Use of HFC-125 as a Simulant for Engine/Nacelle Fire Extinguishing Testing

Katie Whelply
Aeronautical Engineer Sr
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Presentation Overview

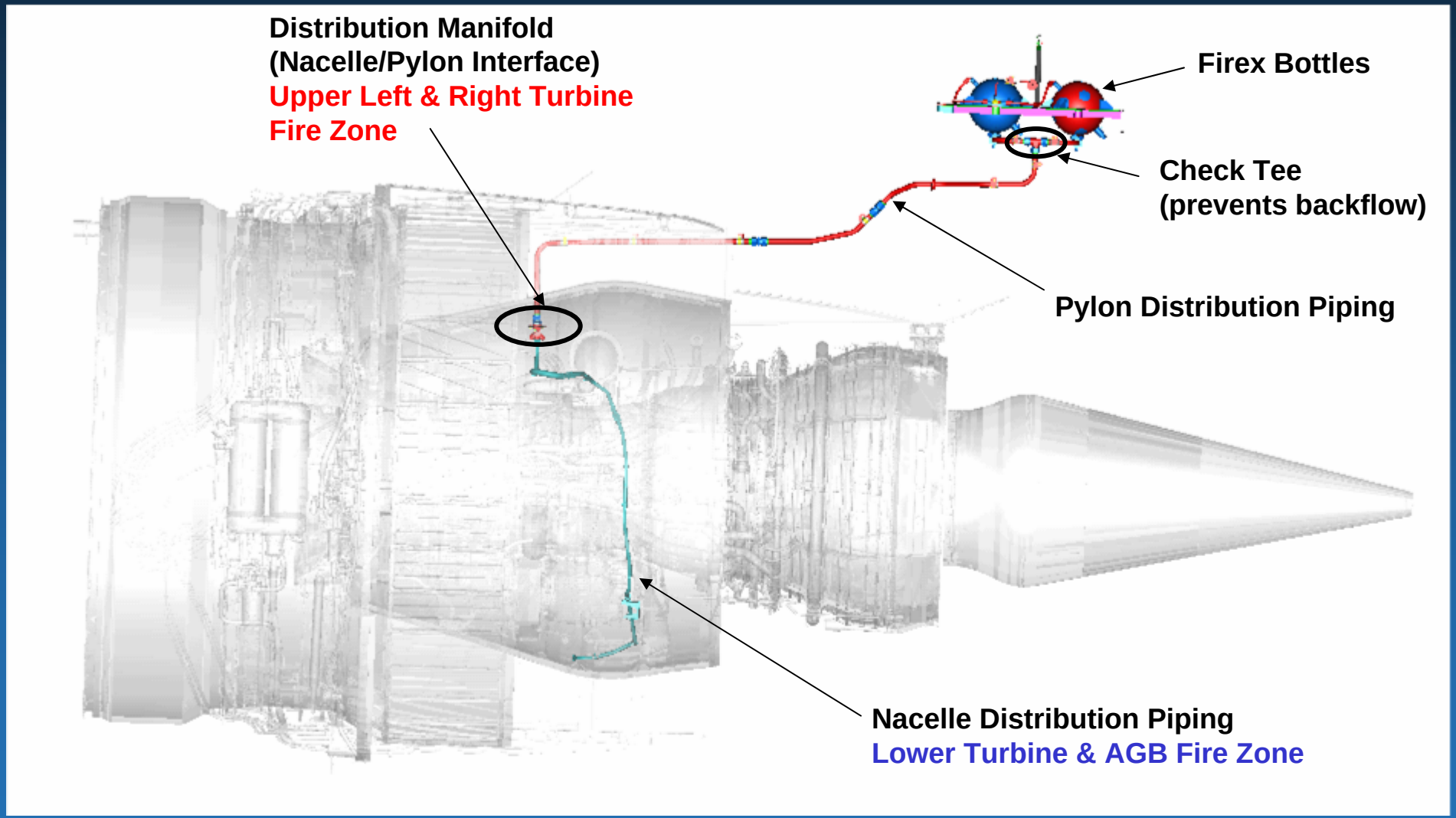
- **Justification**
- **System Description**
- **System Requirements**
- **Agent Comparison**
- **Test Conditions**
- **Test Results**
- **Conclusion**

