Federal Aviation Administration

Aircraft Cargo Compartment

“Testing Update”

Presented to: International Aircraft Systems Fire Protection Working Group

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Date: April 16-17, 2007

Outline

- **MPS Bulk-Load Test:**
  - European cardboard boxes versus U.S. FAA cardboard boxes
- **MPS Aerosol Can Simulation Explosion:**
  - Arc delay versus explosion overpressure
  - Determine synergistic effects when combining Halon 1301 and Nitrogen
- **Final Words**

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MPS Bulk-Load Test

Why?

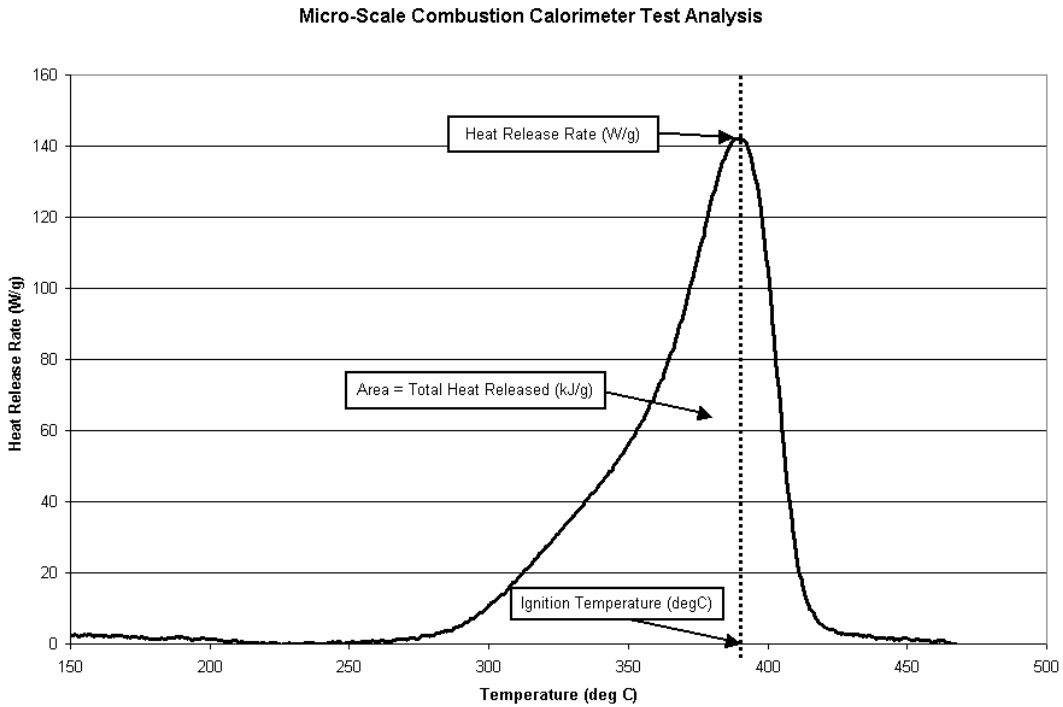
- European Working Group partner noticed lower temperatures in the cargo compartment while conducting MPS Bulk-Load tests
- Among other factors, such as ceiling configuration and thermocouples placement, the flammability of the European cardboard boxes may be slightly different from the ones used by the FAA
- European boxes have fire retardant additives

MPS Bulk-Load Test

Micro-Scale Combustion Calorimeter Test (Flammability Test)

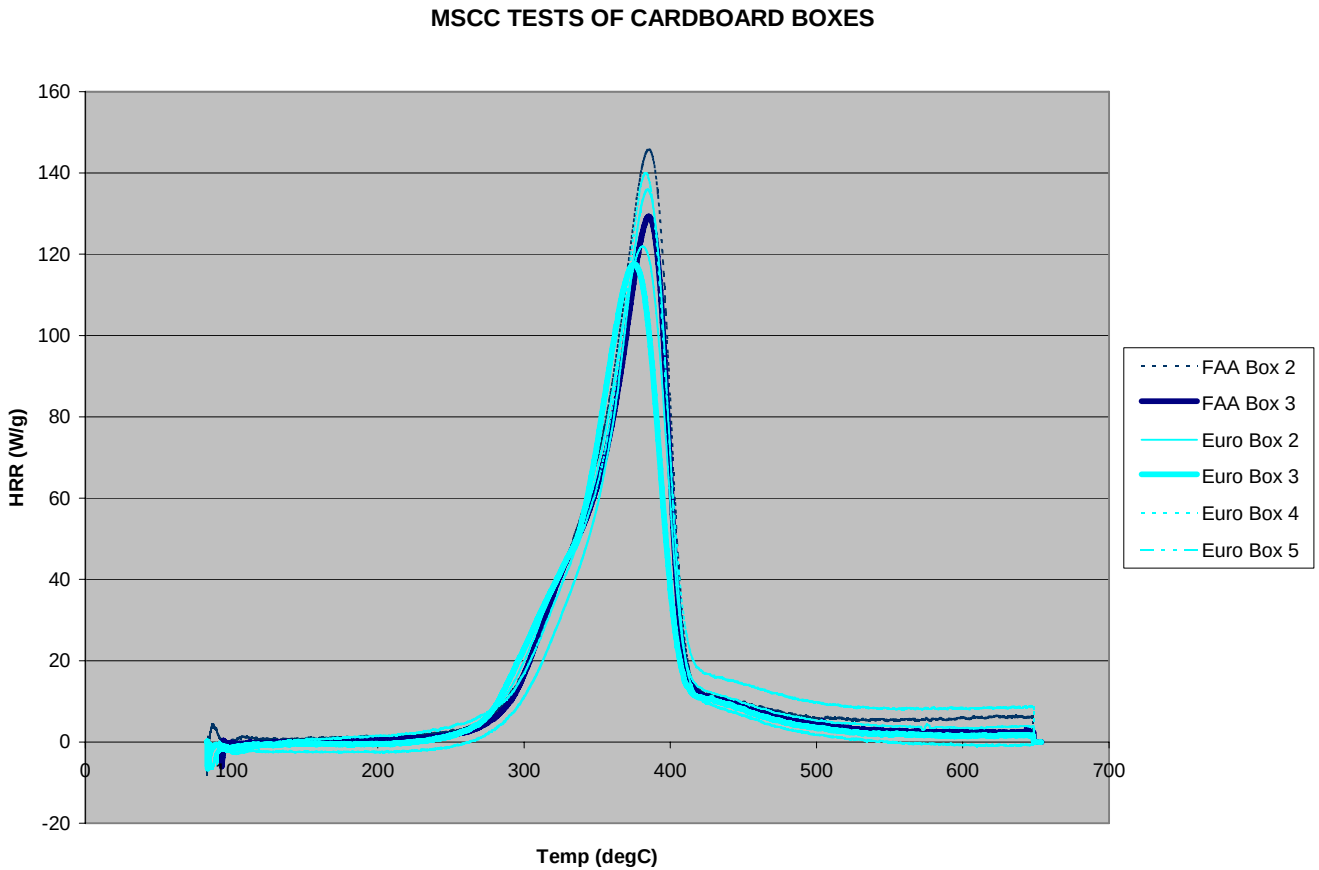
Results showed that:

- Both boxes have similar ignition temperatures
- The total heat released by both boxes are almost identical
- The European box resulted in a slightly slower heat release rate (due to the fire retardant additive) when compared to the FAA's box.



