Engine Nacelle Halon Replacement, FAA, WJ Hughes Technical Center

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- *Goal :*

  Provide engine nacelle/APU certification criteria addressing halon replacement agents/technologies for commercial aircraft manufacturers

- *Project Participants :*
  - Airframe manufacturers
  - Component level manufacturers
  - System level manufacturers
  - Operators
  - Regulatory authorities
- *Supporting Documentation :*
  - "Minimum Performance Standard for the Engine and Auxiliary Power Unit Compartments," July 1996 draft
  - DOT/FAA/AR 96/80, "User Preferred Fire Extinguishing Agents for Engine and Auxiliary Power Units," August 1996
  - white paper, "Options for Aircraft Engine Fire Protection," September 2000

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• *Brief History :*

- First meeting, October 1993
- Fabrication of a nacelle simulator started, October 1993
- Second (??) draft of the Minimum Performance Standard for the Engine and Auxiliary Power Unit Compartments (MPSE), March 1995
- Independent gas analysis capability established, 1995
- Task group meeting, completed standing revision of the MPSE, July 1996
- HFC-125, CF_3I, HFC-227ea selected as agents for review, August 1996
- Simulant protocol for Halon 1301 discharge published, August 1999
- Completed simulator at Technical Center, April 2000
- Started shaking down simulator in preparation for testing, August 2000
- Task group meeting, discussed issues resulting from simulator shake down, August 2000
- Agent selection reviewed and reduced to HFC-125 and CF_3I, September 2000
- Gas analysis capability failed, September 2000

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•*Minimum Performance Standard for the Engine and Auxiliary Power Unit Compartments (MPSE)*

- Current revision finalized in July 1996
- Process intended to demonstrate equivalence of alternate agents/technologies to that of Halon 1301 (the current level of safety)
- Process crafted to control the drift in results associated with test fixtures dedicated to fire testing
- Process addresses issues directly related to the application
- Document specifies :
  - the geometry of a simulator
  - the type and quantity of testing required
  - the sequence in which to carry it out

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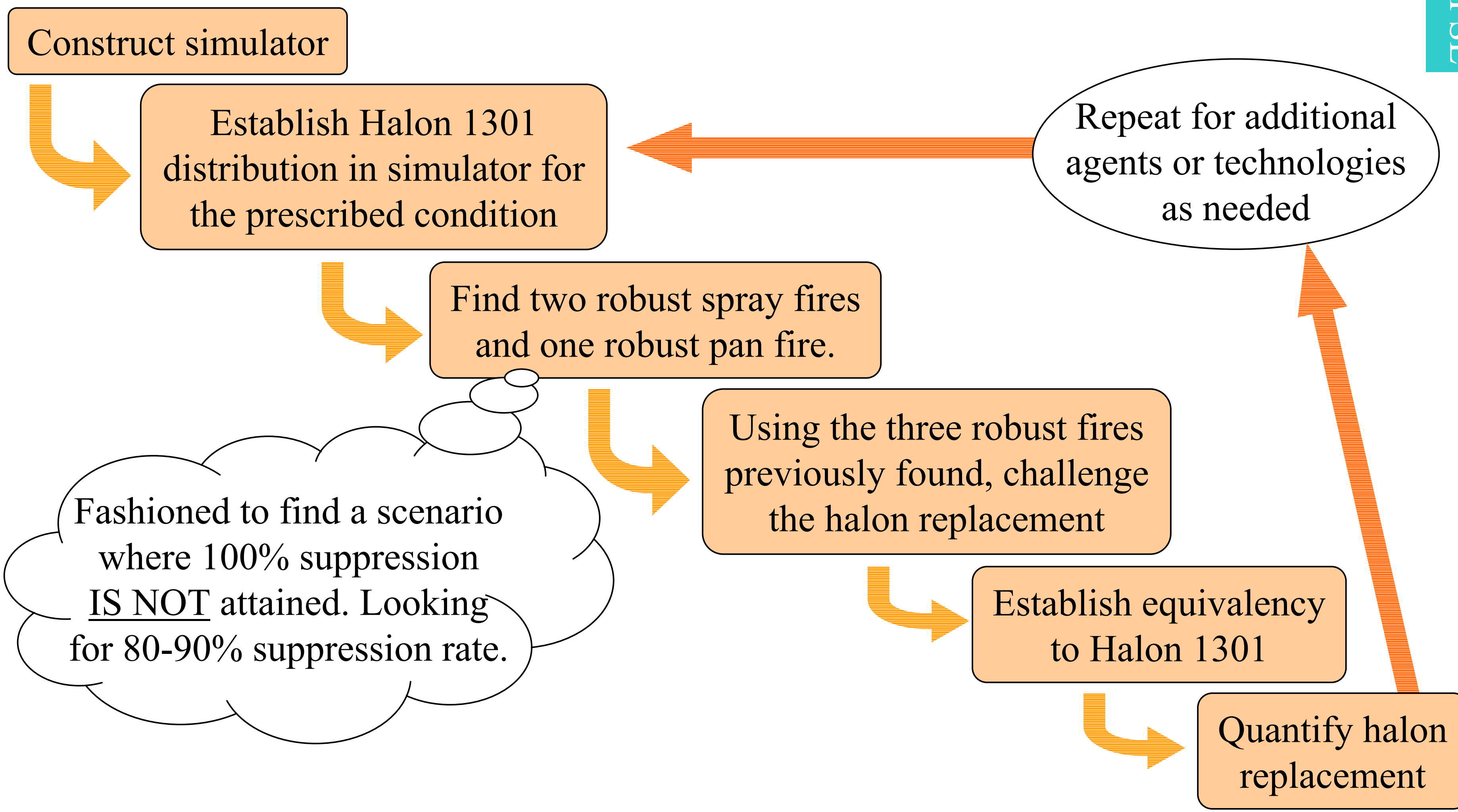
Project, MPSE



•*Simulator Geometry*

Volume & Area

Minimum compartment volume : 65 ft^3 (1.84 m^3).

Minimum annular cross sectional area : 5.5 ft^2 (0.51 m^2).

Hot Surface

Length, longitudinal : 2.0 ft (61.0 cm).

"Width" : minimum 90° arc.

Location : proximal to spray and pool fire simulations.

