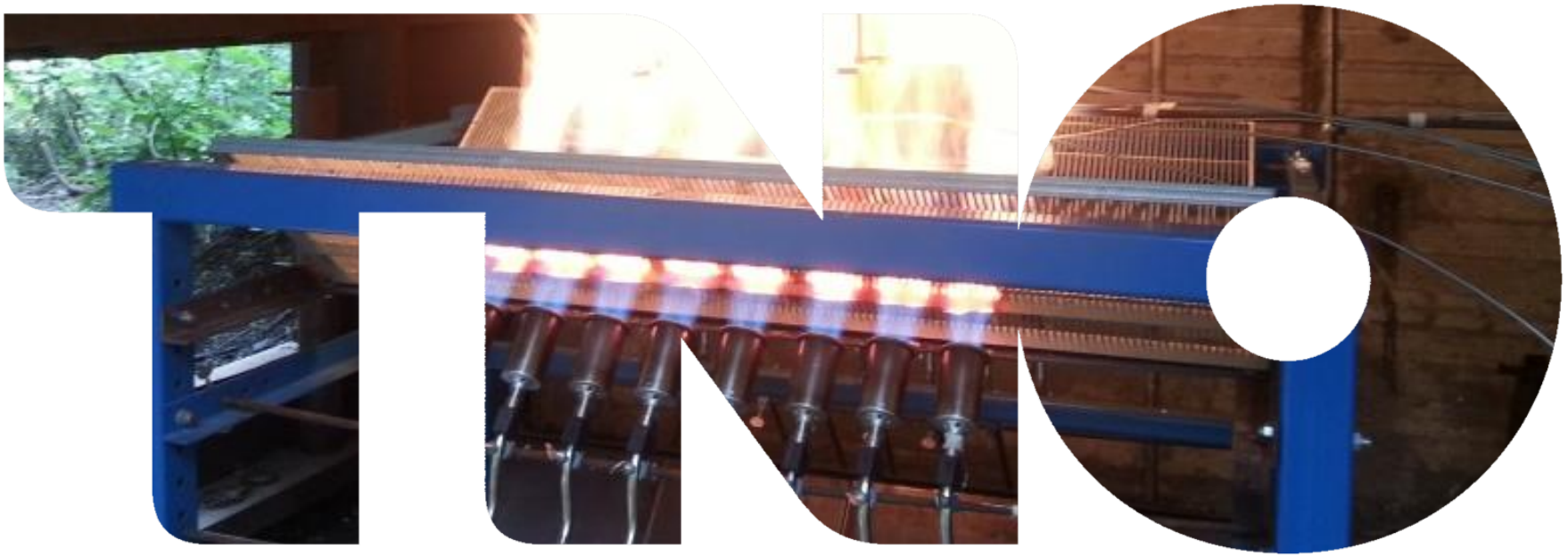


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Overview

- Introduction
- STANAG requirements, wishes and other considerations
- Design and components used
- Preliminary testing and adjustments
- Test series at ‘t Harde with MOD
- Results of test series
- Conclusions
- Upcoming activities


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Introduction

- Fuel fire test in STANAG 4240
- Use of Jet Fuel/Kerosene or Wood (UN)
- Severe pollution: rising problem with future environmental legislation
- MoD The Nederlands limited use of fuel fire equipment per year
- Looking for a ‘clean’ solution


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STANAG 4240 requirements

- Average T, measured with a minimum of 4 TC's: > 800°C and heat flux > 100 kW/m^2 (Value still under discussion)
- For 2 out of 4 TC's after 30 seconds T> 550°C
- Proper ignition for good flame spread
- Minimum sampling frequency of T: 0.2 Hz
- Munition item engulfed by flames
- Wind speed <10 km/h
- Munition article free in order to measure blast and fragments
  - Distinction between Type IV or V reaction
- Radiation large component of heating
- Heating duration minimal 150% of the estimated test time


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Requirements

- Cheap test set-up components for easy replacement in case of (severe) reaction of article
- Fast replacement of damaged components
  - ‘Nuts and bolts’ instead of welding
- Requirement by Dutch MoD
  - To enable testing of 155 mm munition item (1 m in length)