Justification

- **The results presented herein demonstrate the capability to eliminate release of Halon 1301 for development/qualification purposes**

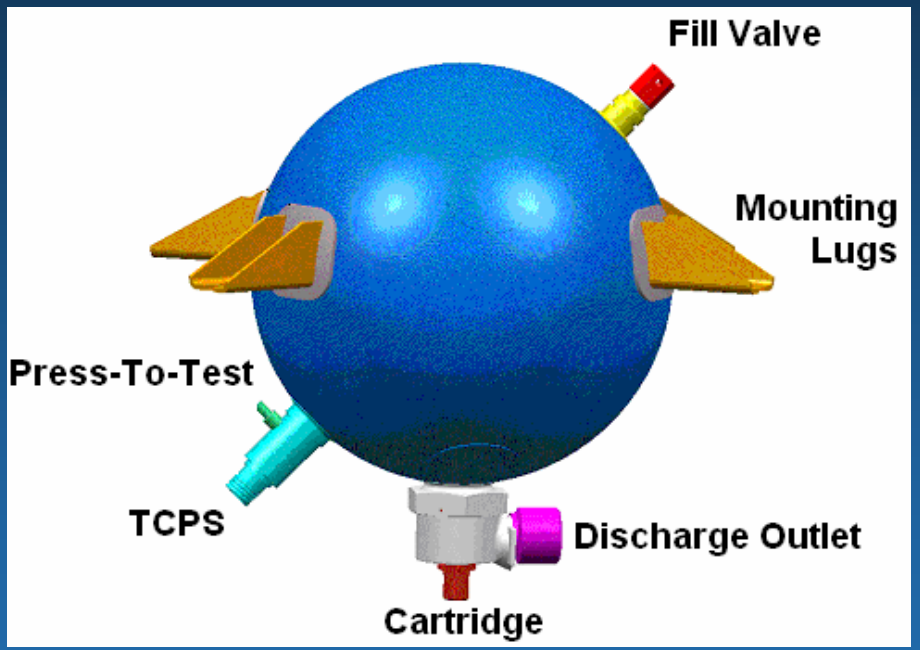
System Description

C-5 Fire Extinguishing (Firex) System



System Description – Firex Bottles

- 2 bottles per pylon (“dual shot”)
- 536 in^3, hermetically-sealed sphere
- Contains 14 lbs Halon 1301 (CF_3Br)
- Supercharged with N_2 for faster release
- Operating temp: -65°F to +250°F
- Nominal charge pressure: 600 psig
- Electrical current from cockpit ruptures cartridge, releasing pressurized agent thru discharge outlet into distribution piping



System Requirements

- MIL-22285 requires Halon 1301 concentration levels must be greater than 6% by volume in air for a minimum of 0.5 seconds simultaneously in 12 locations throughout the protected fire zone
  - -- To guarantee 6%, all Halonyzer channels must = 6.72%
  - -- AC 20-100 provides requirements for 12 sample probe locations

- If possible, reduce halon emissions during certification and system development testing by using a simulant agent
  - -- MIL-22285 requires use of HFC-125 for any halon system qual
  - -- Clean Air Act 40 CFR 82.270 (b)(3) requires use of simulant in lieu of halon unless technical reasons prevent
  - -- DOT/FAA/AR-TN99/64 defines simulant fill parameters
  - -- B777-300ER certified with simulant by FAA (provides Halonyzer system test equipment calibration basis)

Agent Comparison – Fill Parameters

- **Fill bottle to 77% weight of Halon 1301 (MIL-22285 Sec 4.3.2.2.1)**

$$W_{HFC} = 77\%W_{Halon}$$
$$W_{HFC} = (0.77)*(14\ lbs)$$
$$W_{HFC} = 10.78\ lbs$$