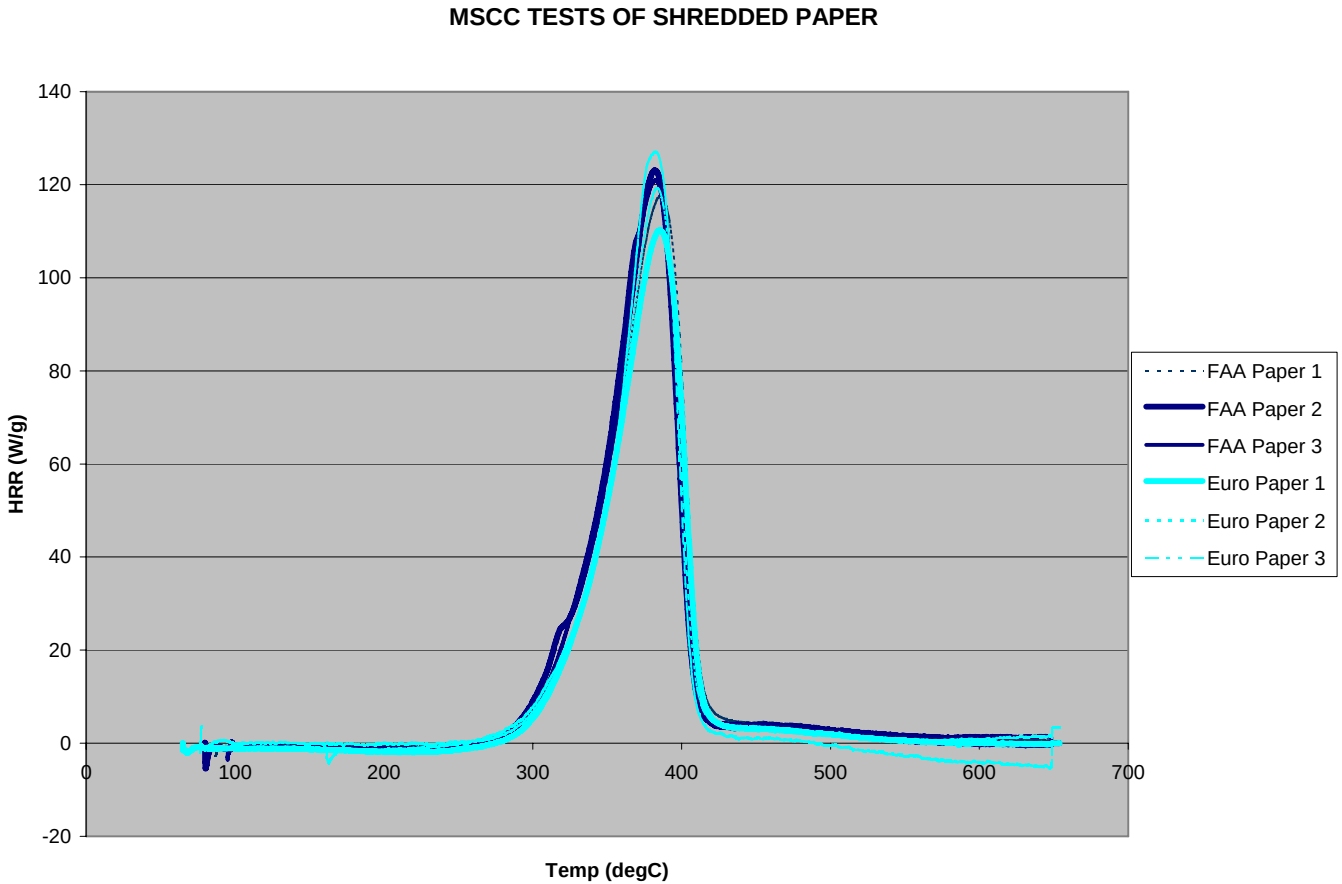
Box Type	Ignition Temperature (degC)	Total Heat Released (kJ/g)	Peak Heat Release Rate (W/g)
FAA	387 (Std Dev: 2.7)	8.7 (Std Dev: 0.2)	138 (Std Dev: 8.8)
European	382 (Std Dev: 4.5)	8.6 (Std Dev: 0.3)	128 (Std Dev: 9.1)

MPS Bulk-Load Test



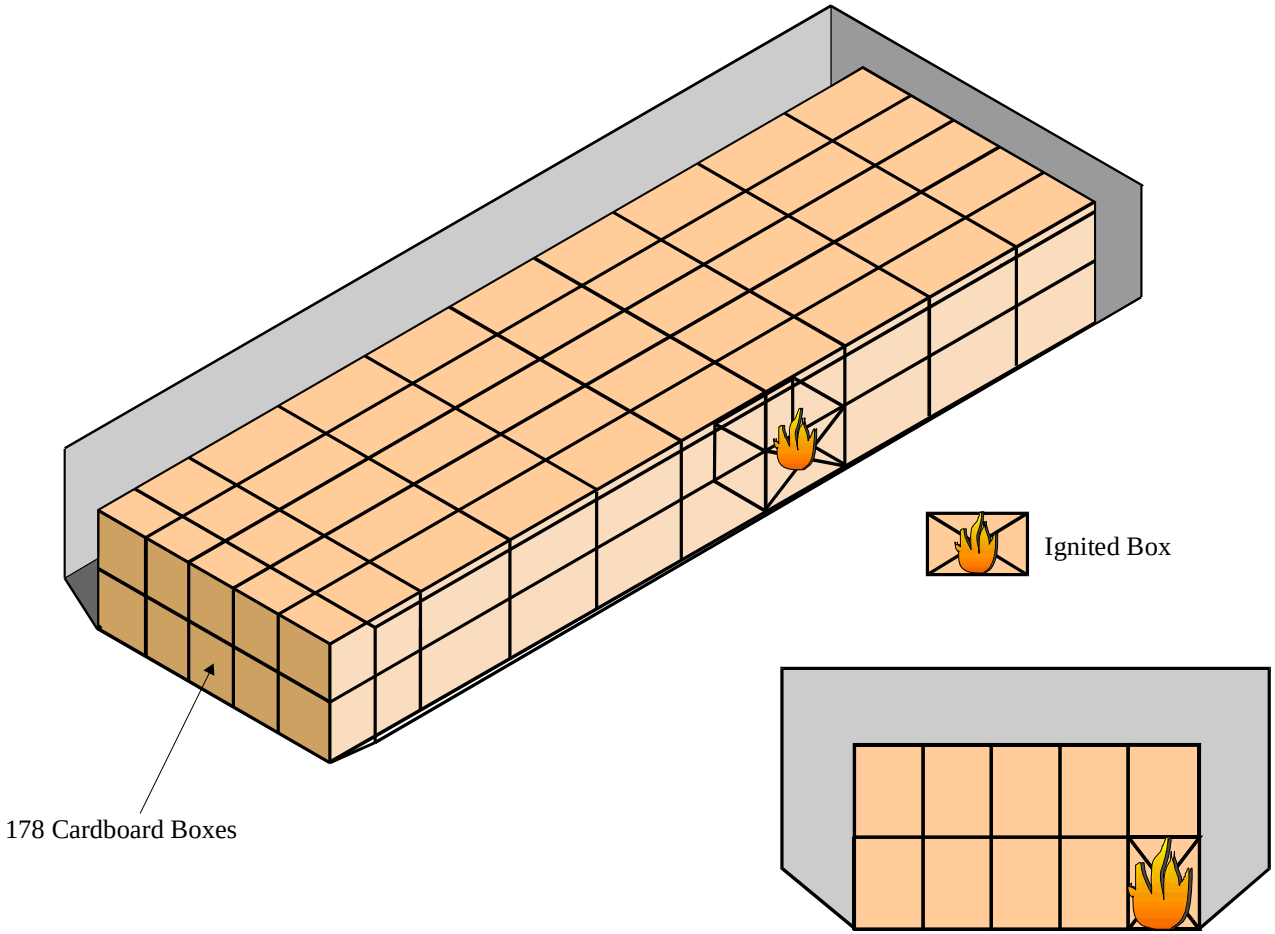
Note: The flammability properties of the FAA cardboard boxes are almost identical to the European cardboard boxes (within the scatter)

