Fire Extinguishing Agents Tested Using the Aircraft Cargo Compartment MPS Standard

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Outline

- Background
- MPS Fire Test Methods
- Fire Extinguishing Agents Tested
- Fire Test Results
- Final Words

BACKGROUND

- FAA requires fire protection systems for Class C aircraft cargo compartments (FAR 25.851 – 857)
- Aircraft industry selected Halon 1301 systems to comply with the FARs
- Halon 1301 is an ozone depleting agent
- Montreal Protocol banned production of Halon 1301 in 1994
- FAA established the IHRWG in 1993
- IHRWG commissioned work to develop MPS tests

BACKGROUND (CONT.)

- In 2000, the FAA published the aircraft cargo compartment MPS for gaseous extinguishing agents
- In 2003, the aircraft cargo compartment MPS was re-published to include non-gaseous extinguishing agents
- In 2005, the 2nd version of the MPS was re-published (Below inert condition)

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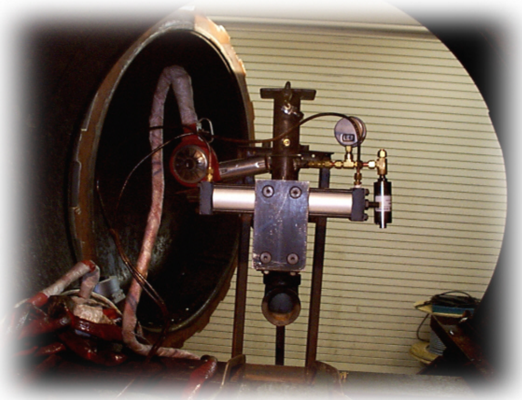
MPS Fire Test Methods

Bulk Load Fires

Containerized Fires

Flammable Liquid Fires



Aerosol Can Explosion Simulation

MPS Fire Test Methods

TEST CELL

- The fire tests are to be conducted inside a simulated below floor cargo compartment of a wide-body aircraft

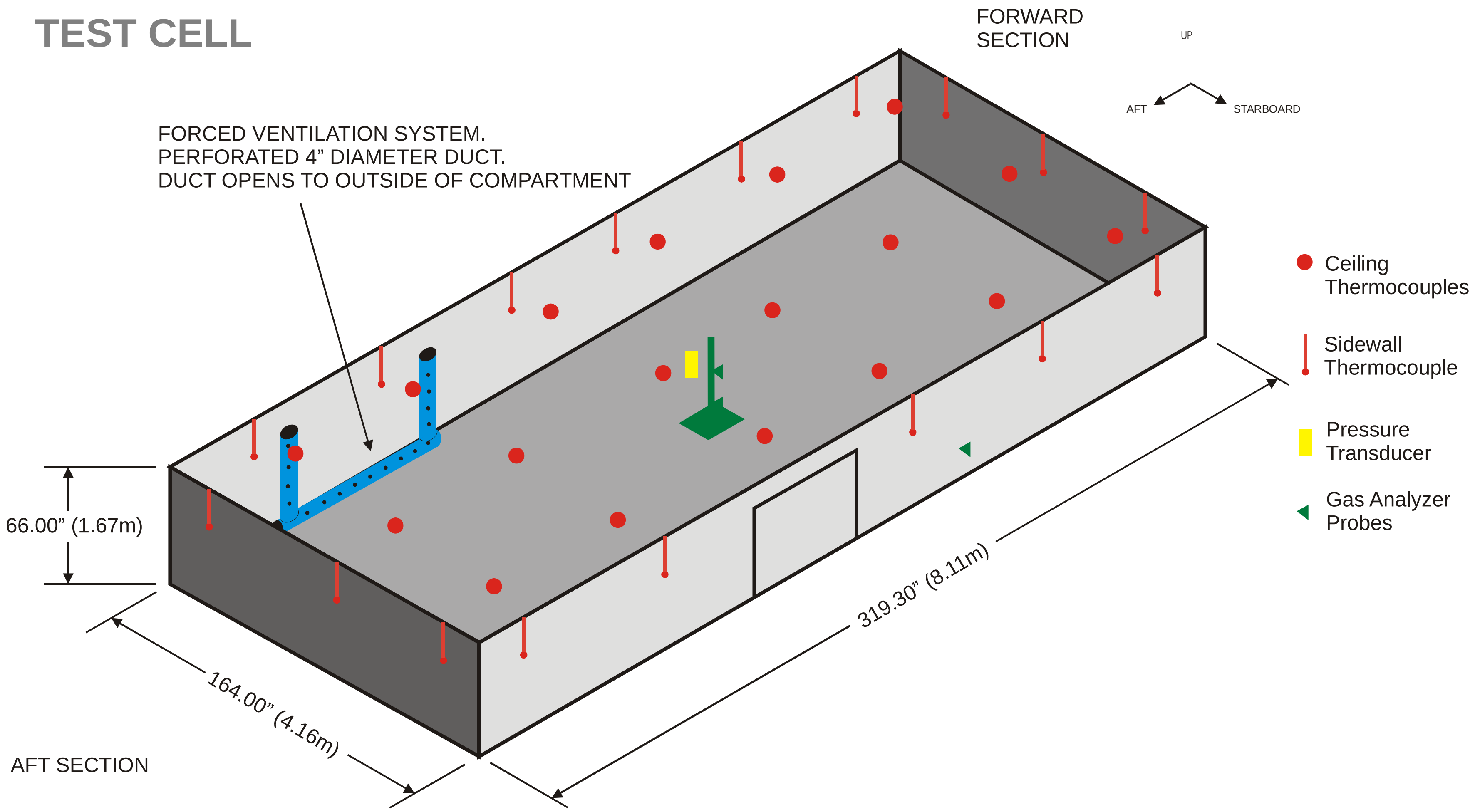
- Cargo Compartment Volume = 2000 ft^3

- Compartment Leak Rate = 50 CFM

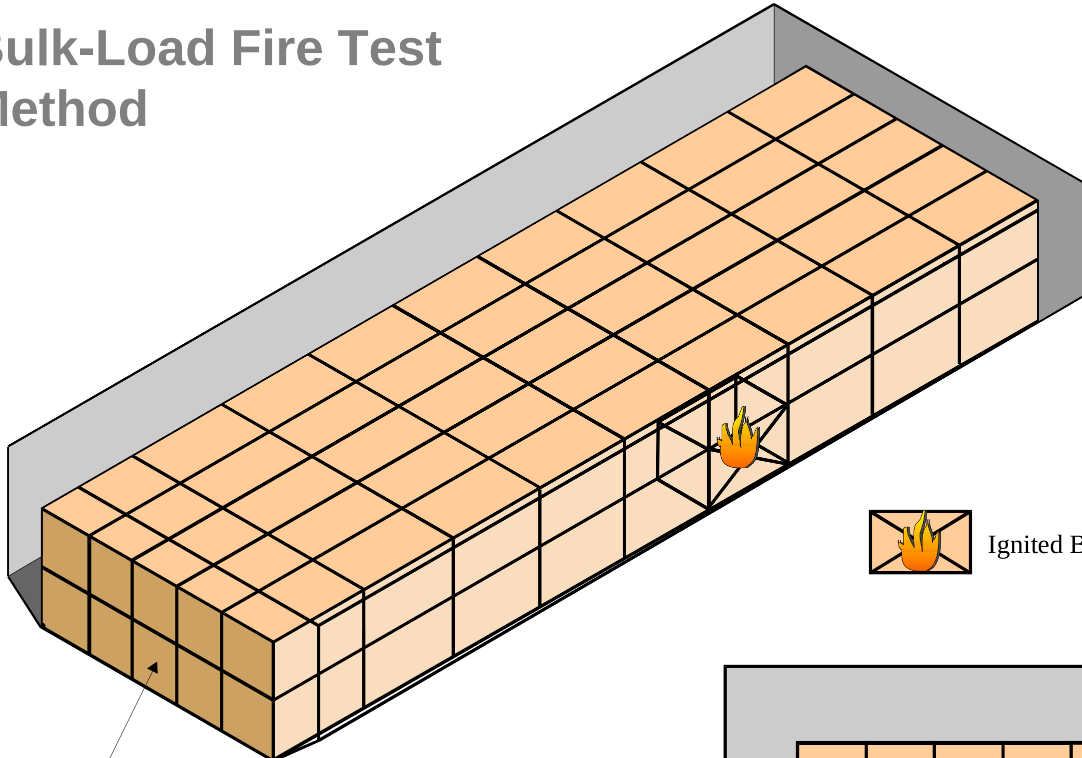
- Instrumented with thermocouples, gas analyzers, and pressure transducers