Fire Scenarios

Types : Spray → upper half of annulus
Residual (a.k.a. pool) → lower half of annulus

Pre-burn time : spray → $t \geq 5$ seconds
residual → $t \geq 15$ seconds

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•*Simulation Parameters*

Air supply

Air flow rate, high setting : 2.5 - 3.0 lbm/s (1.1-1.4 kg/s)

Air flow rate, low setting : 0.2 - 0.9 lbm/s (0.09-0.4 kg/s)

Air supply temperature, high setting : 400 °F (204°C)

Air supply temperature, low setting : 100 °F (38°C)

Fuel Supply & Delivery

Fuel types : turbine fuel, hydraulic fluid or lubricant

Supply temperature : 150°F (66°C)

Spray fire nozzle supply flow rate : 0.1 - 1.0 gpm (0.4-3.8 lpm)

Pan fire pool volume : 0.25 gal (with 1.5 inch tall freeboard)
0.94 l (with 3.8 cm tall freeboard)

Agent Storage & Delivery

Storage temperatures : -65 °F (-54°C)
100 °F (38°C)
200 °F (93°C)

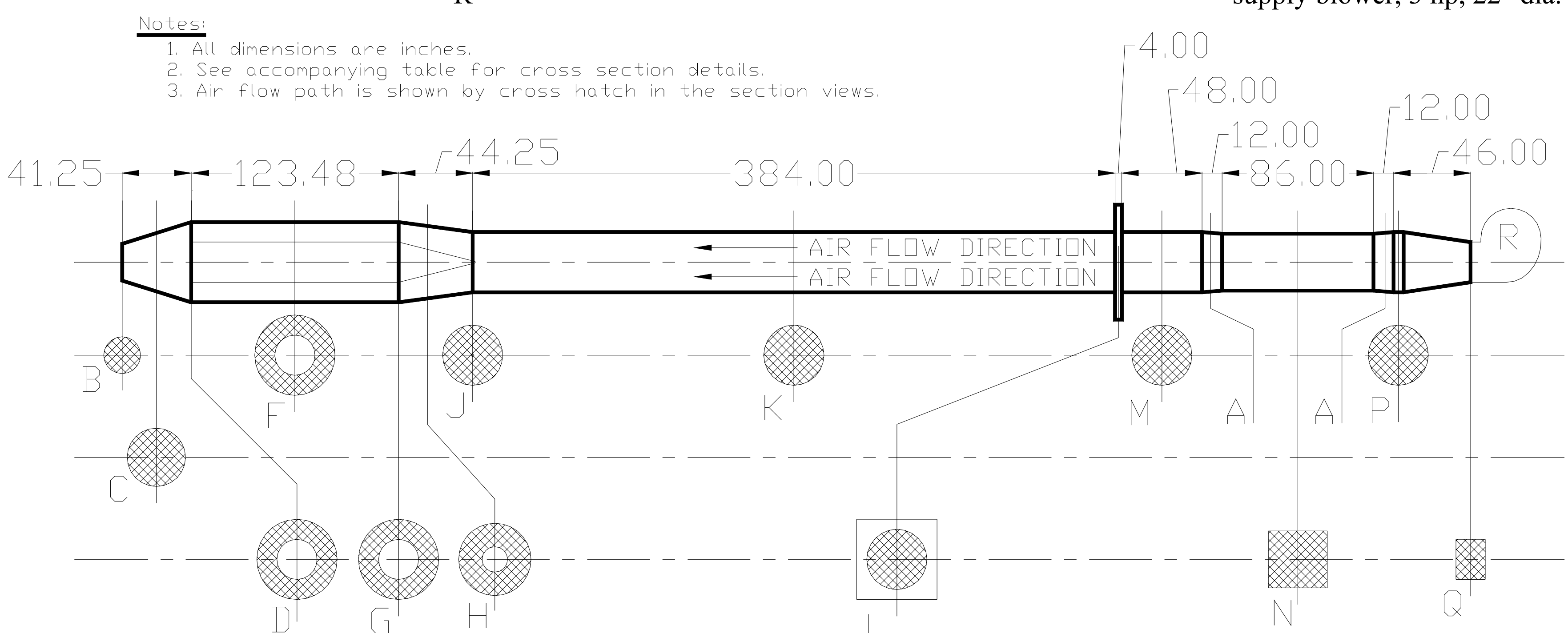
Volume : as dictated by agent and conditions

Engine Nacelle Halon Replacement

Schematic of the Simulator

Dimensions of Various Cross Section for the Nacelle Simulator

	R_o or H (in)	R_i or W (in)	area (in^2)	area (ft^2)	comment
A	-	-	-	-	transition duct
B	11	0	380	2.64	exhaust nozzle cross section
C	17.5	0	962	6.68	exhaust nozzle cross section
D	24	12	1357	9.42	test section aft end
F	24	12	1357	9.42	test section middle
G	24	12	1357	9.42	test section inlet
H	21	6.51	1252	8.69	inlet diffuser middle
J	18	1.02	1016	7.06	inlet diffuser entrance
K	18	0	1018	7.07	approach duct
L	18	0	1018	7.07	straightening grill
M	18	0	1018	7.07	straightening grill entrance
N	35	35	1225	8.51	tube bank heat exchanger shell
P	18	0	1018	7.07	transition duct
Q	24	17.5	420	2.92	blower outlet
R	-	-	-	-	supply blower, 3 hp, 22" dia. inlet