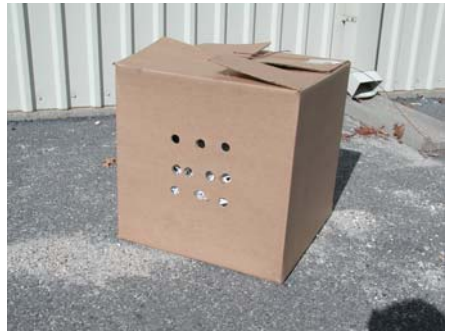
MPS Bulk-Load Test



Note: The flammability properties of the FAA paper is almost identical to the European paper (within the scatter)

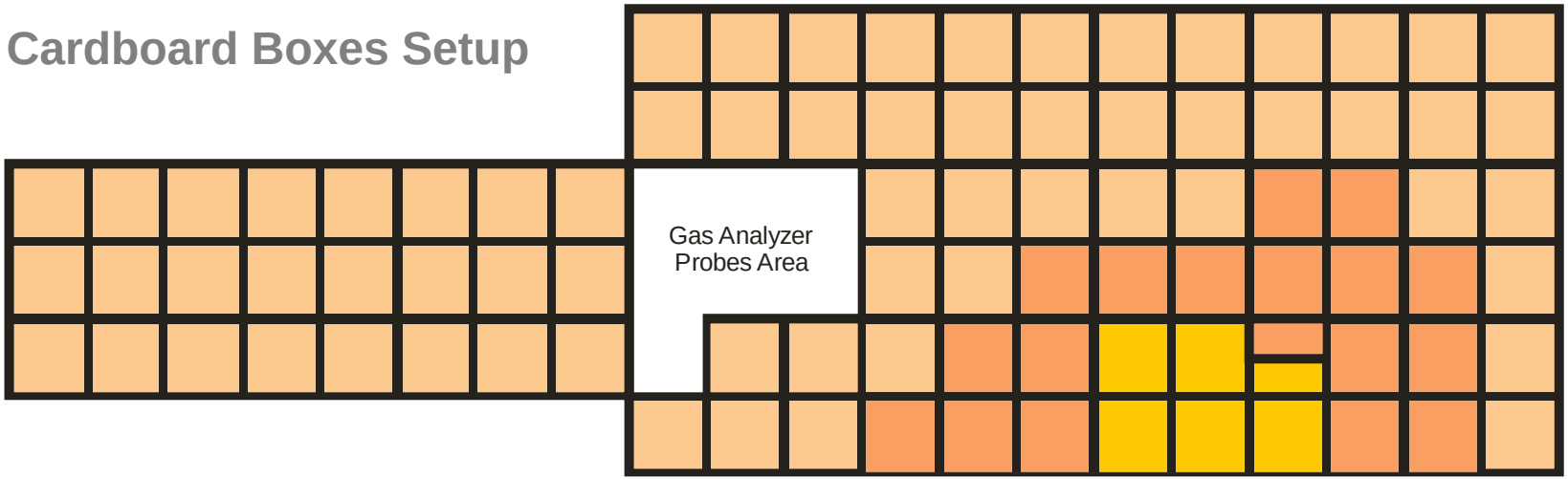
MPS Bulk-Load Test





MPS Bulk-Load Test

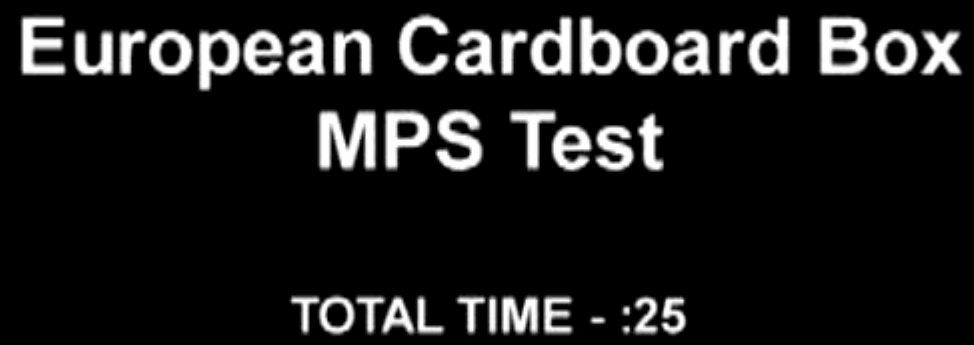
Cardboard Boxes Setup



LEGEND:

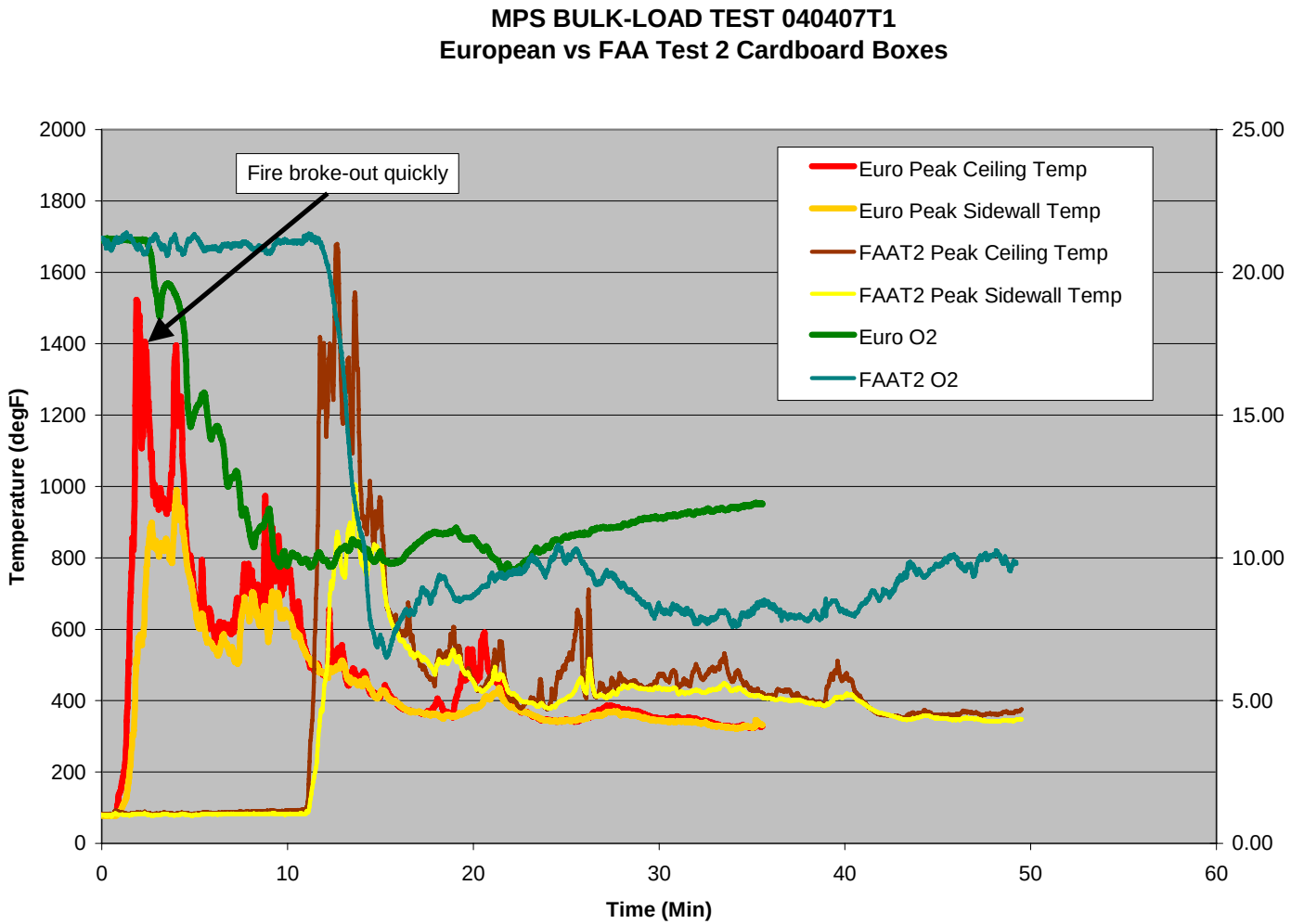
- European Box with European Paper
- European Box with FAA Paper
- FAA Box with FAA Paper
- Upper Box: European Box with FAA Paper
  Lower Box: European Box with European Paper

