# Minimum Performance Standard

## For Aircraft Cargo Compartment Built-In Fire Suppression Systems




**THE FOURTH TRIENNIAL INTERNATIONAL AIRCRAFT FIRE CABIN SAFETY RESEARCH CONFERENCE**
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# Outline

- Development of MPS to Address Aircraft Cargo Compartment Fire Suppression Systems

- Latest MPS for Aircraft Cargo Compartments

- Full-Scale Evaluation Fire Tests of New Agents

# Development

Federal Aviation Regulations and Joint Airworthiness Requirements, such as 25.851 - 25.857, require fire protection systems for Class C aircraft cargo compartments

In the past, the aircraft industry has selected Halon 1301 total flood fire suppression systems as the most effective systems for complying with the FARs. But, it is an ozone depleting agent.

Because of the ban on production of Halon 1301 (Montreal Protocol, 1994), new fire suppression systems will need to be certified when the use of halon is no longer viable.

# Development

In 1994, the FAA sponsored International Halon Replacement Working Group created a task group to develop the MPS for aircraft cargo compartment. IHRWG is now IAFPSWG.

The FAATC Fire Safety Section developed the standard, in conjunction with the IAFPSWG task group members, and ran the necessary tests to back the developed document.

The MPS document defines the fire test protocols required to test Halon 1301 replacements/alternatives.

# Development

## MPS Published Documents:

- Development of a Minimum Performance Standard for Aircraft Cargo Compartment Gaseous Fire Suppression Systems (DOT/FAA/AR-00/28, Sept 2000)

- "Minimum Performance Standard for Aircraft Cargo Compartment Halon Replacement Fire Suppression Systems" (DOT/FAA/AR-TN03/6, April 2003)

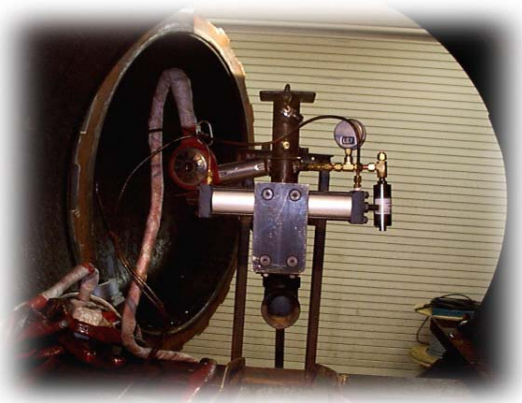
- Update to report DOT/FAA/AR-TN03/6, expected by December 2004.

# Cargo MPS

Bulk Load Fires

Containerized Fires

Flammable Liquid Fires



Aerosol Can Explosion Simulation

# Cargo MPS

## TEST ARTICLE

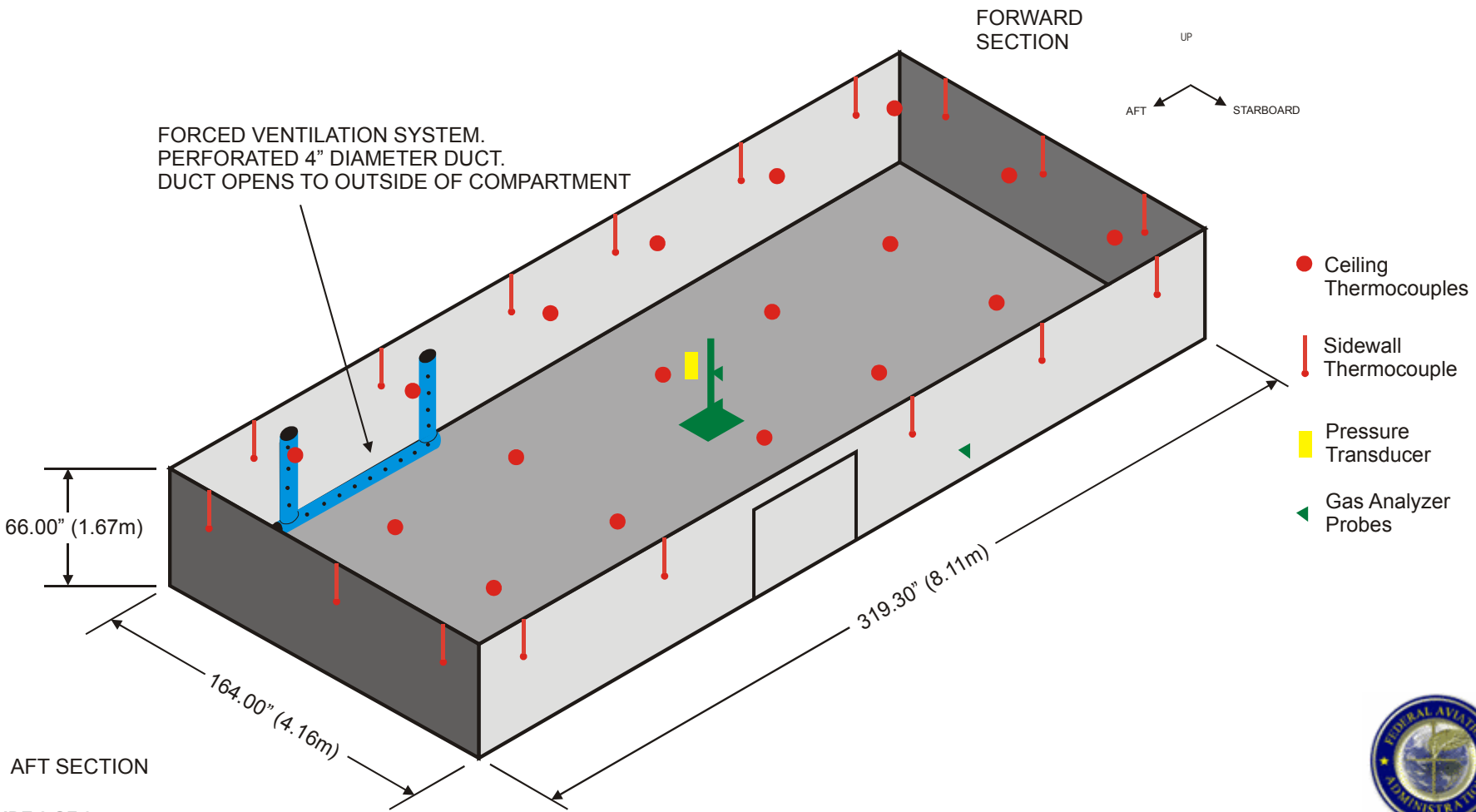
The fire tests are to be conducted inside a simulated below floor cargo compartment of a wide-body aircraft

Cargo Compartment = 2000 $ft^3$

Leak Rate = 50 CFM

Instrumented with thermocouples, gas analyzers, and pressure transducers

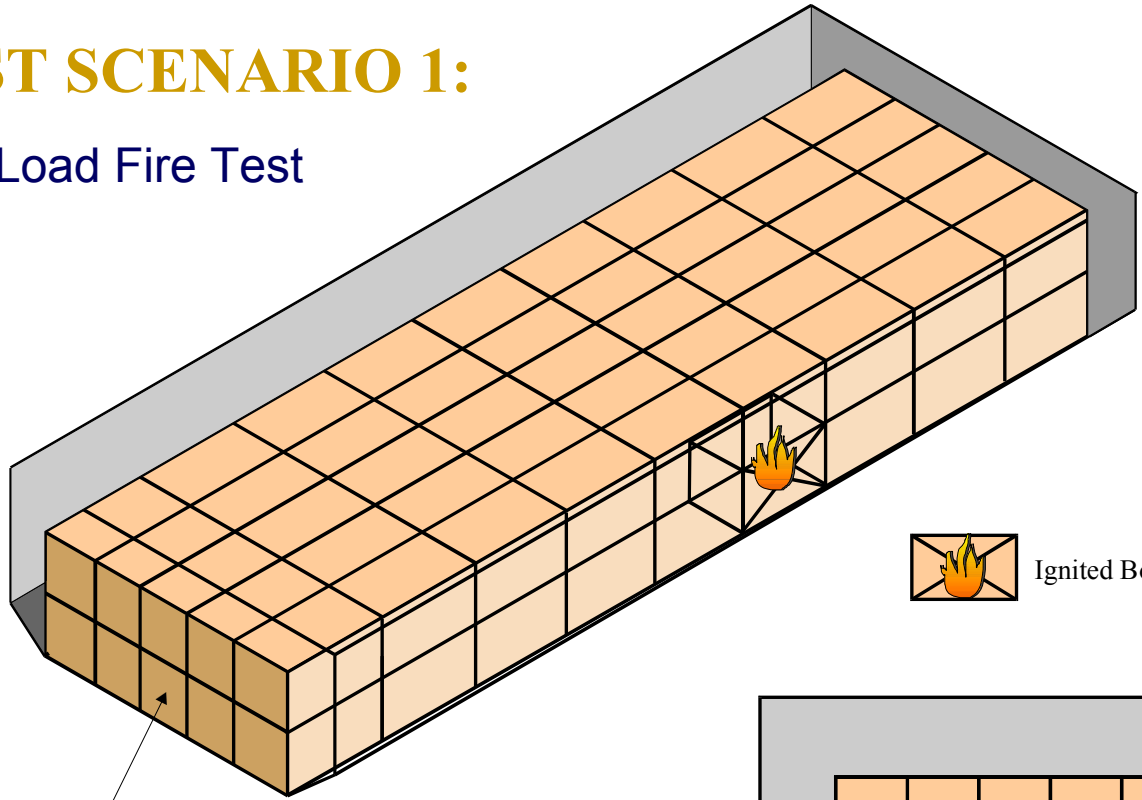
# Cargo MPS


FORWARD
SECTION
UP
AFT
STARBOARD
FORCED VENTILATION SYSTEM.
PERFORATED 4” DIAMETER DUCT.
DUCT OPENS TO OUTSIDE OF COMPARTMENT
Ceiling
Thermocouples
Sidewall
Thermocouple
Pressure
Transducer
Gas Analyzer
Probes
66.00” (1.67m)
319.30” (8.11m)
164.00” (4.16m)
AFT SECTION

