The Synergistic Effect When Combining Nitrogen and Halon 1301 During the MPS Aerosol Can Simulation Explosion

Federal Aviation Administration

Presented to: The Fifth Triennial International Aircraft Fire and Cabin Safety Research Conference

By: John Reinhardt, Project Manager, PMP

Date: October 30-November 1 2007

Outline

Presentation Outline:

- Background
- Scope
- Technical Approach
- Test Results
- Conclusion

Background

BACKGROUND

- FAA continues its efforts, in conjunction with the IAFPSWG, in the investigation and evaluation of new Halon 1301 replacement/alternate agents/systems and reduction techniques.
- A Halon 1301 system is usually design to operate in two stages in the aircraft cargo compartment: (1) High rate of discharge (total flood) (2) slow rate discharge (metering)
- Nitrogen (OBIGGS) will soon be available to a significant number of air transport aircraft (+3200) to inert fuel tanks
- No public data available on the performance of these two gases when combined to protect a cargo compartment against a propane explosion.

Outline

Presentation Outline:

- Background
- Objective
- Technical Approach
- Test Results
- Conclusion

Objective

The objective of this project was to determine the effects of the introduction of nitrogen, into the aircraft cargo compartment, on the performance of Halon 1301 during a propane explosion. Would the introduction of nitrogen be an antagonistic, an additive, or a synergistic interaction with Halon 1301?

Outline

Presentation Outline:

- Background
- Objective
- Technical Approach
- Test Results
- Conclusion

Technical Approach

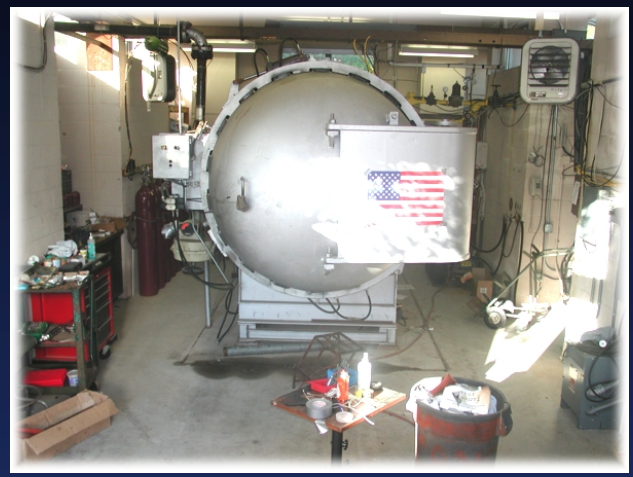
WORK BREAKDOWN STRUCTURE

1. Test Selection
   - 1.1 Test Setup
   - 1.2 Test Procedure
2. Conduct Tests
   - 2.1 Baseline (No Inert)
   - 2.2 Nitrogen Only
   - 2.3 Halon 1301 Only
   - 2.4 Nitrogen & Halon 1301 Combined
3. Analyze Data (Interaction Effects)
4. Prepare Final Report

