Engine Nacelle, Halon Replacement

Assessing a Blended Candidate

Presented to:

FAA International Aircraft Systems Fire Protection Working Group,
Atlantic City, NJ USA

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Presentation Content…

A Brief Review of the Minimum Performance Standard for Halon Replacement in the Civilian Engine Nacelle

- Test Process
- Test Article – FAATC NFS

A Review of the Recent MPSHRe Project

- Descriptions of the Various Aspects
  - Ownership, Responsibilities, & Completion Schedule
  - The Candidate
  - Observations & Results
- Additional Investigations Resulting from the Observations
  - Observations at the Duct Interface
  - The Failure Pressure of the Foil Diaphragms

FAATC = FAA Technical Center
NFS = nacelle fire simulator

Service &/or product identifications made in this presentation are not endorsements.

Federal Aviation Administration

Brief Review / MPSHRe

Test Process

1. Currently exists in its 4TH revision (a working draft)
2. Candidate is reasonably "mature"; i.e. capable of real-world use
3. Halon 1301 parity is attained in a "realistic" nacelle-fire simulator

Generic Testing

A. Comparing flame suppression behaviors (reignition time delay)
   i. Suppression relates to extinguishant distribution in the forced flow
   ii. Extinguishant distributions are described by measured delivery criteria