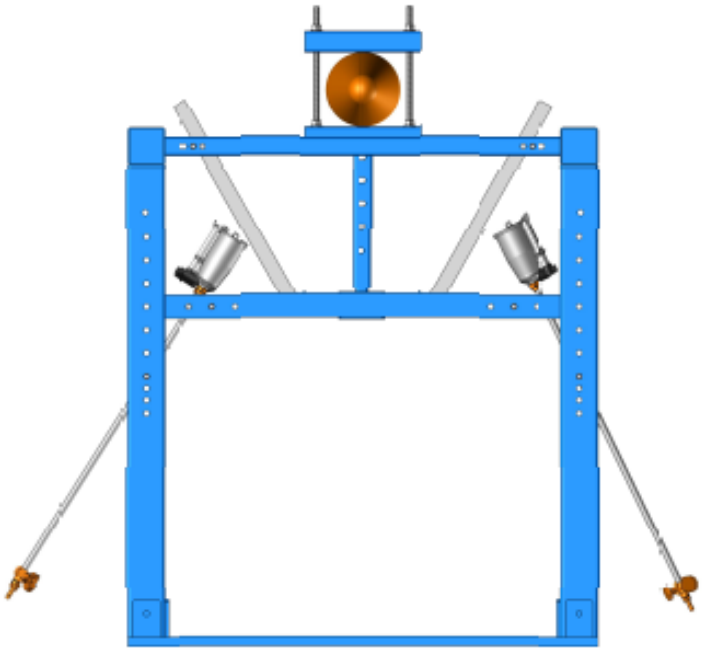
- Safety!!

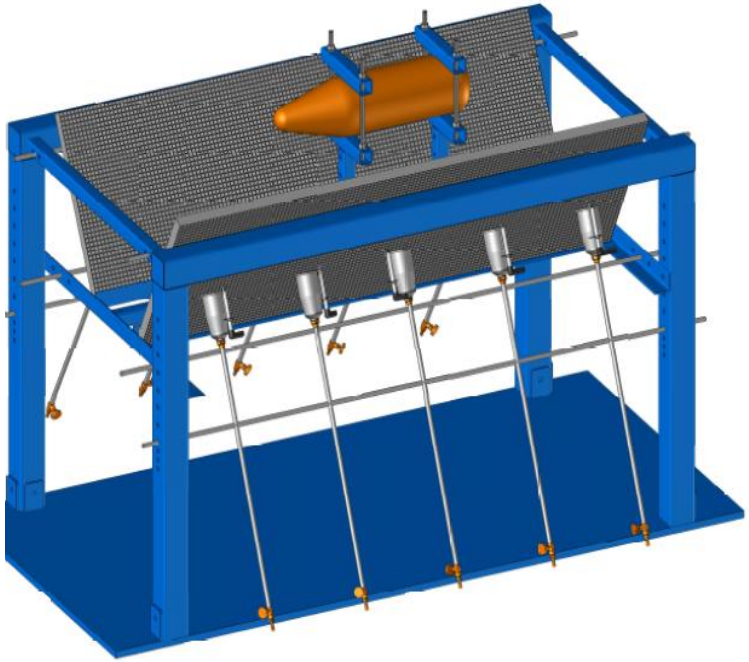

Design: Heat source

- Propane burns ‘clean’
- Heat Flux
  - Measured heat flux fuel fire:10-400 kW/m^2 (reduces fast to 50 kW/m^2)
  - Propane 20-134kW/m^2
- Energy propane: ~ 13 kWh per kilogram
- Roof burner uses 10 kg/h resulting in ~130 kW in case of optimal burning (pressures between 2-4 bar, 27-54 Psi)
- Munition item of 1 meter in length < 1,8 m^2 surface area
- For obtaining 200 kW/m^2 → 400 kW power is required

- For a homogeneous heating of such a large item the total amount of burners is estimated at 16