Technical Approach

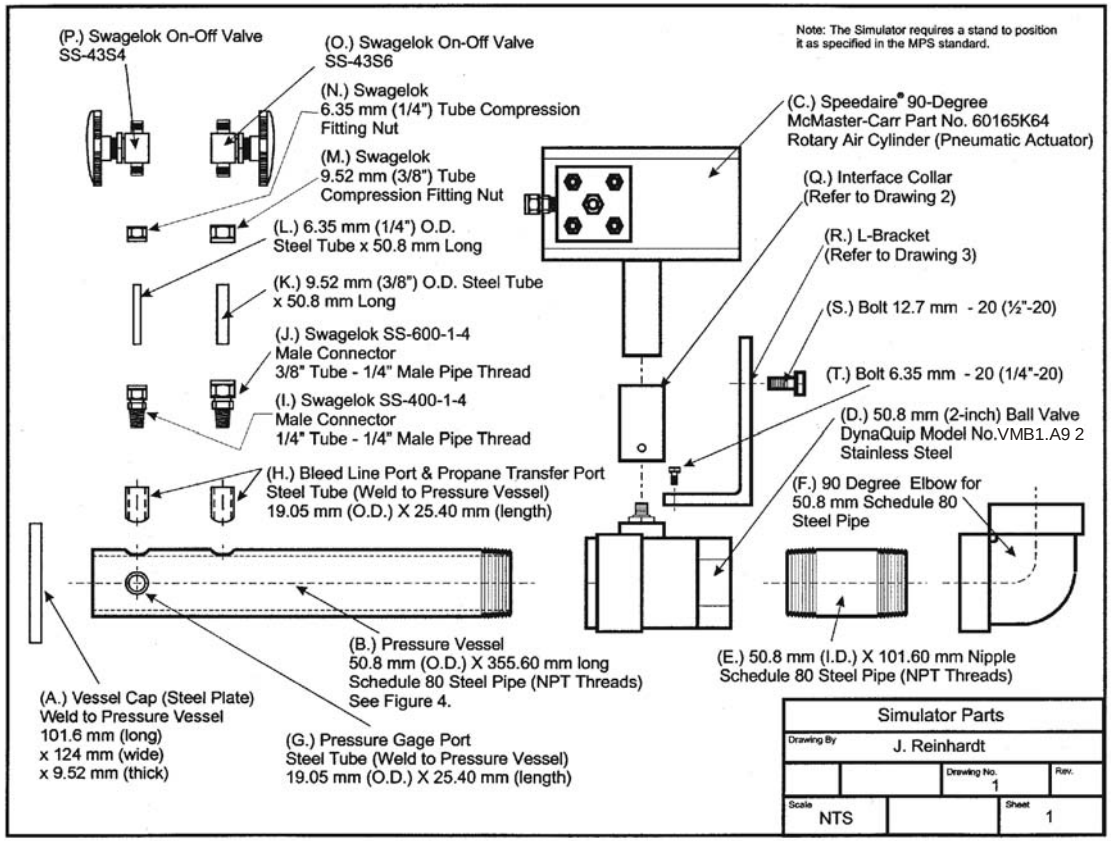
1. TEST SELECTION

- The test selected was a modified version of the aerosol can simulation explosion test described in FAA report DOT/FAA/AR-TN05/20, entitled “Minimum Performance Standard for Aircraft Cargo Compartment Halon Replacement Fire Suppression Systems (2nd Update).”
- Modification included: volume size (2000 ft^3 vs. 402.6 ft^3) and air leakage rate (50 CFM vs. 0.0 CFM)