MPS Bulk-Load Test



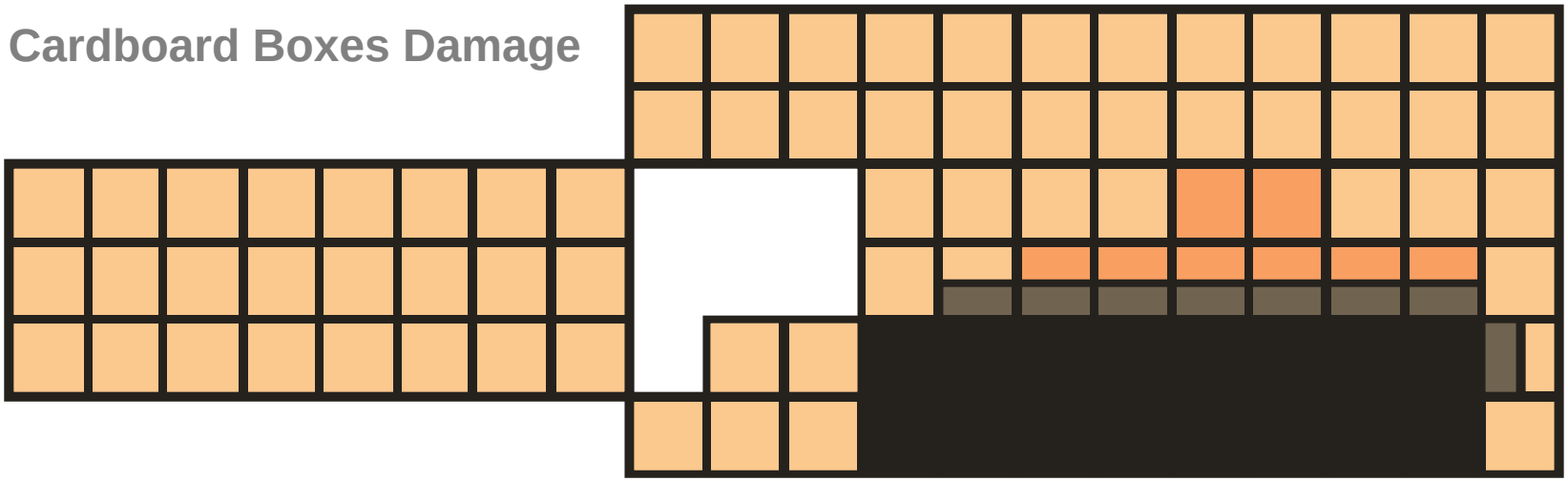
Two clips merged: 10 sec after ignition and 1 minute after ignition

MPS Bulk-Load Test



MPS Bulk-Load Test

Cardboard Boxes Damage



LEGEND:

Burned Boxes

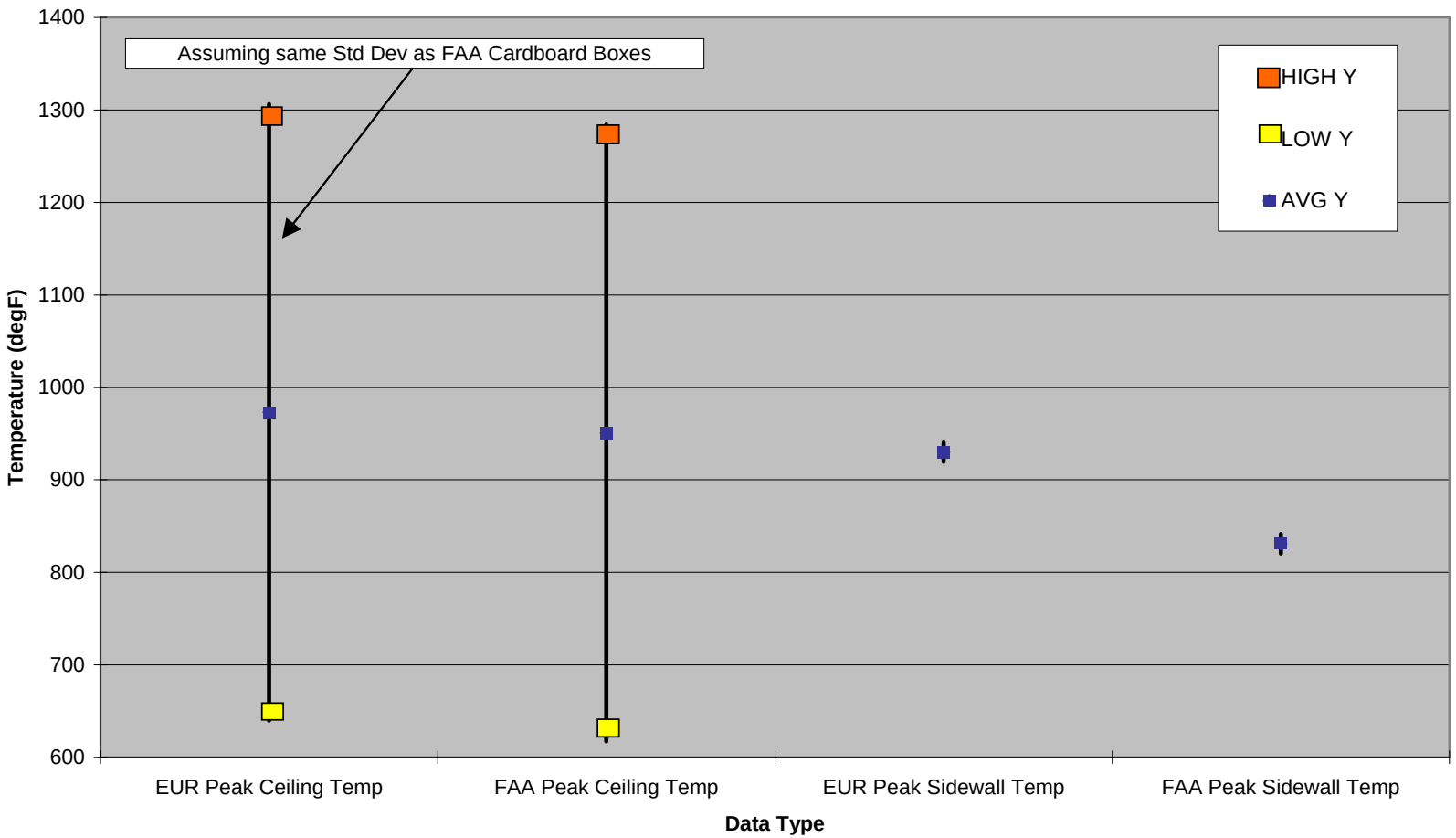
Upper Box: No Damage
Lower Box: Partly Burned Boxes

