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Aerojet Solid Propellant and Hybrid Fire Extinguishers for Halon Replacement

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Agenda

- Solid Propellant Fire Extinguisher (SPFE) Technology
- Aircraft Dry Bay Fire Protection Systems
- Hybrid Fire Extinguisher (HFE) Technology
- Vehicle Fire Protection Systems
- Advantages of Chemically Active Propellant
- Applying HFEs to Aircraft Engine Nacelle Fire Protection
- Advantages of Using HFEs for Aircraft Fire Protection
- Conclusions

Solid Propellant Fire Extinguisher (SPFE)

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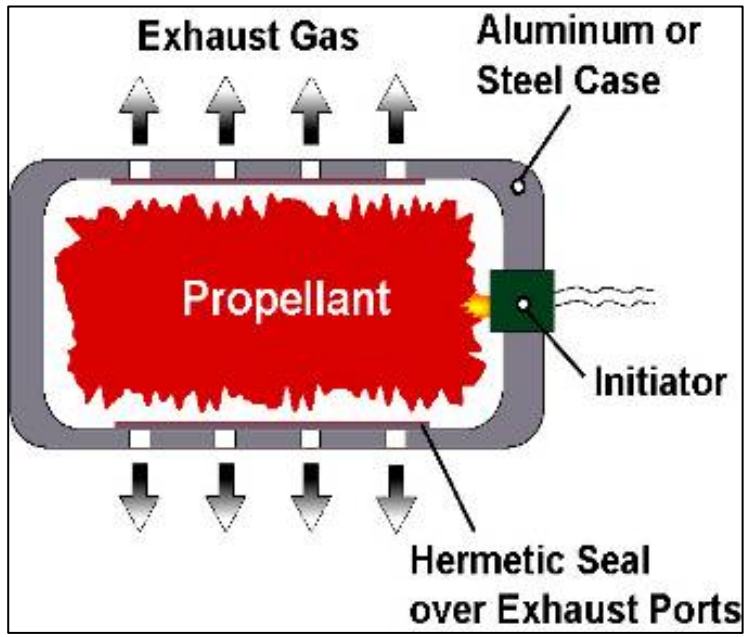
- Based on Automotive Airbag Technology
  - It's like your car airbag without the bag
- Solid Propellant Combustion Produces Non-toxic Gas Which Is Used as the Suppression Agent
  - Inert or chemically active propellant available
- Typical Applications:
  - Non-occupied spaces
  - Aircraft dry bays
  - Engine compartments



Quick Acting

Safe – Not Pressurized Until Activated

Environmentally Friendly

Compact and Lightweight

Maintenance Free

Qualified And Proven In Military Aircraft

Aircraft Dry Bay Fire Protection Systems

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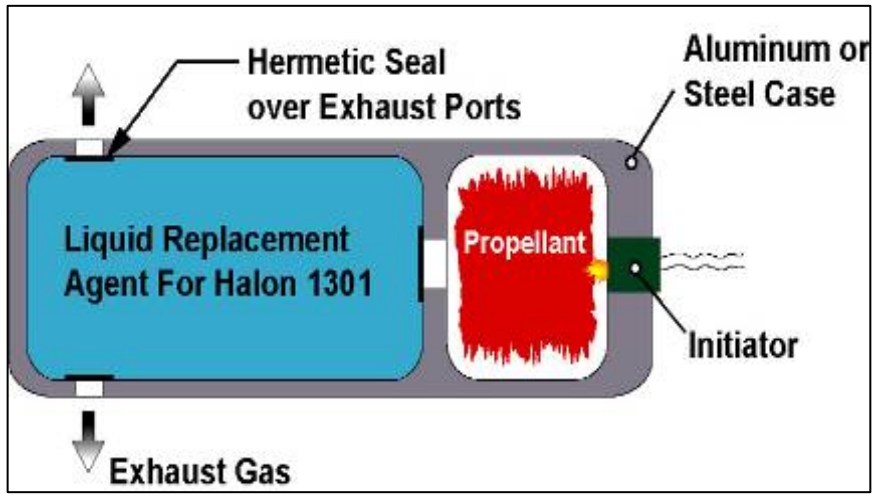
- Autonomous Suppression of Dry Bay Fires Resulting from Ballistic Penetration of Fuel Tanks and Hydraulic Lines
- SPFE Performance is Equivalent To Or Better Than Conventional Halon Systems
- SPFEs are Fully Qualified to Military Environments (MIL-D-21625)
- Aerojet Supplies Integrated Systems with Fire Suppression Electronics Including Optical Detectors and Controllers
  - Fire suppression system electronics integrate seamlessly with SPFEs
- Features and Benefits:
  - Compact and lightweight
  - Highly effective
  - Quick (<200 milliseconds)
  - No maintenance

Ballistically induced fire in the fuselage dry bay of an aircraft detected and extinguished < 200 milliseconds

Hybrid Fire Extinguisher (HFE)