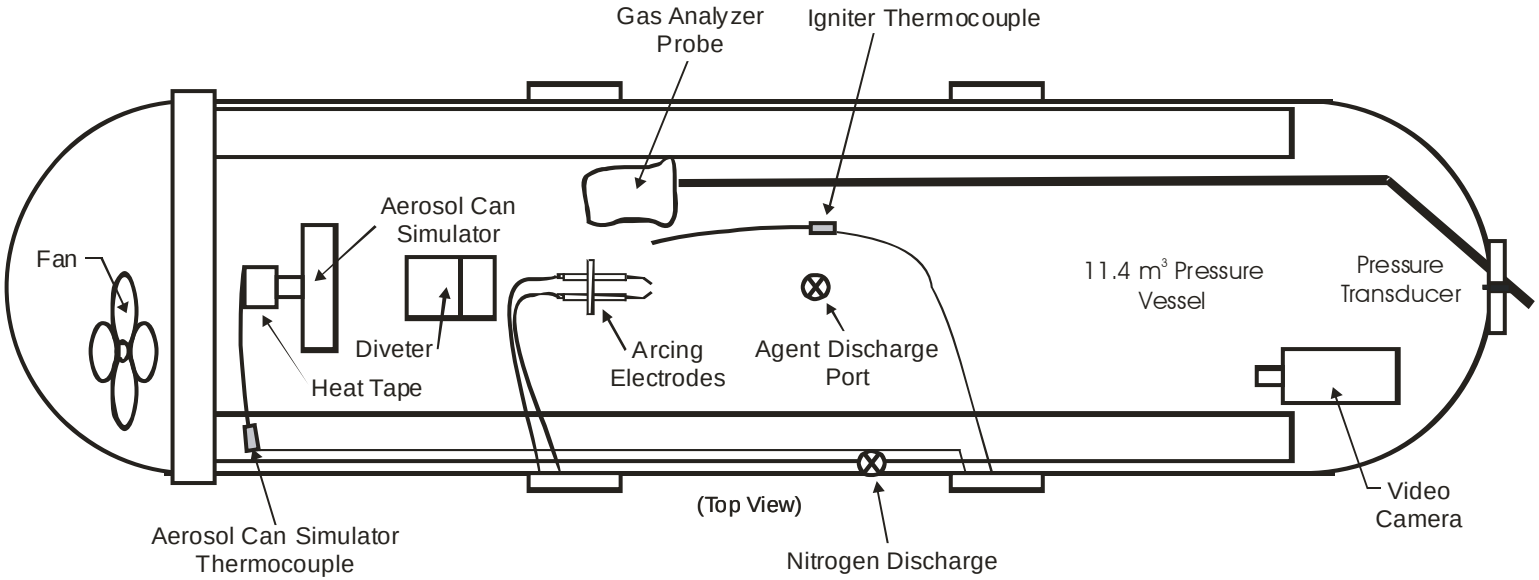
Technical Approach

1.1 TEST SETUP



Technical Approach

1.1 TEST SETUP



PRESSURE VESSEL SETUP

Aerosol Can Simulator

Technical Approach

1.2 TEST PROCEDURE

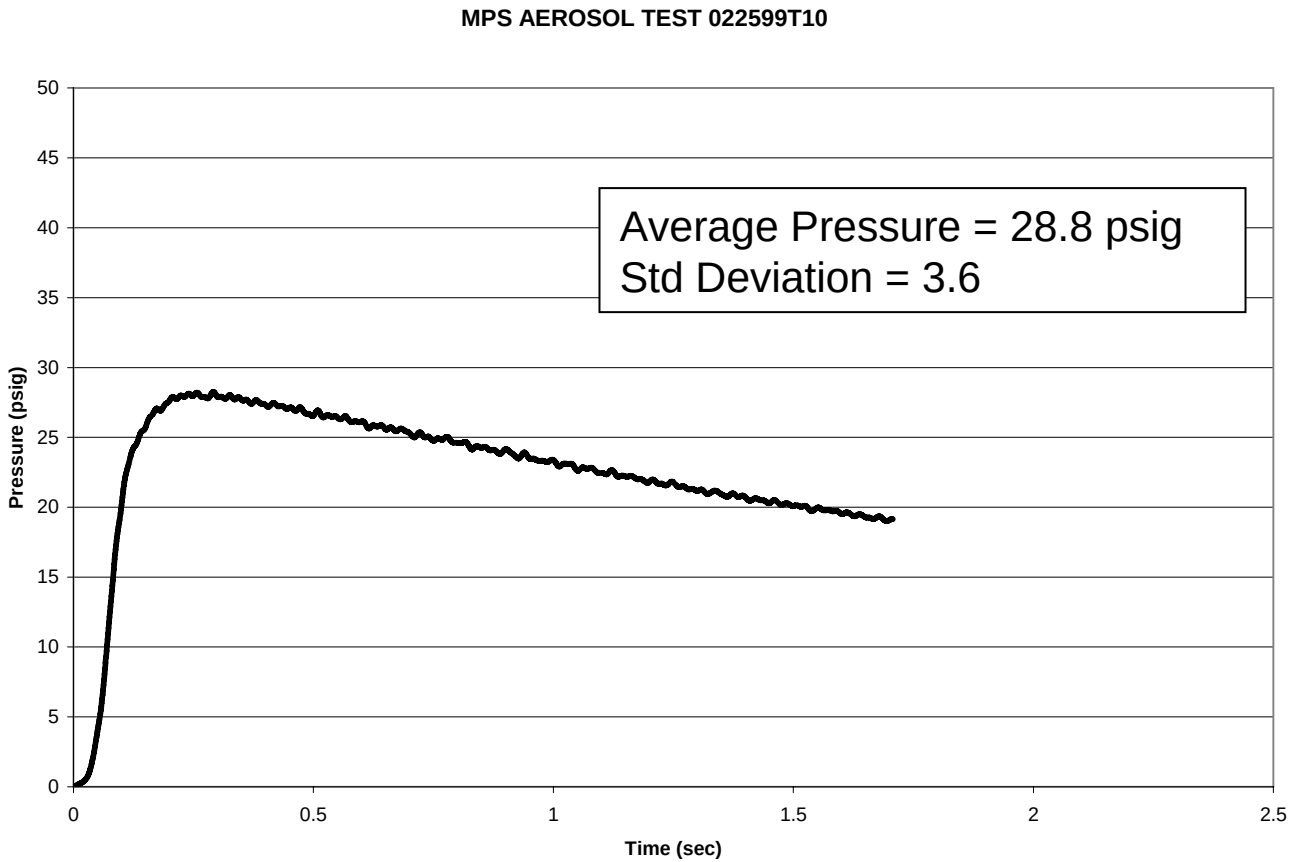
- Prepare aerosol can simulator with 0.2 lb of propane, 0.2 lb of water and 0.6 kg of denatured alcohol and install inside the pressure vessel.
- If Halon 1301 is to be used, fill fire bottle to required agent mass to reach desired concentration and install outside pressure vessel.
- If nitrogen is to be used, connect nitrogen generator feed line to the side of the pressure vessel. Get nitrogen generator readied.
- Close pressure vessel, turn mixing fan on and initiate the data acquisition system.
- Introduce agent(s) to desire concentration(s).