Sketches of first test set-up



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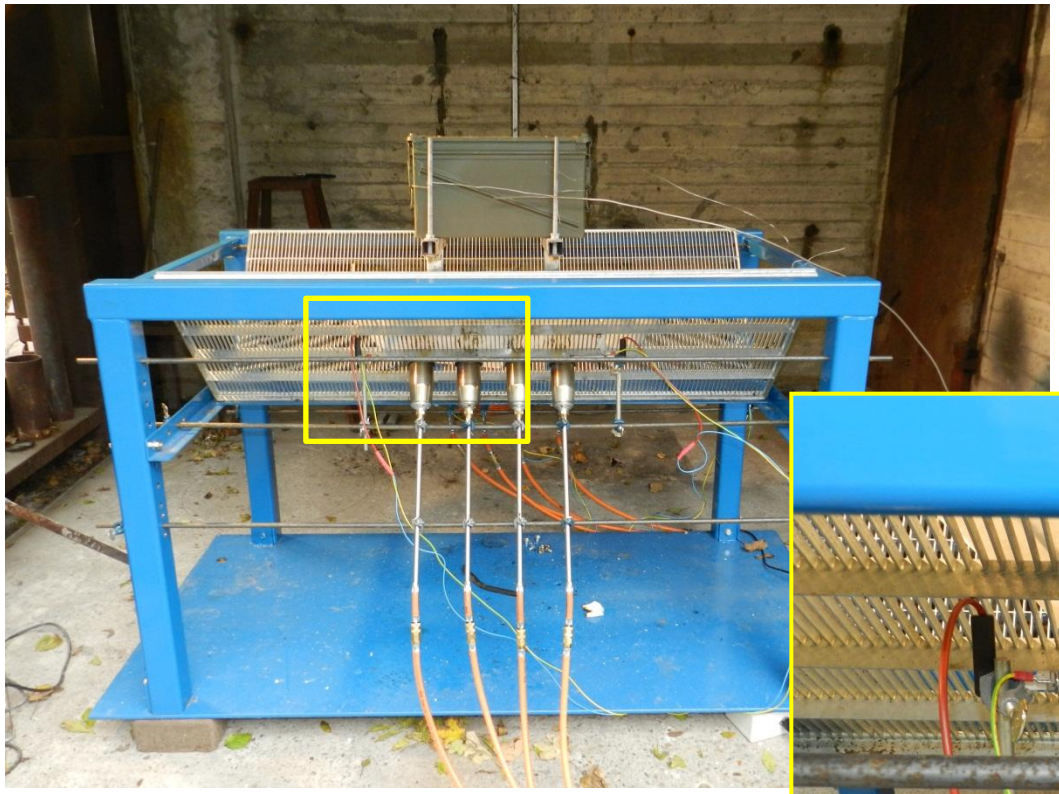
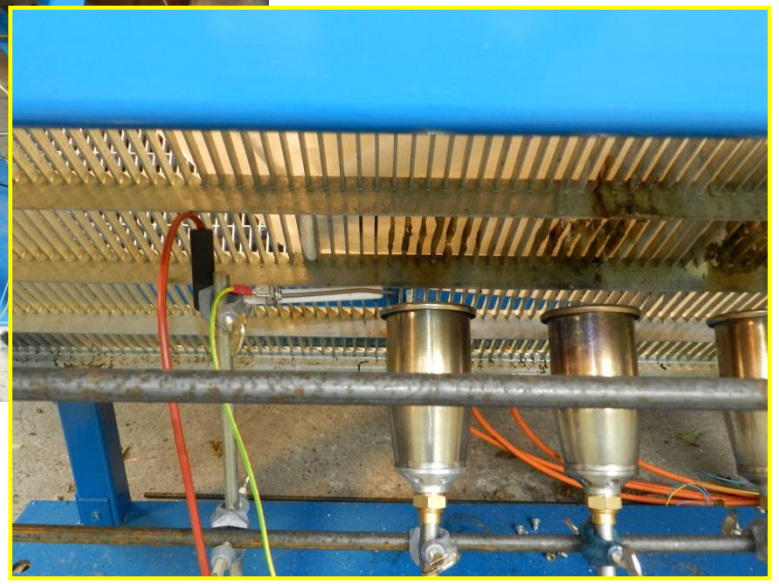
Selection of components

- Roof burners
  - Industrial burners too expensive
  - Customized burners too expensive
- Gas: propane can also be used at low T's while realising enough heat
- Remote ignition
  - Safety issue
  - Ignition from central heating system

- Safety components
  - Check valves (closes in case of hose rupture)
- Sonic wind meter
- Data acquisition for
  - K-type thermocouples (16 TC)
  - Sonic windmeter

Test set-up, Mk1





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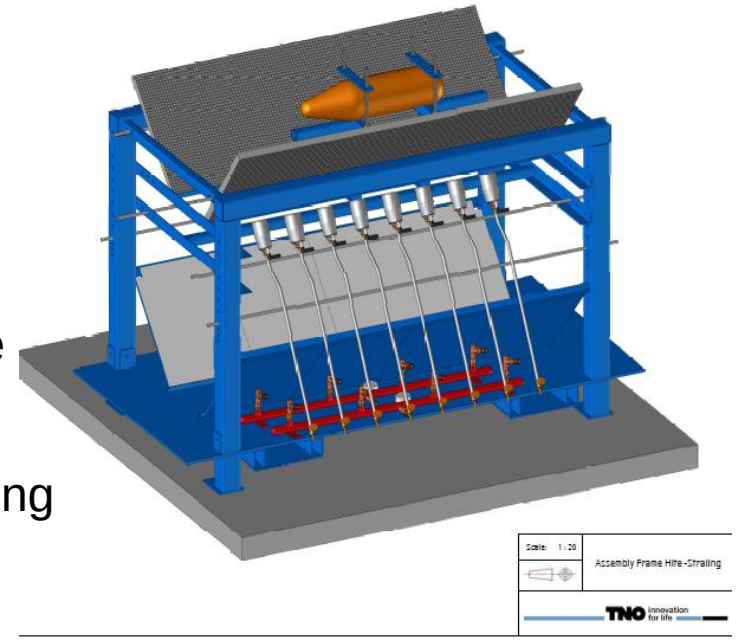
Latest adjustments (co-operation MoD)