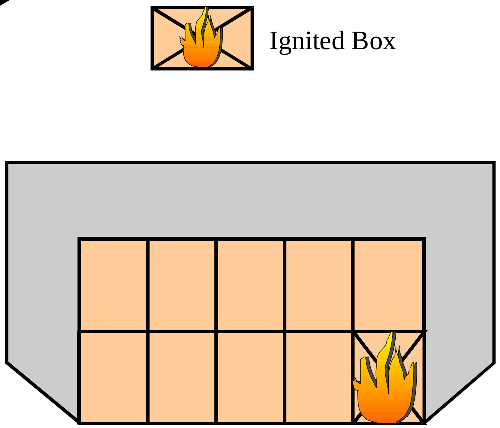
MPS Fire Test Methods

TEST CELL



Bulk-Load Fire Test Method





MPS Fire Test Methods

Bulk-Load Fire Test Method

- **Fire Load =** 178 card board boxes (30% of Vol.) containing 2.5 lbs of shredded office paper (strips, not confetti) at standard room temp.

- **Boxes** nominal dimensions: 18’x18”x18”

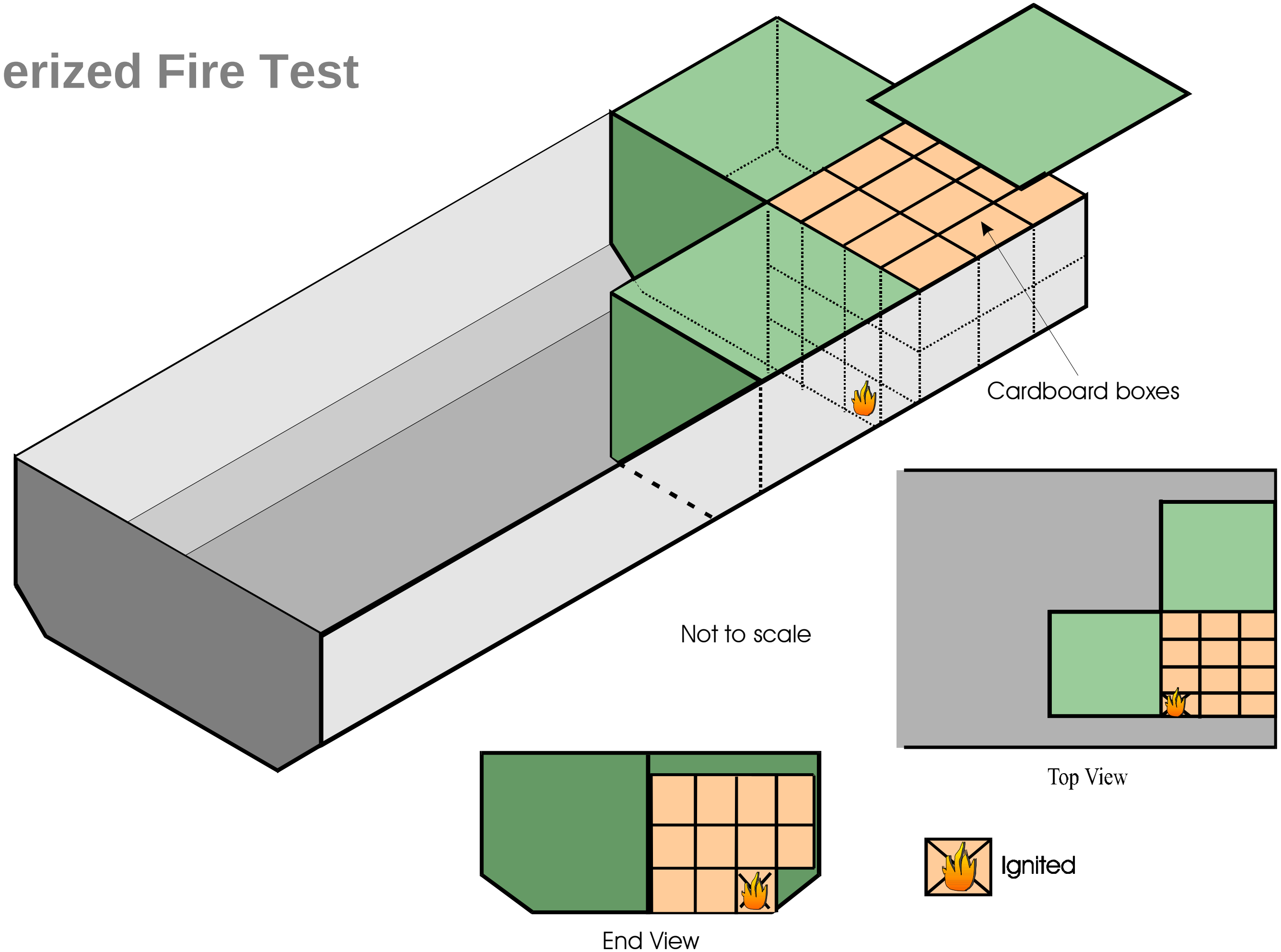
- **Fire Ignition =** 7 ft of nichrome wire wrapped around four folded paper towels (Energized with 120 Vac) inside box (with 1” holes).

- **Fire Suppression System Activation =** 1 minute after one of the ceiling T/C reaches 200 ºF

- **Test Duration =** Four tests @ 30 minutes each; fifth test shall for at least 180 minutes. Hybrid systems shall run for 180 min.