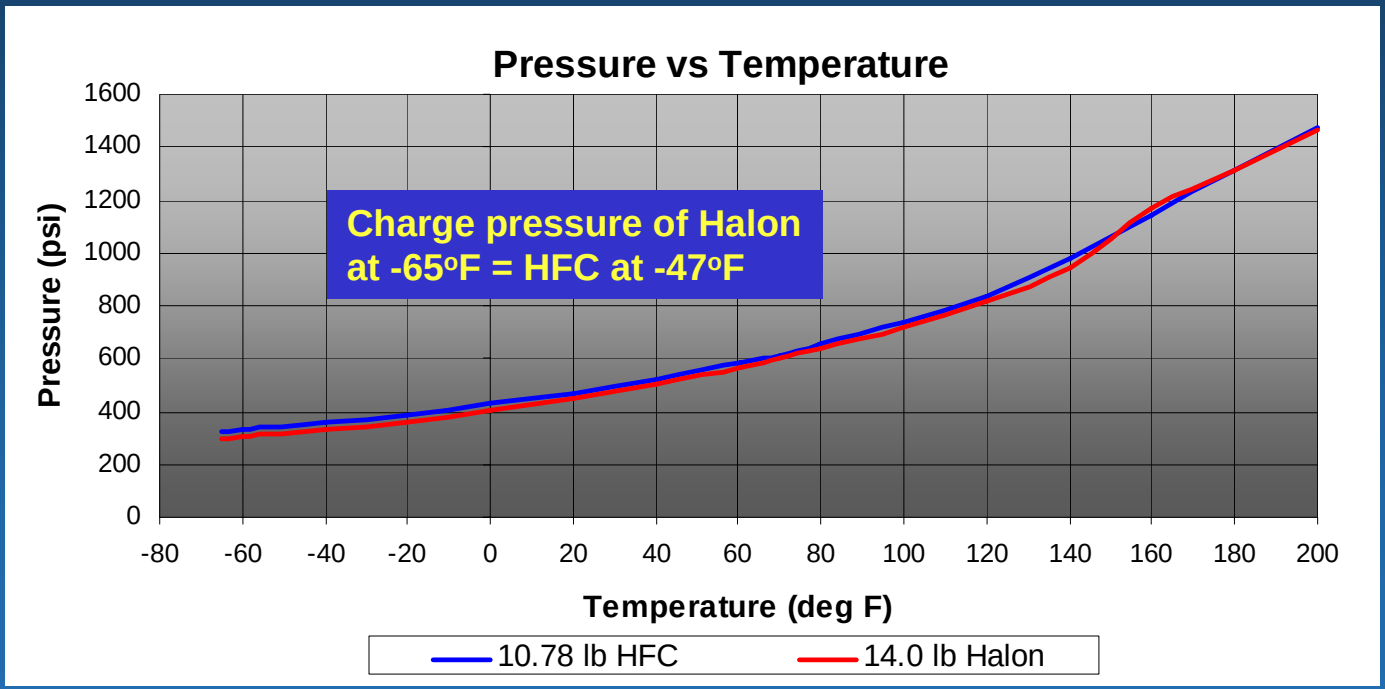
- **Nitrogen pressurization of the simulant/test bottle is equivalent to the actual extinguishing system bottle**

Agent Comparison – Physical Properties

- **Because of the different gas and liquid characteristics of HFC-125 and Halon 1301, the test conditions were tailored to account for the differences in gas dispersion characteristics, vapor pressure and Jakob's number of the two test materials**