- Based on Automotive Airbag Technology
  - Solid propellant gas generator exhausts into tank rather than an airbag
- Solid Propellant Combustion Produces Gas which is Used to Pressurize and Discharge the Suppression Agent
- Can Match Fluid (agent) to Fire Threat
  - 3M™ Novec™ 1230
  - Water-Surfactant-Foam Blends
  - HFC-125, HFC-227ea, etc.
- Typical Applications:
  - Occupied spaces
  - Crew compartments
  - External vehicle fires



Quick Acting

Safe – Not Pressurized Until Activated

Environmentally Friendly

Maintenance Free

Can Be Mounted In Any Orientation

Consistent Operation Over Wide Temperature Range

Qualified And Proven In Military Ground Vehicles And Commercial Automobiles

Vehicle Fire Protection Systems

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- HFEs and SPFEs Provide Effective, Rapid, Automatic Protection Against a Variety of Vehicle Threats
- Crew Compartments
  - HFEs utilizing various agents such as 3M™ Novec™ 1230, HFC-227ea and water based solutions efficiently extinguish crew compartment fires
  - HFEs are well suited for occupied spaces
- Engine & Cargo Compartments
  - SPFEs effectively suppress fire threats in unoccupied engine compartments
  - HFEs and/or SPFEs are useful for vehicle cargo compartment fire protection
- External
  - HFEs dispensing water-surfactant-foam blends are effective against pool fires under or surrounding vehicle

External Fire Threat

Suppressant Discharge

Egress Path Sustained

Advantages of Chemically Active Propellant

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- Inert SPFEs Extinguish Fires Mainly Through the Removal of Oxygen
  - SPFE combustion gases consist of nitrogen, water vapor and carbon dioxide
- Most Acceptable Non-Halon Fire Suppression Fluids are Inert
  - Inert HFEs extinguish fires by removing oxygen and heat
- Chemically Active Propellant Can Be Used in SPFEs and HFEs
  - Increases effectiveness by adding the interruption of the chemical chain reaction to the extinguishment mechanisms
  - Active chemicals present in gas are dispensed along with fluid
- Research Has Validated the Effectiveness of Even a Small Amount of Active Agent
  - Reduced required agent weight by 30-70%
- Chemically Active Propellant Results in Smaller System Weight with Equivalent Effectiveness

Advantages of Chemically Active Propellant

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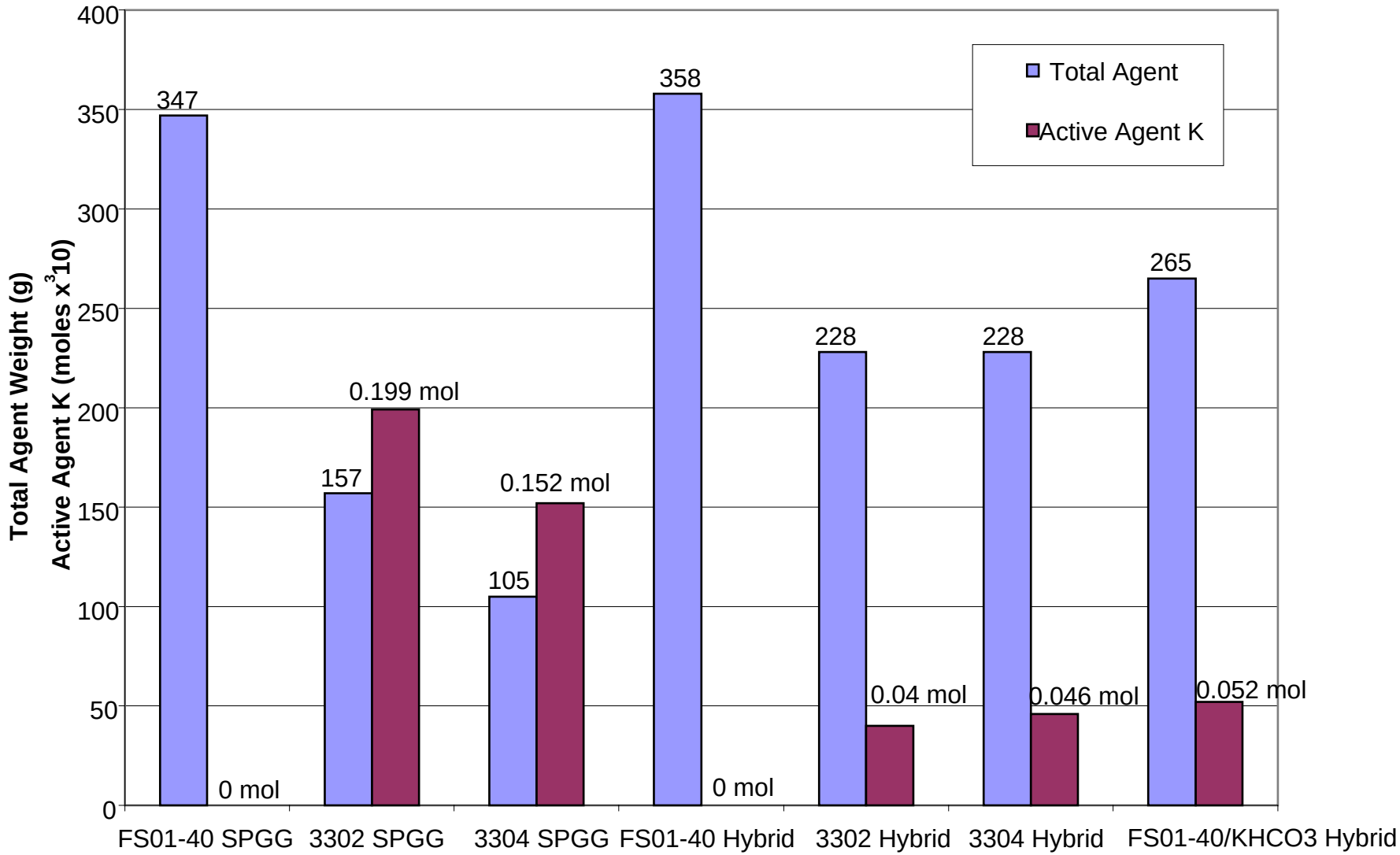