Technical Approach

1.2 TEST PROCEDURE (CONT.)

- At the same time, heat up the aerosol can simulator to increase its pressure to 210 psig.
- Once the agent(s) concentration(s) has been reached, turn the mixing fan off, initiate the high speed data acquisition system and camera, secure testing personnel, then activate the simulator.
- Save and print collected data
- Open, vent and overhaul pressure vessel
- Monitor environment

2.1 CONDUCT TESTS – BASELINE (FROM HISTORICAL DATA)



Technical Approach

2.2 CONDUCT TESTS – NITROGEN ONLY

- From literature search, the NFPA Fire Protection Handbook (18th Edition) indicates that by diluting the oxygen to 11.5% or less, nitrogen is capable of preventing (inerting) the ignition of propane.
- A few tests were conducted to verify the test setup.

Technical Approach

2.3 CONDUCT TESTS – HALON 1301 ONLY

- NFPA 12A, “Halon 1301 Fire Extinguishing Systems” (1992 Edition), specifies that the design concentration for inerting against propane with Halon 1301 is 6.7% (10% safety factor included).
- A few tests were conducted to verify the test setup.

Technical Approach

2.4 CONDUCT TESTS – NITROGEN & HALON 1301 COMBINED

TEST NO	TARGET O2	TARGET H1301	HALON 1301 MASS (LBS)
1	21.0	0.0%	0.00
2	0.0	6.7%	10.38
3	11.8%	0%	0.00
3	21.0	3.3%	5.11
4	13.0%	0%	0.00
5	18.0%	1.5%	2.32
6	19.0%	2.0%	3.10
7	17.5%	2.0%	3.10
8	18.0%	2.5%	3.87
9	17.0%	1.5%	2.32
10	16.0%	1.0%	1.55
11	15.0%	1.0%	1.55
12	14.0%	0.5%	0.77
13	20.0%	3.0%	4.65
14	19.50%	2.50%	3.87
15	18.50%	1.50%	2.32