MPS Fire Test Methods

Containerized Fire Test Method



MPS Fire Test Methods

Containerized Fire Test Method

- **Fire Load =** 33 card board boxes inside an LD3. 3 LD3 in Compartment

- **Two ventilation slots** in main LD3 container size 12” x 3” +/-1/4 (access panel, and lower right panel)

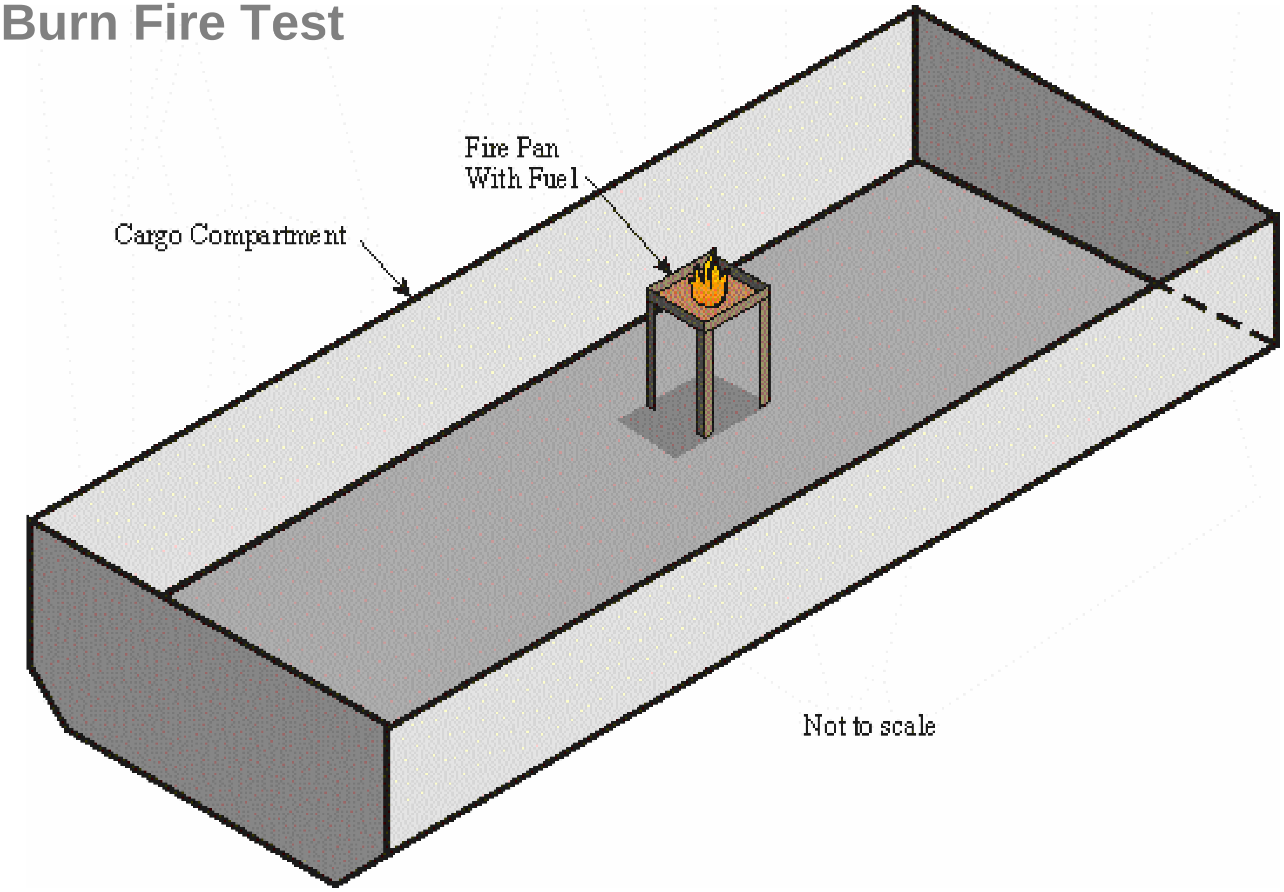
- **The LD3 access panel is made out of 0.08” polycarbonate sheet**

- **Fire Ignition =** 7 ft of nichrome wire wrapped around four folded paper towels (Energized with 120 Vac)

- **FSS Activation =** 1 min. after one of the ceiling T/C reaches 200 ºF

- **Test Duration =** Four tests @ 30 minutes each; fifth test shall for at least 180 minutes. Hybrid systems shall run for 180 min.

Surface Burn Fire Test Method



MPS Fire Test Methods

Surface Burn Fire Test Method

- **Fire Load =** 0.5 U.S. Gallon of Jet A fuel inside a 2 ft x 2 ft x 0.33 ft pan

- **Add 13 oz of gasoline** to make ignition easier; add 2.5 gallons of **water** to reduce pan warping.

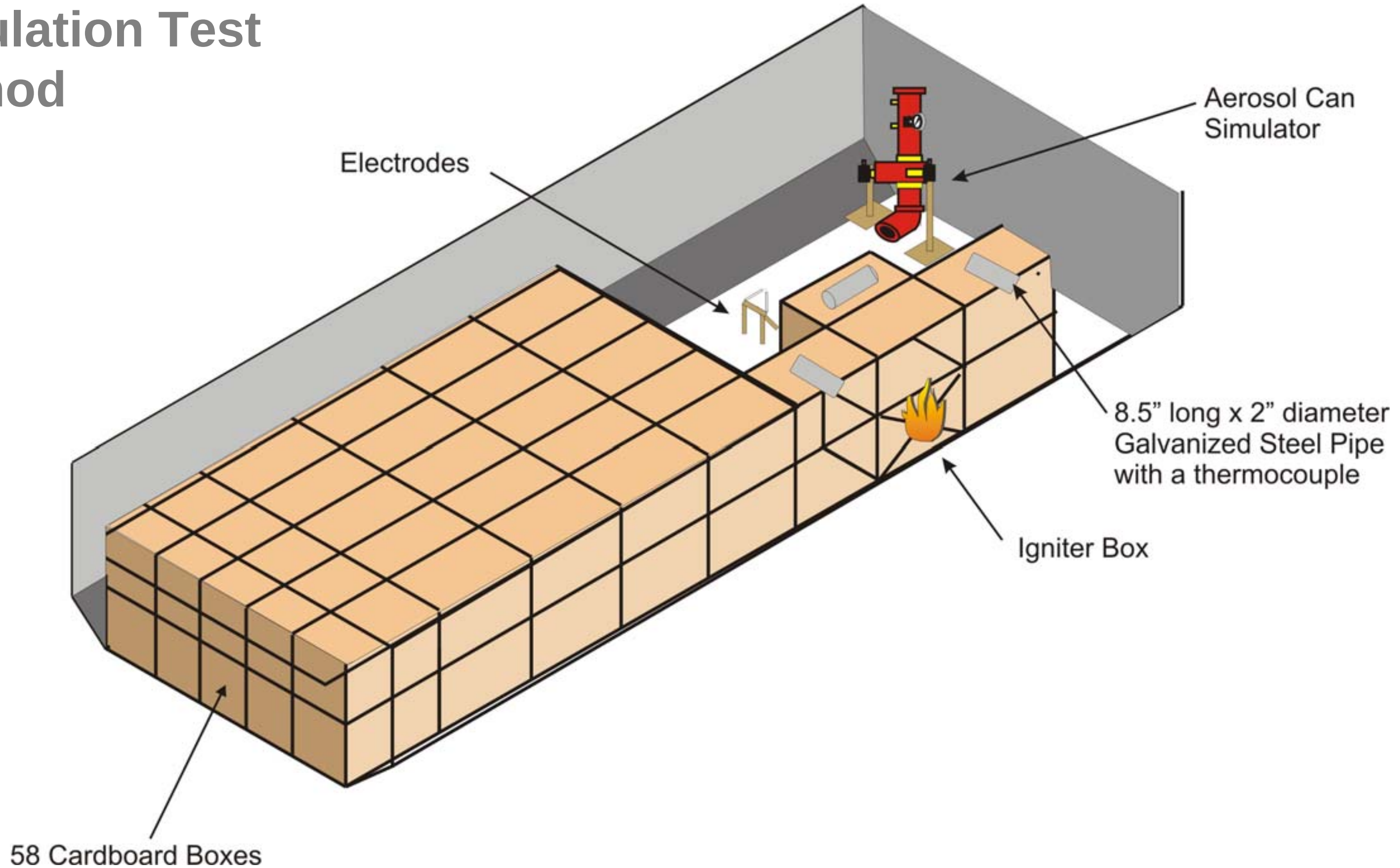
- **Place pan in most difficult location (1 ft)**