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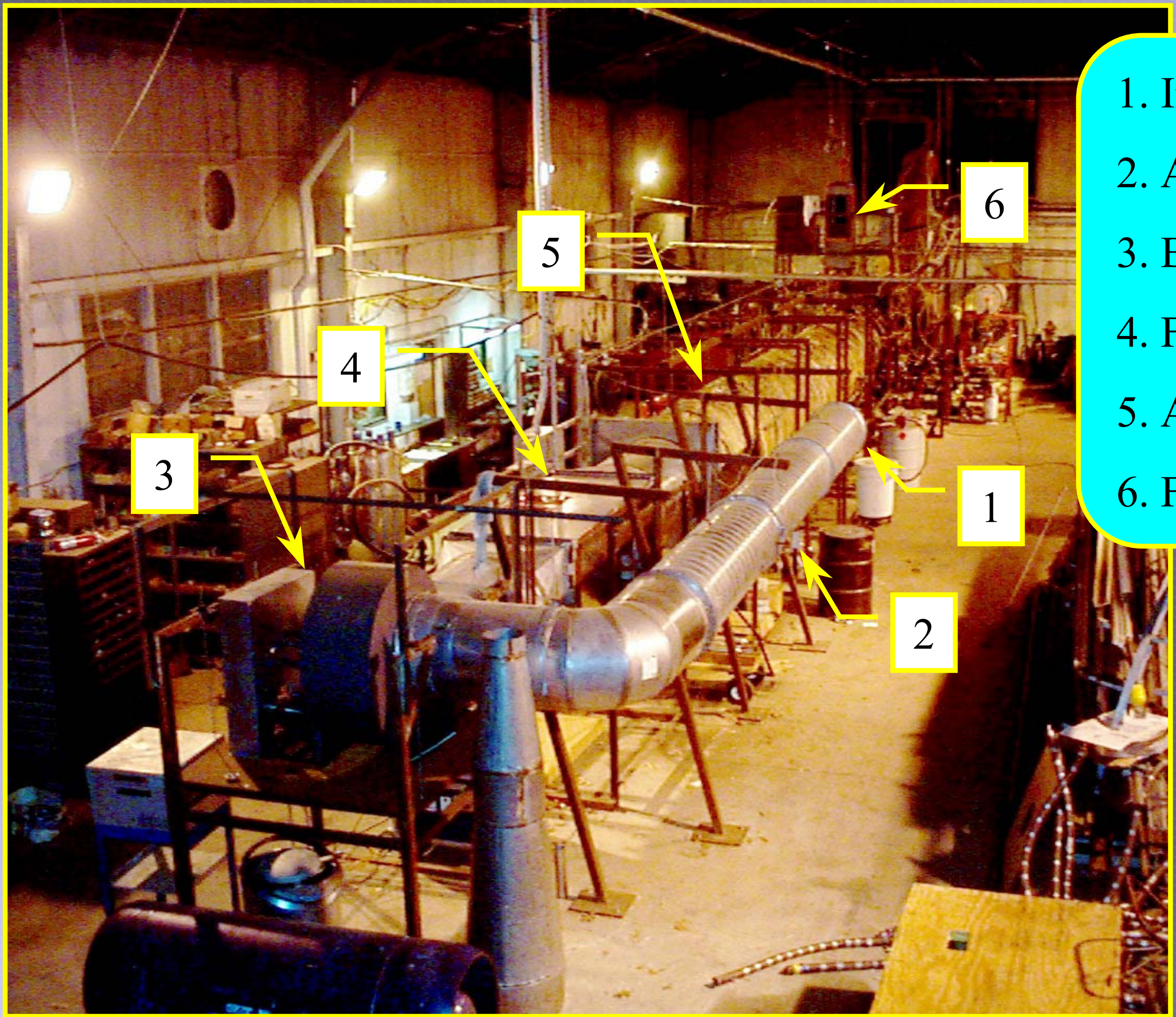

1. Inlet
2. Air Flow Measurement
3. Blower
4. First Heat Addition
5. Approach Duct
6. Firex

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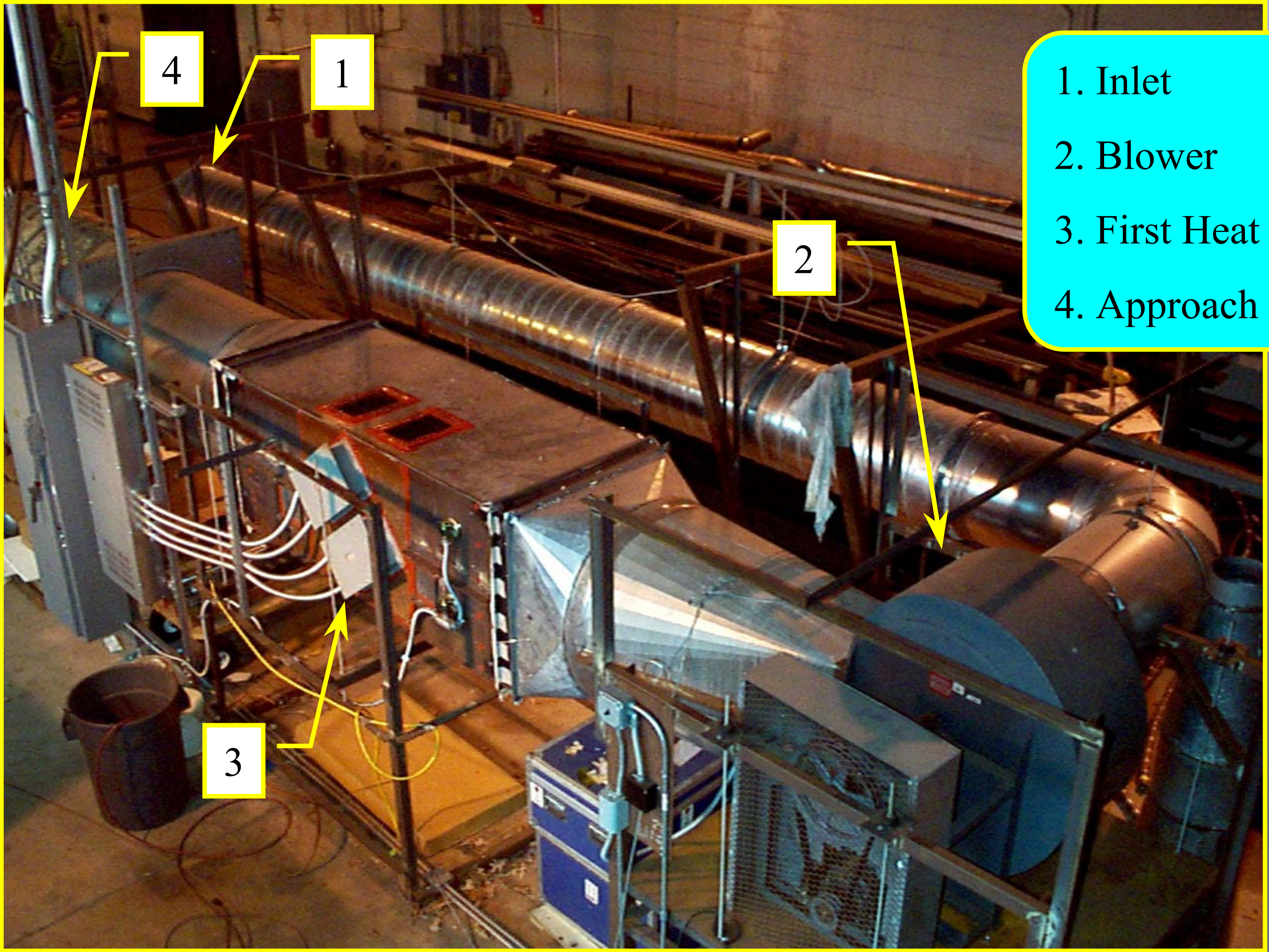
Project, Simulator