B. Candidate is challenged by 4 test configurations (2 flows x 2 fire threats)

C. Halon 1301 benchmarks are known for each test configuration

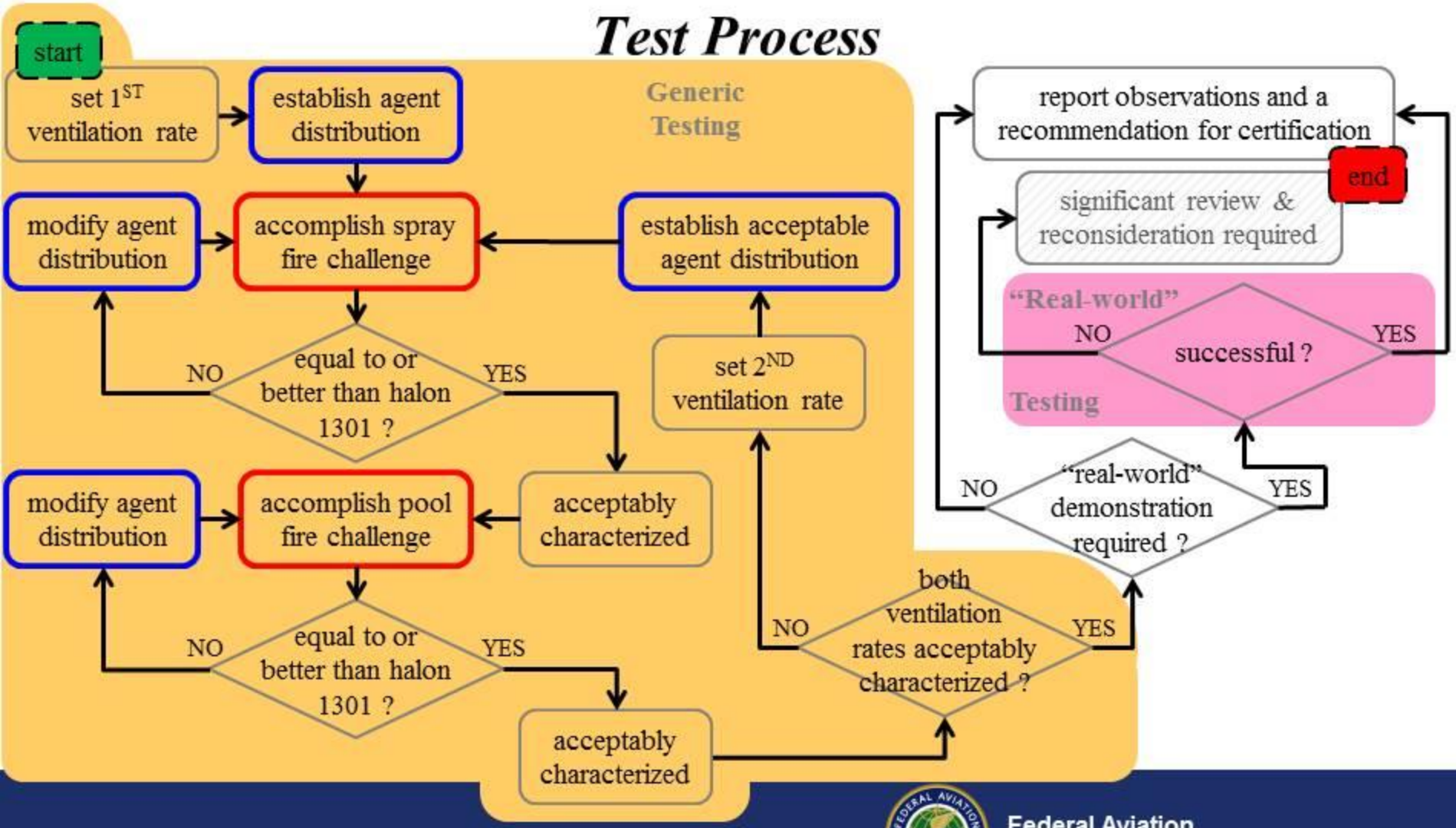
"Real-world" Testing

