Fire protection in ammunition storage spaces
An evaluation of the water application rate

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Presentation Overview

- Introduction FiST project
- Aim of the experiments
- Experiment set-up
- Results
- Conclusions/Follow up
FiST – Project

• Cooperation between Ministry of Defense of
  • Canada, Sweden and The Netherlands
New Fire Suppression Technologies on board naval craft (FiST)

Problem definition
It is unclear how existing commercial fire fighting systems will react on battle damage, and what the residual capacity will be.

Objective
To develop knowledge on design and specification of fire suppression technologies specifically for naval vessels that operate in hostile environments, i.e. where damage from energetic weapons like anti-ship missiles can be expected.
FiST – Project partners

- FireTech Engineering
- SP Technical Research Institute Sweden
- FOI - Swedish Defence Research Agency
- FMV - Swedish Defence Materiel Administration
- Defence R&D Canada (DRDC)
- Netherlands’ Ministry of Defence – Defence Materiel Organisation
- TNO - Dutch Organization for Applied Scientific Research
Experimental program (Jan-Feb 2012)

- Evaluate the necessity of the prescribed water discharge density (24-32 $\ell/m^2$ per minute)
  - ANEP-77 Naval Ship Code
  - Class regulations (like DNV)
  - The U.S. Navy’s handbook on magazine sprinkling

- High flow rates are a burden on system design

- Rapid flooding decreases ship stability

- Assess the feasibility of reducing flow rate
  - If necessary/advantageous in conjunction with low pressure WMS
How much is 32 litres/m² per minute?

Ship compartment (10x10x3m)

32 cm of water after 10 minutes

Nearly 1 meter of water after 30 minutes

In a 10 × 10 m² compartment, this is 3200 kg or two midsized cars every minute!!
Experimental program

Total of 27 tests at SP in Sweden

Fire suppression configurations
- WMS at ~6 ℓ/m²/min
- Drencher at 10 ℓ/m²/min
- Drencher at 32 ℓ/m²/min
- Dual system: WMS at ~6 ℓ/m²/min + Drencher 5 ℓ/m²/min

Obstructions
- None: Free burning
- Dummy torpedo
- Dummy torpedo + Promatect sheet
Experimental set-up - Geometry

- Promatect board walls
  - 12 mm thick
  - Calcium Silicate
Experimental set-up – Dummy torpedo

Dummy torpedo
- 3 mm steel (65 kg)
- Ø 350 mm x 2000 mm
- Filled with dry sand
Experimental set-up – Dummy torpedo

Dummy torpedo over fuel pan #1
Experimental set-up – Fuel pan locations

Fuel pan parameters
- Ø 1170 mm
- 15 mm Diesel
- HRR of 1.3 MW
Experimental set-up – Drencher system

Drencher system
- 4x LECHLER nozzles
- Tests with 3 different types (5, 10 and 32 ℓ/m²/min)
Experimental set-up – Water Mist System

Water Mist system
- Low pressure (10 bar)
- 9x BETE TF8-170° nozzles
- K-factor of 5.93 ℓ/min/√bar
- Est. drop size: 133 µm
Experimental set-up - Instrumentation

- Thermocouple trees
  - 5 positions (P1-P5)
  - K-type

- Oxygen measurement
  - 2 heights at P5

- Water flow rate
  - In pipe
  - At pump
Experimental performance criteria

- The **maximum outside surface temperature** of dummy torpedo must not exceed 200 °C.

- **One minute after activation** the outside surface temperature must not exceed 150 °C.

- Temperature on the **inside** of the dummy torpedo must not exceed 150 °C at all times.

- In this research: **No** criteria for extinguishment of flames!
Video Test 14 – free burning
Your Expert opinion required!

Will the drencher system (32 litres/m²/min) extinguish the 1,3 MW fire?

Yes: □ No: □
Test 16: Drencher Fuel pan #1 [32 litres/m²/min.]

Test 22: Drencher Fuel pan #2 [32 litres/m²/min.]
Expert opinion required!