1. Inlet
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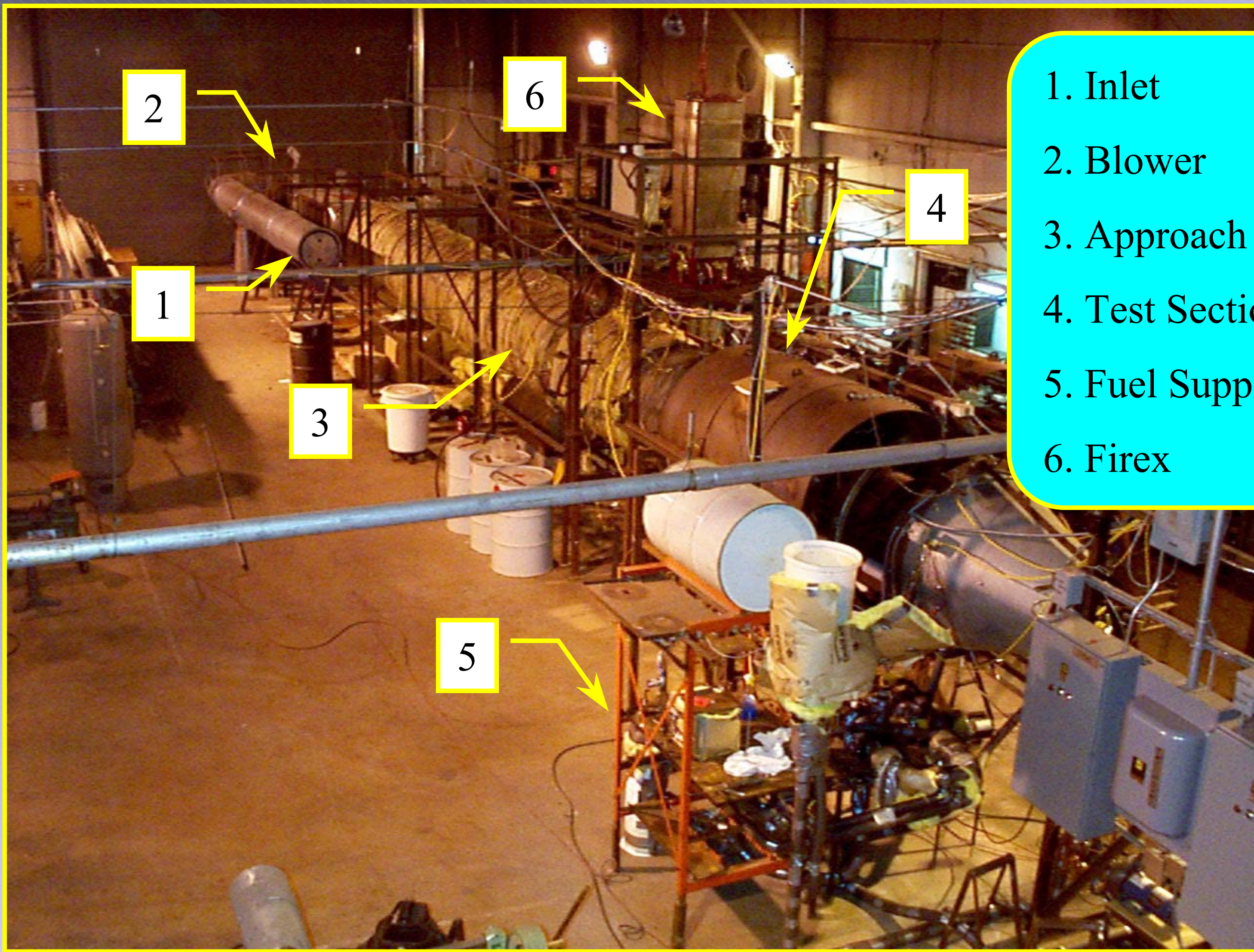
Project, Simulator



1. Inlet
2. Blower
3. Approach Duct
4. Test Section
5. Fuel Supply System
6. Firex

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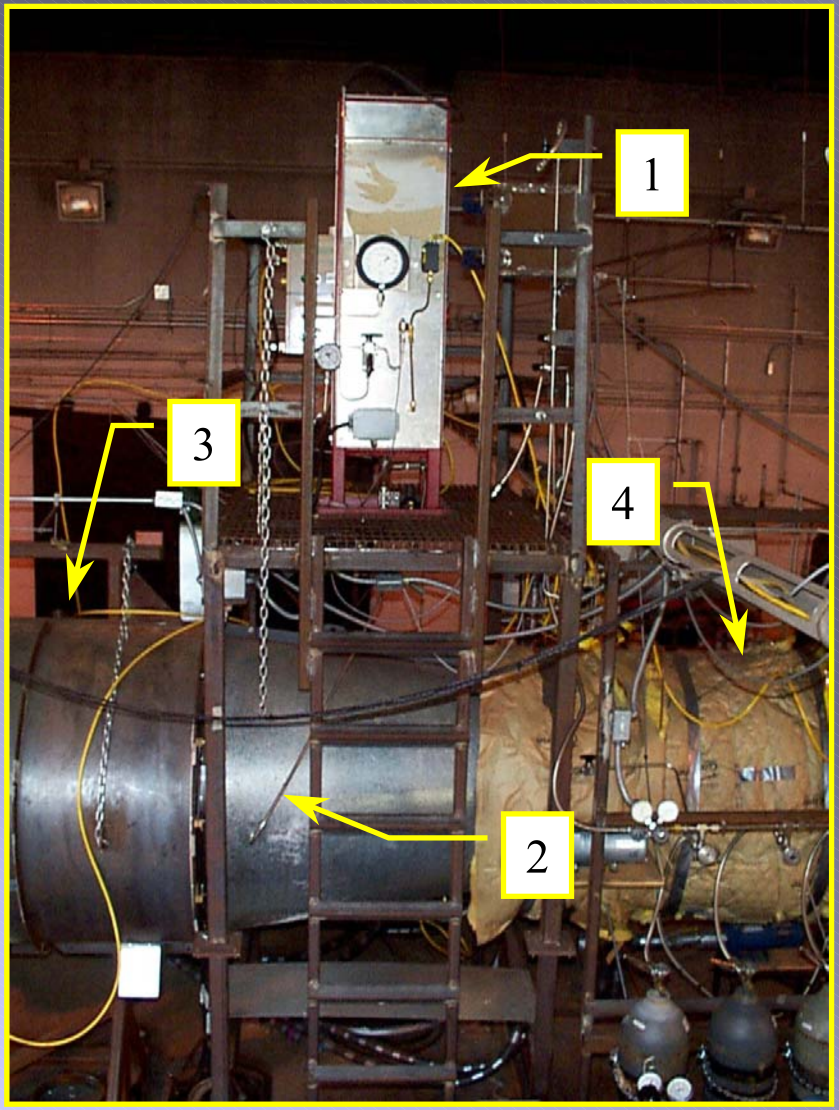
Project, Simulator