D. Optional requirement : "real-world" demonstration for atypical candidates

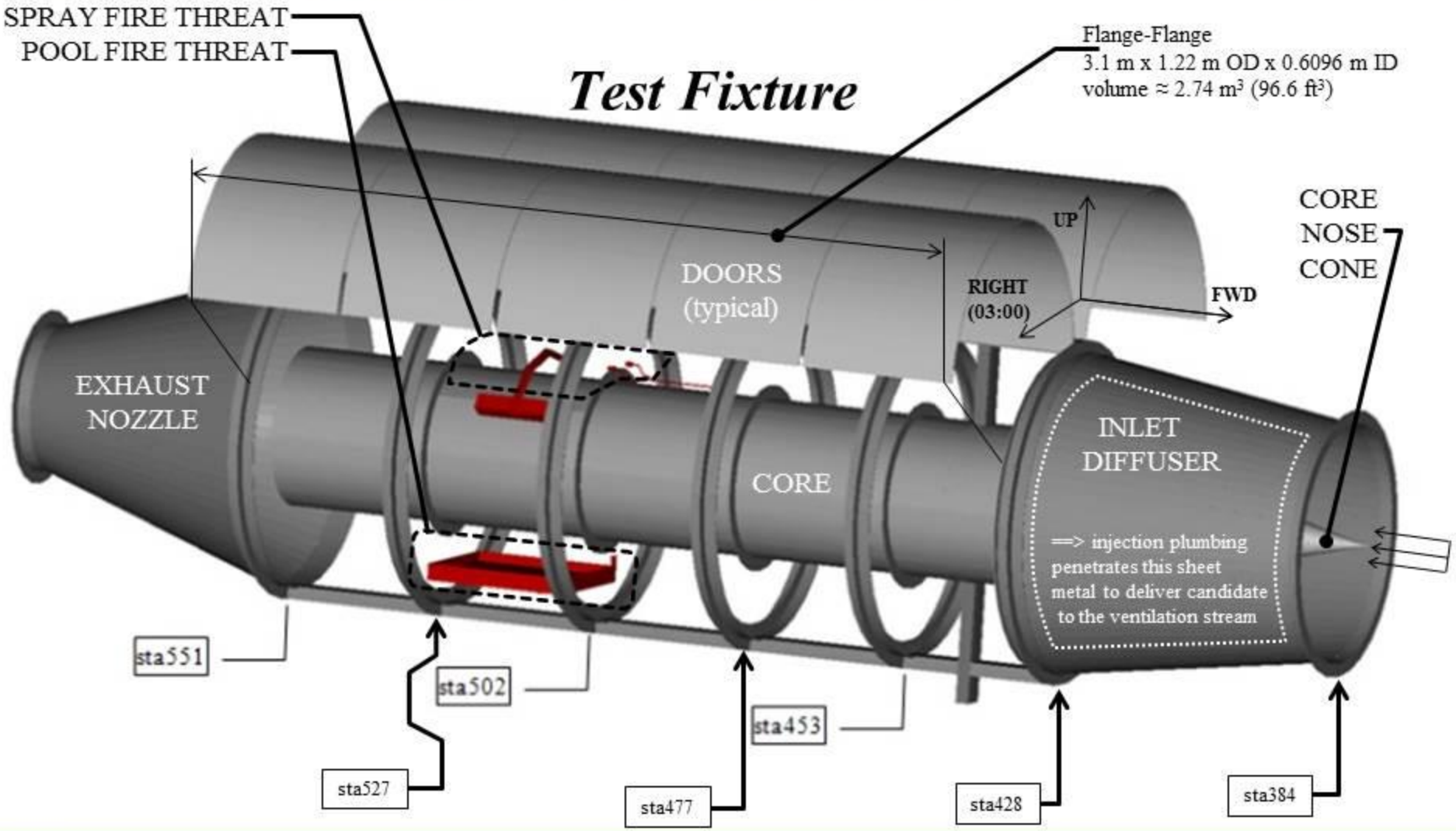
E. A *recommendation for certification* is the "largest" candidate quantity acceptably comparing to the halon benchmark