Will the drencher system (32 litres/m²/min) extinguish the 1,3 MW fire?
Yes: ☑ No: ☐

Will the WaterMist System (6 litres/m²/min) extinguish the 1,3 MW fire?
Yes: ☐ No: ☑
Video Test 15 – Water Mist
Expert opinion required!

Will the drencher system (32 litres/m²/min) extinguish the 1,3 MW fire?
Yes: ☑️ No: ☐

Will the WaterMist System (6 litres/m²/min) extinguish the 1,3 MW fire?
Yes: ☐ No: ☑️

Which system extinguishes the 1,3 MW fire the fastest?
Dual System: ☐ Drencher: ☐
(WMS+Drencher: 6+5 l/m²/min) (10 l/m²/min)
Test 17: Drencher
[10 litres/m²/minute]

Test 18: Drencher + WMS
[5 + 6 litres/m²/minute]
Expert opinion required!

Will the drencher system (32 litres/m²/min) extinguish the 1,3 MW fire?
Yes: ☑️
No: ☐️

Will the WaterMist System (6 litres/m²/min) extinguish the 1,3 MW fire?
Yes: ☐️
No: ☑️

Which system extinguishes the 1,3 MW fire the fastest?
Dual System: ☑️
(Dual System: WMS+Drencher: 6+5 l/m²/min)
Drencher: ☑️
(10 l/m²/min)
Added water mist effect: Explosion suppression

- Full scale explosion trials in TNO bunker
- Dispersion of water mist prior to the explosion:
  - Reduced peak pressure effects by up to 50 %
  - Greatly reduced temperatures inside the compartment (from 600 °C to 100 °C)
## Test results (overview)

<table>
<thead>
<tr>
<th>Test</th>
<th>Drencher ℓ/m²/min</th>
<th>WMS ℓ/m²/min</th>
<th>Fuel pan position</th>
<th>Obstruction</th>
<th>Peak surface T [°C]</th>
<th>Peak surface T &gt; 1 min [°C]</th>
<th>Time to ext. [s]</th>
<th>O2 conc. at ext. [vol%]</th>
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<tbody>
<tr>
<td>14</td>
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<td>203</td>
<td>Did not extinguish</td>
<td>17.9²</td>
<td></td>
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<tr>
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<td>32</td>
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<td>6</td>
<td>2³</td>
<td>Promatect lined up with ordinance</td>
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<td>81</td>
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<td>13.5²</td>
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<td>2³</td>
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<td>2⁴</td>
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<tr>
<td>22</td>
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<td>23</td>
<td>32</td>
<td>-</td>
<td>2⁴</td>
<td>Vertical 460 mm Promatect board</td>
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<td>15</td>
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<td>Promatect lined up with ordinance</td>
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<td>604¹</td>
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<td>15.5²</td>
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</table>
Maximum temperature of dummy torpedo – Fuel pan #1
Temperature difference across the cylinder

![Graph showing temperature difference across the cylinder over time. Each line represents a different test condition: Test 14, free-burning, outside; Test 14, free-burning, inside; Test 15, WMS, outside; Test 15, WMS, inside; Test 16, 32 l/m²/min, outside; Test 16, 32 l/m²/min, inside; Test 17, 10 l/m²/min, outside; Test 17, 10 l/m²/min, inside; Test 18, 5 l/m²/min + WMS, outside; Test 18, 5 l/m²/min + WMS, inside. The graph shows the temperature in °C over time in seconds.]
Oxygen concentration @ 500mm height
Conclusions

• Configurations with drencher capacity well below 32 ℓ/m²/min fulfilled the performance requirements

• Results of a 5 ℓ/m²/min drencher system in conjunction with a 6 ℓ/m²/min WMS are comparable to a 10 ℓ/m²/min drencher system

• WMS at 6 ℓ/m²/min is insufficient to fulfil the assumed performance requirements and the peak surface temperature exceeds 200 °C.

• A dual system may show increased survivability due to inherent redundancy

• A dual system may be costly and complex to implement

• A dual system of which one is a water mist system could be designed for explosion suppression
Follow up / Questions

- Damaged system tests January 2013
  - Damaging of piping is done today at TNO

- Different obstructions

- Different configurations

Questions???
Thank you for your attention!

US Carrier flight deck wash-down