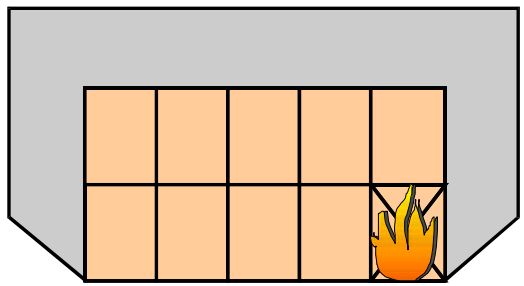
# Cargo MPS

## TEST SCENARIO 1:

Bulk-Load Fire Test




Ignited Box



# Cargo MPS

## BULK-LOAD TEST

Fire Load = 178 card board boxes (30% of Vol.) containing 2.5 lbs of shredded paper

Ignition = nichrome wire wrapped around folded paper towels

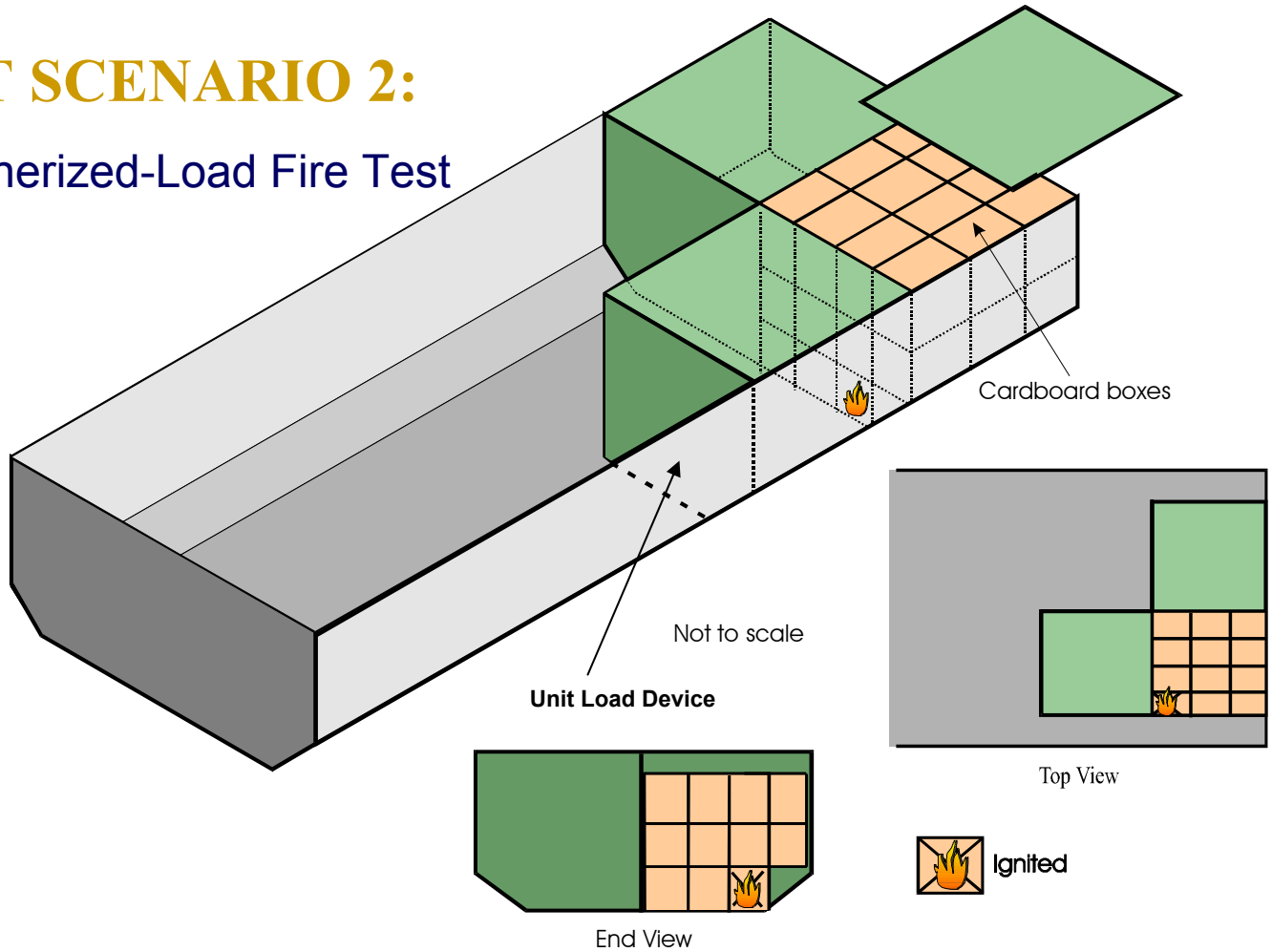
System Activation = 1 min. after one of the ceiling T/C reaches 200 $^{o}$F

Test Duration = Five tests @ 30 minutes each

# Cargo MPS

## TEST SCENARIO 2:

### Containerized-Load Fire Test



# Cargo MPS

## CONTAINERIZED-LOAD TEST

Fire Load = 33 card board boxes inside an ULD3. 3 ULD3 in Compartment

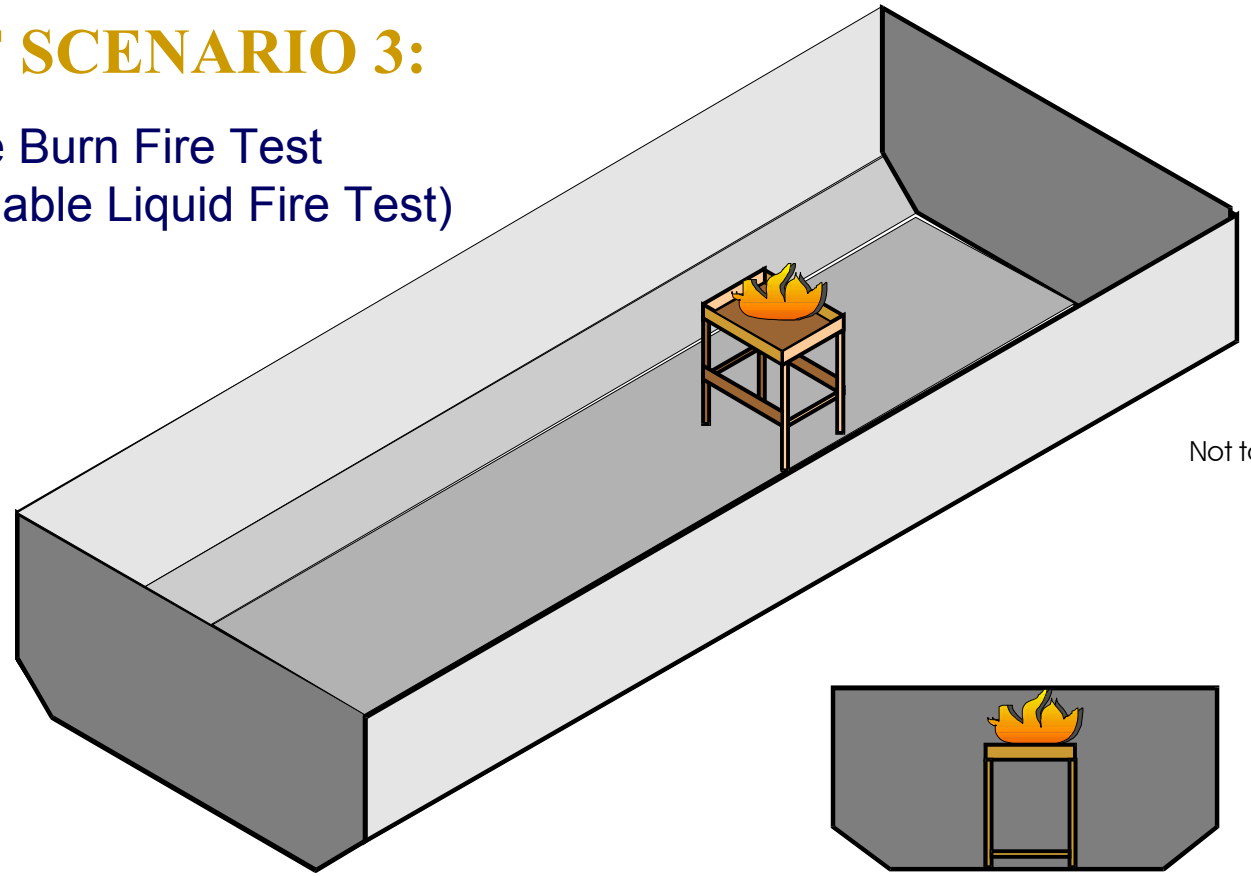
Ignition = nichrome wire wrapped around folded paper towels

System Activation = 1 min. after one of the ceiling T/C reaches 200 $^{o}$F

Test Duration = Five tests @ 30 minutes each

## TEST SCENARIO 3:

Surface Burn Fire Test
(Flammable Liquid Fire Test)



Not to scale



End View

# Cargo MPS

## SURFACE BURN FIRE TEST

Fire Load = 0.5 U.S. Gallon of Jet A fuel (with 13 oz of gasoline)