Jakob's #, $Ja_{HFC,-47F} = Ja_{Halon',-65F} = 0.02$

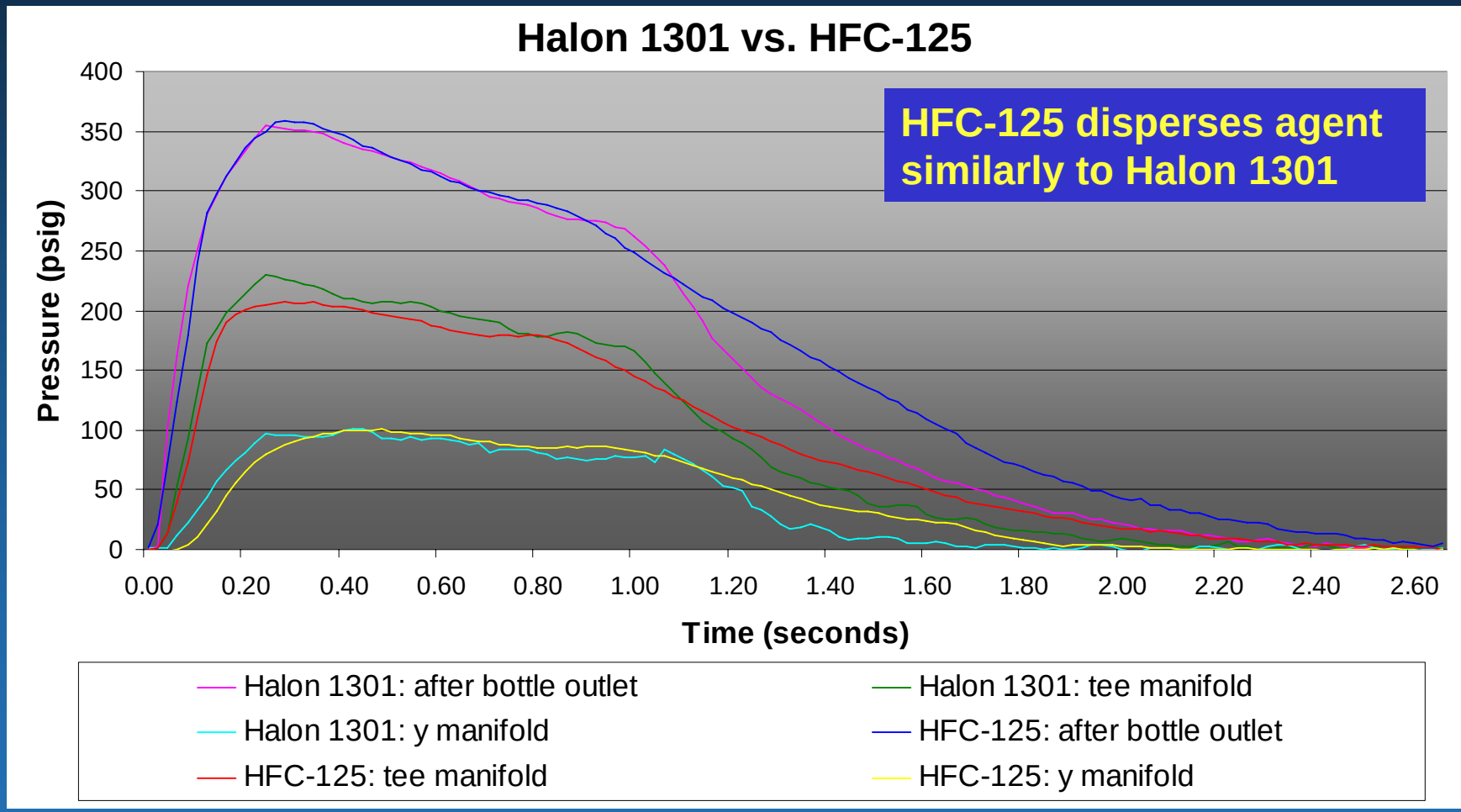
Vapor Pressure, $vp_{HFC,-47F} = vp_{Halon',-65F} = 17.7$ psia