- Single igniters on each burner
- Covered manifolds
- Reduced amounts of gas hoses to the test set-up
- Space for parts/pieces that fall off during testing
- Electrical valves for gas supply



- Design and built of mock-up
  - Inert 155 mm artillary grenade
  - 4 thermocouples
  - Sand-filled body

Test set-up, Mk2 and preliminary testing


Test set-up, Mk2 and preliminary testing of ignition

Test set-up, Mk2 and preliminary testing of number of gas hoses

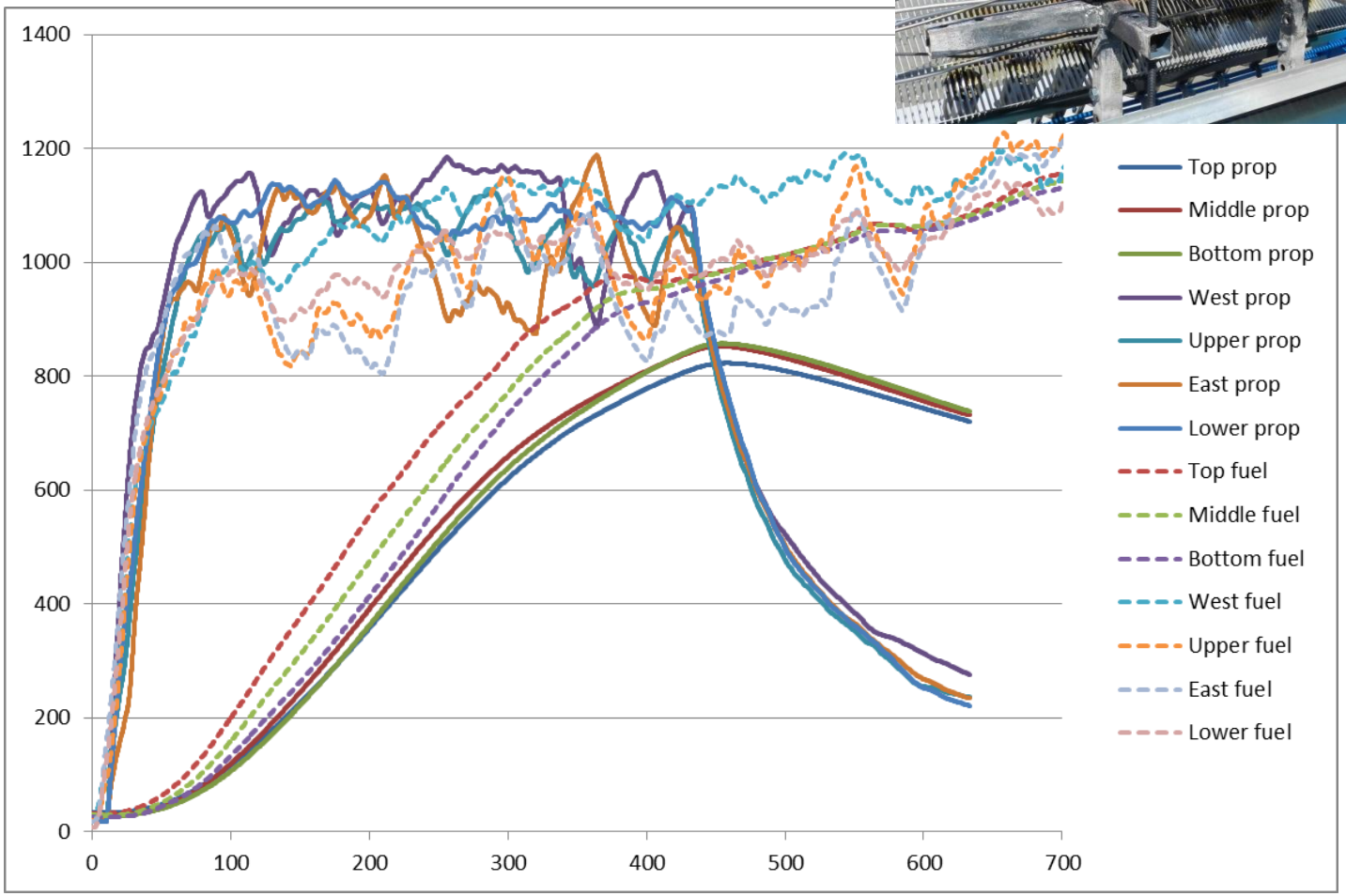
Test series at ‘t Harde with MOD

- Comparison between Fuel fire and new propane set-up

- Test items:
  - Steel cylinder
  - Sphere
  - 155 mm Mock-up
  - Munition box filled with empty bullets
  - Flux and temperature profile measurements in co-operation with NAVSEA