Ignition = Arc created by two spark plugs

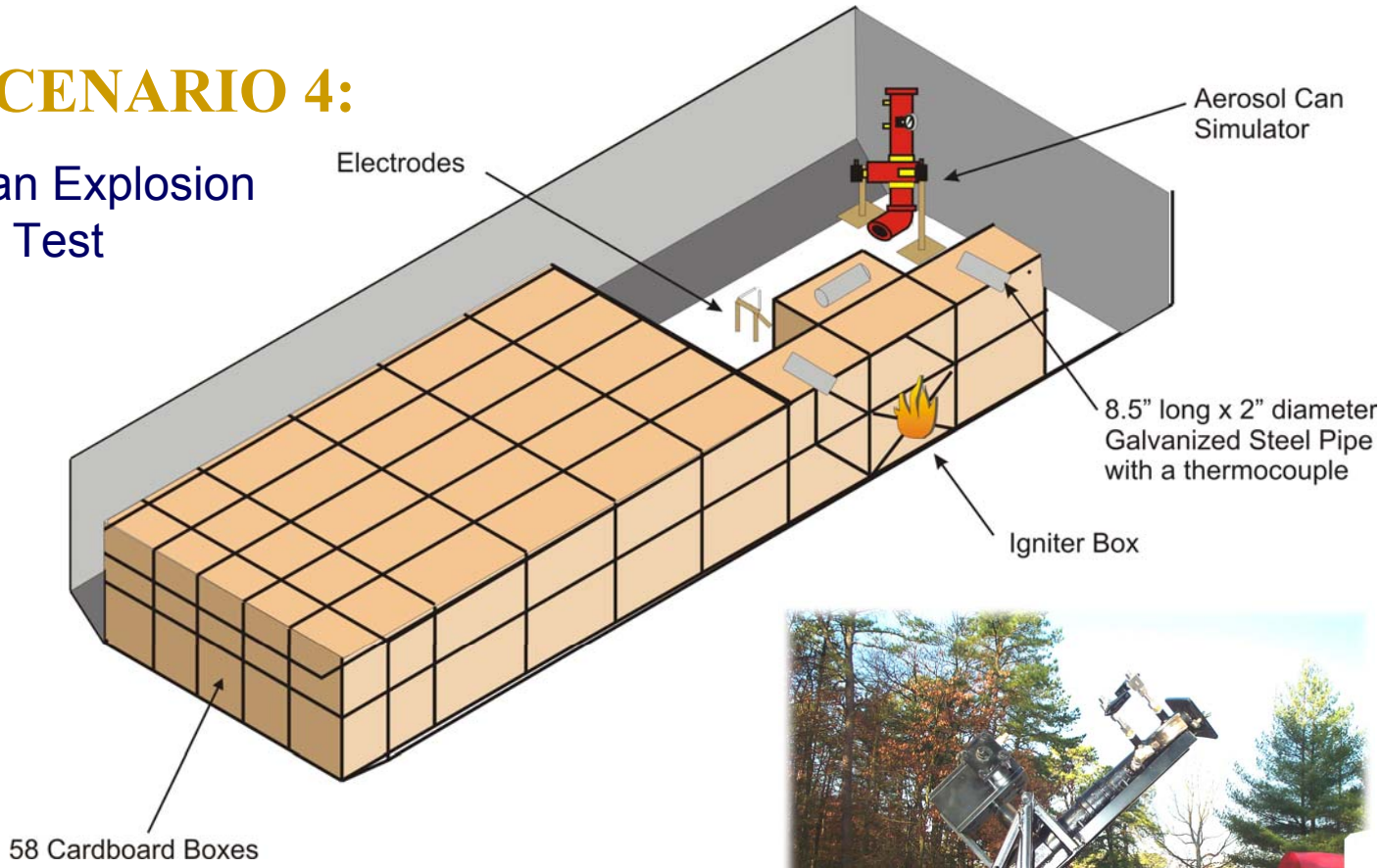
System Activation = 1 min. after one of the ceiling T/C reaches 200 $^{o}$F

Test Duration = 5 minutes

# Cargo MPS

## TEST SCENARIO 4:

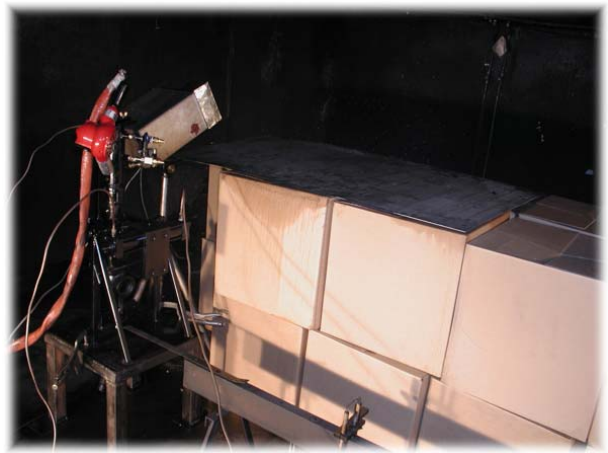
Aerosol Can Explosion Simulation Test



# Cargo MPS

## AEROSOL EXPLOSION TEST

**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 (3 ft away from simulator)**

**Fire Suppression System Activation = 1 min. after one of the ceiling thermocouple reaches 200 °F**

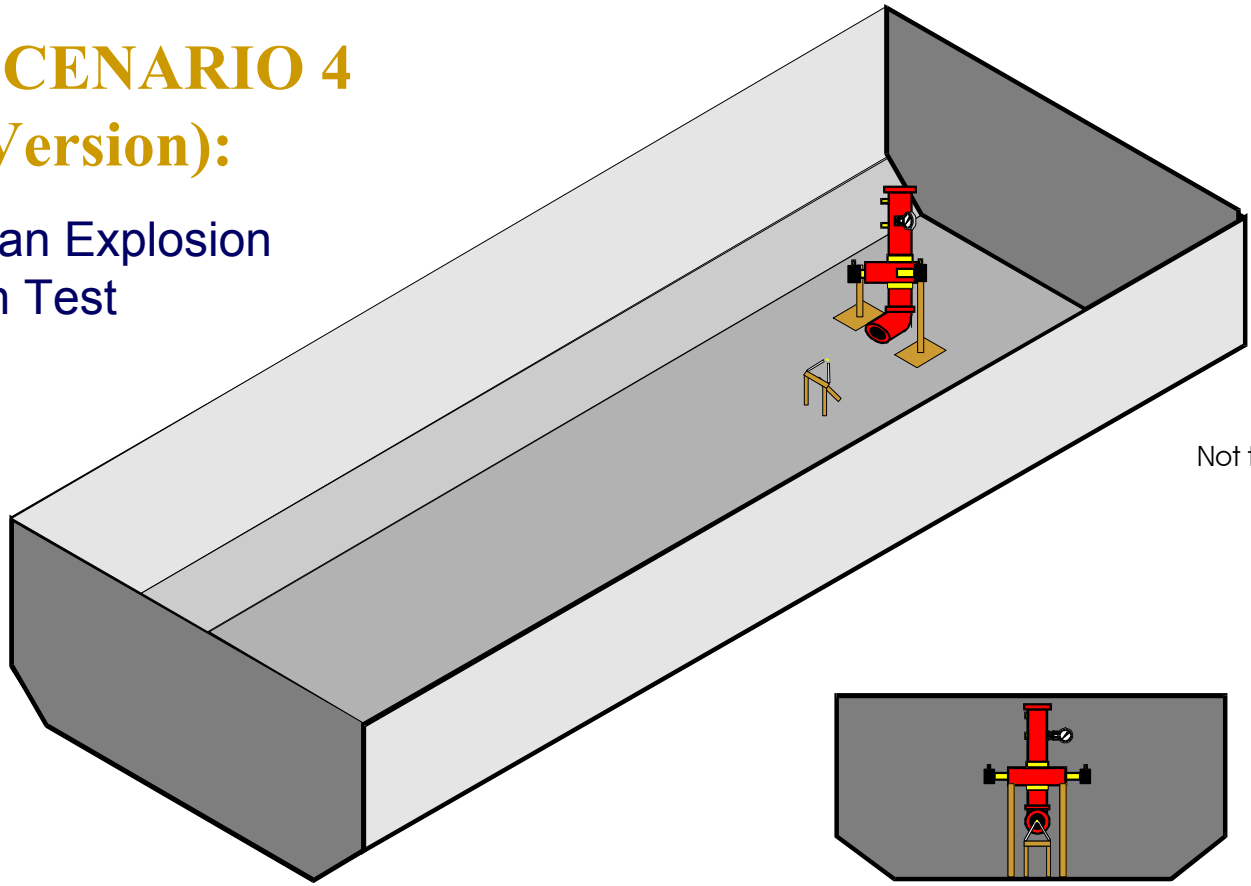
**Heat up simulator to increase pressure in content chamber to 240 psig**