HFC-125 at -47°F is equivalent to Halon 1301 at -65°F

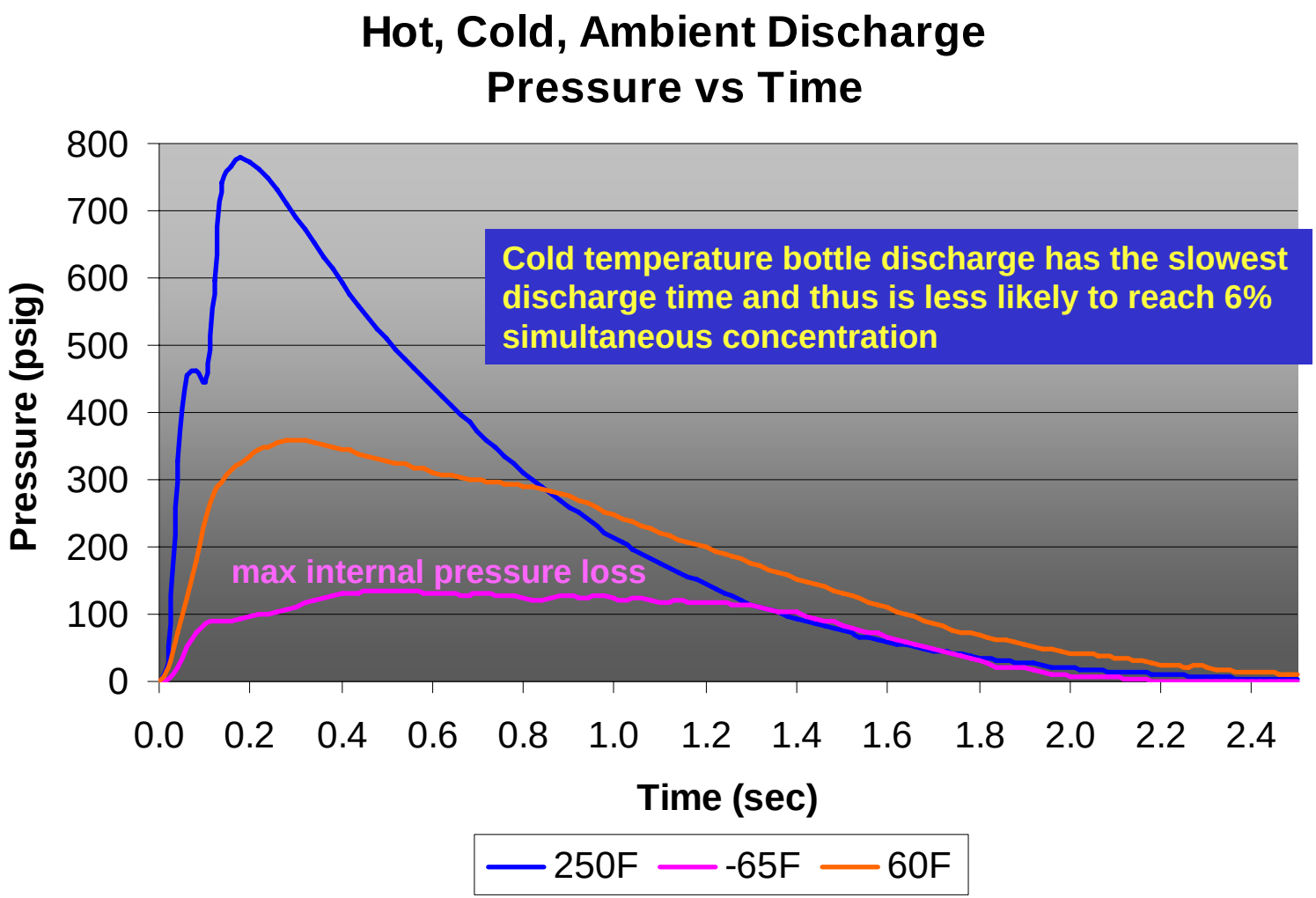
Agent Comparison – Discharge Testing

Agent discharge testing was conducted with HFC-125 and compared with Halon 1301 discharge test results