1. Firex
2. Agent Distribution Line
3. Test Section
4. Approach Duct

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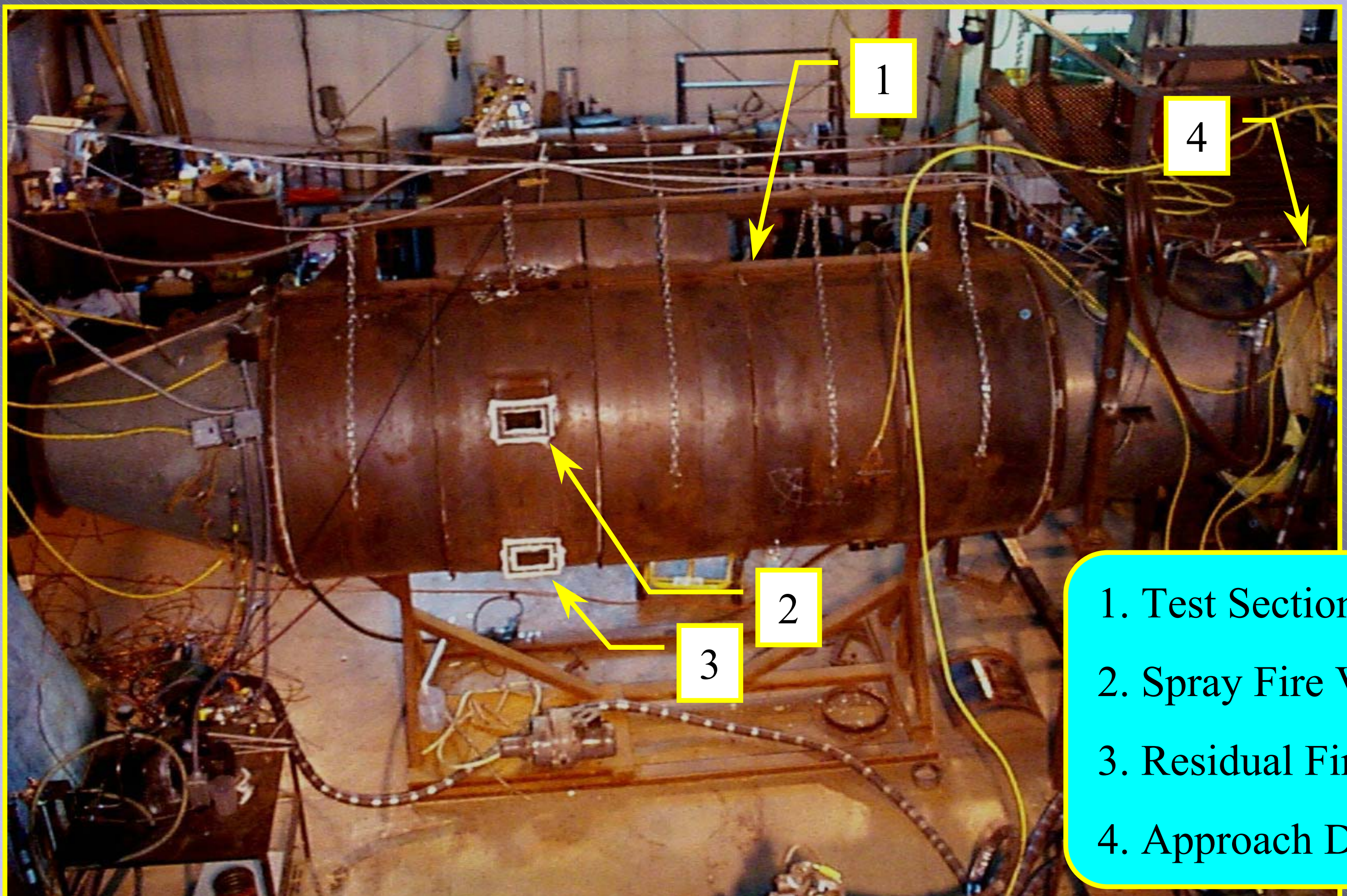

1. Test Section
2. Spray Fire View Port
3. Residual Fire View Port
4. Approach Duct

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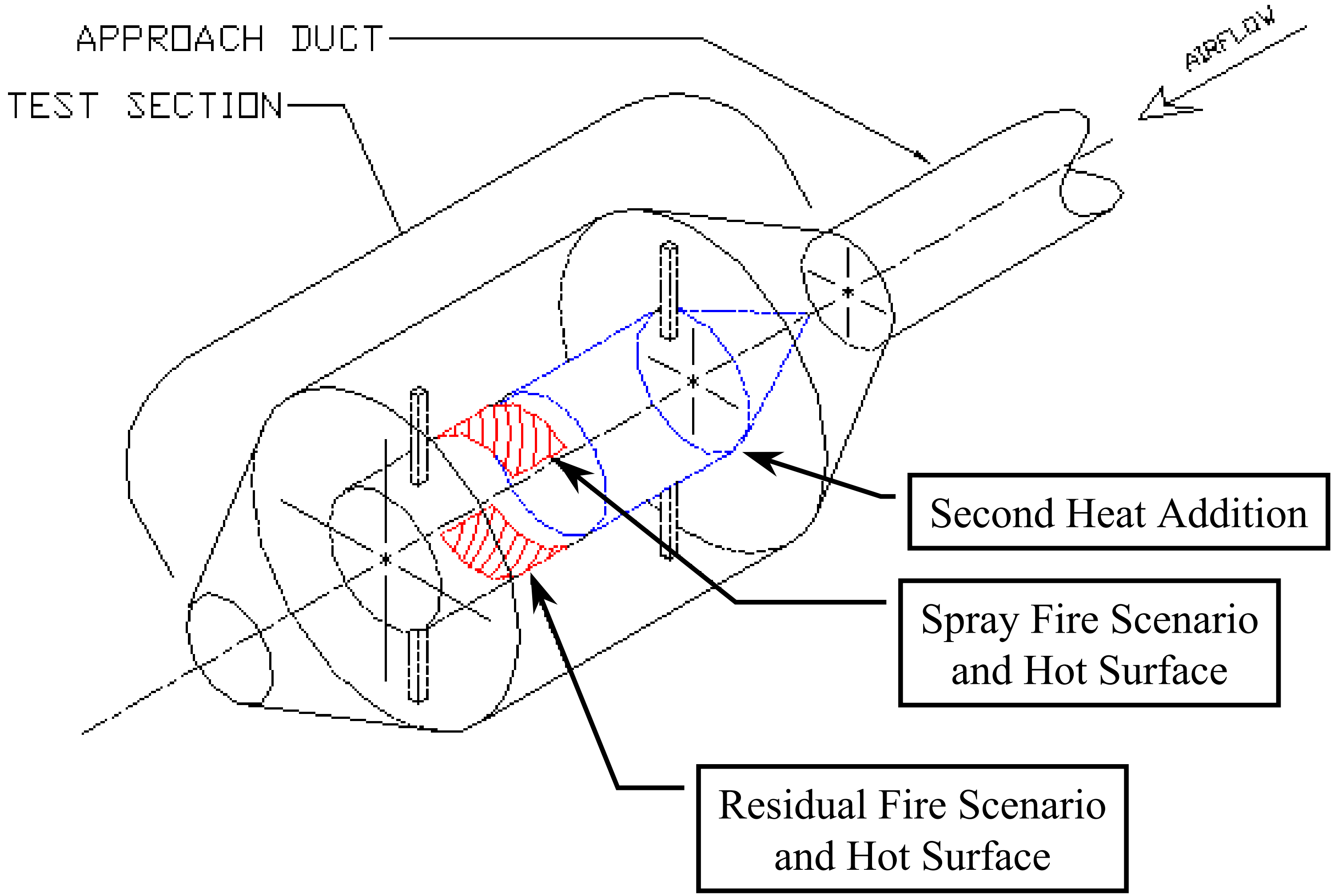
Schematic View Locating the Fire Scenarios