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

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

## TEST SCENARIO 4 (Short Version):

Aerosol Can Explosion Simulation Test



Not to scale



End View

# Cargo MPS

## AEROSOL EXPLOSION TEST

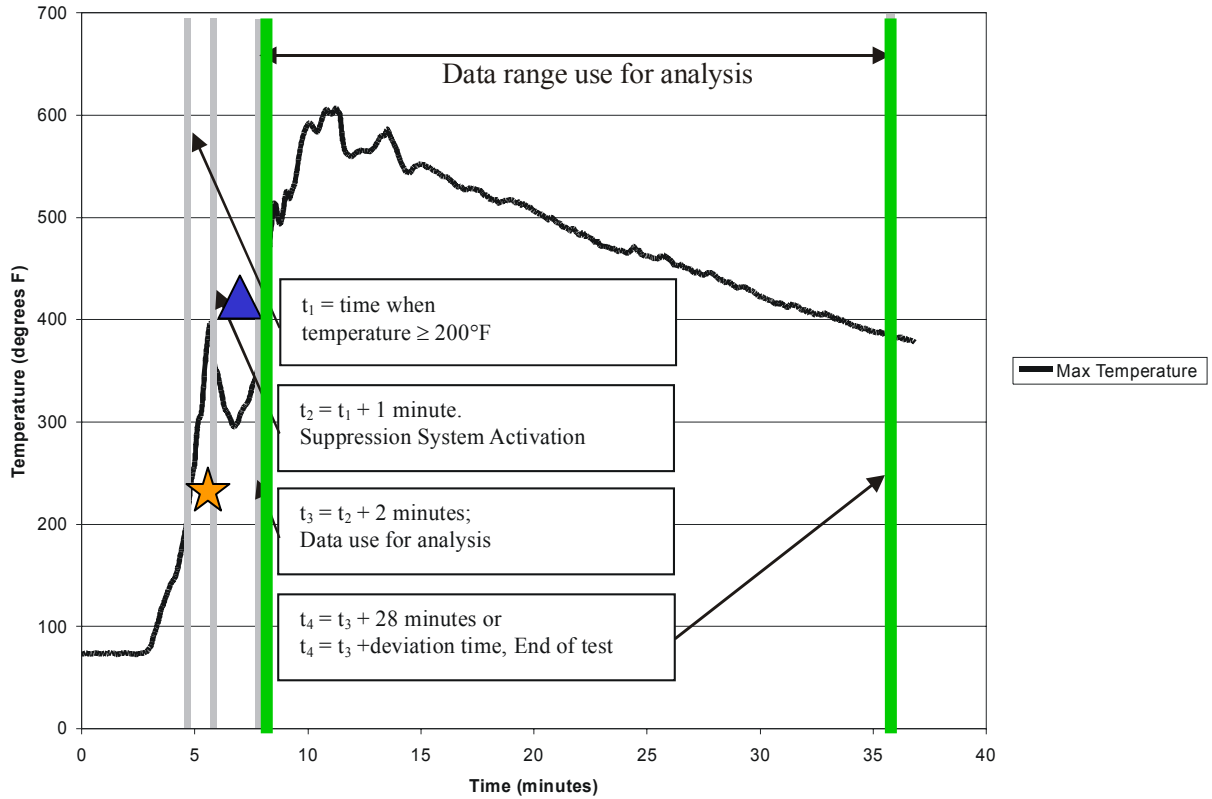
Fire Load = 0.2 lb. Propane, 0.6 lb. of Denatured Alcohol, 0.2 lb of water

Ignition = Arc created by two spark plugs (230 W)

Simulator Activation = When the agent, at 2 feet from the floor, is at the minimum inert concentration

Test Duration = 15 seconds after the activation of the simulator

# Acceptance Criteria For Bulk Load, Containerized, Flammable Liquid Tests Only



# ACCEPTANCE CRITERIA

| MPS FIRE SCENARIO | MAXIMUM TEMPERATURE (DEGF) | MAXIMUM TIME-TEMPERATURE AREA (DEGF-MIN) | PRESSURE (PSIG) | COMMENTS |
|---|---|---|---|---|
| Bulk-Load Fire | 720 | 9940 | Not Applicable | To determine these values, use the data that is between 2 and 28 minutes after suppression system activation |
| Containerized Load Fire | 650 | 14040 | Not Applicable | To determine these values, use the data that is between 2 and 28 minutes after suppression system activation |
| Surface Burn Fire | 570 | 1230 | Not Applicable | To determine these values, use the data that is between 2 and 28 minutes after suppression system activation |
| Aerosol Explosion Test | Not Applicable | Not Applicable | 0 | There shall be no evidence of an explosion. And, at sub-inert agent concentrations, the agent shall show signs of blast pressure reduction and not enhancement. |

# Tests

## AGENTS TESTED AT THE WJH FAA TECHNICAL CENTER:

- Halon 1301 – FY1998
- Pentafluoroethane (HFC-125) – FY1999 and FY2004
- Water Mist – FY2001
- Water Mist/Nitrogen – FY2001
- Bromotrifluropropene (BTP) – FY2003

# Tests

## TEST REPORTS PUBLISHED:

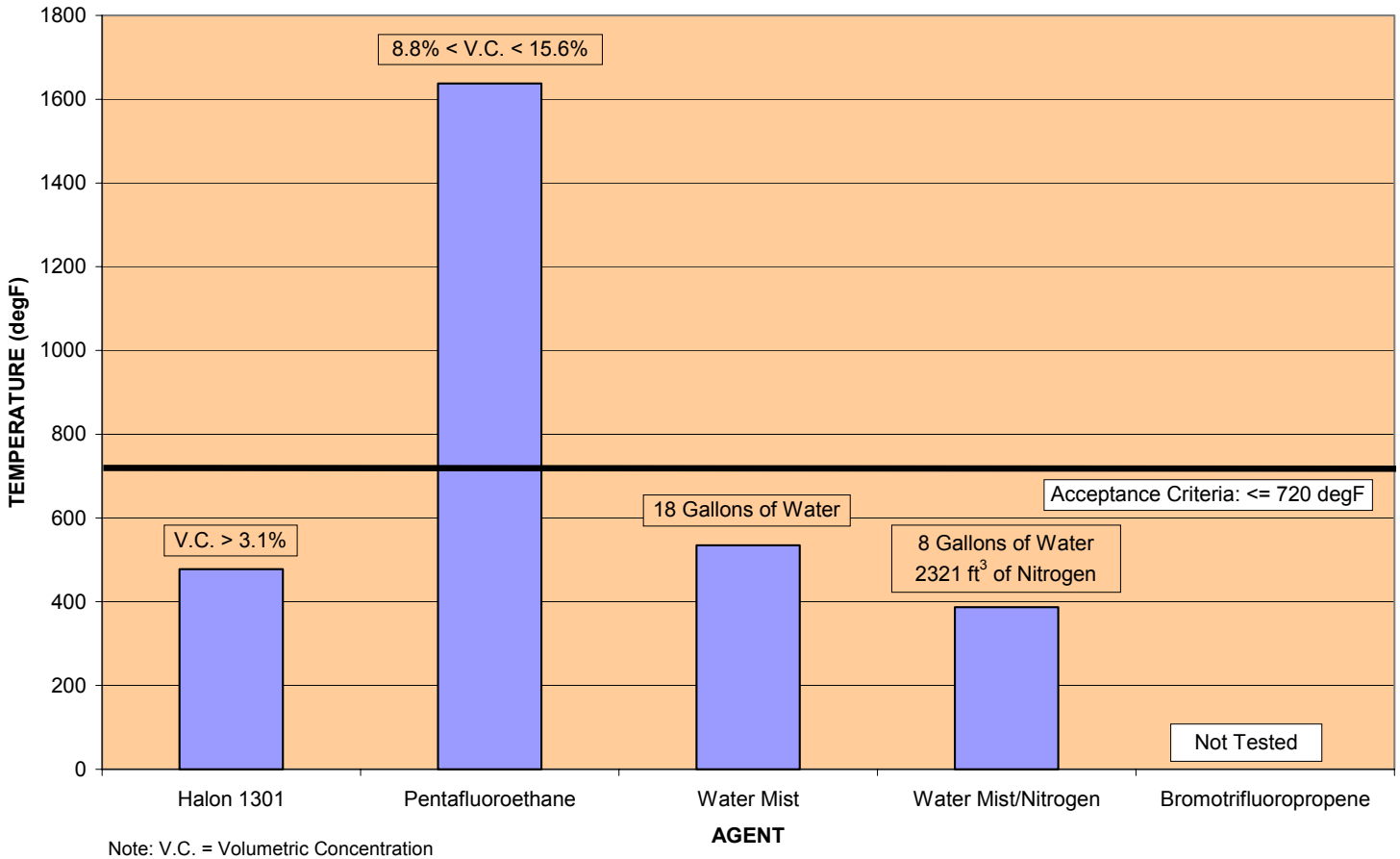
- "Development of a Minimum Performance Standard for Aircraft Cargo Compartment Gaseous Fire Suppression Systems" (DOT/FAA/AR-00/28, Sept 2000)

- "The Evaluation of Water Mist With and Without Nitrogen as an Aircraft Cargo Compartment Fire Suppression System" (DOT/FAA/AR-01/121, Feb 2002)

- "Behavior of Bromotrifluoropropene and Pentafluoroethane When Subjected to a Simulated Aerosol Can Explosion" (DOT/FAA/AR-TN04/4, March 2004)