- **Fire Ignition =** Arc created by two electrodes

- **FSS Activation =** 1 min. after one of the ceiling T/C reaches 200 ºF

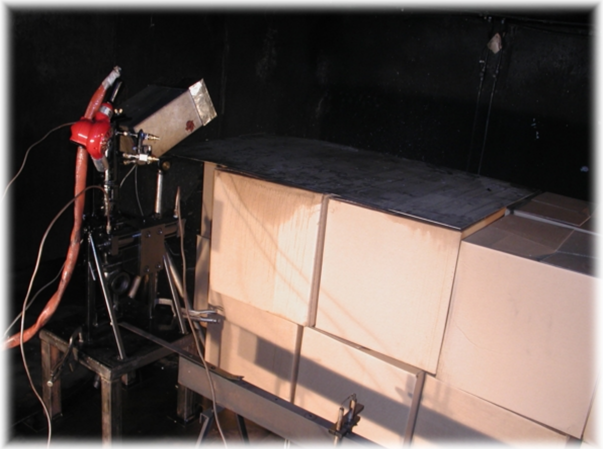
- **Test Duration =** 5 minutes after agent discharge

Aerosol Can Explosion Simulation Test Method



MPS Fire Test Methods

Aerosol Can Explosion Simulation Test Method



- **Fire Load:**
Simulator - 0.2 lb. Propane, 0.6 lb. of denatured alcohol, 0.2 lb of water
Cargo Bay - 59 cardboard boxes

- **Ignition Sources =** Nichrome wire/paper towel and electrodes (away from sim).

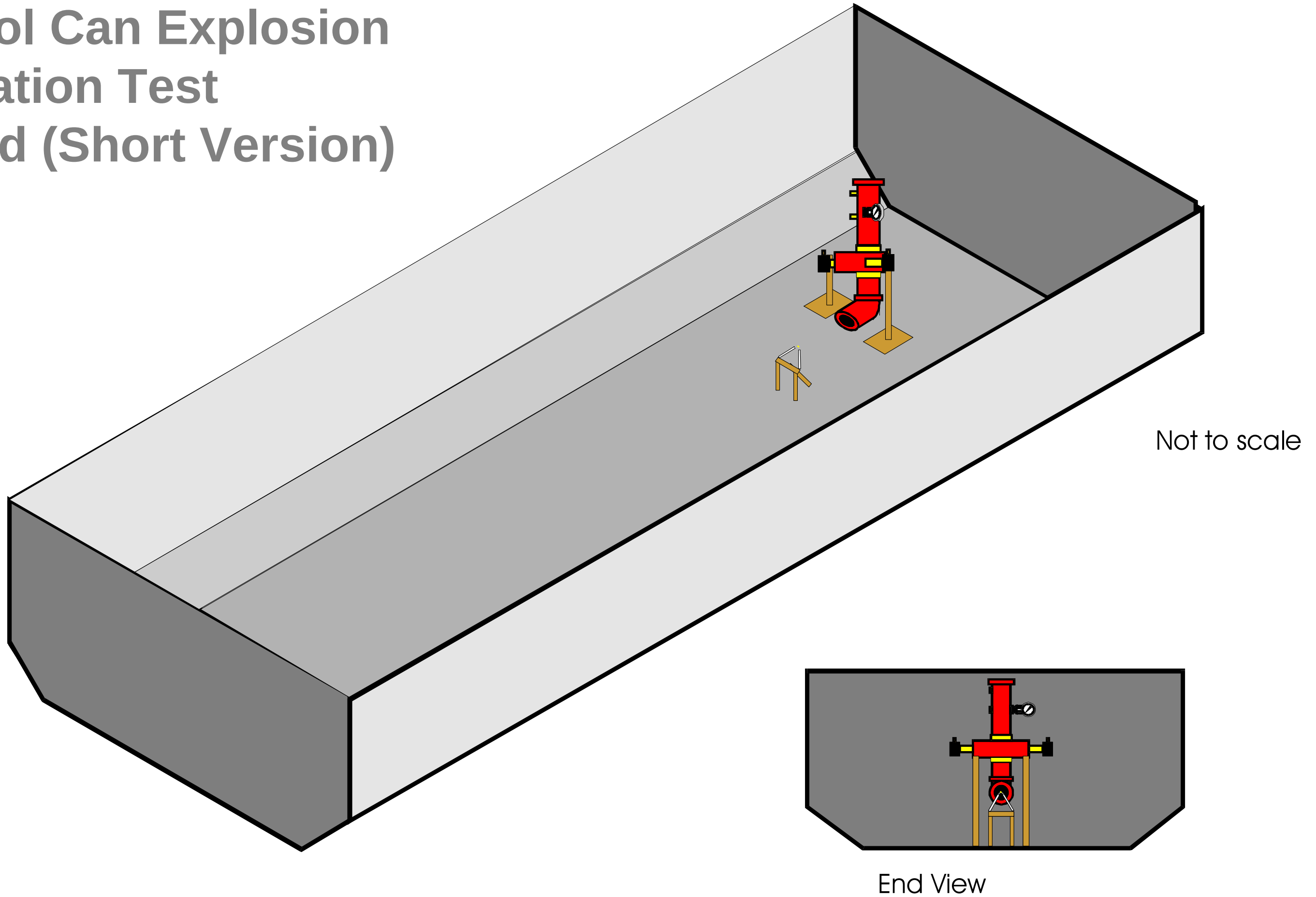
- **FSS Activation =** 1 min. after one of the ceiling T/C reaches 200 ºF

- **Heat up simulator** to increase pressure in content chamber to 210 psig

- **Aerosol Can Simulator Activation =** 5 minutes after one of the TCs, attached to the pipes, reaches 400 degF.

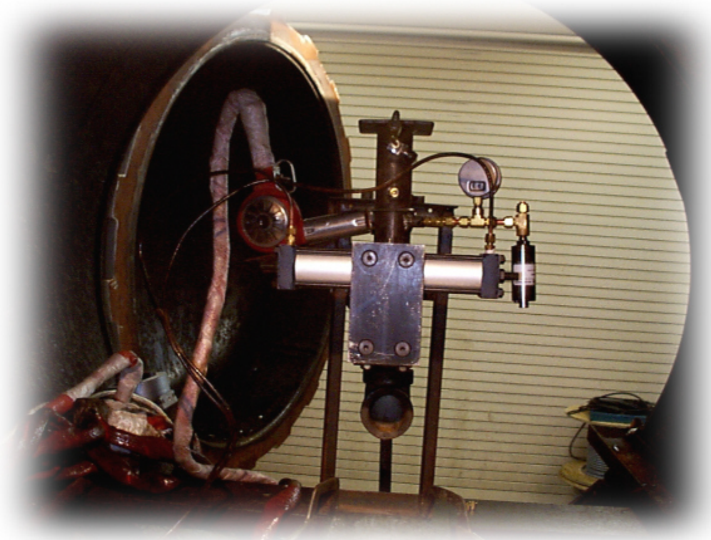
- **Test Duration =** shall be conducted for at least 180 minutes or until the simulator is activated.