Based on discharge test results, HFC-125 is a viable simulant for Halon 1301

Test Conditions – Bottle Discharge



Ground test to be conducted with cold-soaked bottle

Test Conditions – Dilution Flow

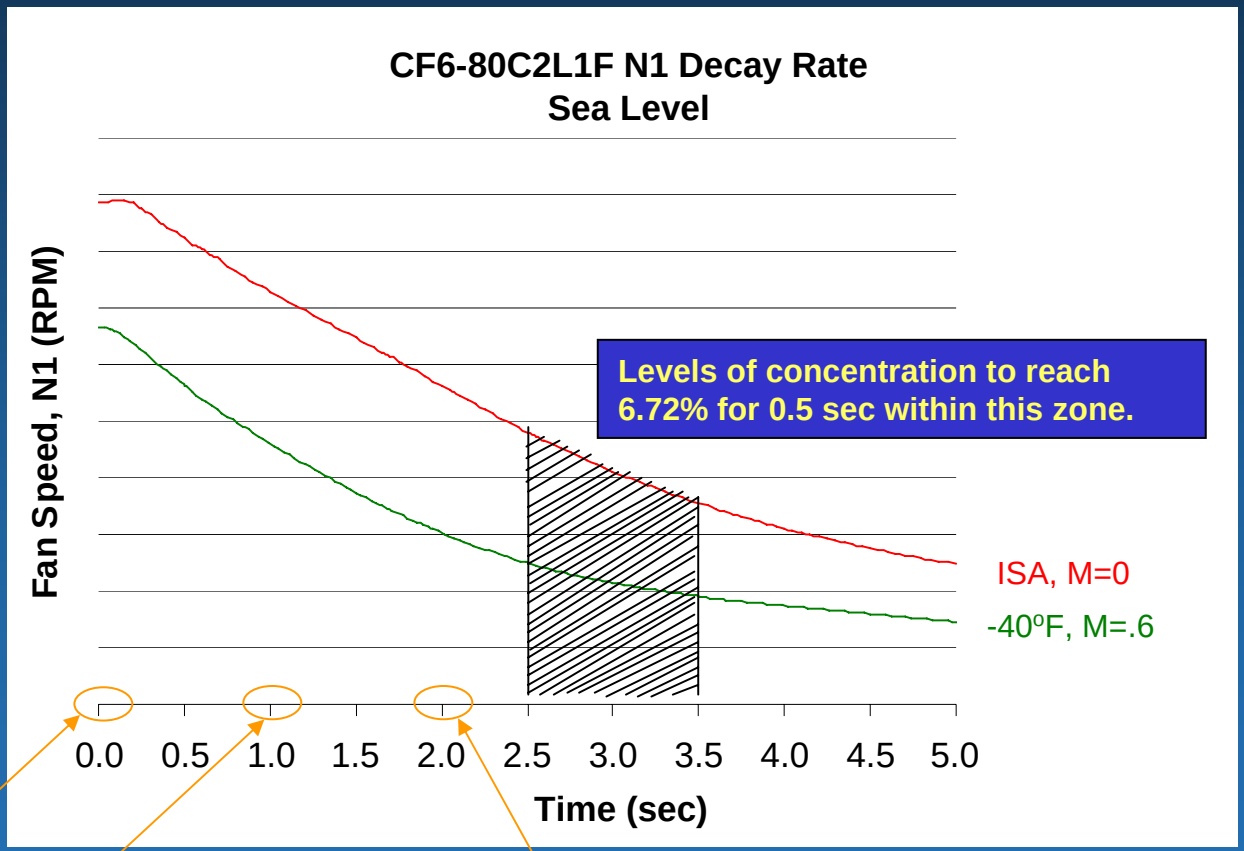
Dilution flow is the primary constraint affecting the ability the of the agent to diffuse in the nacelle fire zone (i.e. the greater the flow, the more agent needed to extinguish a fire). There are two key parameters to set maximum dilution flow rate:

1. **Maximum dynamic pressure occurs at**
   - ***Max aircraft velocity (Bernoulli's equation)***
   - ***Dilution flow DECREASES w/altitude due to density effect so the flight envelope worst-case can be duplicated on the ground***

2. **Maximum N1, highest pressure rise across fan & booster stage where core cooling flow is being taken**
   - ***Discharge of Halon 1301 requires the fire handle to be pulled, shutting off the fuel flow, primary source of fire. But,***
   - ***HFC-125 requires a steady state flow so the fire handle cannot be pulled because it shuts down the engine, providing a variable reduction in speed. Instead, the %N1 of the engine at the time the agent reaches the engine must be determined to adequately simulate a fire handle pull***