Source Fallis, S.; Reed, R.; McCormick, J. L.; Wilson, K. A.; Holland, G. F. Advanced Propellant/Additive Development for Fire Suppressing Gas Generators. Halon Options Technical Working Conference; 2001 April 24-26; Albuquerque, New Mexico. NIST Building and Fire Research Laboratory. http://www.bfrl.nist.gov/866/HOTWC/proceedings.htm.

Applying HFEs to Aircraft Engine Nacelle Fire Protection

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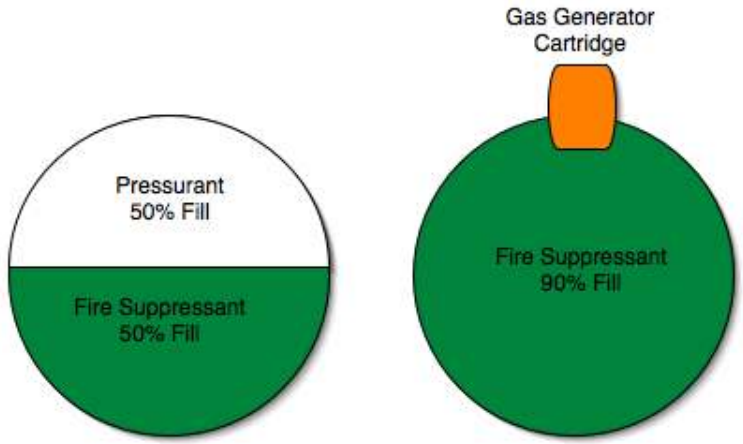
- Typical Engine Nacelle Fire Suppression Systems Use Blown Down Bottles
- Engine Nacelle Systems Configured as HFEs Allow for Higher Density Fill
- Active Propellant Increases Effectiveness of Inert Fire Suppressant
- HFE Vaporizes and Dispenses Fire Suppressant at Cold Temperature
  - Aerojet has conducted cold temperature testing of system with 3M™ Novec™ 1230
  - HFEs offer consistent operation over a wide temperature range
- HFEs Offer a Green Solution that is Non-toxic
- HFEs Can Be Used With or Without Complicated Distribution Systems Depending Upon Aircraft Configuration



HFEs offer more compact fire suppression

HFEs vaporize fire suppressant at cold temperature

Advantages of Using HFEs for Aircraft Fire Protection

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- HFEs Vaporize and Dispense 3M™ Novec™ 1230
  - Zero ozone depletion potential
  - 5 day atmospheric lifetime
  - Global warming potential of 1
  - Safe - effective concentration much less than No Observable Adverse Effects Level (NOAEL)
- HFEs Offer a More Compact Design
  - Higher fill density
  - Active propellant can be utilized to reduce necessary amount of fluid
- HFEs Exhibit Consistent Operation Over a Wide Temperature Range
  - No need to compensate for dispersion difficulties at cold temperature
- HFEs Can Function in Any Orientation
  - Increases flexibility of system integration
- Solid Propellant Gas Generator (pressurization cartridge) Design Can be Tailored to Utilize Existing Bottle and Distribution Designs When Practical
  - Discharge pressure, duration and gas flow-rate are adjustable parameters

Conclusions

- SPFEs are Effective Fire Extinguishers in Aircraft Dry Bay and Vehicle Engine Compartment Applications
- HFEs Have Been Proven Effective for Vehicle Fire Protection Applications
  - Crew Compartments
  - Engine Compartments
  - External Vehicle Fires
  - Rear Impact Collisions
- Active Propellant Increases the Effectiveness and Decreases the Total System Size and Weight for SPFEs and HFEs
- HFE Technology Can Be Used to Create Efficient Fire Suppression Systems for Aircraft
  - Effectively dispenses 3M™ Novec™ 1230
  - Compact design
  - Consistent operation over wide temperature range
  - Drop in replacement when practical