Aerosol Can Explosion Simulation Test Method (Short Version)



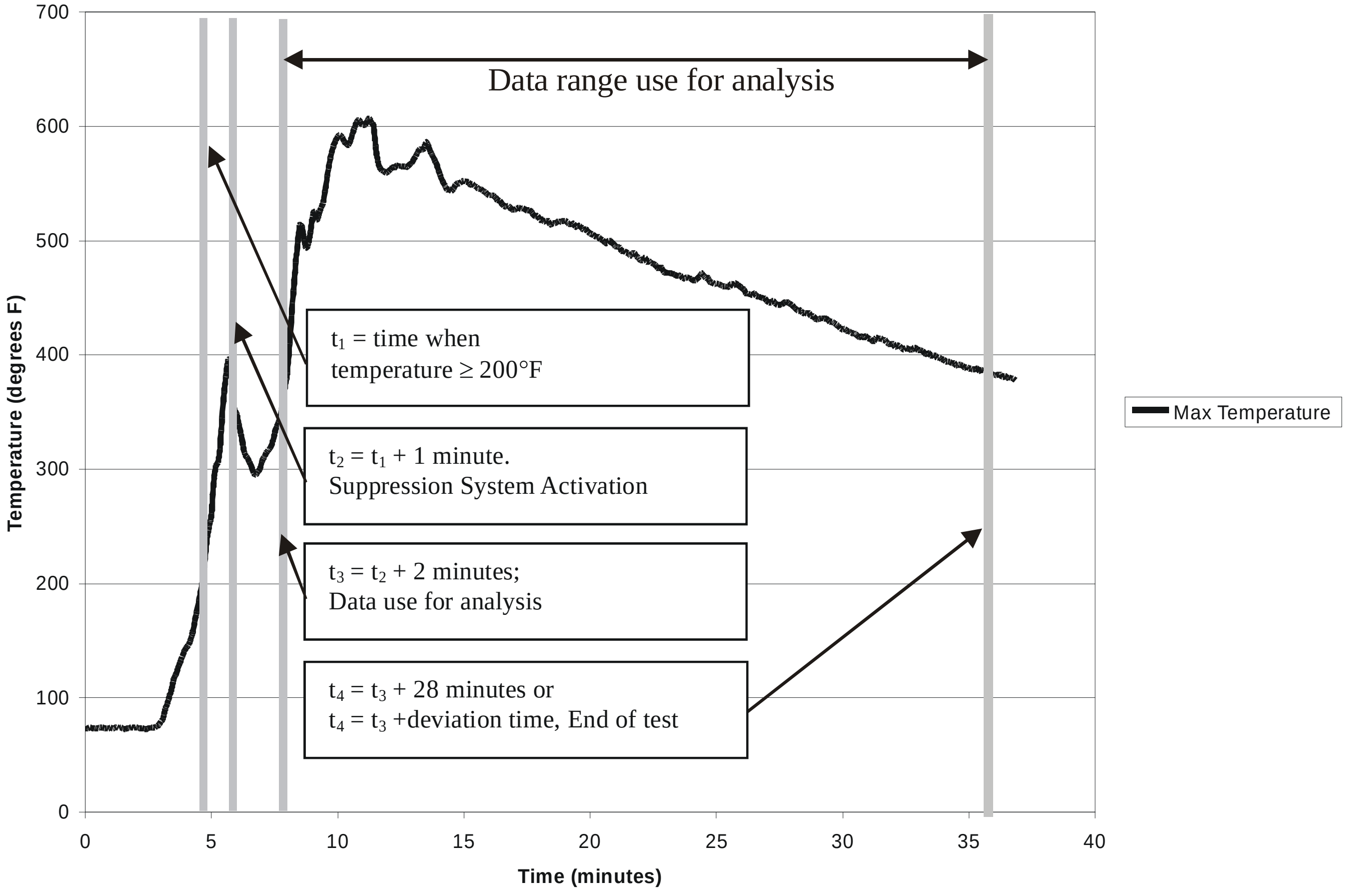
MPS Fire Test Methods

Aerosol Can Explosion Simulation Test Method (Short Version)



- **Fire Load =** 0.2 lb. Propane, 0.6 lb. of Denatured Alcohol, 0.2 lb of water
- **Ignition =** Arc created by two electrodes (230 W) that are 2 ft from the floor and 3 ft away from the simulator
- **Test Initiation =** Discharge agent and allow 2 minutes for dispersion
- **Simulator Activation =** When the agent, at 2 feet from the floor, is at the minimum protection concentration (must be measured)
- **Test Duration =** After the simulator is activated and data saved.

Acceptance Criteria



For Bulk Load, Containerized, Surface Burn Tests Only

MPS Fire Test Methods

Acceptance Criteria

FIRE SCENARIO	MAXIMUM TEMPERATURE ^{o}F (^{o}C)	MAXIMUM TIME-TEMPERATURE AREA ^{o}F -MIN (^{o}C-MIN)	PRESSURE PSIG (KPa)	COMMENTS
Bulk Load	720 (382)	9940 (5504)	N/A	Use the data that is between 2 minutes and 28 minutes after suppression system activation. See figure.
Containerized Load	650 (343)	14040 (7782)	N/A	Use the data that is between 2 minutes and 28 minutes after suppression system activation. See figure.
Surface Burn	570 (299)	1230 (665)	N/A	Use the data that is between 3 minutes and 5 minutes after reaching 200 degF.
Aerosol Explosion	N/A	N/A	0	There shall be no evidence of an explosion. No enhancement of explosion at below inert.

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Fire Extinguishing Agents Tested

Compound	Atmospheric Lifetime (yrs)	ODP	GWP_{100}
2-BTP (CH_2CBrCF_3)	0.008	0	Not Available
FK-5-1-12 ($CF_3CF_2C(O)CF(CF_3)_2$)	0.014	0	1
FM-200 (CF_3CHFCF_3)	36.5	0	3,800
Halon 1301 (CF_3Br), Baseline	65	12	6,900
HFC-125 (CF_3CF_2H)	29	0	3,400
Water Mist/N2	Not Applicable	0	Not Applicable

Fire Extinguishing Agents Tested

Compound	State	Use Concentration	NOAEL
2-BTP (CH_2CBrCF_3)	Liquid	6% (6%)	0.5%
FK-5-1-12 ($CF_3CF_2C(O)CF(CF_3)_2$)	Liquid	>4.2% (8.1%)	10%
FM-200 (CF_3CHFCF_3)	Gas	>8.5%	9%
Halon 1301 (CF_3Br), Baseline	Gas	5% (6%)	5%
HFC-125 (CF_3CF_2H)	Gas	>11.3% (15.6%)	7.5%
Water Mist/N2	Liquid/Gas	66g/m3 (<12% O2)	<19.5% O2 OSHA