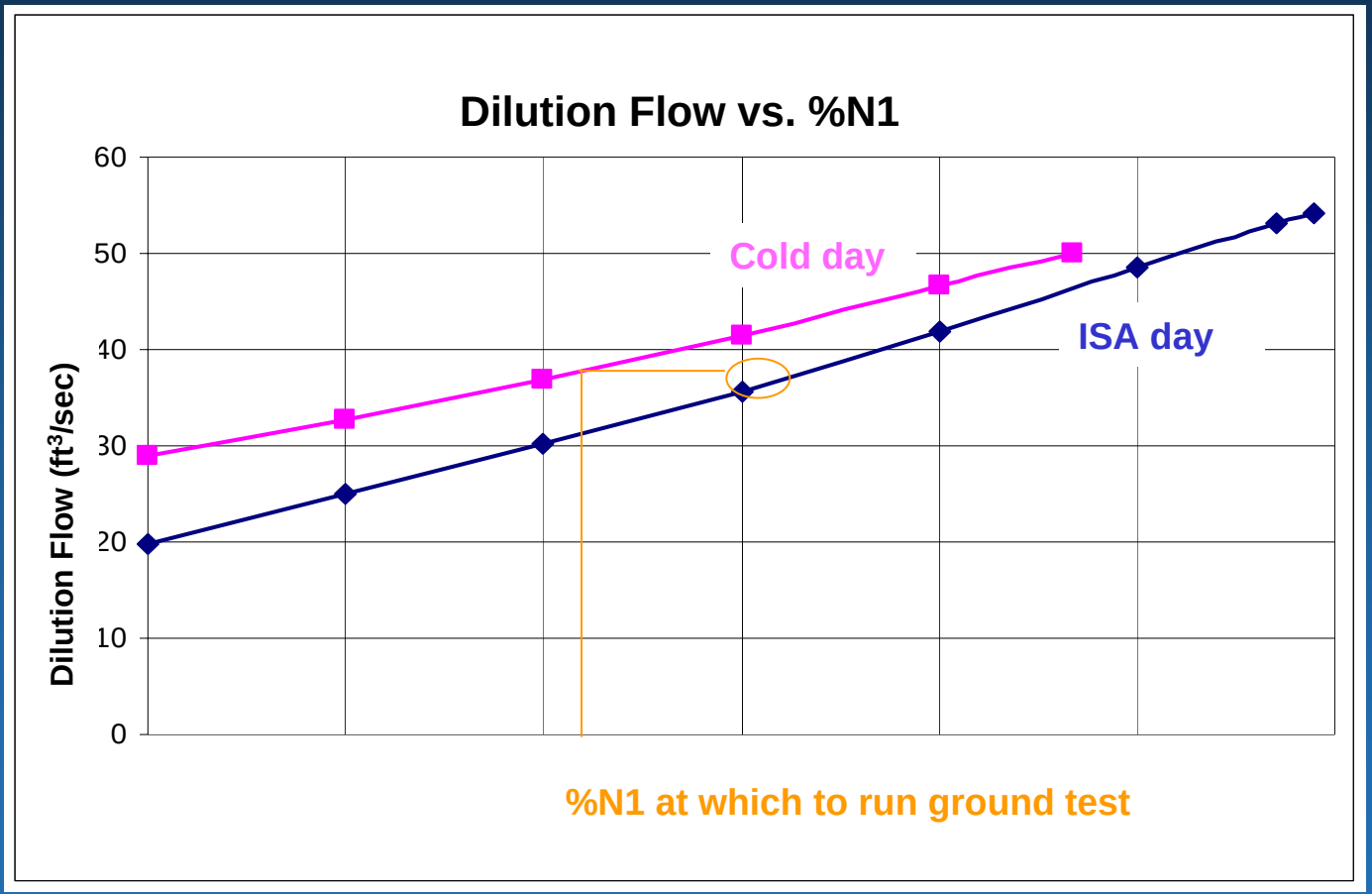
Test Conditions – %N1 Decay Rate

- Since HFC-125 requires a steady-state flow, the N1 decay rate is examined to determine the speed at which the engine should be set during ground test
- Calculations take into account the time required for cold day bottle discharge, time to activate fire bottle and time for agent to reach engine



Test Conditions – %N1 Density Correction

- Ground test is conducted with M=0 on a standard day
- To determine correct steady state %N1, a density correction must be performed