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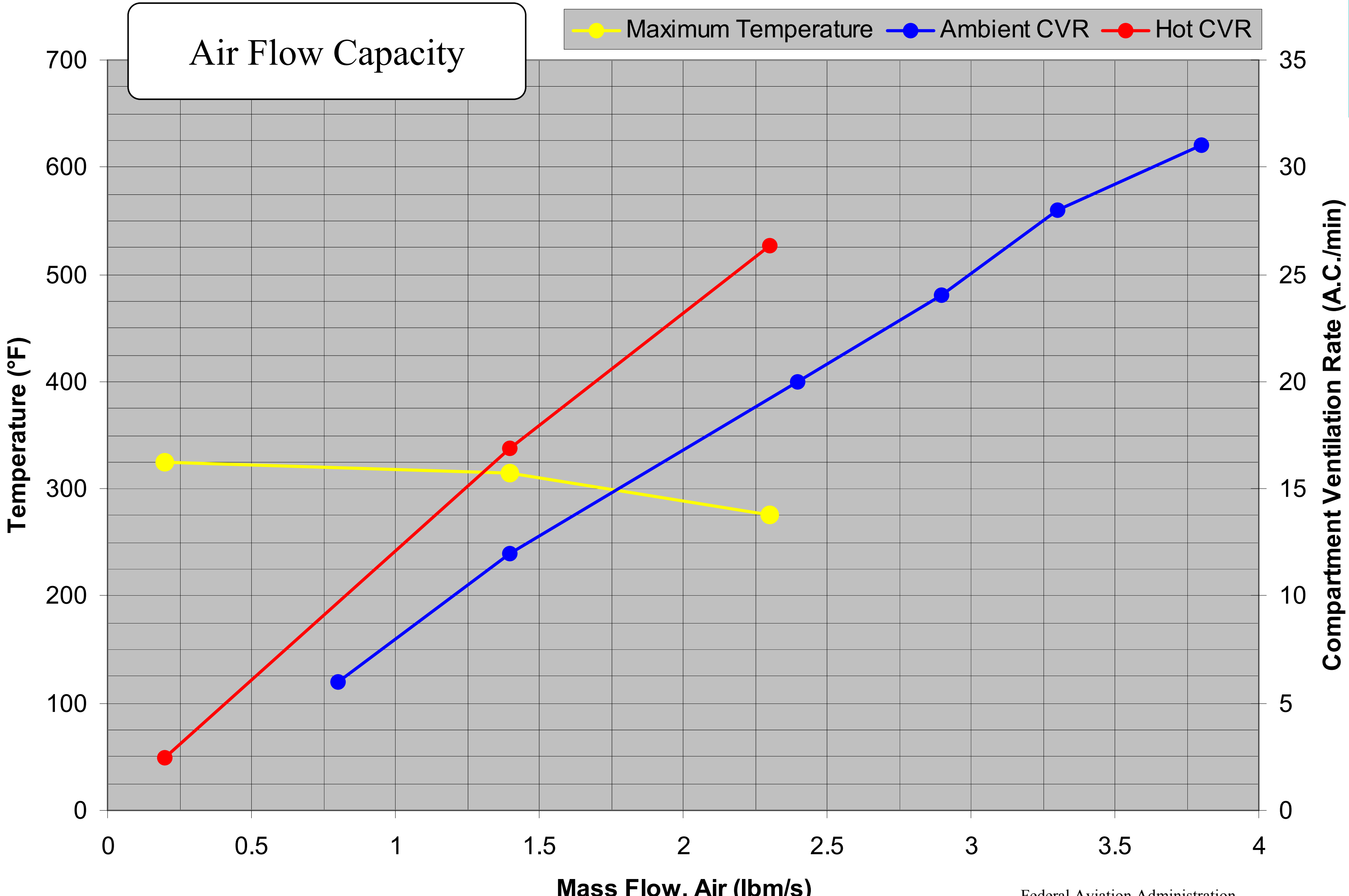

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•*Gas Analysis*

- Analyzer Background
  - U.S. patent # 2,586,899 issued 26February1952
  - The determination of volumetric concentration in a binary gas mixture is possible if :
    - constant flow and temperature are maintained through an orifice
    - each constituent has a different viscosity
  - The pressure drop of a flow across a porous plug is the measurement principle
    - differential pressure = constant * viscosity * volumetric flow rate
    - typically, the gaseous binary mixture is composed of air and agent
    - air is part of the binary mix as all its components have a similar "delta P" across the porous plug
    - water vapor can produce slight error in measurement
    - not compatible with particulate producing events such as combustion
  - Two manufacturers to date: Statham Laboratories and Pacific Scientific HTL
  - North American companies capable of such services are the Boeing Company, Kidde Aerospace, and Pacific Scientific HTL