link to MPSHRe rev 04 :
http://www.fire.tc.faa.gov/pdf/systems/MPSErev04_MPSeRev04doc-02submtd.pdf

Brief Review / MPSHRe



Brief Review / MPSHRe

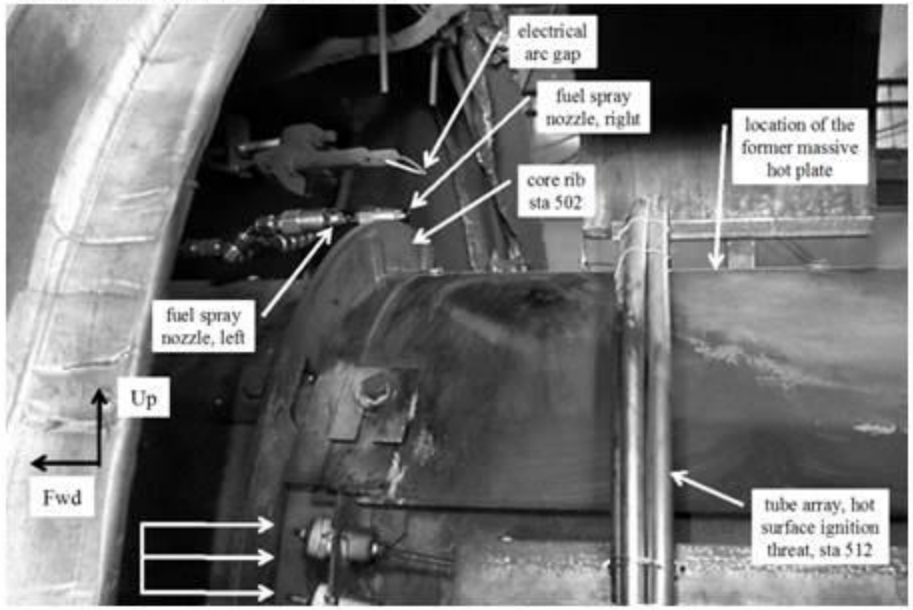


NOTES : Station (sta) numbers are incremented as inches.
Some details omitted for clarity.
This is a schematic view. Not drawn to scale.