Note: Add other tests as needed

Technical Approach

3. ANALYZE DATA - DEFINITIONS:

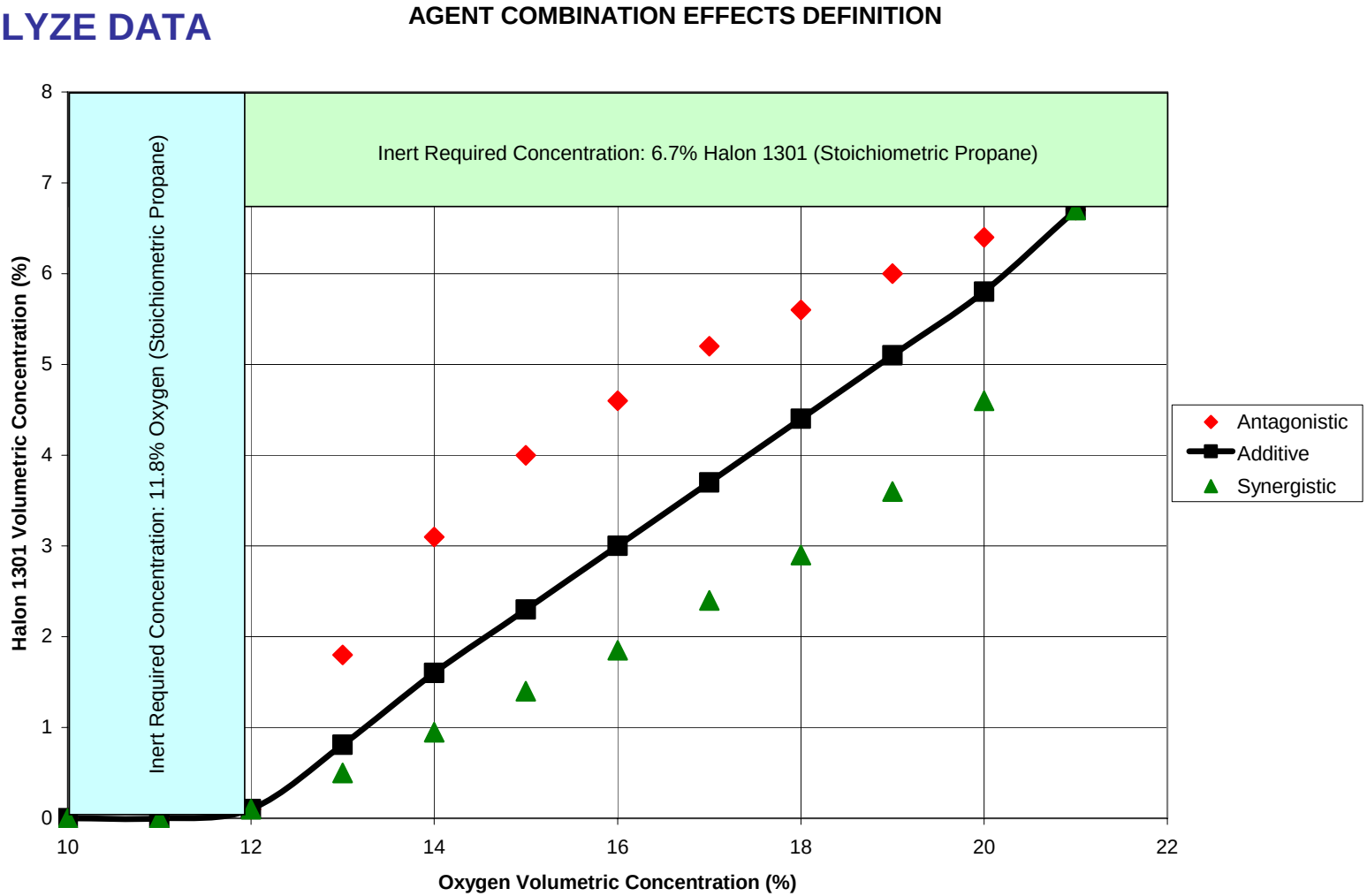
Antagonism - the phenomenon where two agents in combination have an overall effect which is less than that predicted from their individual effects.