MPS Bulk-Load Test

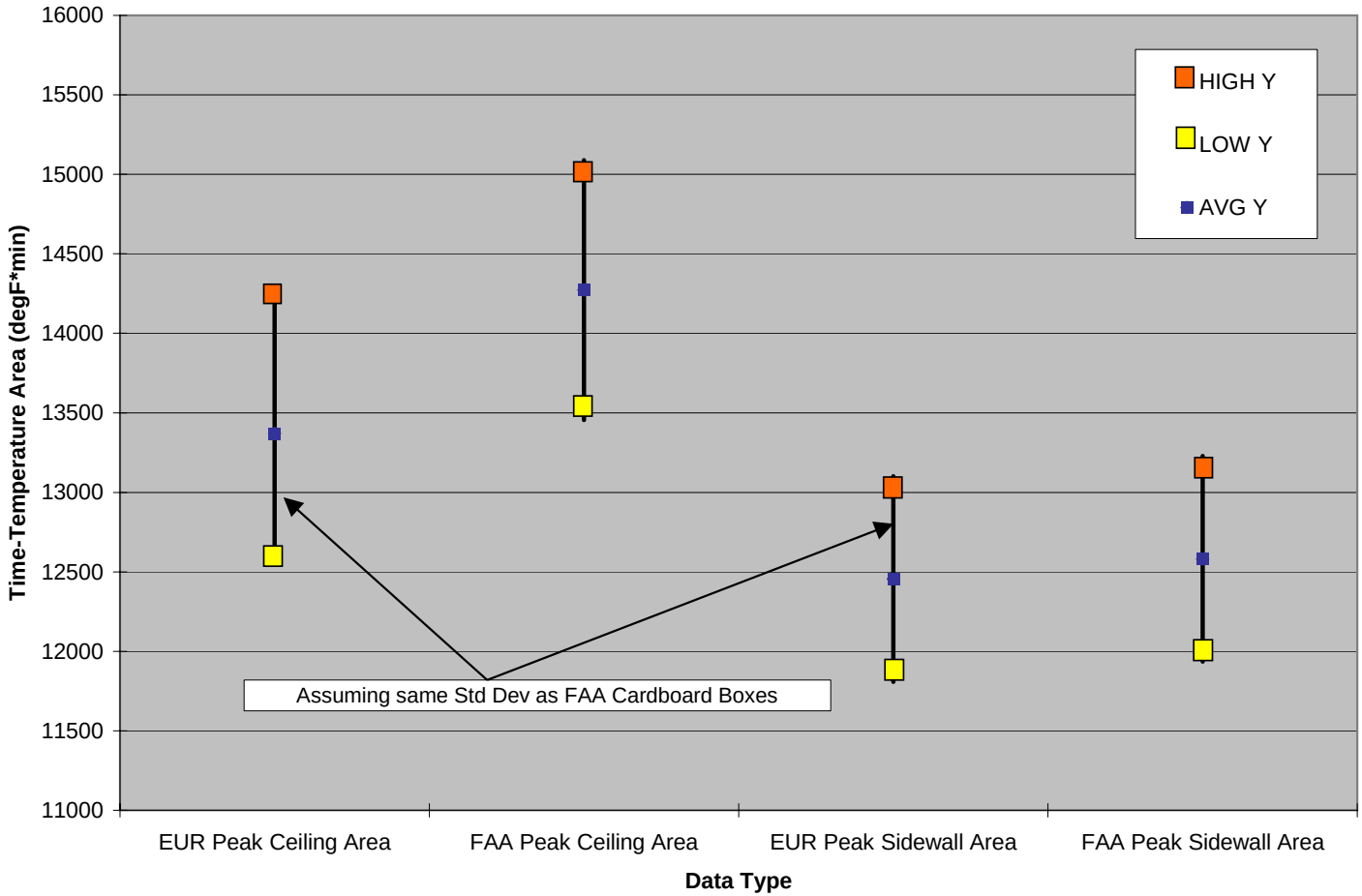
MPS BULK-LOAD ACCEPTANCE CRITERIA & STATISTICS SUMMARY

TEST	THERMOCOUPLE LOCATION	PEAK TEMP (DEGF)	PEAK AREA (DEGF-MIN)
European Boxes Test	Ceiling	973	13370
European Boxes Test	Sidewall	930	12455
FAA Baseline Test 1	Ceiling	970	13473
FAA Baseline Test 1	Sidewall	838	12656
FAA Baseline Test 2	Ceiling	1274	14237
FAA Baseline Test 2	Sidewall	819	13188
FAA Baseline Test 3	Ceiling	608	15106
FAA Baseline Test 3	Sidewall	836	11901

FAA Baseline Average	Ceiling	951	14272
FAA Baseline Average	Sidewall	831	12582
FAA Baseline Std Dev	Ceiling	333	817
FAA Baseline Std Dev	Sidewall	10	647


MPS BULK-LOAD FIRE TEST ACCEPTANCE CRITERIA
PEAK TEMPERATURE DATA COMPARISON
Assuming same Std Dev as FAA Cardboard Boxes
HIGH Y
LOW Y
AVG Y
Temperature (degF)
1400
1300
1200
1100
1000
900
800
700
600
EUR Peak Ceiling Temp
FAA Peak Ceiling Temp
EUR Peak Sidewall Temp
FAA Peak Sidewall Temp
Data Type

MPS BULK-LOAD FIRE TEST ACCEPTANCE CRITERIA
PEAK AREA DATA COMPARISON



MPS Bulk-Load Test

Test Result:

- The Micro-scale Combustion Calorimeter test indicated that the FAA and European cardboard boxes and paper had very similar flammability characteristics: same total heat released, same ignition temperature, and very similar heat release rate (European slightly lower)
- After conducting the MPS Bulk-Loaded Fire Test, results showed that their Acceptance Criteria values were very similar. There was no statistical significant difference between their peak temperature and peak time-temperature area.

MPS Bulk-Load Test

Test Result (Cont.):

- The European boxes started to burn rapidly after ignition (within 1 minute), with less smoke than the FAA boxes, which makes it desirable for testing.
- FAA researcher finds that the submitted European cardboard boxes and paper are acceptable for MPS testing.

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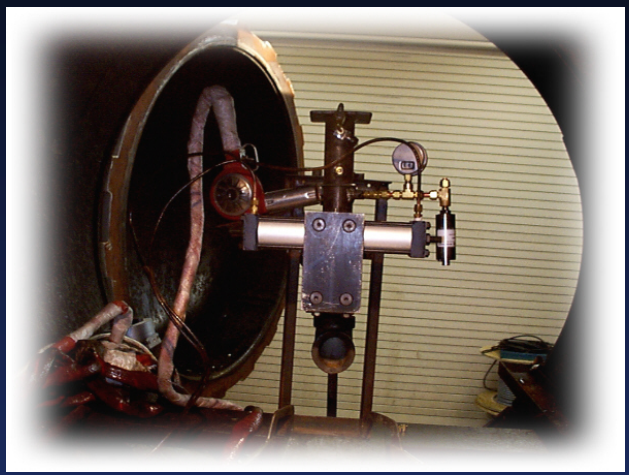
Arcing Delay vs Explosion Overpressure

Why?

- A hypothesis was stated in the previous meeting suggesting that the excessive overpressures (higher that the baseline) achieved by some of the tested fire extinguishing agents were due to ignition (arcing) delay.
- To demonstrate that the increase in pressure is related to the amount of fuel in the fuel-to-air mixture of the explosive vapor rather than the ignition delay of a static arcing source.