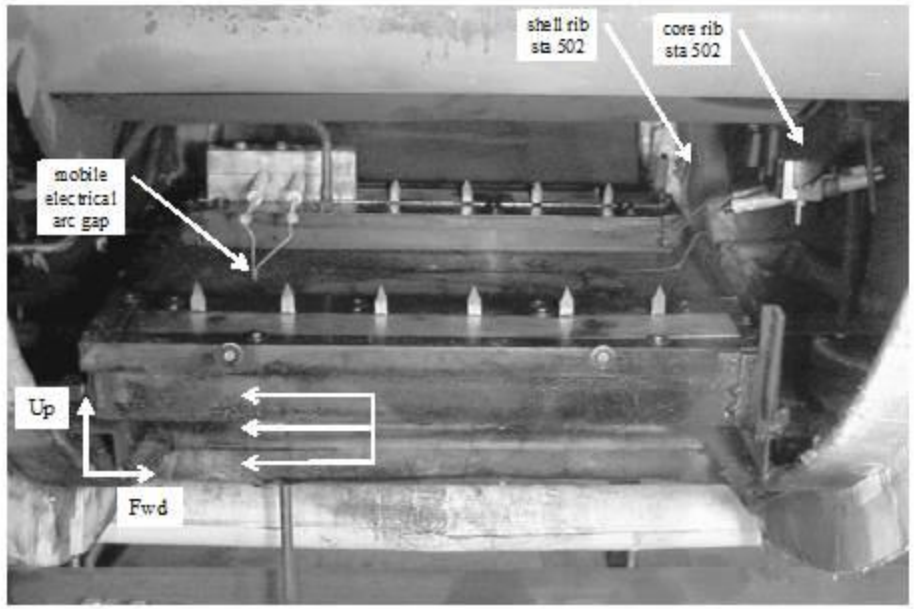
Brief Review / MPSHRe

Test Fixture

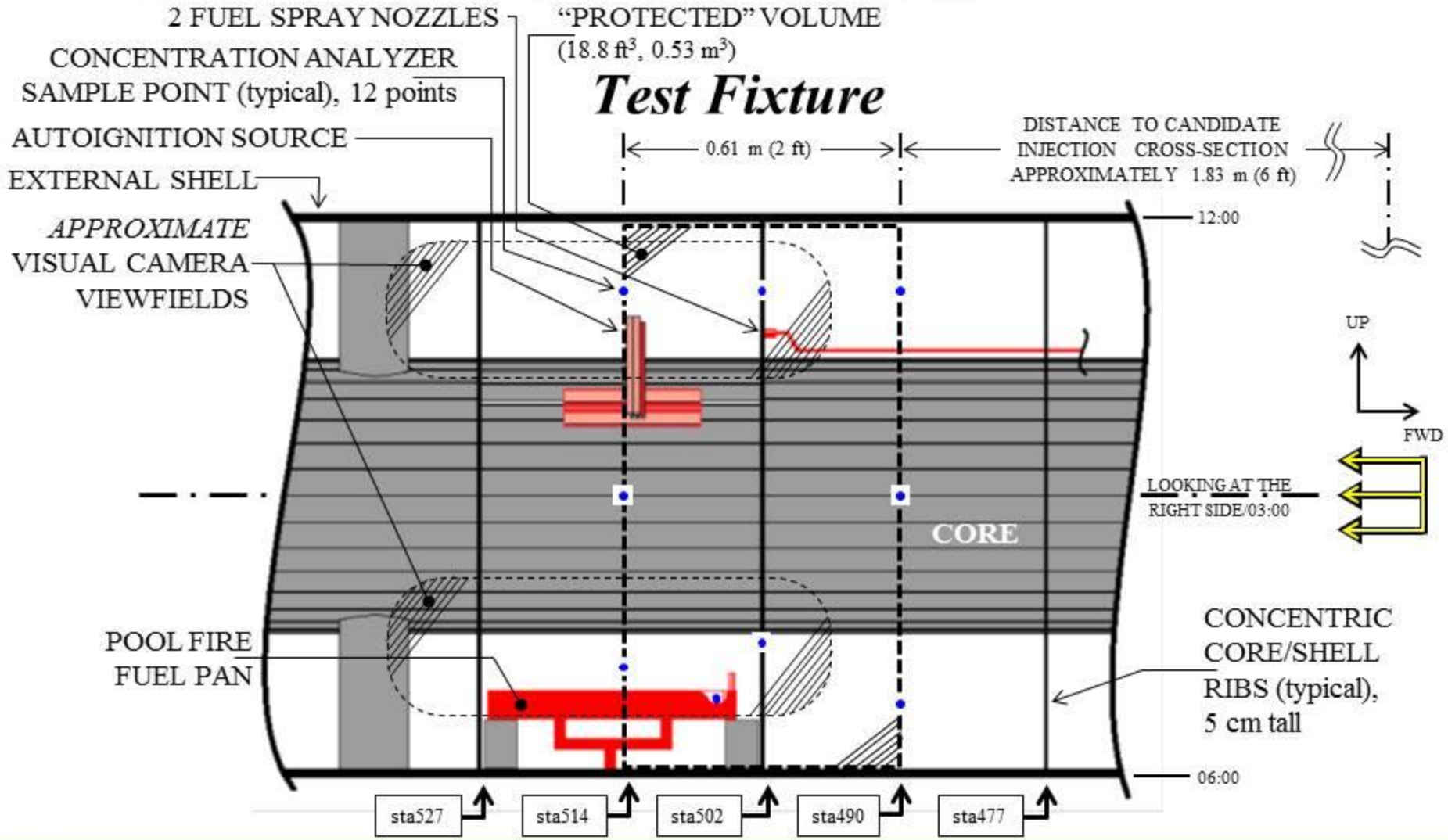
SPRAY FIRE THREAT



POOL FIRE THREAT



Brief Review / MPSHRe



NOTES : Station (sta) numbers are incremented as inches.
Some details omitted for clarity.
This is a schematic view. Not drawn to scale.

Review / Recent MPSHRe Project

Ownership, Responsibilities, & Completion Schedule

1. Owners : Airbus, Meggitt Safety Systems Inc. (MSSI)
2. Responsibilities :
   A. Industry team: candidate, packaging/delivery, concentration measurement
   B. FAA Fire Safety Branch: operational NFS, measurements/indications (thermal, pressure, visual over time), procedural guidance
3. Completion Schedule :
   A. Preliminary activities: June 2013 - August 2014
   B. MPSHRe:
      i. "High" ventilation testing: October - November 2014
      ii. "Low" ventilation testing: November 2014 - January 2015
      iii. Follow-on testing: January - February 2015

Review / Recent MPSHRe Project

Various Aspects / The Candidate

1. Candidate assessed : Blend A, manufactured by MSSI
2. Blend A composed of CO_2 & FK-5-1-12 (3M Novec 1230)
   - A. CO_2
     - i. @ 1 atm : solid &/or gas, FP = -78°C/-109°F; liquefies ≈ 5.1 atm
     - ii. Recognized fire extinguishing agent per FAA AC 20-100/1977
   - B. FK-5-1-12
     - i. @ 1 atm : solid, liquid, &/or gas, FP = -108°C/-162°F, BP = 49°C/121°F
     - ii. Recognized fire extinguishing agent per MPSHRe rev03 (2006)
3. Intended usage characteristics
   - A. Stored in "traditional" fire extinguisher bottle
   - B. Delivered/injected via "traditional" valve & plumbing components
   - C. Fire zone distribution measured by Statham-derivative gas analyzer

