HALON REPLACEMENT PROGRAM FOR COMBAT VEHICLES A STATUS REPORT

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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

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

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

Status

Handheld Fire Extinguishers

- Efficacy testing underway
- Personnel heater decomposition products testing completed
- Pyrolysis products testing scheduled

Agents/Systems Tested
Phase I

Iodocarbon- C_3F_7I	Pyrotechnic Aerosol (2)
Envirogel	Hybrid Gas Generators
Gas Generators	Water Mist
$NaHCO_3$ Dry Powder	FM200, FE36, FE25
Water + Additives	Halon 1301
CO_2	

Agent Weight & Volume Required

Agent	Agent Weight	Agent Volume	%Volume Increase
Halon 1301	7.0	204	0
Dessikarb	6.6	204	0
FM 200	9.0	288	41
FE 36	9.0	288	41
Hybrid Gas Generator	12.4	320	57
FE 25	9.0	388	90
c 0 2	12.0	516	182
Water Mist	17.0	610	199

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 Oa (two rakes) worked better

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** in^3 (std extinguishers)

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

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

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

Agents/Systems Tested

- Vendor sponsored Phase II tests
  - Envirogel
  - Aqueous salts

Agent Weights & Volumes Required

	Weight		Volume	
Agent	Phase 1	Phase 2	Phase 1	Phase 2
Amerex	------	9.1	------	204
Hybrid/FM-200	12.4	9.5	320	240
Halon 1301	7.0	10.0	204	288
Dessikarb	6.6	9.0	204	288
Envirogel	------	11.5	------	288
FM-200	9.0	12.0	288	408
FE-36	9.0	12.0	288	408
Hybrid/water	11.5	------	344	------
Ansul Plus 50	>10.0	------	>204	------

Results

- Limited testing of dry powder in next smaller bottle (5 lb/144 in^3)
  - determine margin of safety
  - evaluate 6 different NaHCO, powders
  - successes achieved with 5 lb bottle
- Standard bottle is 7 lb/204 in^3
  - 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

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.

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.

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
  - N_2 plays a significant role in agent performance