Photographs

Comparison prop vs fuel of cylinder

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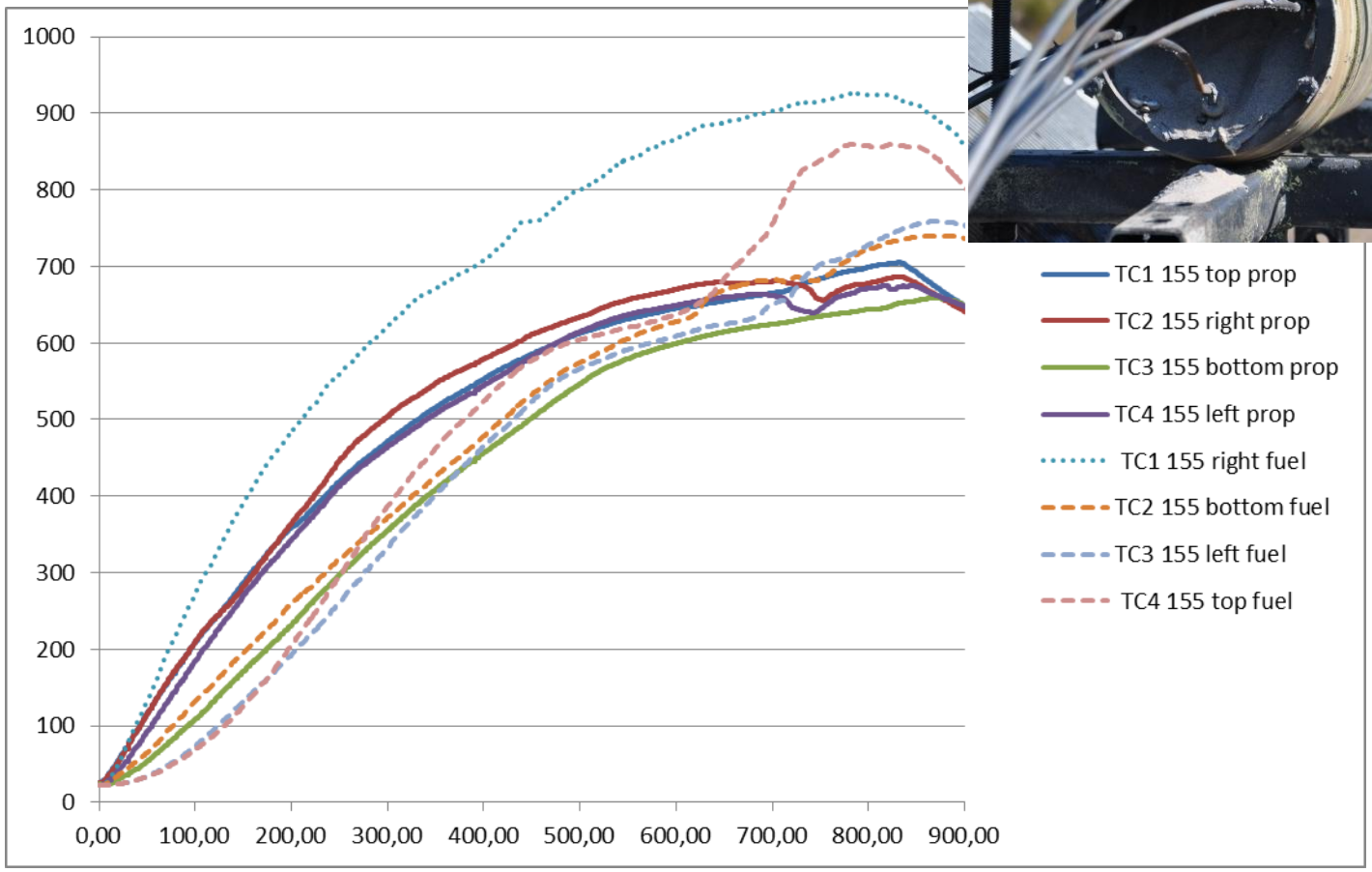
Test set-up, Mk2 and Test series at ‘t Harde (more in presentation of Jon Yagla NSWC)