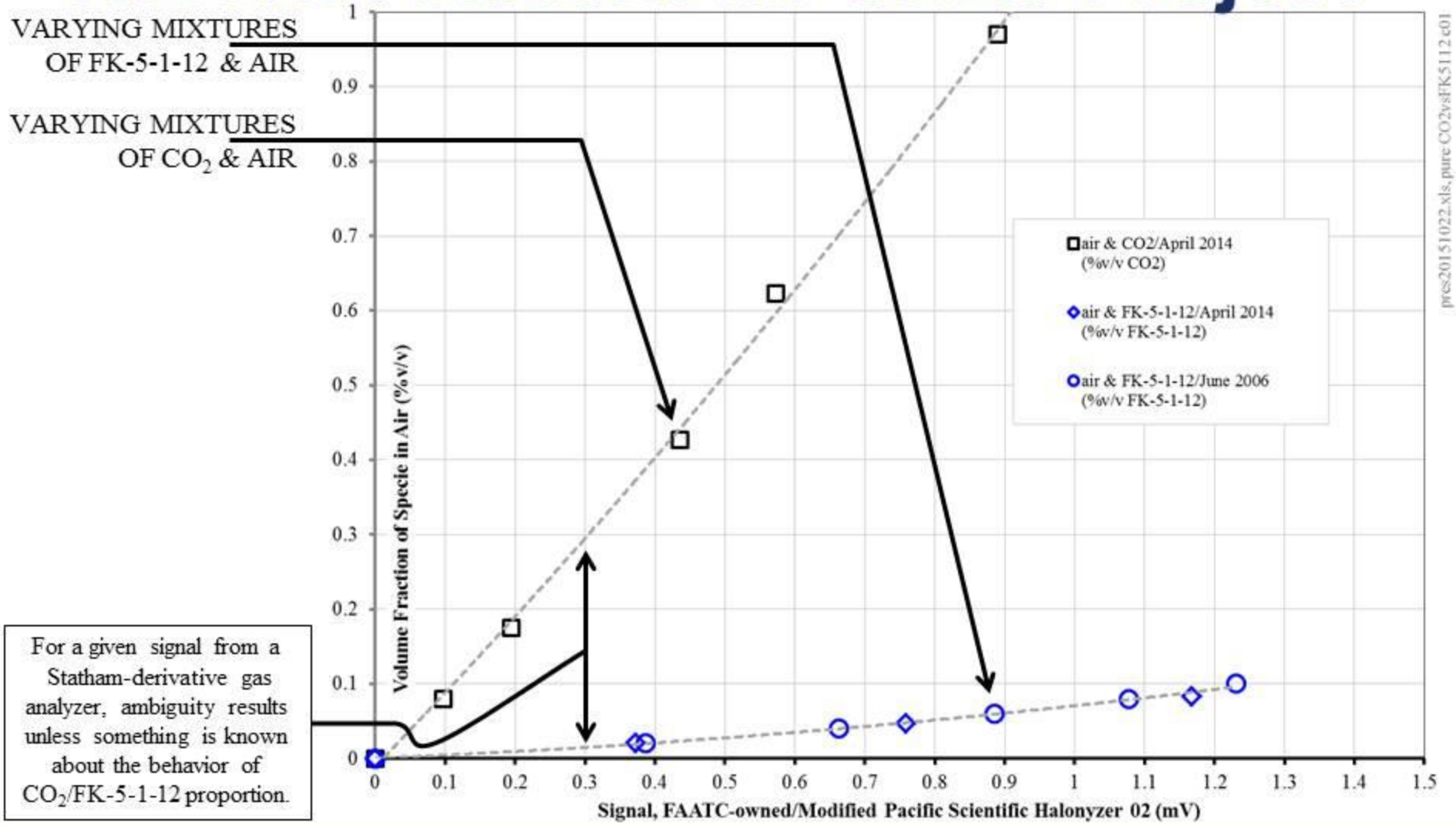
FP = freezing point temperature
AC = Advisory Circular
BP = boiling point temperature

Review / Recent MPSHRe Project

Various Aspects / The Candidate

4. Additional details considered & applied to this project
   - A. No fire extinguishment testing accomplished with hydraulic fluid
     - i. CO_2 already recognized by FAA AC 20-100/1977 as acceptable
     - ii. FK-5-1-12 tested acceptably per MPSHRe rev03/2006
   - B. Statham-derivative gas analyzer can't identify each specie when mixed
     - i. Possible analyzer measurement ambiguity for Blend A distribution
     - ii. Industry team identified/addressed this issue at project's beginning
     - iii. FAA elected to investigate Blend A specie distribution to affirm rationale
       - a. FAA performed point-sampling in the FAATC NFS
       - b. Occurred sporadically during MPSHRe testing