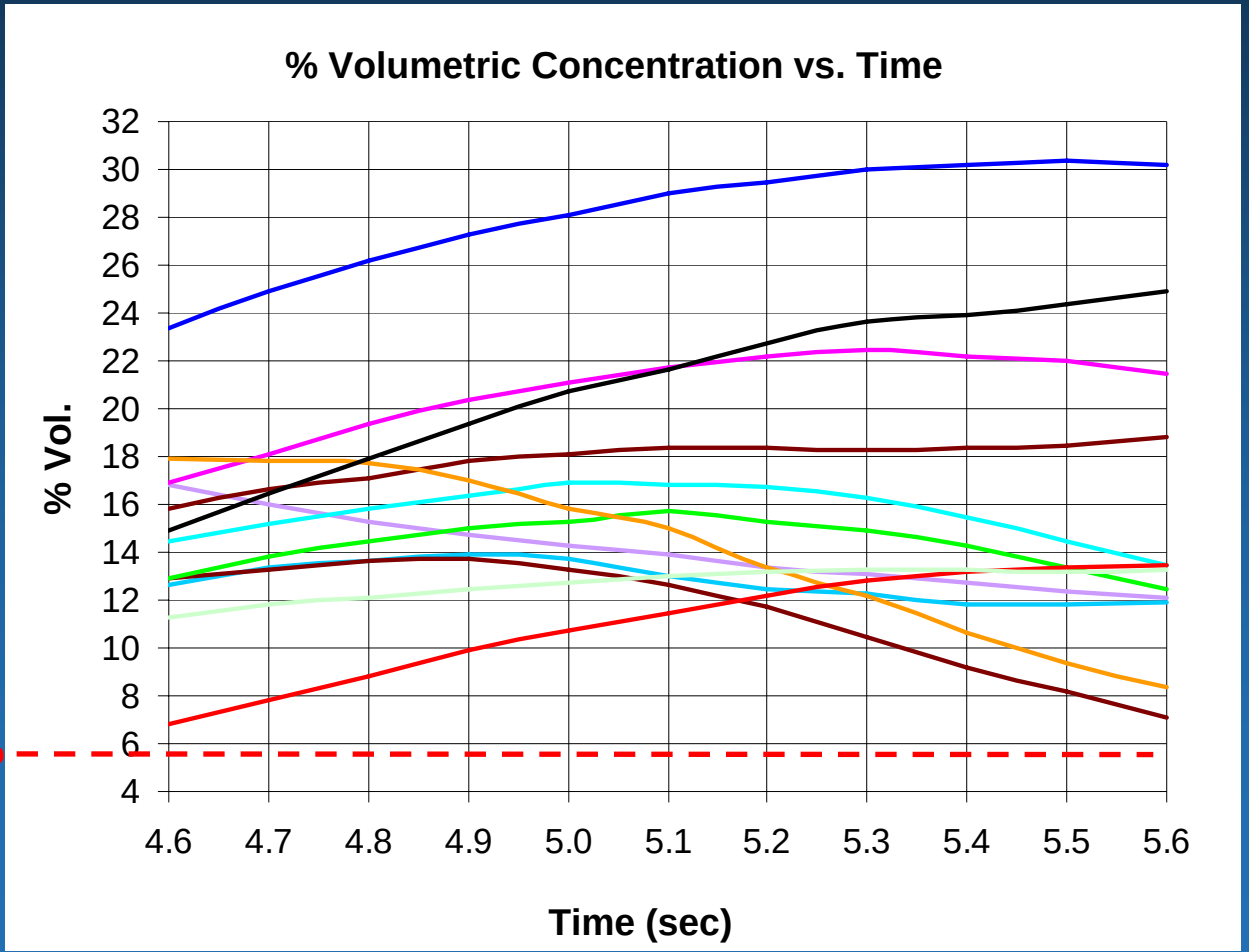
Test Set-up

- **Calibration check performed on Halonyzer III System**
  - ***Halonyzer authorized for use with HFC-125***
- **Leak check performed on the 12 sampling probes**
- **Insulated 10.78 lb HFC-125 bottle cold-soaked to - 90ºF**
  - ***Standard day raises bottle temp quickly, even with insulation***
  - ***Bottle at -47ºF at time of discharge***
- **Relative humidity = 58%**
  - ***must be between 25% and 75%***
- **Advanced test engine to required %N1**
  - ***Speed stabilized for 1 minute before agent release***

Test Results

- **March 2006: using HFC-125 as a simulant, the C-5M CF6-80C2L1F engine firex system agent concentration exceeded FAR 25.1195(b) certification requirements**

Concentration levels ranged from 6.8 to 30.2 for 1 full second, twice the ½ sec requirement



Conclusion

- **HFC-125 successfully simulated an Halon 1301 fire bottle discharge, proving HFC-125 is a viable alternative of Halon 1301**
  - ***HFC-125 "environmentally friendly"***
  - ***Reduction of Halon 1301 emissions during certification and system development testing (Montreal Protocol)***
- **HFC-125 can be used in lieu of Halon 1301 for purposes other than actual fire extinguishing with the following system modifications**
  - ***Refill fire bottle with HFC-125***
  - ***Provide steady-state condition***

Questions?