HALON REPLACEMENT PROGRAM FOR COMBAT VEHICLES A STATUS REPORT

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Army Combat Vehicle Halon Replacement Programs

- Engine Compartment Fire Extinguishing Systems
- Crew Compartment Fire Extinguishing Systems
- Hand-held Fire Extinguishers

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Engine Compartment Program Status

- Phase I - Initial screen w/ generic test fixture
  - Complete - 14 candidate systems tested
- Phase II - Proof of principle in M60A3 tank
  - Complete - 6 candidate systems tested
- Phase III - Vehicle specific systems
  - *2* candidate systems tested
  - Abrams & Bradley programs 90% complete
  - FAASV underway; other vehicles pending

Phase 3 - Abrams

- Two shot engine compartment system
  - 1st shot automatic
  - 2nd shot manual w/ 18-sec delay
- Agents tested
  - FM-200
  - Amerex Regular Dry Powder

Abrams - Hardware Tested

- Stock - 7-lb extinguisher w/ Marotta valve and perforated tube distribution system (rakes)
- Prototype
  - Modified rakes (FM-200 only)
  - Nozzle systems
  - 3/4-in diameter piping
  - 3/4-in bulkhead & manifold check valves

Abrams - Test Conditions

- All tests 1st shot conditions - scenario reflects M1 operating conditions
- Threats based on fire history
  - three spray fire locations
  - fuel &.hydraulic fluid fires
- Three engine speeds: low &tactical idle, full throttle

Abrams - Fire Scenario

- Bilge and fuel spray fire wlairflow
- Engine at operating temperature; hot fuel

T_0	start bilge fire
T_0+10	adjust engine speed
T_0+15	start fuel spray
T_0+20	ignite fuel spray
T_0+22	discharge agent
T_0+35	**stop** fuel spray
T_0+180	test complete

Abrams - Results: Dry Powder

- Fires extinguished w/ 10-lbs in stock extinguisher @ 750-psi with Mod P-12 distribution system:
  - **9** powder nozzles
  - 3/4" piping between extinguisher & manifold
  - new manifold w/ 3/4" check valves
- Fire out times: 1-3 sec. w/ total bum of 20-22 sec.

Abrams - Results: Mod P-12

Temperature	Engine Speed	Amerex	FM-200
Ambient	Full	4/4*	5/5
	Tac	313	3/3
	LOW	313	313
Cold	Full	111	313
	Tac	NT	NT
	LOW	NT	414

* Includes Mod P-11 data

Abrams - Results: FM-200

- Not effective w/ standard hardware
- Effective in powder distribution hardware (P-12)
- Mixed results w/ new piping system @ full throttle (Mod 8)
  - 3/4" piping between extinguisher & manifold
  - new 3/4" manifold & bulkhead check valves (ball type)
  - branch rakes; new hole pattern

Summary

- Phase **3** fires were extinguished w/o incurring a volume penalty.
  - Distribution hardware changes are required.
  - P-12 distribution system effective with either FM-200 or powder.
  - P-12 nozzle system provides effective performance w/o volume penalty.
  - Powder and liquid agents can work in the same hardware.
  - Equivalence to halon was not established.

Phase *3* - Bradley

- Single shot manual engine compartment system
- Agents tested
  - Amerex Regular Dry Powder
  - FM-200
  - FE-36

Bradley - Hardware Tested

- Stock - 7-lb extinguisher w/ Ansul valve
- Prototype
  - Stock w/ bent dip tube
  - Stock w/ 10-lb extinguisher
  - 10-lb w/ Marotta valve
  - 2 nozzle distribution system (FM-200/powder)
  - 4 nozzle distribution system (powder only)
- Limited powder testing

Bradley - Test Conditions

- All tests vs Type 2 fires: scenario modified to reflect M2 operating conditions
- Engine shut down; agent released when fan speed decayed to 750 rpm
- Three spray fire locations: based on ignition source & potential for fuel leaks
- Class A components protected until hardware design frozen

Bradley - Fire Scenario

- Bilge & fuel spray, decaying airflow
- Engine at operating temperature; hot fuel

T_0	start bilge & fuel spray fire
T_0+2	engage engine cooling fan
T_0+45	shut off engine fuel
T_0+47	shut off master power
T_0+4x	discharge agent @ 750 rpm
T_0+49	stop fuel spray

Bradley Results

- Effective w/ stock system w/ 8.5-lbs FM-200
- Fire out times: 20-25 seconds
- Engine must be stopped
- Unprotected pack - significant component damage
- HFCs successful - powder evaluation terminated

Conclusions

- **Abrams** :
  - satisfactory performance with powder & FM-200
  - no volume penalty over existing Halon system
  - major hardware changes are required
- **Bradley:**
  - satisfactory performance with liquid agents
  - no volume penalty over existing Halon system
  - minor hardware changes are required
  - fire detection system desirable

Conclusions

- Distribution system design is critical for high airflow conditions:
  - good design can reduce agent requirement
  - complexity of distribution system:

    Powder > Liquid > Gas
  - properly designed powder systems can also work for liquid or gaseous agents: Abrams P-12 system successful w/ both powder and FM-200.

Conclusions

- Shutting down engine airflow prior to discharge of agent can drastically reduce the amount of agent required and the complexity of the distribution system:
  - Bradley system is a near "drop-in": only necessary to change dip tube and pressure gage
  - System is unsuccessful if the engine is running.

Issues

- Single replacement agent for all vehicle systems desirable from logistics standpoint, but may not result in optimum or lowest cost system for each vehicle.
- Choice of single/multiple agents will be driven by Abrams/Bradley requirements and life cycle costs.

Crew Compartment Systems

Crew system requirements greater than for engine
- Heat flux low enough to prevent second degree burns on exposed skin
- Fire out time (< **250** msec)
- Neat agent & decomposition product toxicity

Combat fire scenarios
- Simulated - electrically initiated JP-8 spray
- Ballistic - shaped charge thru fuel cell w/ JP-8

Evaluation Parameters

- Performance
  - Burn potential: < 2400°F-sec (10-sec interval)
  - Operating range: -25 to +140°F
  - Peak pressure: < 11.6-psi
  - Volume < 600-in^3
- Environmental
  - ODP = 0 GWP: as low as possible
- Toxicity
  - Neat agent: ≤NOAEL
  - Acid by-products: <1000-ppm

Program Status

Crew Compartment

- Test fixture constructed
  - Ballistic proof testing completed
  - Test instrumentation installed
  - Simulator development tests underway
- RFP issued by TACOM 11 Feb 97
- Proposals received 01 Apr 97
- Contracts awarded 3rd Qtr 97

HFE Program Status

- 2.5-lb CO, will replace 2.75-1b Halon 1301 HFE for most applications; conversion underway
- Potential toxicity problems w/ C02 in some vehicles w/ small compartments; FM-200 or FE-**36** HFE being considered for these applications

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