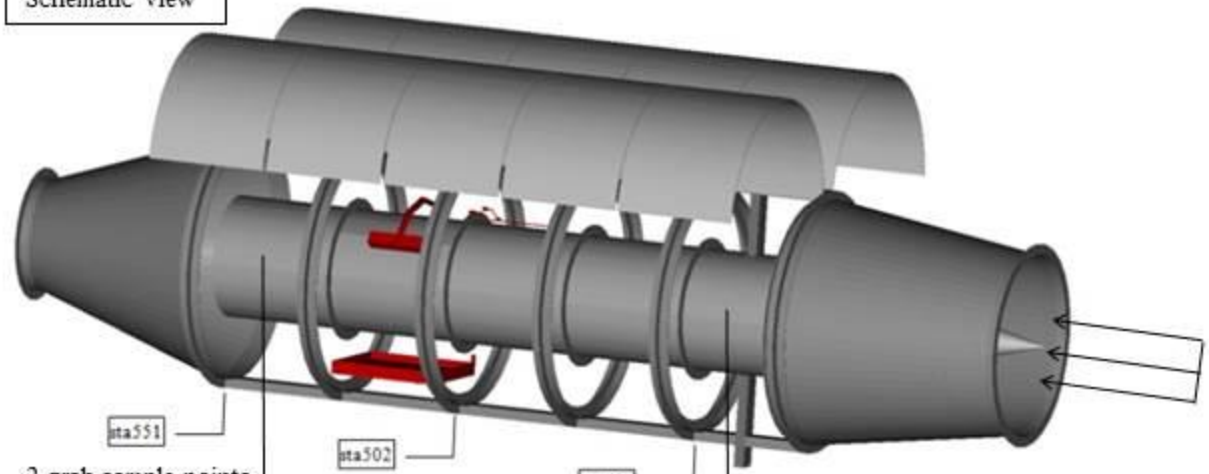
Review / Recent MPSHRe Project



For a given signal from a Statham-derivative gas analyzer, ambiguity results unless something is known about the behavior of CO_2/FK-5-1-12 proportion.

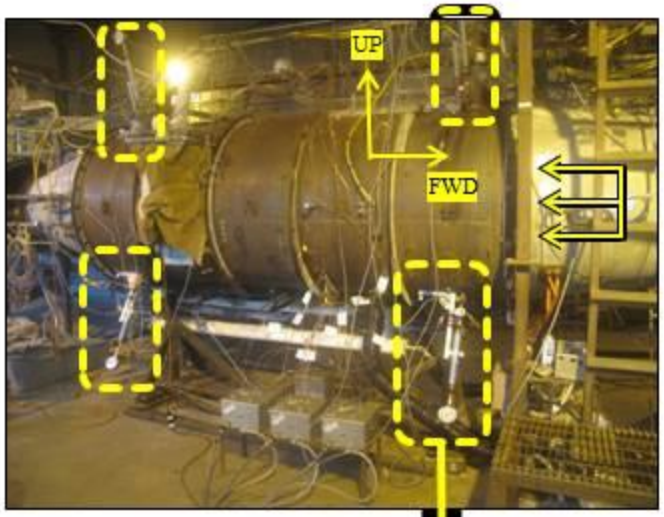
Review / Recent MPSHRe Project

NFS Perspective
Schematic View



2 grab sample points, sta537, 1 near 12:00 & 1 near 06:00

2 grab sample points, sta441, 1 near 12:00 & 1 near 06:00



1. Looked at specie distributions as affected by internal & external energies (diffusion, injection).
2. Accomplished by grabbing samples in:
   A. forward & aft cross sections
   B. upper & lower hemispheres
3. Grabbed samples analyzed by non-dispersive infrared (NDIR) technique