Arcing Delay vs Explosion Overpressure

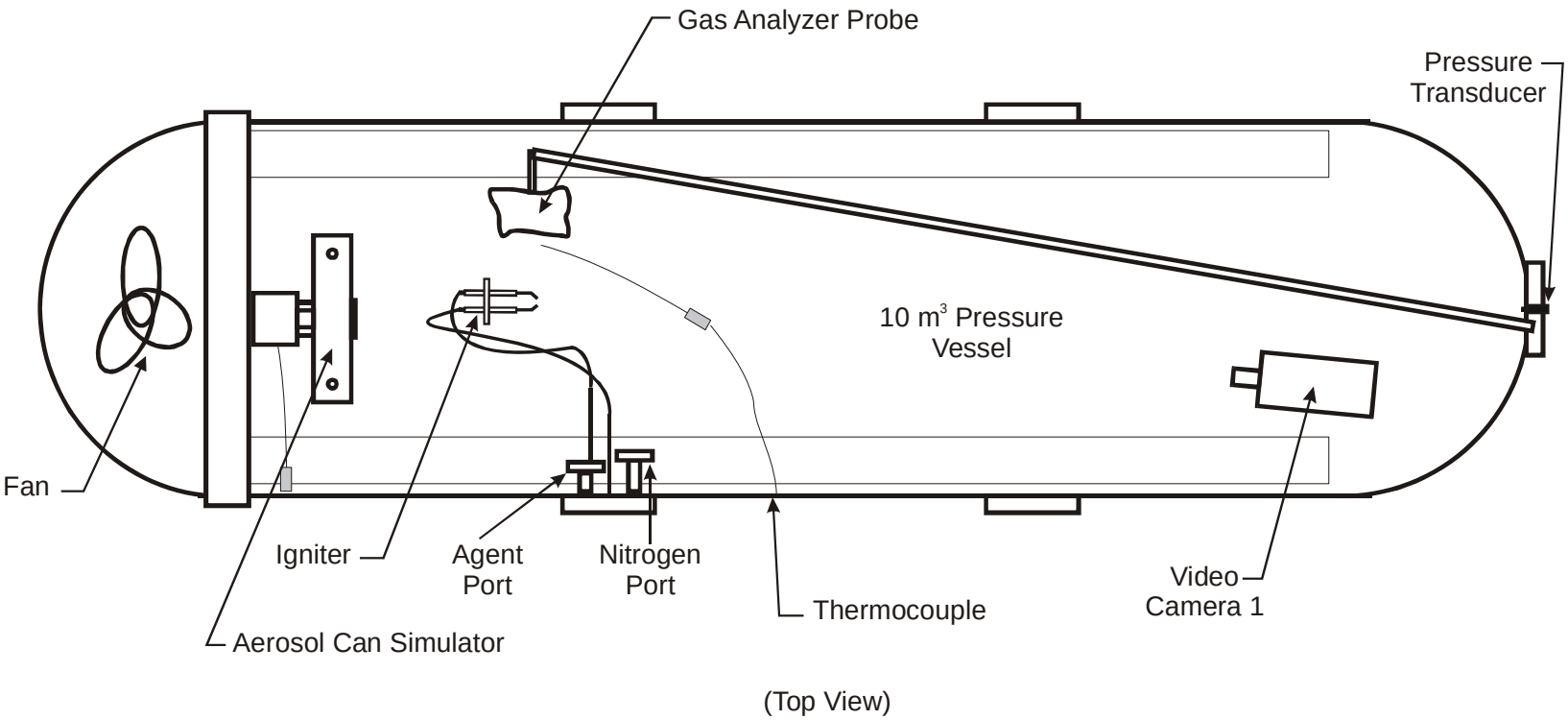
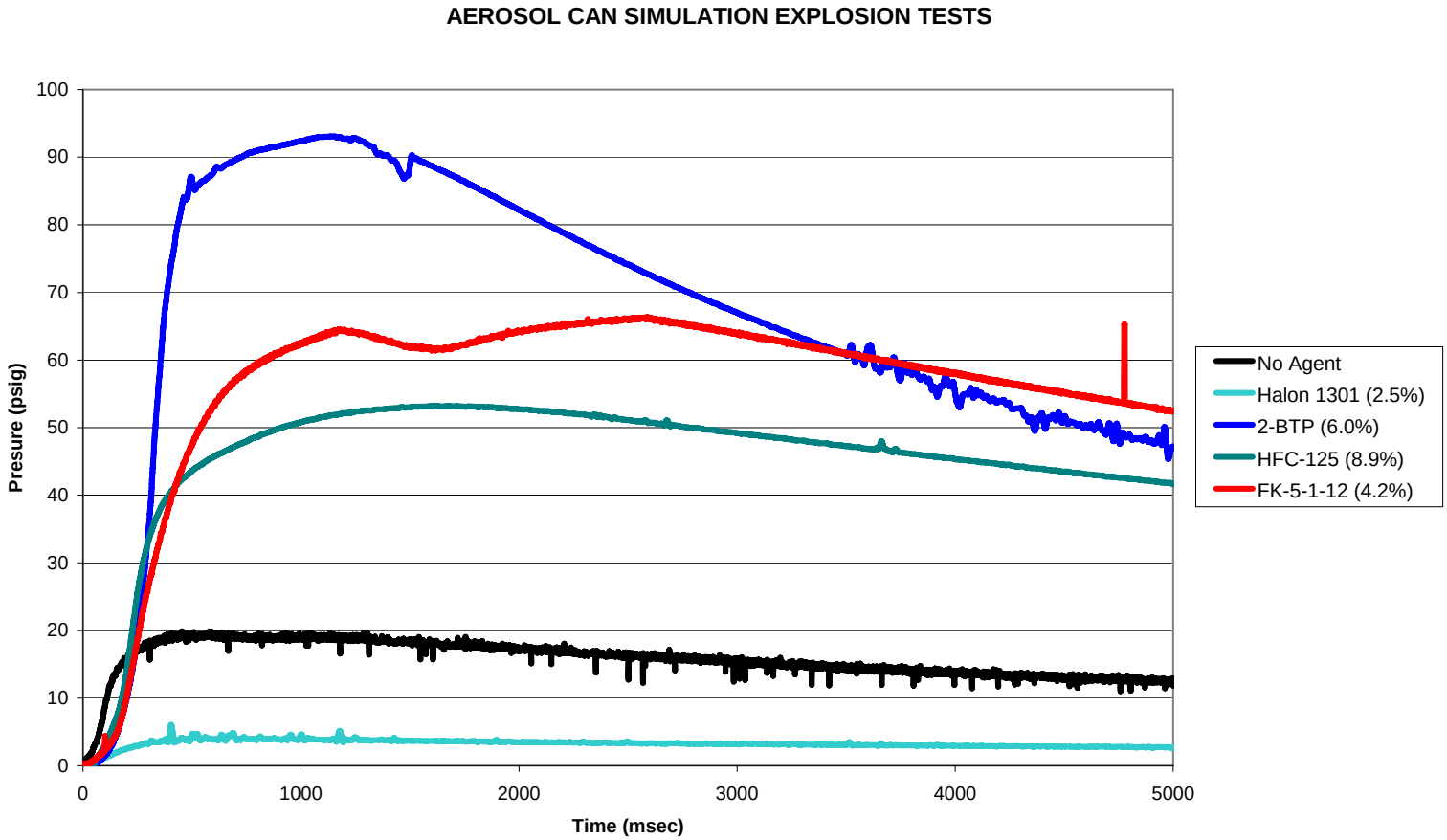