# Results

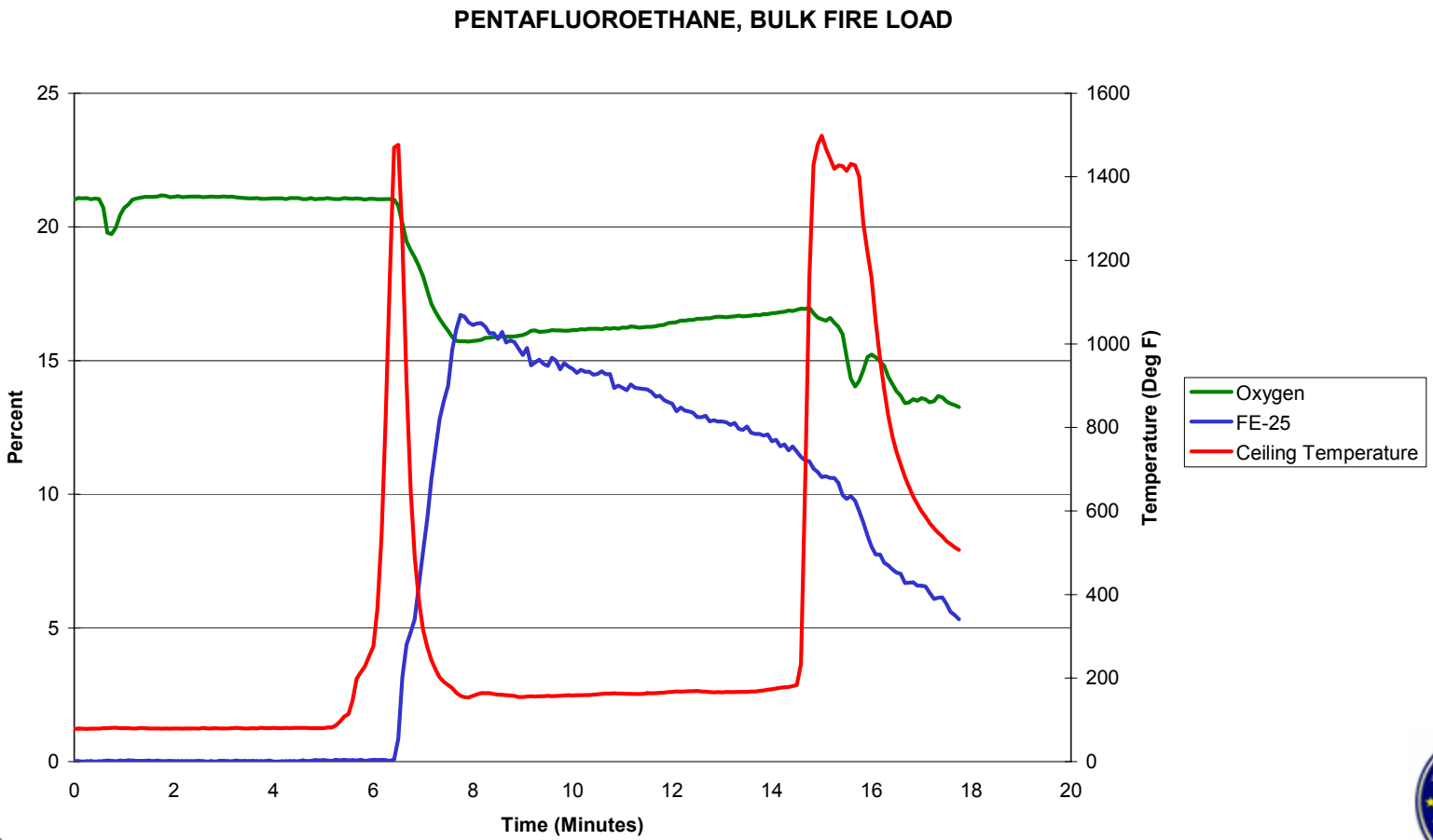
**MPS BULK-LOAD FIRE TEST RESULTS**



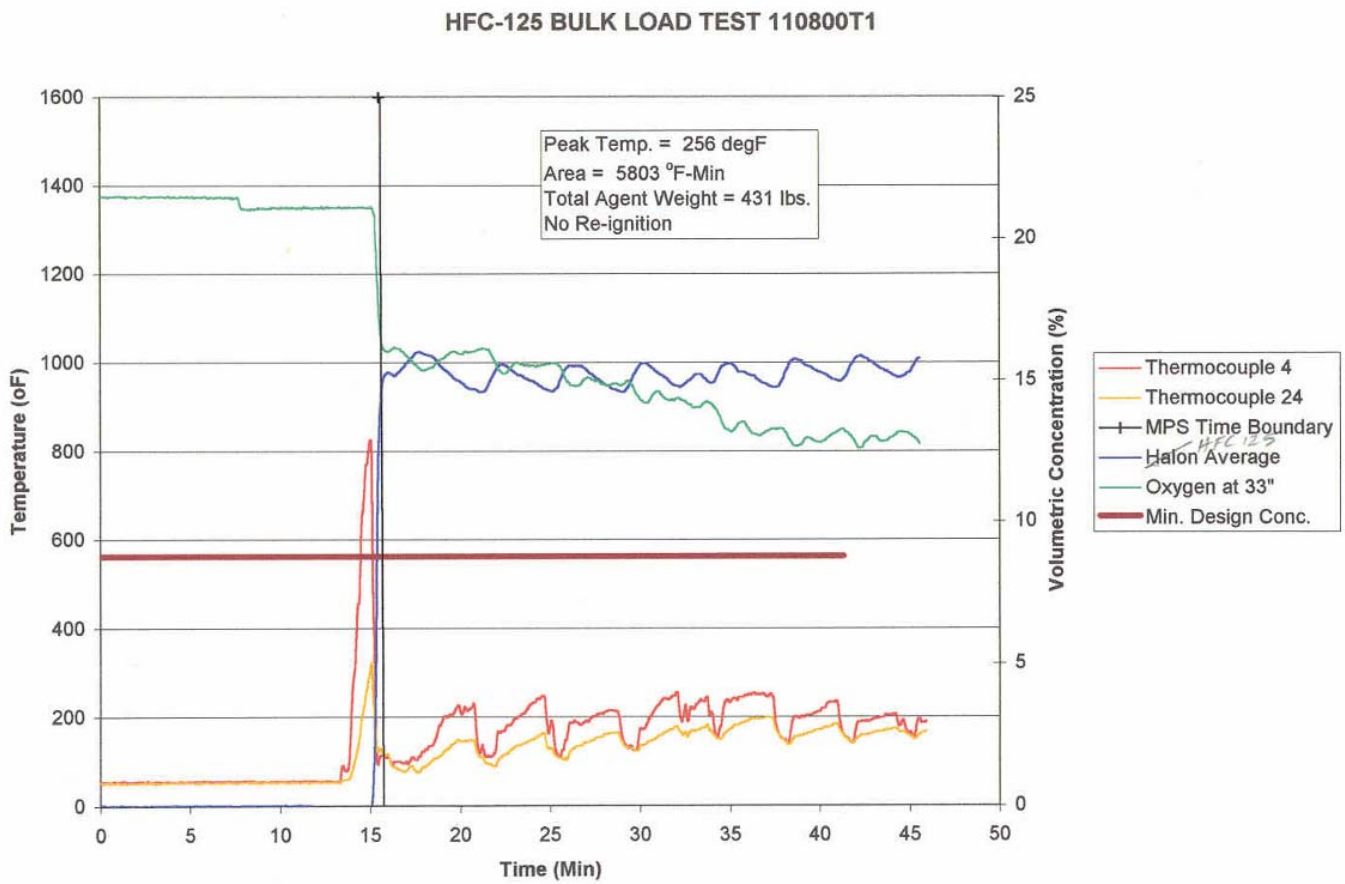

Note: V.C. = Volumetric Concentration

# Results

## Result For Pentafluoroethane During Bulk-Load Fire Tests

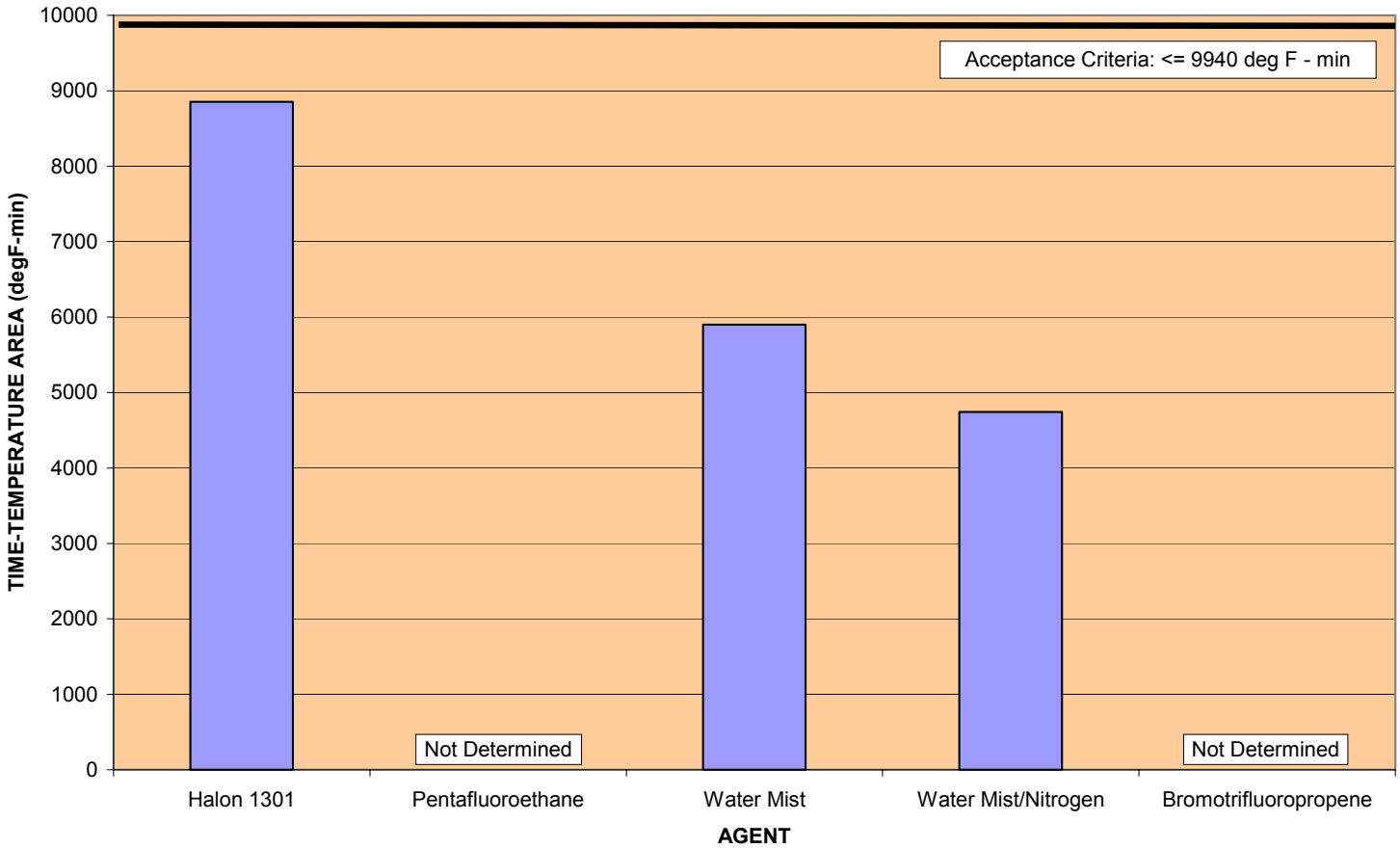


# Results


HFC-125 BULK LOAD TEST 110800T1
Peak Temp. = 256 degF
Area = 5803 °F-Min
Total Agent Weight = 431 lbs.
No Re-ignition
Temperature (oF)
Volumetric Concentration (%)
Time (Min)
Thermocouple 4
Thermocouple 24
MPS Time Boundary
Halon Average
Oxygen at 33"
Min. Design Conc.