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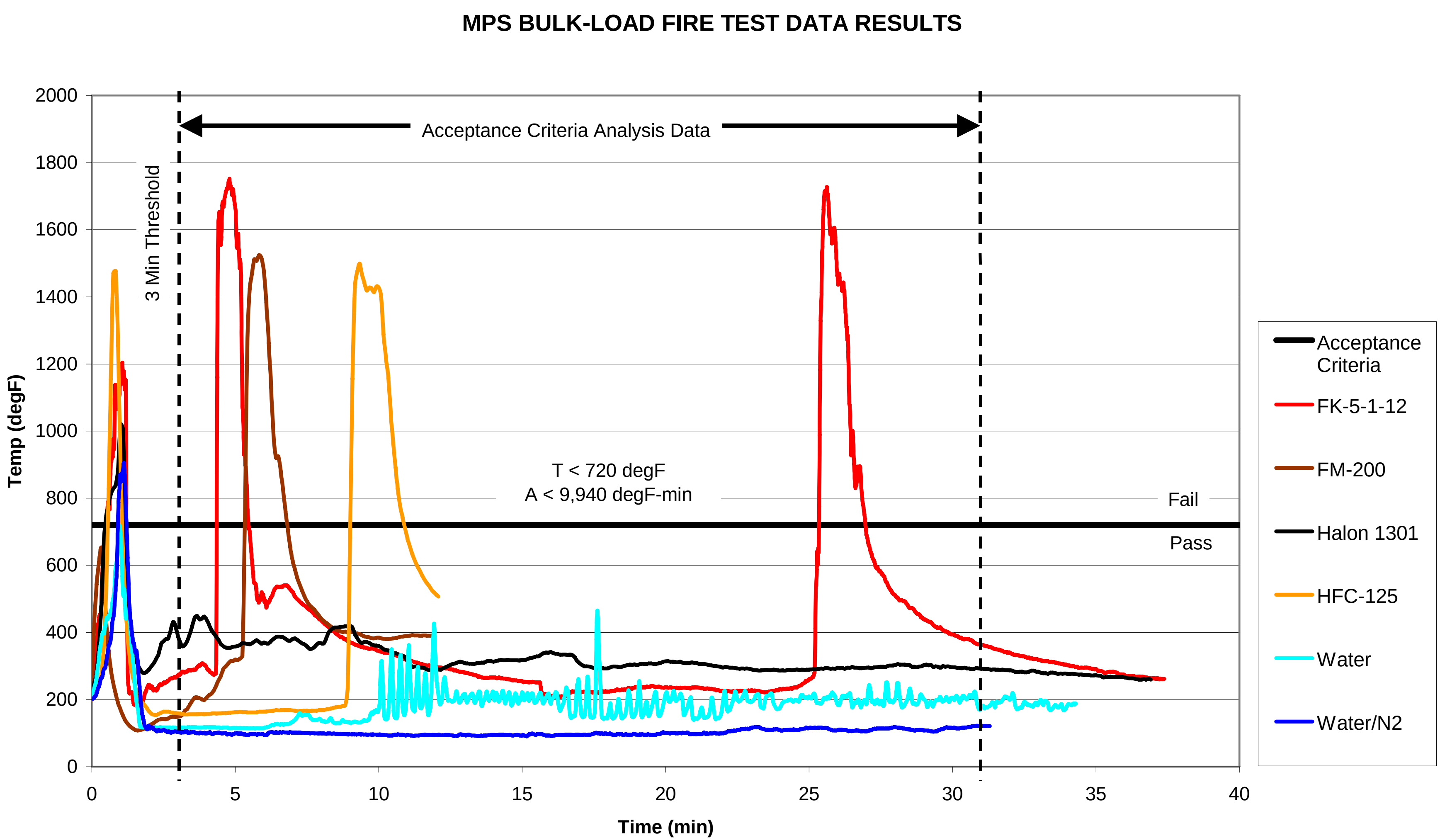
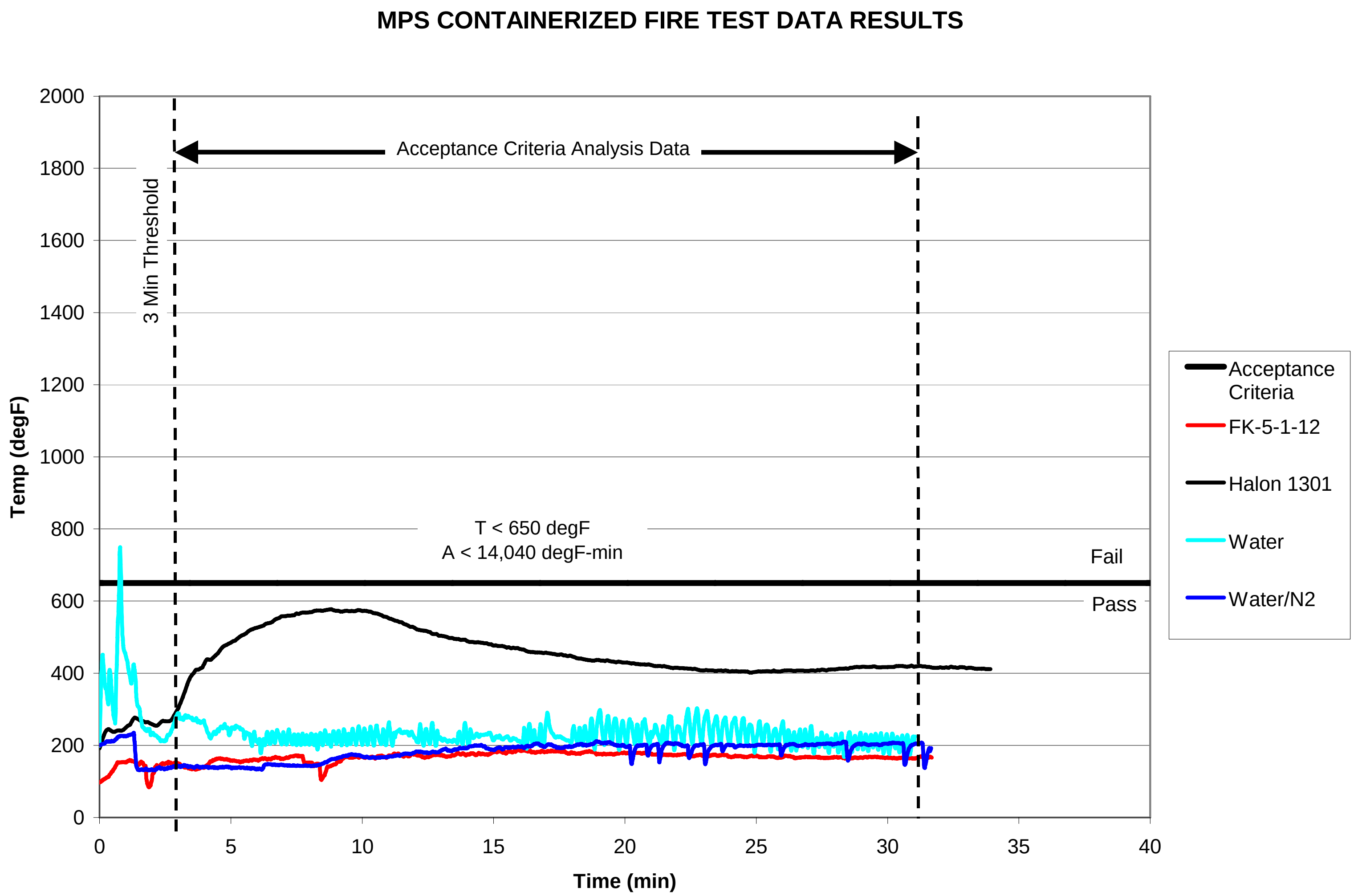
Bulk-Load Fire Test Movie