FIGURE 1. PRESSURE VESSEL SETUP

Arcing Delay vs Explosion Overpressure



COMPARISON OF OVERPRESSURE HISTORIES OF VARIOUS AGENTS

Arcing Delay vs Explosion Overpressure

Ignition Delay Test Matrix & Results

Test	Time Delay (sec)	Pressure (psig)
1	0.0	26
2	0.5	8
3	1.0	2
4	2.0	0
5	3.0	0
Note: Propane mass = 0.2 lb; arcing for 5 seconds, 230W		

Computer controlled time delay and simulator activation

Arcing Delay vs Explosion Overpressure

Zero Delay Test

Arcing Delay vs Explosion Overpressure

Keep an eye on the explosive cloud (starts in about 5 seconds after title)

Keep an eye on the ignition arc (starts in about 52 seconds after title)

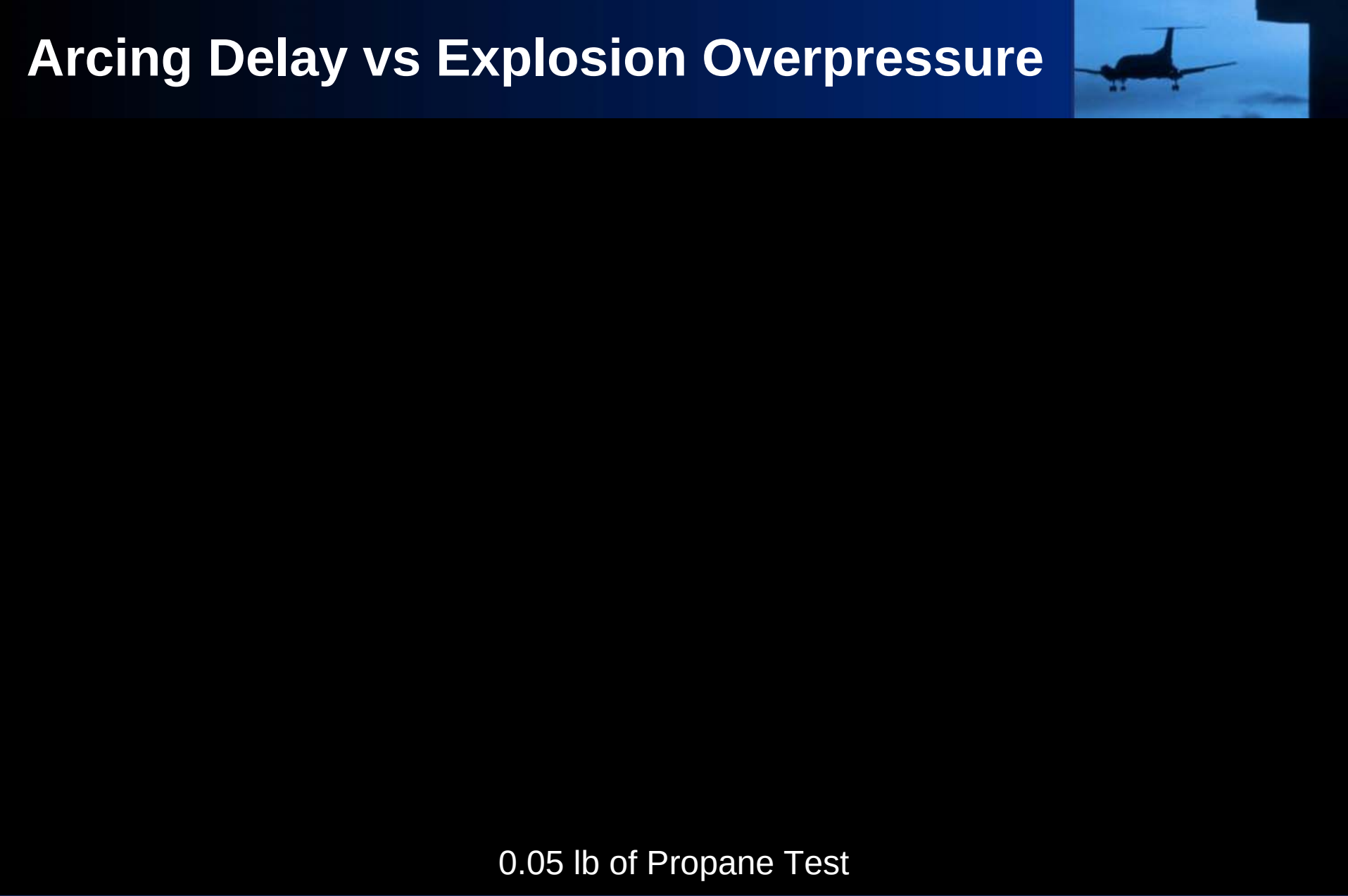
3 Seconds Delay Test

Arcing Delay vs Explosion Overpressure

Change of Fuel Mass Test Matrix & Results

Test	Mass of Propane (lb)	Pressure (psig)
1	0.05	10
2	0.10	15
3	0.14	20
4	0.20	26
5	0.24	30
Note: No ignition time delay; arcing for 5 seconds, 230W		

Arcing Delay vs Explosion Overpressure



0.05 lb of Propane Test

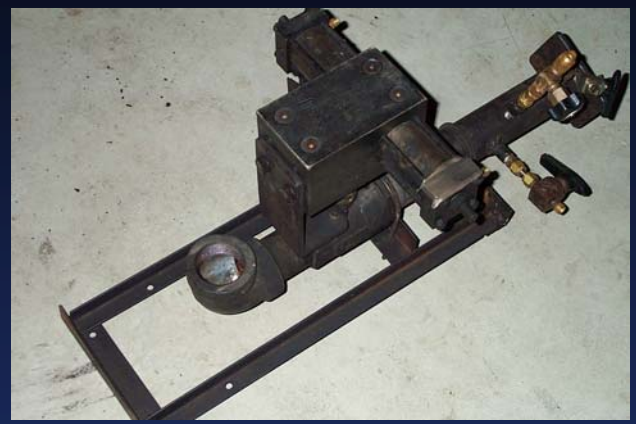
Arcing Delay vs Explosion Overpressure

0.24 lb of Propane Test

Arcing Delay vs Explosion Overpressure

Test Conclusion

The increase in explosion overpressure during the MPS Aerosol Can Explosion Test was due to the increase in the fuel mass (up to a point) in the fuel-to-air ratio of the explosive vapor and not due to the ignition source activation delay.



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Why?

- This effort is to continue with the FAA's search for environmentally-friendly fire extinguishing agents and techniques to minimize or eliminate the use of Halon 1301 onboard the aircraft.