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•*Gas Analysis (continued)*

- FAA Technical Center is the owner of one of four Halonyzer II gas analyzers, as manufactured by Pacific Scientific HTL
  - Operational from 1986 to September 2000
  - At minimum, used during :
    - US Air Force concentration testing, February/March 1996
    - US Navy concentration testing, March, April, & August 1998
    - miscellaneous testing at FAA Technical Center
- Analyzer declared unserviceable, September 2000
- Decided upon in-house solution for repair, October 2000-October 2001
  - evaluated overall system
  - determined method for repair
  - implemented repair
- Analyzer currently undergoing software design for numerical control

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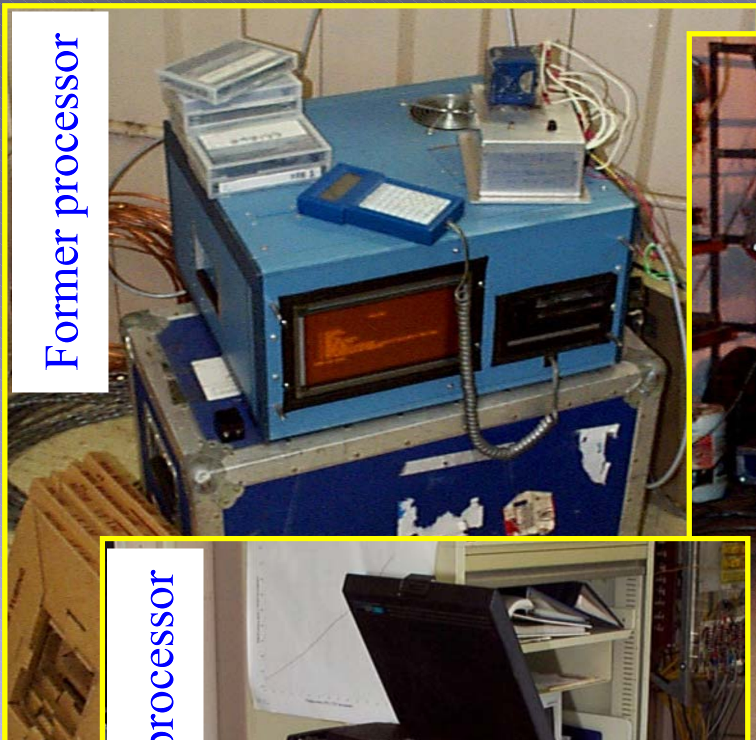
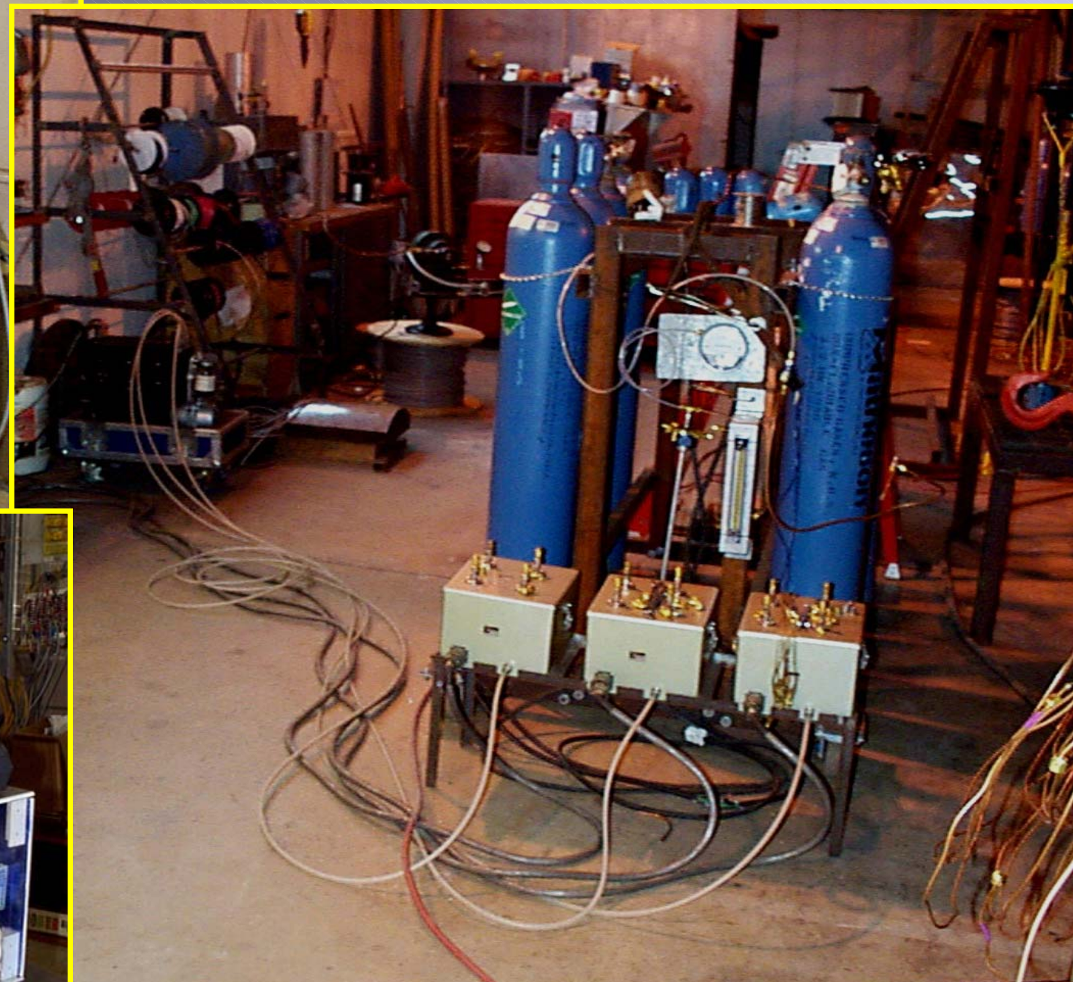
Project, Gas Analysis





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•*Status*

- Gas analyzer undergoing software development and calibration
- Spray hot plate damaged due to overheat condition attained, October 2001
- Firex discharge rate evaluated and determined unacceptable, September 2001

•*Resolution*

- Spray hot plate undergoing repair, completion October 2001
- Gas analyzer completion, November 2001
- Firex distribution difficulties currently being discussed with Kidde Aerospace