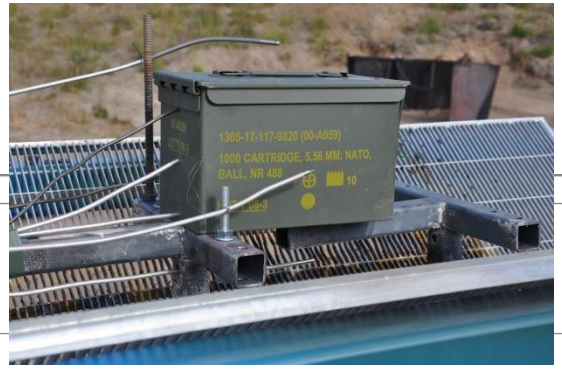
155 in Gas burner set-up

155 mm mock-up in Fuel fire, open at back

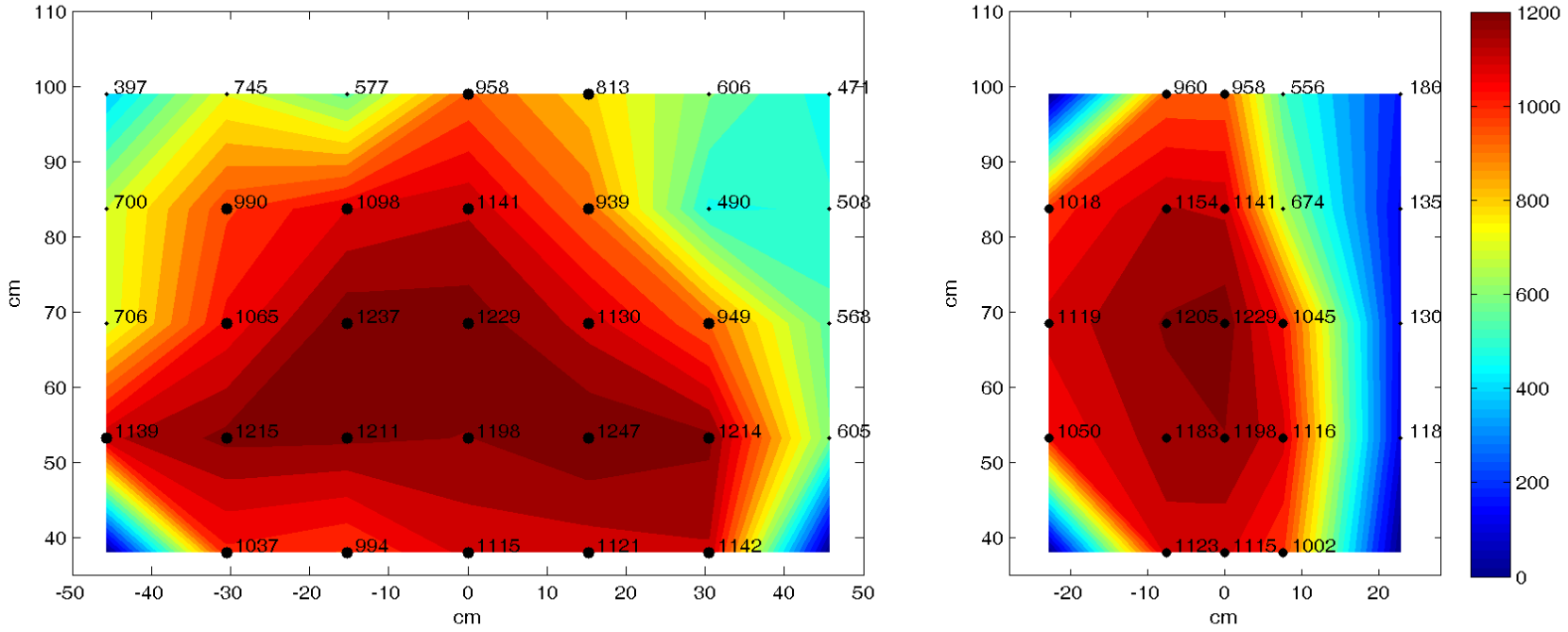
Comparison fuel vs propane of 155 mm mock-up



