HALON REPLACEMENT PROGRAM
FOR COMBAT VEHICLES
A STATUS REPORT

William Bolt, Craig Herud, Terry Treanor
U.S. Army Aberdeen Test Center
Steven McCormick
U.S. Army Tank-Automotive and Armament Command

Halon Replacement Program Overview

- **Engine Compartment**
  - Phase I - Fixture test to screen candidates
  - Phase II - Running engine, (proof of principle) and laboratory tests
  - Phase III - Combat vehicle specific

- **Crew Compartment**
  - Combat fires

- **Hand-held Extinguishers**
  - CO, concentration testing
  - Alternate agent tests

9 May 1996
Status

Engine Compartment
• Phase I - Completed
  – 14 agents tested
• Phase II - Testing in progress
  – 6 agents tested
• Phase III - Vehicle modifications underway
  Sheridan, M1 and Bradley

9 May 1996

Status

Crew Compartment
• Combat fire scenarios
  – Test fixture constructed
  – Test instrumentation installed
  – Baseline characterization tests underway
• Peacetime fire scenarios
  – Pan fire tests underway
  – Class A/B fire scenario being developed
  – Crew heater testing underway

9 May 1996
Status

Handheld Fire Extinguishers
• Efficacy testing underway
• Personnel heater decomposition products testing completed
• Pyrolysis products testing scheduled

Agents/Systems Tested
Phase I

Iodocarbon- $\text{C}_3\text{F}_7\text{I}$  Pyrotechnic Aerosol (2)
Envirogel                 Hybrid Gas Generators
Gas Generators           Water Mist
NaHCO$_3$ Dry Powder     FM200, FE36, FE25
Water + Additives        Halon 1301
CO$_2$

9 May 1996
### Agent Weight & Volume Required

<table>
<thead>
<tr>
<th>Agent</th>
<th>Agent Weight</th>
<th>Agent Volume</th>
<th>% Volume Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halon 1301</td>
<td>7.0</td>
<td>204</td>
<td>0</td>
</tr>
<tr>
<td>Dessikarb</td>
<td>6.6</td>
<td>204</td>
<td>0</td>
</tr>
<tr>
<td>FM 200</td>
<td>9.0</td>
<td>288</td>
<td>41</td>
</tr>
<tr>
<td>FE 36</td>
<td>9.0</td>
<td>288</td>
<td>41</td>
</tr>
<tr>
<td>Hybrid Gas Generator</td>
<td>12.4</td>
<td>320</td>
<td>57</td>
</tr>
<tr>
<td>FE 25</td>
<td>9.0</td>
<td>388</td>
<td>90</td>
</tr>
<tr>
<td>CO₂</td>
<td>12.0</td>
<td>516</td>
<td>182</td>
</tr>
<tr>
<td>Water Mist</td>
<td>17.0</td>
<td>610</td>
<td>199</td>
</tr>
</tbody>
</table>

9 May 1996

### Engine Phase II

M60A3 w/ operating engine

- Provides realistic geometry and airflow
- Initially used standard M60 distribution system
- Type 2 and Type 3 fire scenarios tested
- Mod Qa (two rakes) worked better

9 May 1996
Test Conditions

- **All** tests vs Type 2 and Type 3 fires
- Results based on best distribution system design to date
- Data compared to Halon 1301 performance
- Limited extinguisher size:
  
  144,204 & 288 in³ (std extinguishers)

9 May 1996

Type 2 Fire Scenario

- Type 2 fire - bilge & fuel spray, no airflow:

  TO; start bilge fire
  T+20; start fuel spray
  T+25; start engine
  T+35; stop engine,
  T+40; discharge agent
  T+65; stop fuel spray
  T+180; test complete

9 May 1996
Type 3 Fire Scenario

- Type 3 fire - bilge fire only w/airflow:

  TO; start bilge fire
  T+20; start engine (run @1000 RPM)
  T+50; discharge agent
  T+180; test complete

9 May 1996

Agents/Systems Tested

- TACOM sponsored Phase II tests
  FM200 - (HFC - 227ea)
  FE 36 - (HFC - 236fa)
  Sodium bicarbonate, (6 candidates)
  Hybrid Gas Generators w/FM 200

9 May 1996
Agents/Systems Tested

- Vendor sponsored Phase II tests
  - Envirogel
  - Aqueous salts

Agent Weights & Volumes Required

<table>
<thead>
<tr>
<th>Agent</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amerex</td>
<td></td>
<td>9.1</td>
<td></td>
<td>204</td>
</tr>
<tr>
<td>Hybrid/FM-200</td>
<td>12.4</td>
<td>9.5</td>
<td>320</td>
<td>240</td>
</tr>
<tr>
<td>Halon 1301</td>
<td>7.0</td>
<td>10.0</td>
<td>204</td>
<td>288</td>
</tr>
<tr>
<td>Dessikarb</td>
<td>6.6</td>
<td>9.0</td>
<td>204</td>
<td>288</td>
</tr>
<tr>
<td>Envirogel</td>
<td></td>
<td>11.5</td>
<td></td>
<td>288</td>
</tr>
<tr>
<td>FM-200</td>
<td>9.0</td>
<td>12.0</td>
<td>288</td>
<td>408</td>
</tr>
<tr>
<td>FE-36</td>
<td>9.0</td>
<td>12.0</td>
<td>288</td>
<td>408</td>
</tr>
<tr>
<td>Hybrid/water</td>
<td>11.5</td>
<td></td>
<td>344</td>
<td></td>
</tr>
<tr>
<td>Ansul Plus 50</td>
<td>&gt;10.0</td>
<td></td>
<td>&gt;204</td>
<td></td>
</tr>
</tbody>
</table>

9 May 1996
Results

- Limited testing of dry powder in next smaller bottle (5 lb/144 in³)
  - determine margin of safety
  - evaluate 6 different NaHCO₃ powders
  - successes achieved with 5 lb bottle
- Standard bottle is 7 lb/204 in³
  - no practical advantage to reducing volume
  - volume saved can not be utilized

Conclusions

- Performance equivalent to Halon 1301 cannot be achieved without some modifications to hardware (No “drop-in” agent)
- Distribution system design is critical and must consider engine compartment geometry & airflow
  - Importance of distribution system:
    - Powder > Liquid > Gas
  - good design can reduce agent requirement
Conclusions

- Shutting down engine airflow prior to discharge of agent can drastically reduce the amount of agent required; all fires become Type 4
- Adjustment of the Phase I distribution system required to achieve equivalent or better performance in Phase II
  - Type 3 fire more severe than Phase I
  - Type 2 fire less severe than Phase I

9 May 1996

Conclusions

- Dry chemical: No volume penalty over existing Halon 1301 systems, but major distribution system hardware changes are required: (new piping, nozzles)
- Liquid agents: -40% volume penalty over existing Halon systems, but minor hardware changes are required.

9 May 1996
Issues To Consider

- Single replacement agent for all vehicle systems highly desirable from logistics standpoint.
- May not result in optimum agent for each system.
- Choice will be driven by Abrams/Bradley requirements.

9 May 1996

Lessons Learned

- Engine can be destroyed in less than 3 minutes
- Detection system recommended
- Additional clutter and differences in airflow made the Type 3 scenario more severe
- Extinguisher ullage critical:
  - more required for liquid agents (30-40%)
  - < 5% for dry powders
  - N₂ plays a significant role in agent performance

9 May 1996