•*End Point*

- Draft report on test results, April 2002
- Revision of the primary specification for agent distribution within the MPSE
  - currently specified as a Halon 1301 distribution
  - likely replace Halon 1301 with either HFC-125 or CF_3I
  - the fire scenarios can not be the primary specification
    - the environments are very complex and likely difficult to specify
    - they vary in intensity as required by the test process

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•*Discharge Simulation Background*

- Certification procedure for fire suppression systems in the nacelle and APU compartments requires agent discharge to demonstrate adequate performance
- The use of a simulant during system development and certification is an intermediate effort to reduce halon emissions
- HFC-125 and Halon 1301 distribute nearly the same in this application based on their similar physical properties
- Based on equivalent liquid fill densities
- Quantities of HFC-125 determined by using this process are for simulating Halon 1301 distribution and are not expected to be adequate for fire suppression
- Process :
  - bottle loaded with HFC-125 to a weight of 77% of the Halon 1301 charge
  - bottle pressurized with nitrogen as would the associated Halon 1301 bottle
  - data from Statham similar analyzers should be manipulated to indicate a volumetric concentration profile for HFC-125
  - the acceptability of the fire suppression system is determined by comparing the HFC-125 distribution profile to the current Halon 1301 acceptance criteria

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•*Discharge Simulation Background (continued)*

"... EPA recognizes that when certain conditions exist, intentional releases of halon during testing will be necessary to verify system performance, which is essential to prevent loss of life and environmental damage. Therefore, today's action exempts from the ban on intentional releases, halon applications meeting the following four criteria:

(1) Systems or equipment employing suitable alternative fire extinguishing agents are not available,
(2) system or equipment testing requiring release of extinguishing agent is essential to demonstrate the functionality of the system,
(3) failure of the system or equipment would pose great risk to human safety or the environment, and
(4) *a simulant agent cannot be used in place of the halon during system or equipment testing for technical reasons*.

Should conditions change such that an application currently meeting these criteria no longer met these criteria, then that application would no longer be exempt from the ban on intentional releases of halons during testing."

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•*Discharge Simulation Background (continued)*

- Once this guidance material is implemented, discharging Halon 1301 for the purpose of demonstrating acceptable compliance with FAA regulation will be illegal. This is based on compliance with the United States Environmental Protection Agency (EPA) regulatory activity.
- EPA citation, *"Halon Emissions Reduction"* :
  - 63 FR 11084, Halon Emissions Reduction
  - dated 3March1998, effective 6April1998
  - 40 CFR, §82.270 (b)

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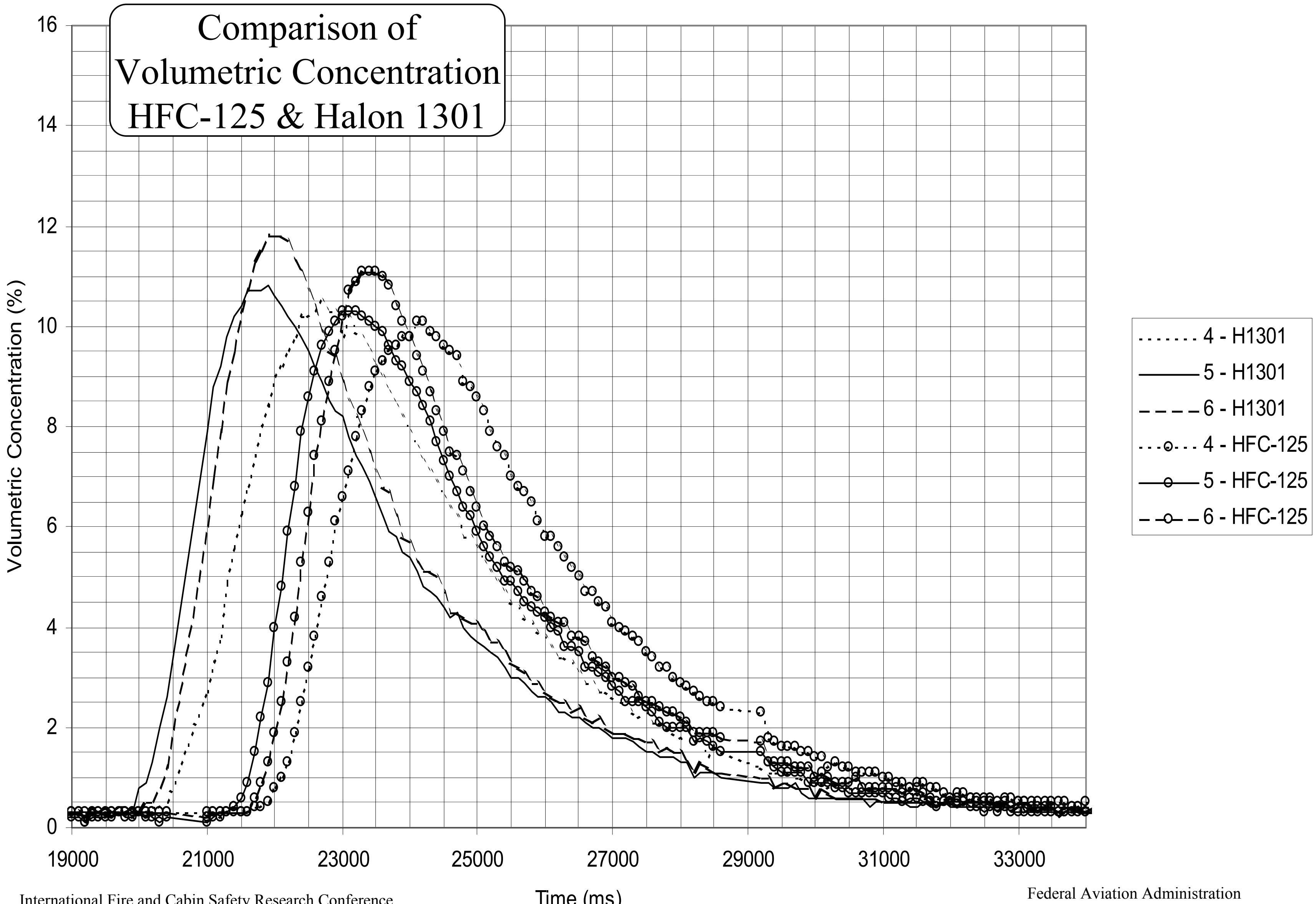
Simulation



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•*Simulation Status*

- Technical note published :
  DOT/FAA/AR-TN99/64, "Simulating the Distribution of Halon 1301 in an Aircraft Engine Nacelle with HFC-125," August 1999
- Draft advisory circular presented to FAA regulatory personnel, December 2000
- Material currently in review