Halon 1301/N2 Synergism

To Conduct these tests, we used …

FAA Building 276

Pressure Vessel

NEA Machine to produce N2

Halon 1301 Fire Bottle

Halon 1301/N2 Synergism

And …

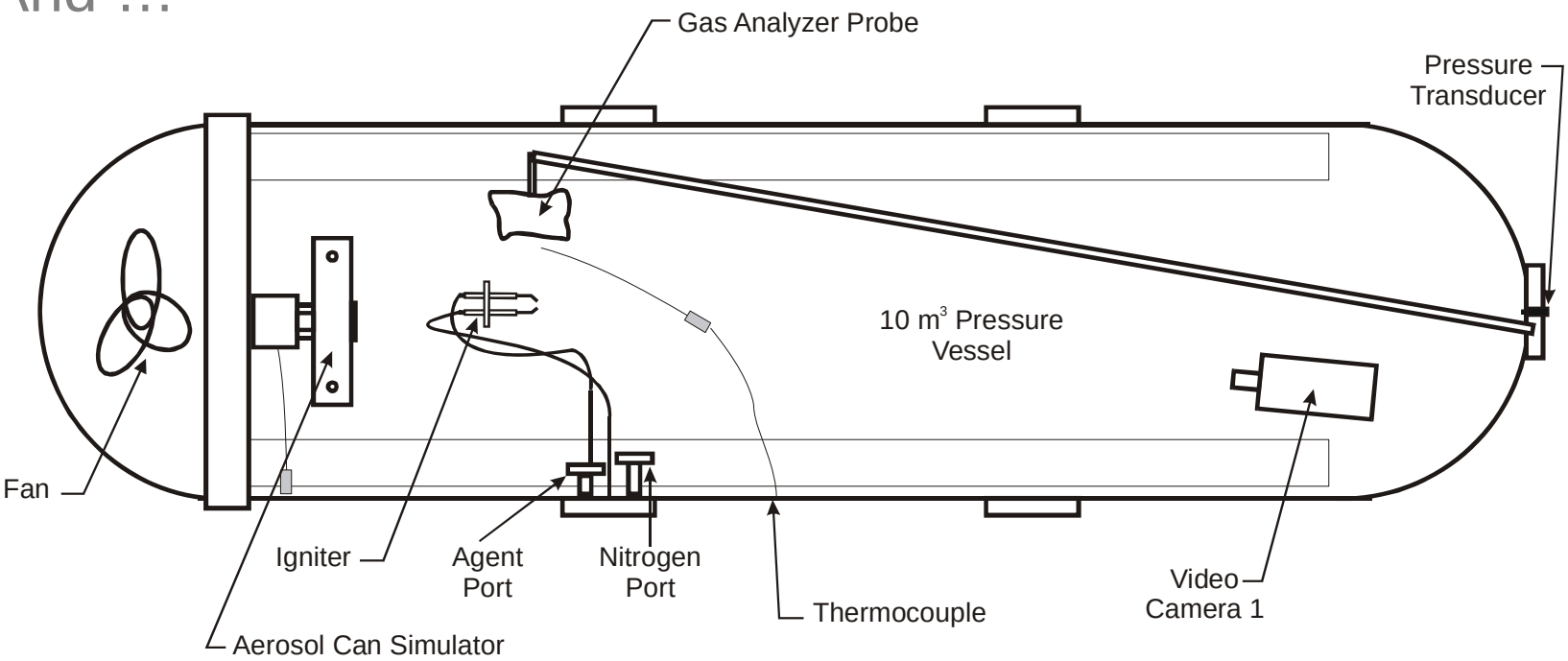


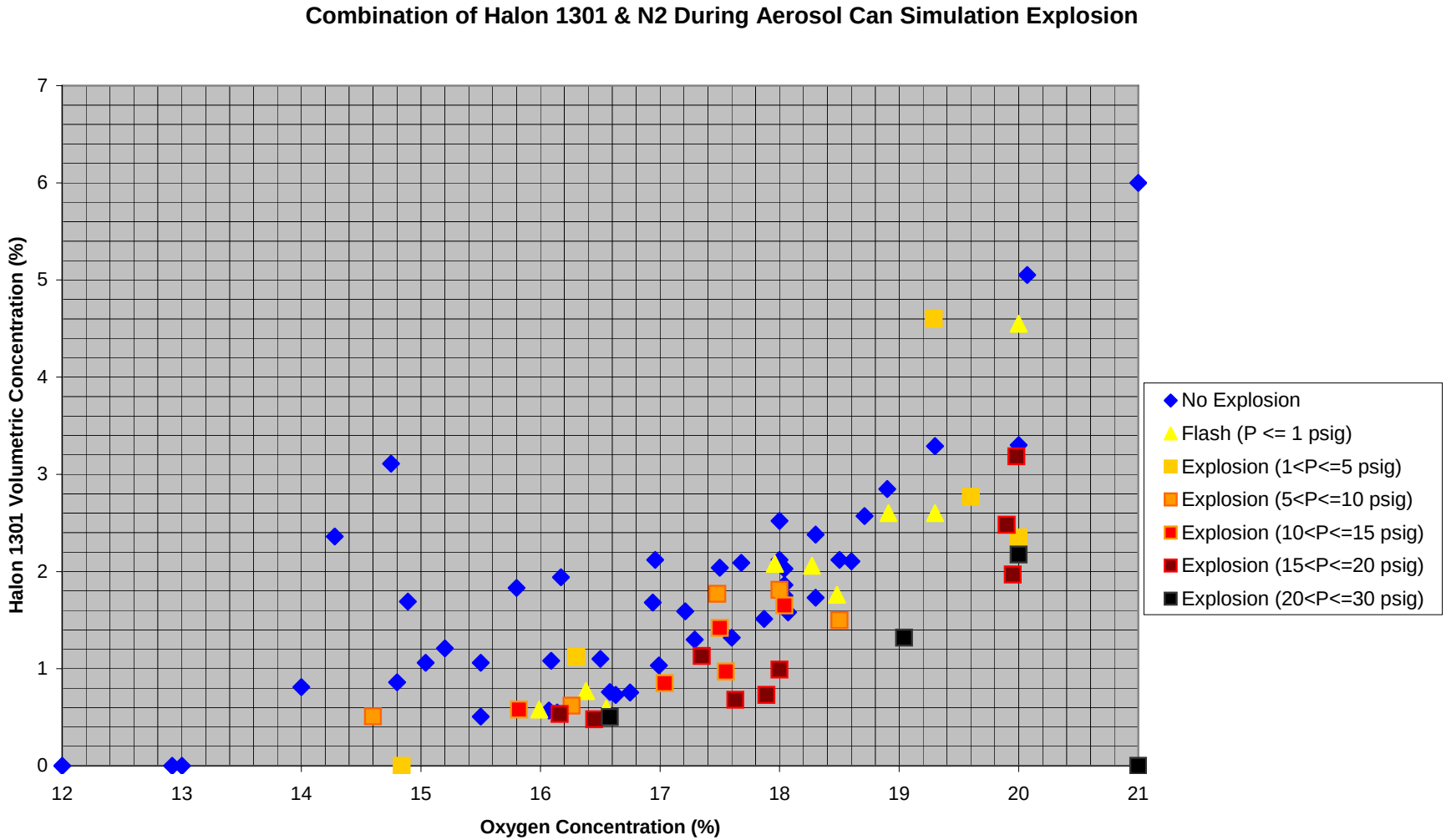
FIGURE 1. PRESSURE VESSEL SETUP

Halon 1301/N2 Synergism

Procedure

- Prepare aerosol can explosion simulator with 0.2 lb of propane, 0.2 lb of water and 0.6 lb of denature alcohol and install inside the pressure vessel.
- Fill fire bottle to a certain mass of Halon 1301 to reach desired concentration and install outside pressure vessel
- Close pressure vessel, turn mixing fan on and initiate the data acquisition system.
- Introduce nitrogen to desire volumetric concentration.
- At the same time, heat up the simulator to increase the simulator's pressure to 240 psig.
- Once the nitrogen level has been reached, discharge fire bottle.
- After the Halon 1301 concentration is level, activate simulator.

Halon 1301/N2 Synergism



Halon 1301/N2 Synergism

Test Conclusion

Results show that in fact a synergistic effect between nitrogen and Halon 1301 exist. Even when the concentration of these gases are not at their corresponding inert concentrations, their mixing at certain concentration ratios do provide significant protection against a propane explosion.

Final Words

In Conclusion:

- The European cardboard boxes and paper are acceptable to be used during MPS tests.
- The increase in explosion overpressure during the MPS Aerosol Can Explosion Test is due to the increase in the fuel mass (up to a point) in the fuel-to-air ratio of the explosive vapor.
- A significant synergistic effect between nitrogen and Halon 1301 exist.