Additive - the phenomenon where two agents in combination have an overall effect which is equal to the predicted individual effect.

Synergy (from the Greek *synergos*, meaning working together) refers to the phenomenon in which two or more discrete influences or agents acting together create an effect greater than that predicted by knowing only the separate effects of the individual agents.

Technical Approach

3. ANALYZE DATA



Outline

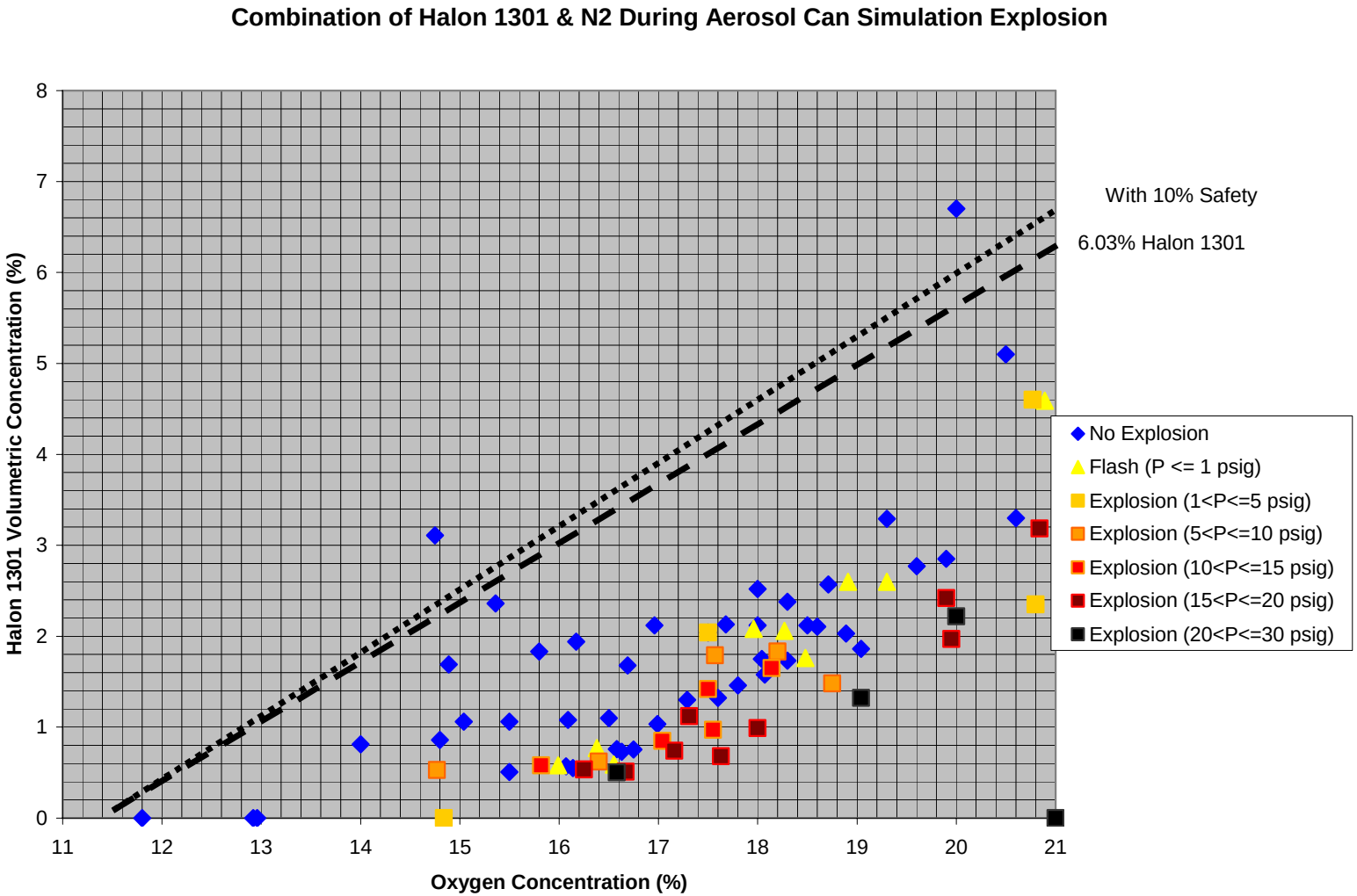
Presentation Outline:

- Background
- Objective
- Technical Approach
- Test Results
- Conclusion

Test Results

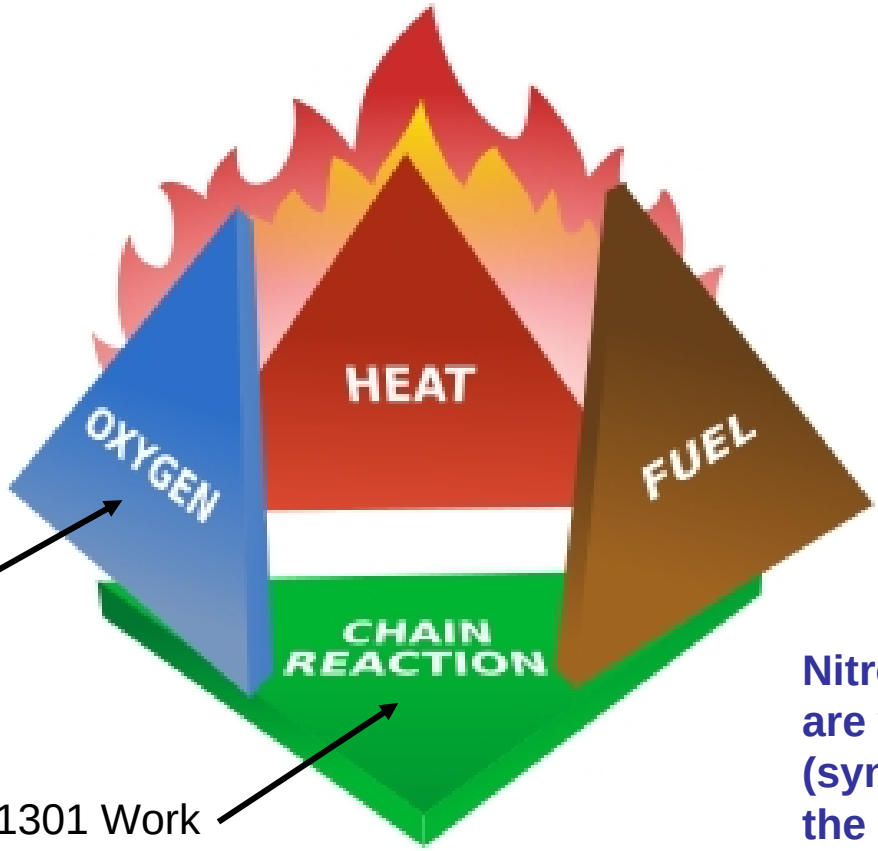
Example of Aerosol Can Simulation Explosion

Test Results



Test Results

WHY? LOOK AT THE FIRE FIGHTING TETRAHEDRON



Nitrogen Work

Halon 1301 Work

Nitrogen and Halon 1301 are working together (synergistically) to fight the rapid fire (explosion)

Outline

Presentation Outline:

- Background
- Objective
- Technical Approach
- Test Results
- Conclusion

Conclusion

CONCLUSION

- Results show that a synergistic effect occurs when Halon 1301 and nitrogen are combined to protect a compartment against a propane explosion.

- This synergistic effect could be used in two ways:
    1. Reduce the amount of Halon 1301 used in the FPS or
    2. Allow more time for an OBIGGS to reach the inert concentration without compromising safety.

Questions?