Comparison of munition box

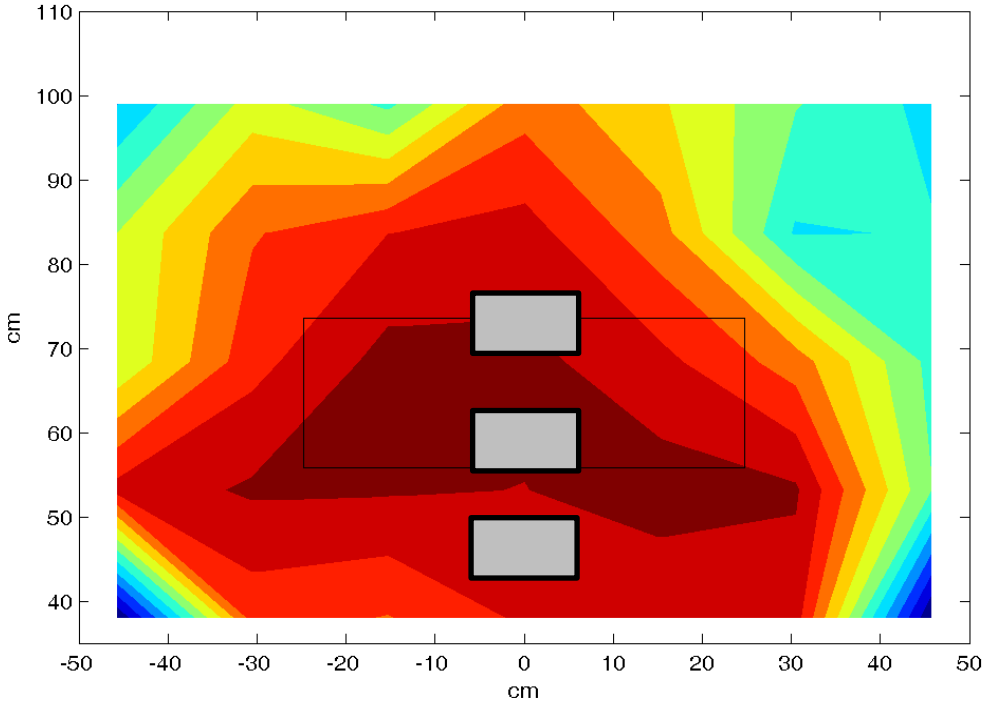


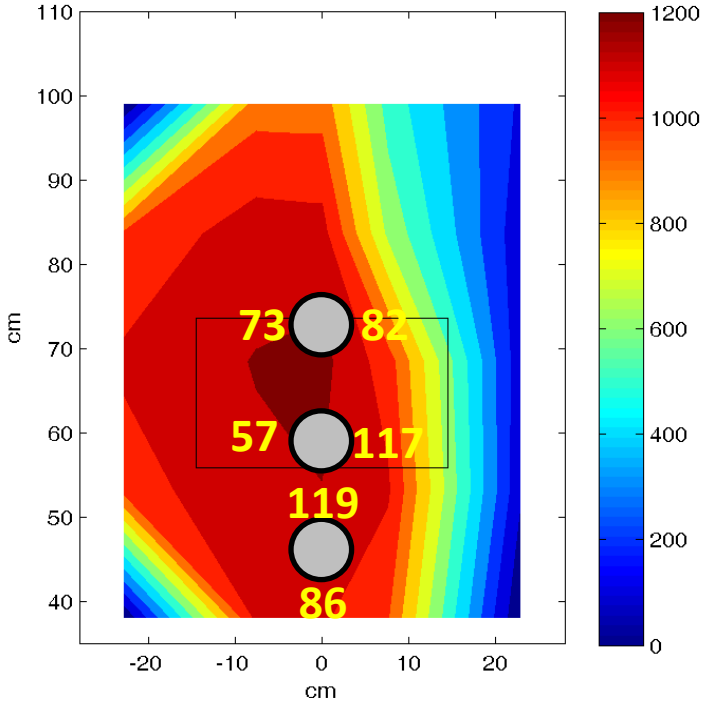
Results of temperature and Flux measurements (results from NSWC Jon Yagla and co-workers)