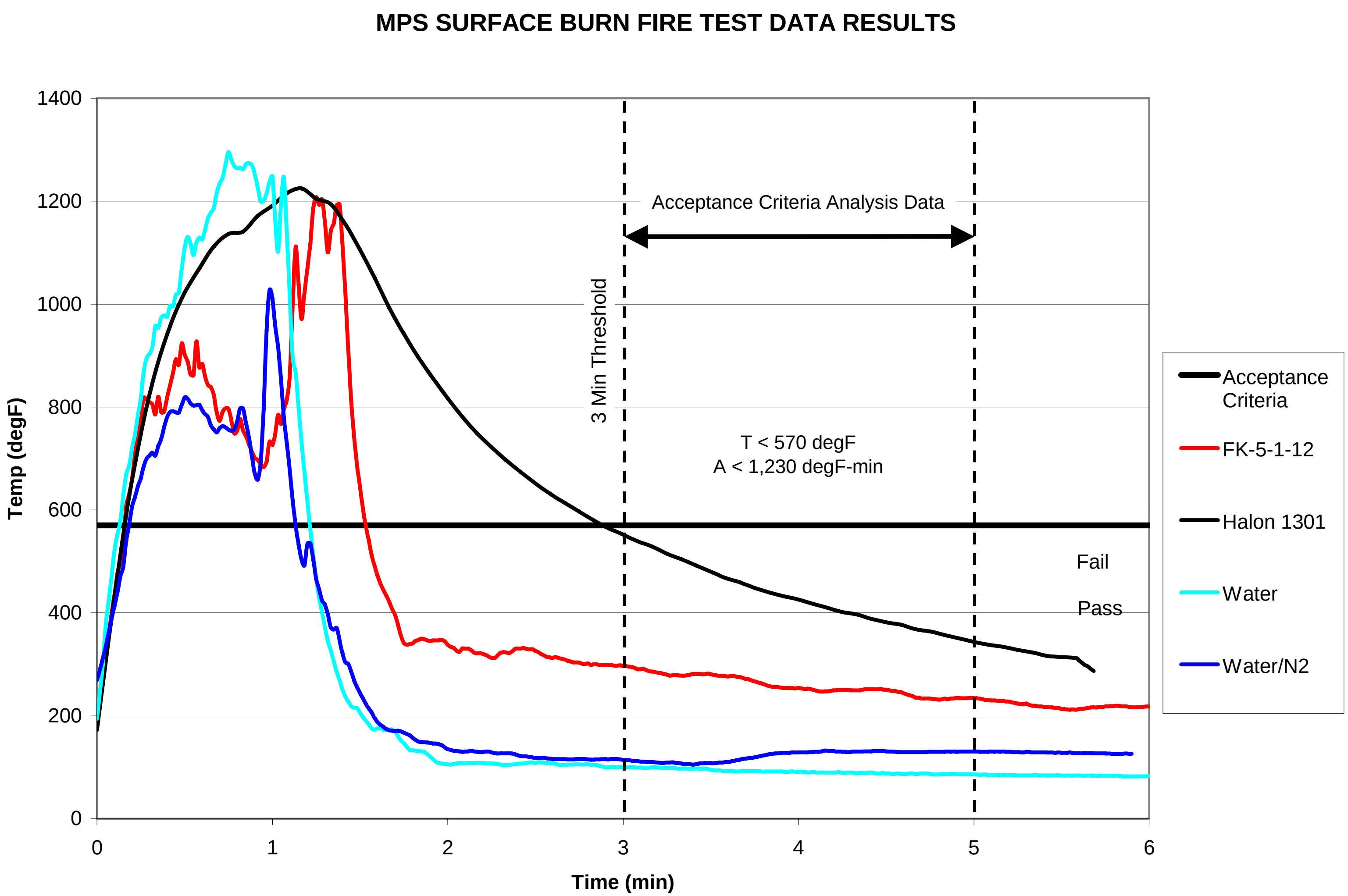
Fire Test Results



Fire Test Results



Fire Test Results



Aerosol Can Explosion Simulation Pre-Test (Screening) Method

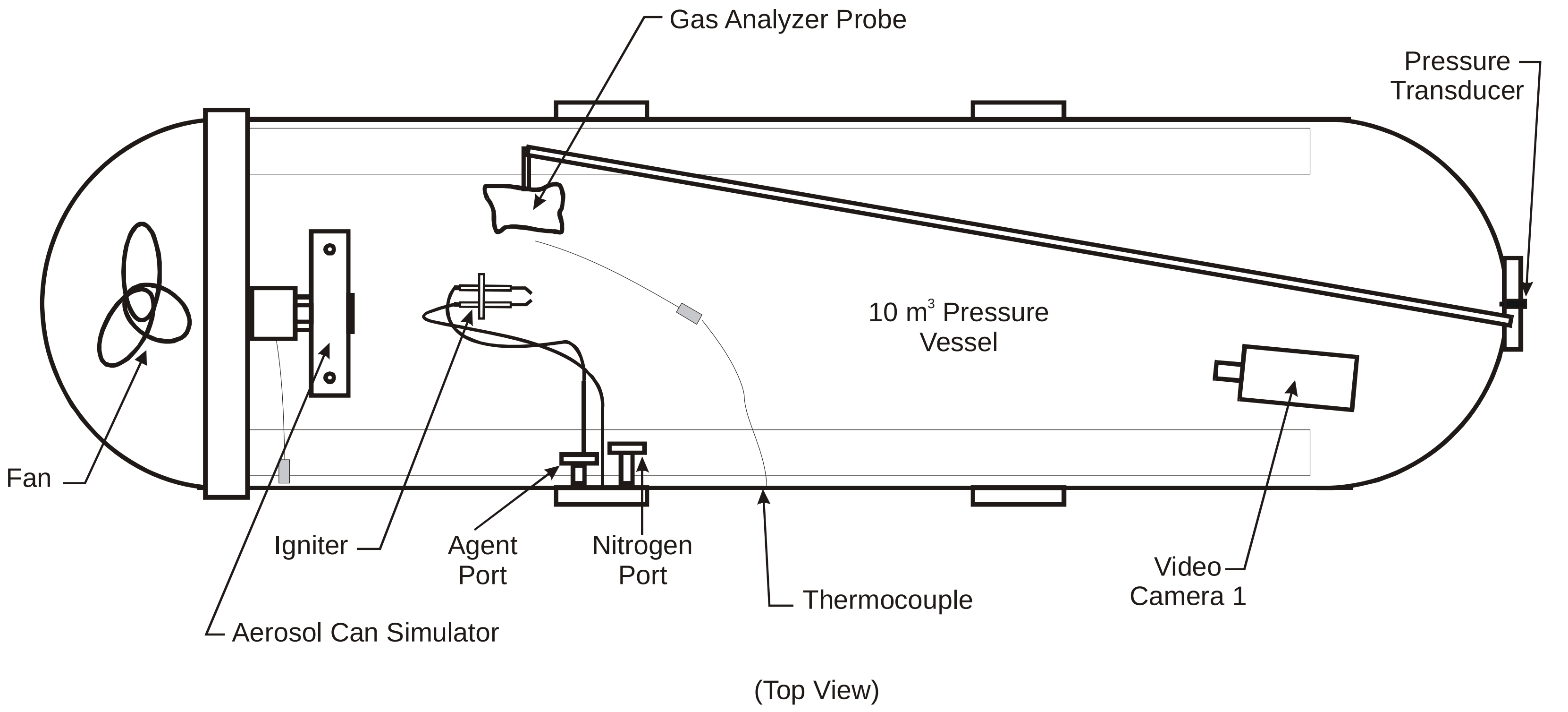
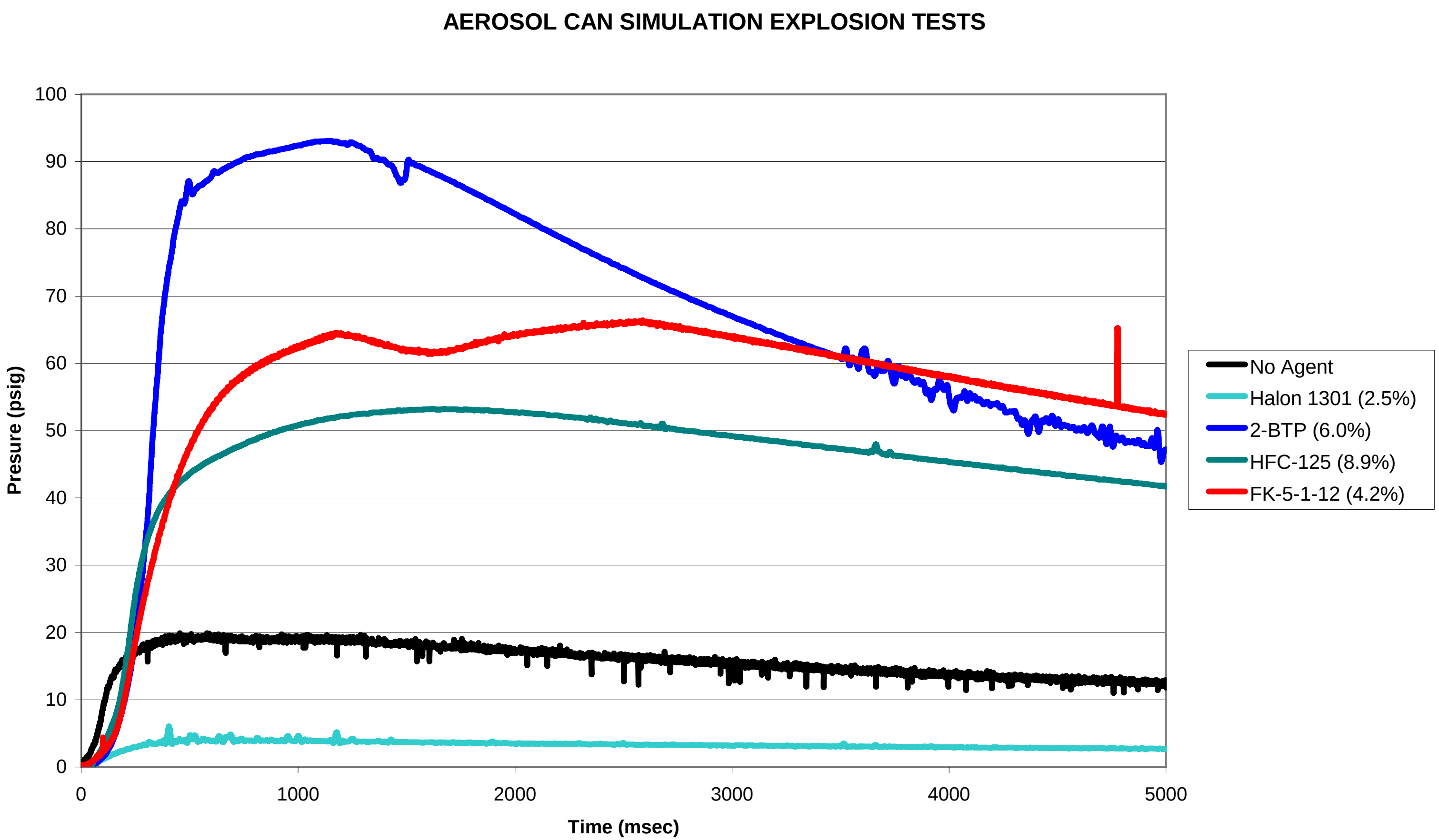


FIGURE 1. PRESSURE VESSEL SETUP

Fire Test Results



COMPARISON OF OVERPRESSURE HISTORIES OF VARIOUS AGENTS

Fire Test Results

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Aerosol Can Explosion Test (Baseline: No XA)

Fire Test Results

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Aerosol Can Explosion Test (Fuel Enhanced)

Fire Test Results

EXT. AGENT	BULK LOAD FIRE TEST	CONTAINERIZED FIRE TEST	SURFACE BURN FIRE TEST	AEROSOL EXPLOSION TEST	COMMENT
2-BTP	Not Tested	Not Tested	Not Tested	Failed (Below Inert)	Agent became part of the fuel that caused significant re-ignition temperatures and explosion enhancement. To prevent these events, it must be at inert concentrations (6%). See report DOT/FAA/AR-TN04/4
FK-5-1-12	Failed	Passed	Passed	Failed (Below Inert)	Agent became part of the fuel that caused significant re-ignition temperatures and explosion enhancement. To prevent these events, it must be at inert concentrations (8.1%). High dielectric strength (+). Report not available at this time.