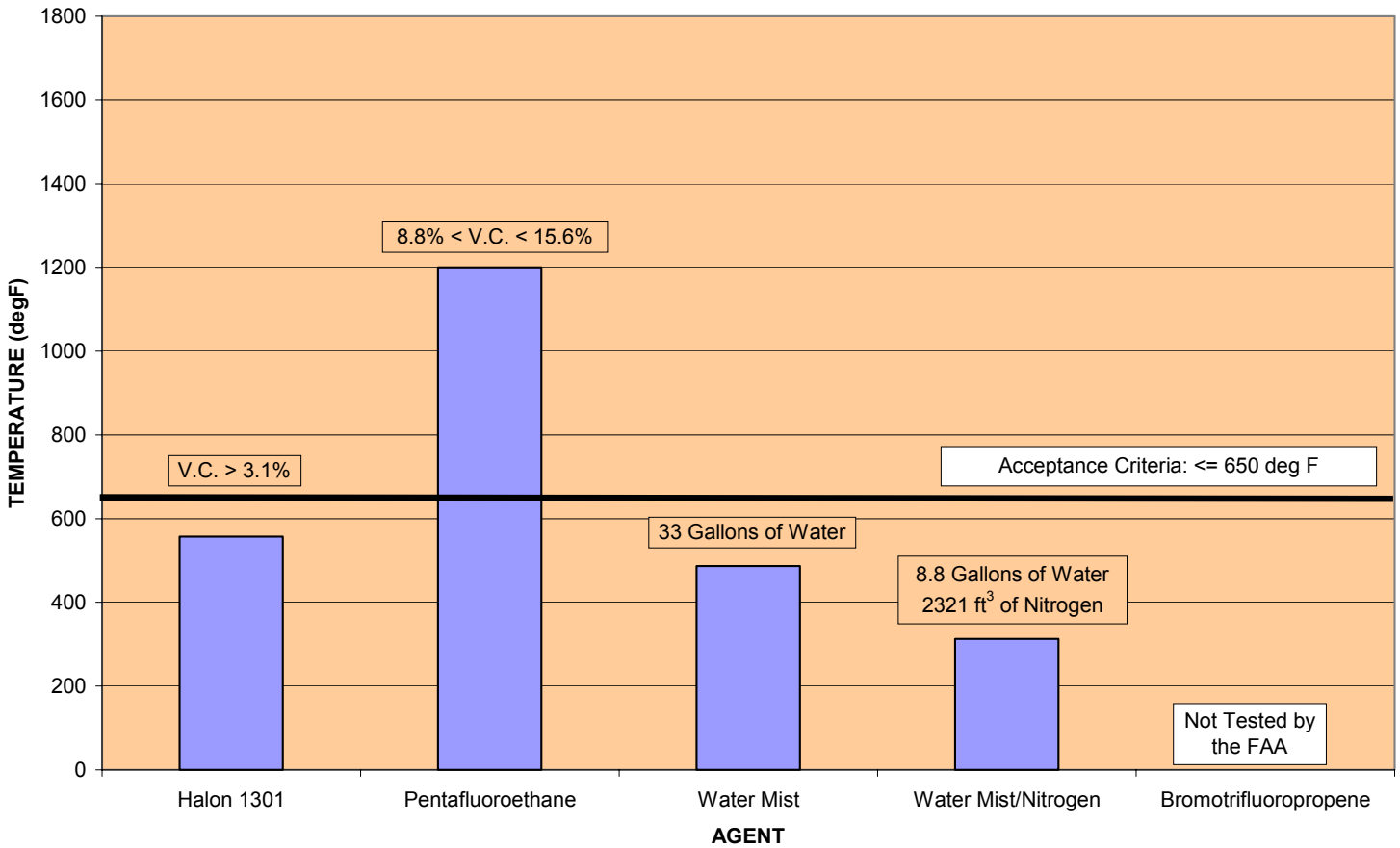
# Results

**MPS BULK-LOAD FIRE TEST RESULTS**

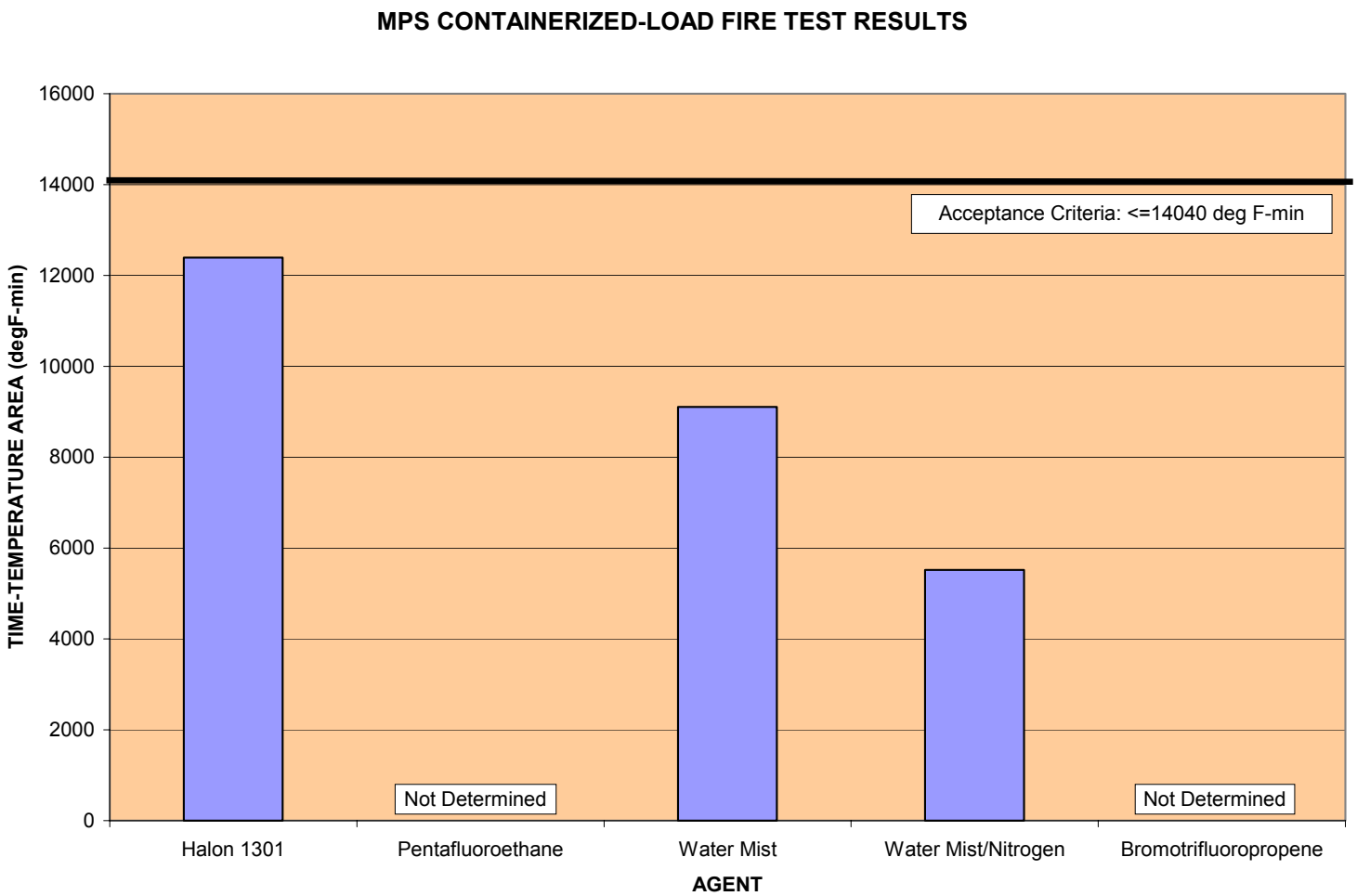


# Results

**MPS CONTAINERIZED-LOAD FIRE TEST RESULTS**

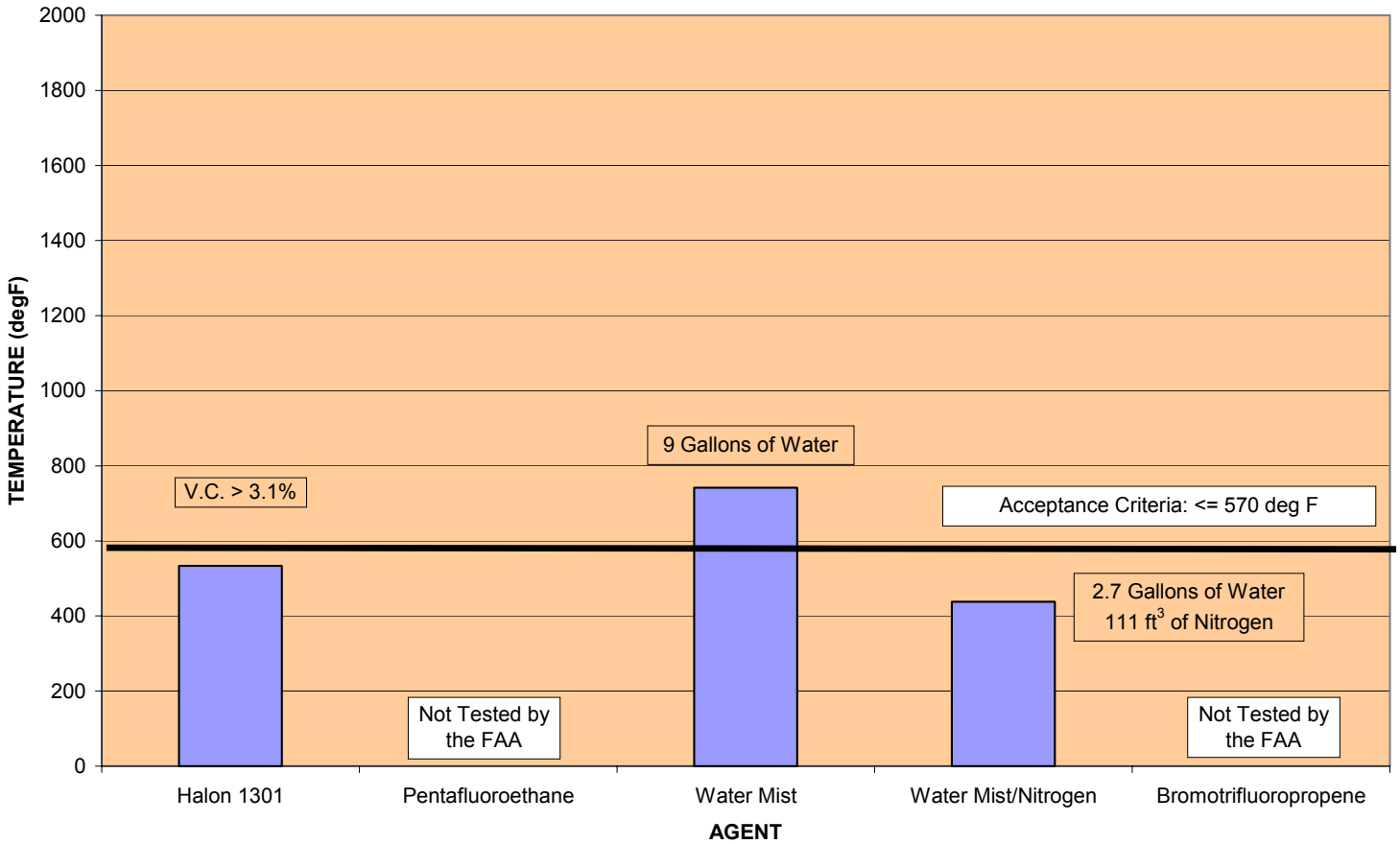


# Results


MPS CONTAINERIZED-LOAD FIRE TEST RESULTS
TIME-TEMPERATURE AREA (degF-min)
16000
14000
12000
10000
8000
6000
4000
2000
0
Acceptance Criteria: <=14040 deg F-min
Not Determined
Not Determined
Halon 1301
Pentafluoroethane
Water Mist
Water Mist/Nitrogen
Bromotrifluoropropene
AGENT