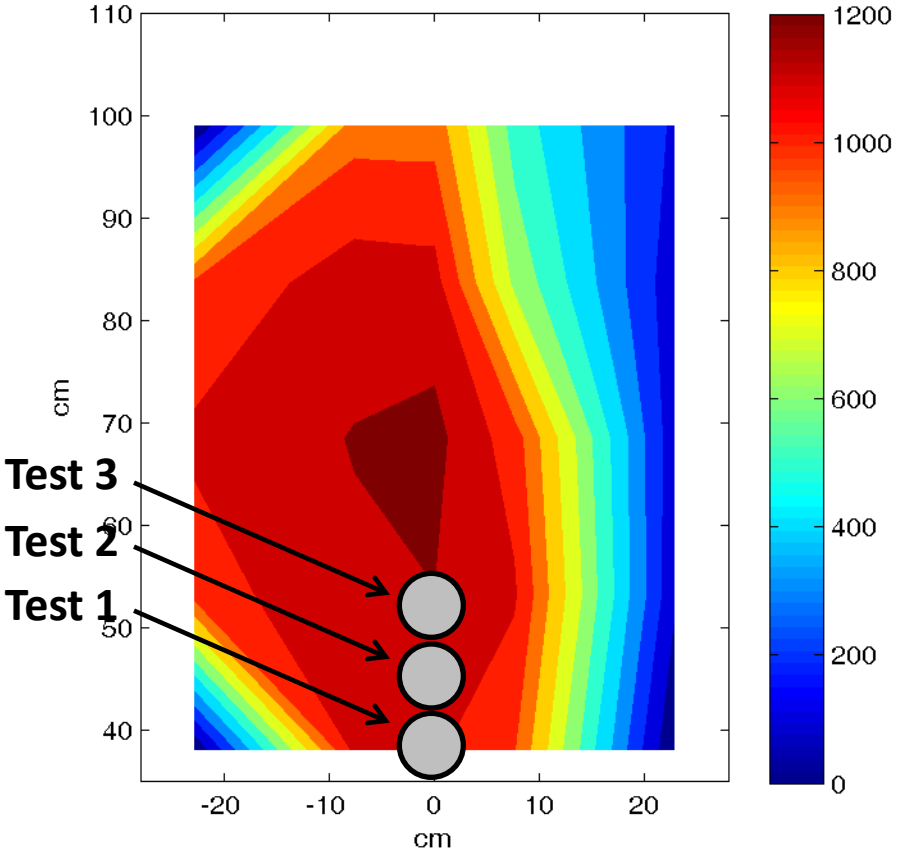
Average temperatures measured over the course of 4 separate tests

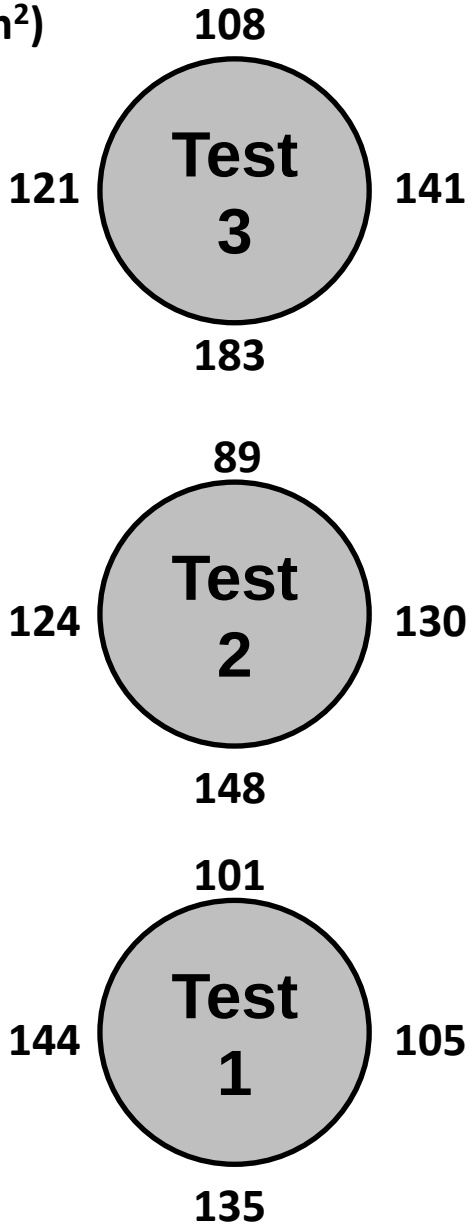
Results of temperature and Flux measurements





Measured Heat Flux (kW/m^2)





The directional slug calorimeter was positioned at three different heights in three sequential tests to measure the heat flux


Conclusions

- Fast cook-off Propane test set-up concept with roof burners and remote ignition works very well
- Meets the criteria of temperature (>800°C), temperature increase (550°C after 30 seconds) and heat flux (100 kW/m2)
- Some interesting differences in type of gas
- Wind influence: probably need of screens around set-up
- Pressure has influence, but nice tool to change flame temperature
- This is basic concept and can easily be adjusted to other forms or larger munition items


Future activities

- Transfer of hardware to MoD
- Full Analyses of data and data exchange with partners
- Test series with live munitions

- Thanks to

- Dutch MOD KC W& M: Albert Bouma
- NSWC Dahlgren: David Hubble, David Griffiths and Jon Yagla
- NAWC: Kevin Ford and Alice Atwood
- NAVSEA: Thomas Swierk
- TNO: John Makkus


Questions?