FM-200	Failed	Not Tested	Not Tested	Expected to Fail (Below Inert)	Agent became part of the fuel that caused significant re-ignition temperatures and explosion enhancement. To prevent these events, it must be at inert concentrations (12%). See report DOT/FAA/AR-TN04/4
Halon 1301	Passed	Passed	Passed	Passed	It is the baseline and the acceptance criteria is based on its performance. See report DOT/FAA/AR-TN05/20
HFC-125	Failed	Data Not Available	Data Not Available	Failed (Below Inert)	Agent became part of the fuel that caused significant re-ignition temperatures and explosion enhancement. To prevent these events, it must be at inert concentrations (15.6%). See report DOT/FAA/AR-TN04/4
Water Mist	Passed	Passed	Passed	Failed	See report DOT/FAA/AR-01/121
Water Mist & Nitrogen	Passed	Passed	Passed	Passed	See report DOT/FAA/AR-01/121

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In Summary,

- The FAA has a test protocol available to determine the fire suppression performance of new Halon 1301 replacement/alternative systems (for certification).

- Out of the seven agents/systems tested, only water mist combined with nitrogen is capable of meeting the MPS for aircraft cargo compartment.

- The FAA Fire Safety Team will continue evaluating agents/systems as they emerge and gain supports from industry.