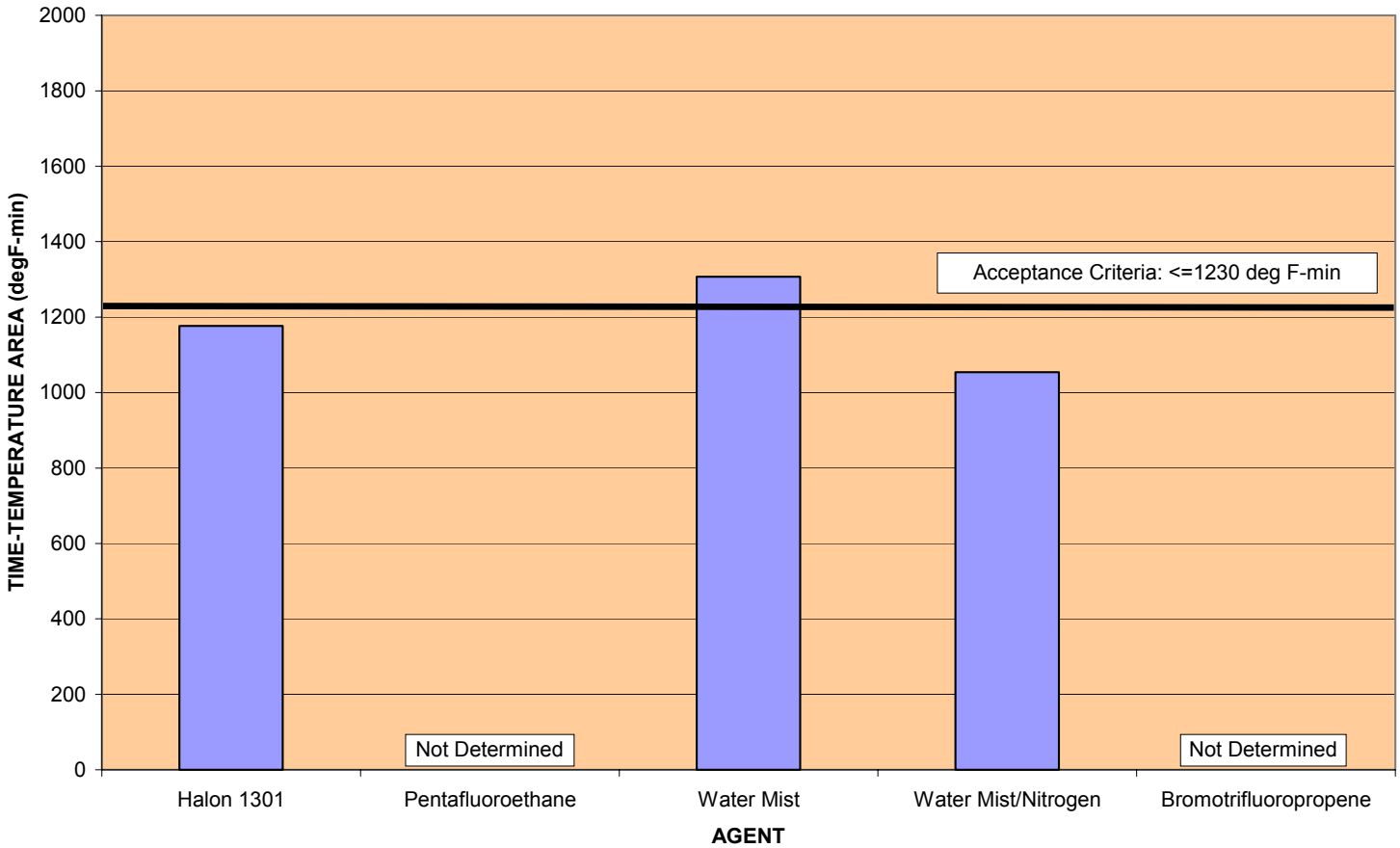
# Results

**MPS SURFACE BURN FIRE TEST RESULTS**



# Results

**MPS SURFACE BURN FIRE TEST RESULTS**



# Results

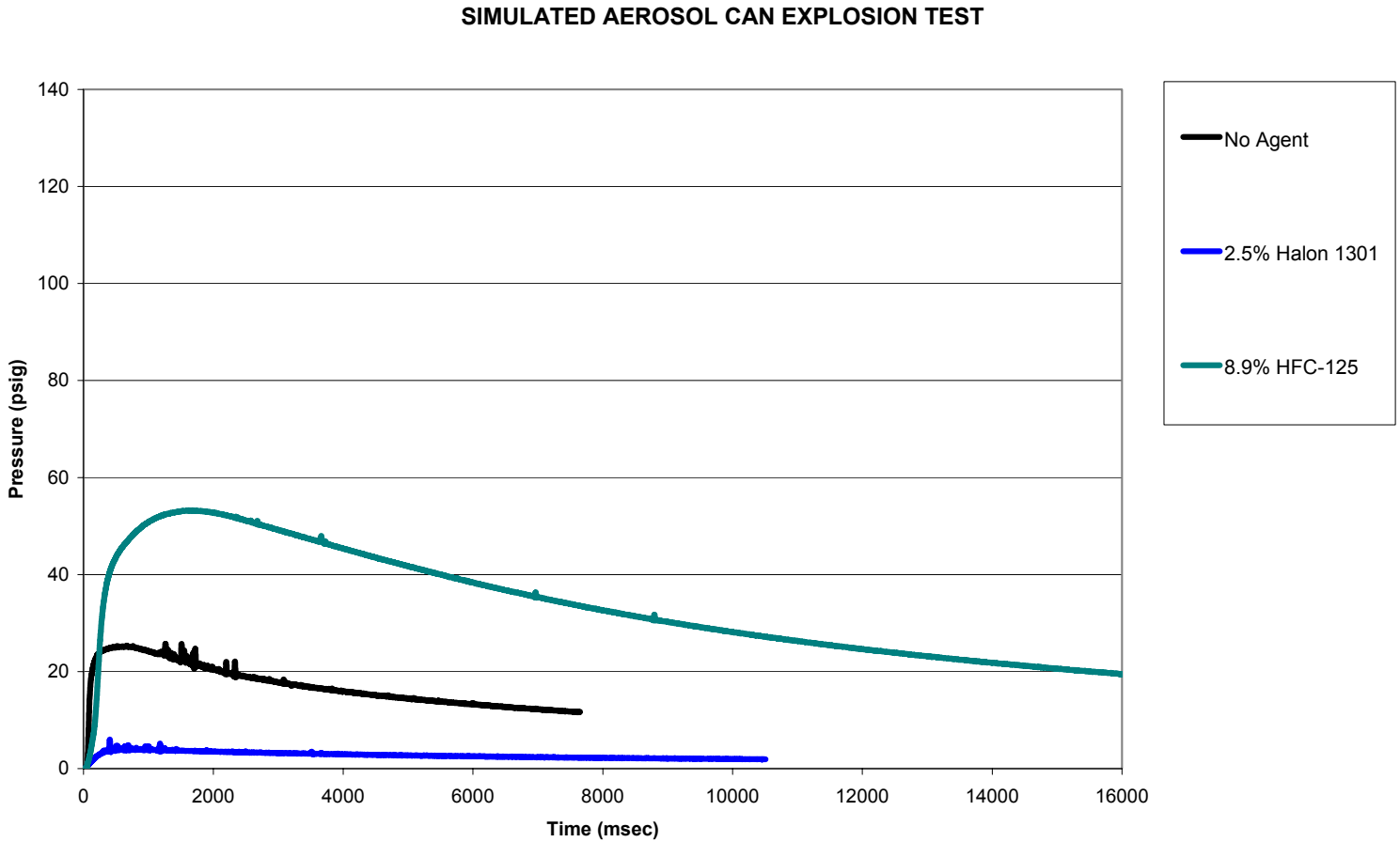
## Results For Various Agents During Aerosol Explosion Tests

| AGENT | AGENT INERT VOL. CON. (%) | COMMENTS |
|---|---|---|
| Halon 1301 | > 6.3% | Inerts Propane (Stoichiometric Conc.) |
| Pentafluoroethane | > 15.6% | Inerts Propane (Stoichiometric Conc.) |
| Water Mist | Not Capable | Unless the cargo compartment is under water |
| Water Mist/Nitrogen | O2 < 12% | Inerts Propane (Stoichiometric Conc.) |
| Bromotrifluoropropene | 8.50% | Inerts Propane (Stoichiometric Conc.) |

| AGENT | AGENT INERT VOL. CON. (%) | COMMENTS |
|---|---|---|
| Halon 1301 | > 3.3% | Inerts Aerosol Simulator (Lean Conc. of Propane) |
| Pentafluoroethane | > 13.5% | Inerts Aerosol Simulator (Lean Conc. of Propane) |
| Water Mist | Not Capable | Unless the cargo compartment is under water |
| Water Mist/Nitrogen | O2 < 12% | Inerts Aerosol Simulator (Lean Conc. of Propane) |
| Bromotrifluoropropene | > 6.5% | Inerts Aerosol Simulator (Lean Conc. of Propane) |

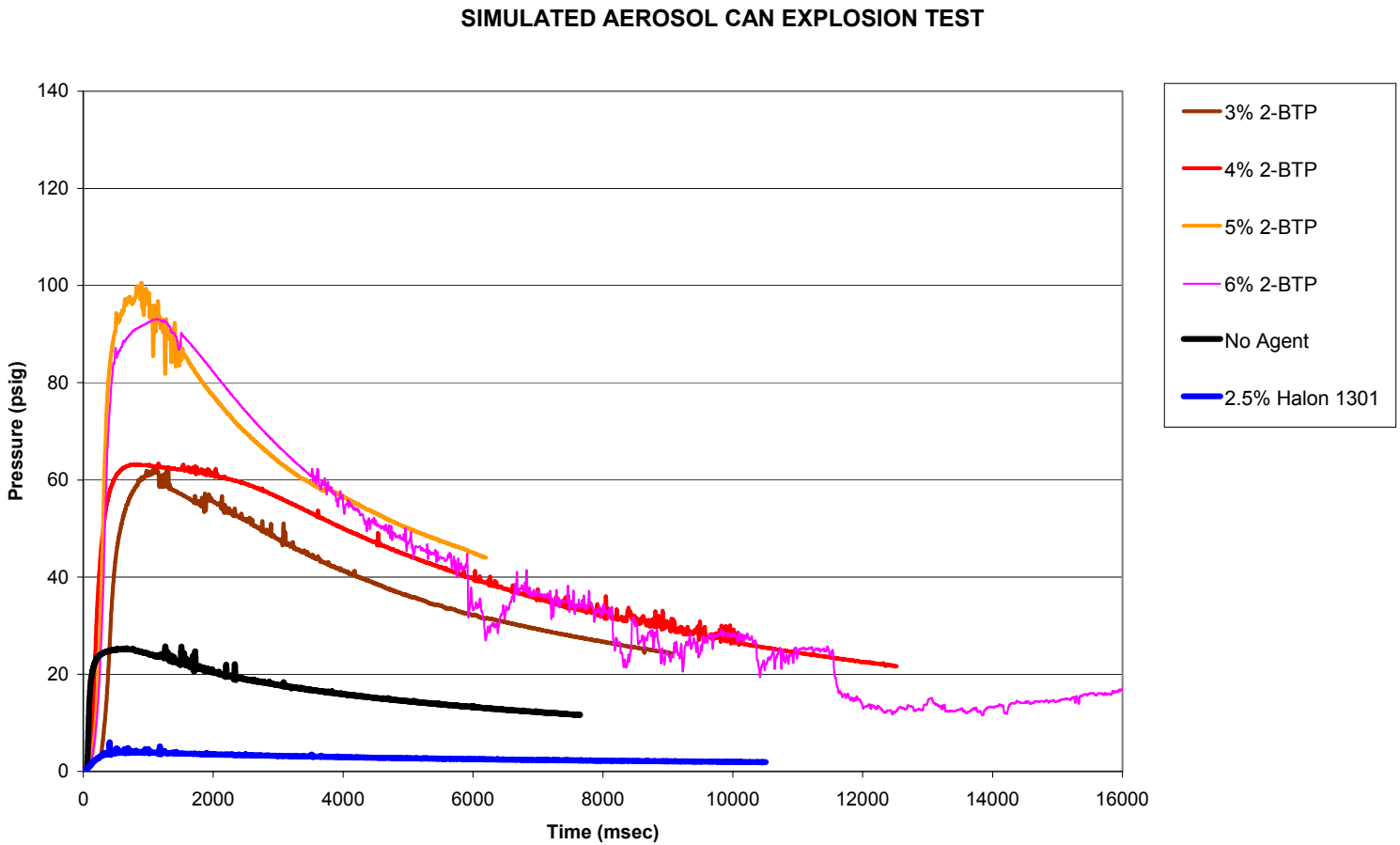
# Results

## Results For Pentafluoroethane During Aerosol Explosion Tests



# Results

## Results For Bromotrifluoropropene During Aerosol Explosion Tests



# Results

| AGENT NAME | MINIMUM PERFORMANCE STANDARD TESTS RESULTS | | | | | |
|---|---|---|---|---|---|---|
| | BULK LOAD | CONTAINERIZED LOAD | SURFACE BURN | AEROSOL EXPLOSION | COMMENTS | PASSED OR FAILED? |
| | (CLASS A FIRE)<br>Max Temp = 720 degF<br>Max Area = 9940 degF-min | (CLASS A FIRE)<br>Max Temp = 650 degF<br>Max Area = 14040 degF-min | (CLASS A FIRE)<br>Max Temp = 570 degF<br>Max Area = 1230 degF-min | | | |
| **Pentafluoroethane (HFC-125)** | Rollover flames reached 1500 degF. Must maintain volumetric concentration above inert concentration (15.6%) to prevent rollover. | Not Conducted | Not Conducted | No over pressure with a concentration above 13.5%. Aerosol explosion enhanced at below inert concentration levels. | A minimum concentration of 15.6% per volume (inert concentration) is required to pass the complete set of MPS fire tests. Main problem is at below inert concentration. | Failed |
| **Water Mist** | Max Temp = 535 degF<br>Max Area 5900 degF-min | Max Temp = 487 degF<br>Max Area 9106 degF-min | Max Temp = 742 degF<br>Max Area 1307 degF-min | Explosion Occurred | | Failed |
| **Water Mist Combined With Nitrogen** | Max Temp = 387 degF<br>Max Area 4744 degF-min | Max Temp = 313 degF<br>Max Area 5518 degF-min | Max Temp = 438 degF<br>Max Area 1054 degF-min | No Explosion | It requires a minimum of 8.8 gallons of water to suppress the fire (5 minutes knockdown). Used 10 Size T nitrogen cylinders | Passed |
| **Bromotrifluoropropene (BTP)** | Not Conducted | Not Conducted | Not Conducted | Aerosol explosion enhanced at below inert concentration levels. | | Failed |

# Final Remarks

Thanks to the efforts of the IAFPWG in the last 10 years, the FAA has a comprehensive standard that the aviation industry could use as a means of compliance during the certification process of a new fire suppression system for aircraft cargo compartments.

As of today, the only fire suppression system capable of passing the FAA's Cargo Compartment MPS tests is a system that combines water mist and nitrogen. Two different systems have proven these results.


# The Fourth Triennial International Aircraft Fire and Cabin Safety Research Conference