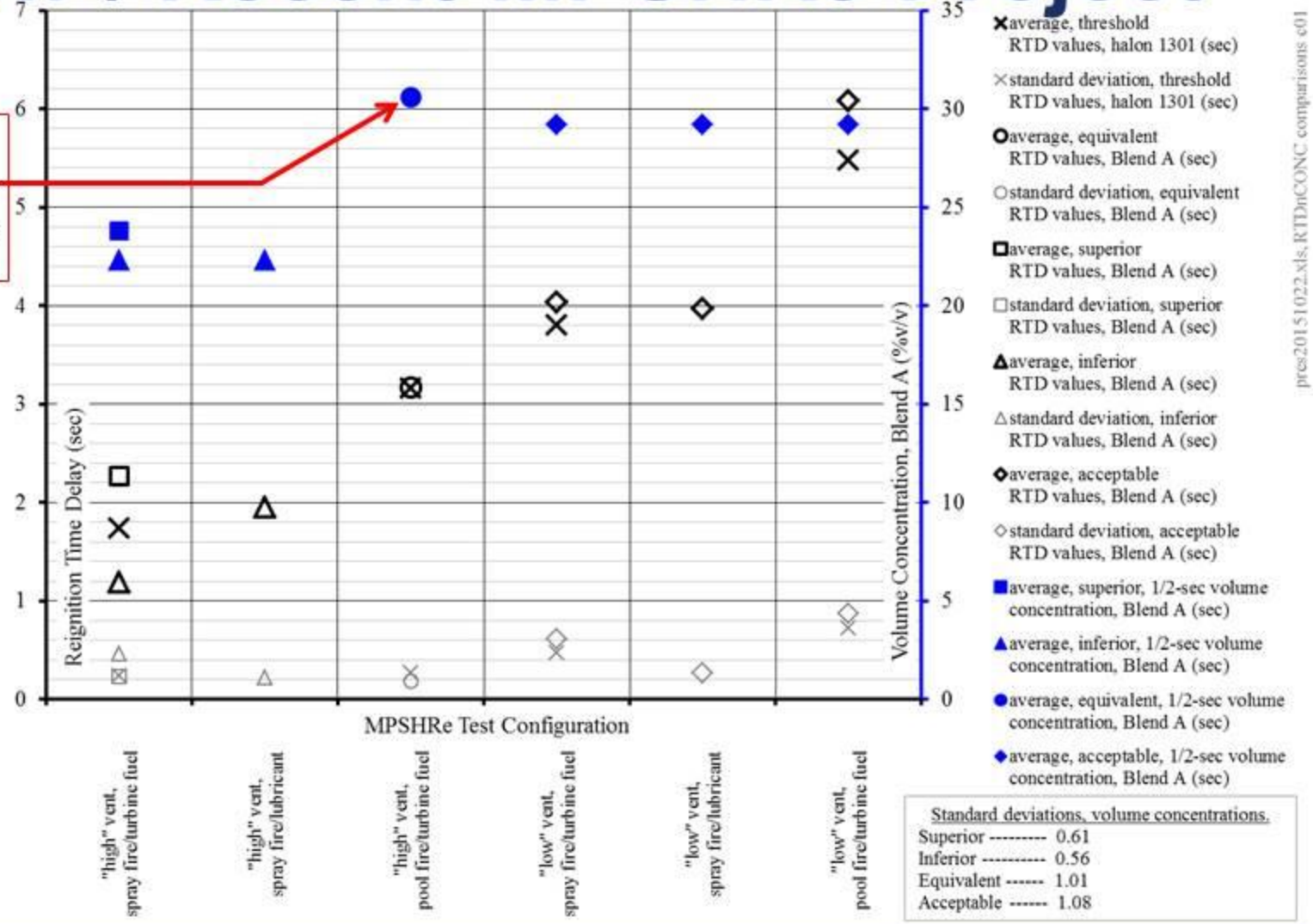
Review / Recent MPSHRe Project

Various Aspects / Observations & Results

1. "Typical" experiential learning as testing progressed
   A. Adjusted/modified plan as needed while progressing through test process
      i. Started with an initial Blend A configuration; subsequently modified it
      ii. Found 2 other configurations to bracket "high" vent/spray (superior, inferior)
   B. Crucial equivalence achieved for "high" ventilation/pool fire (equivalent)
   C. For "low" ventilation:
      i. Delivered Blend A similar (acceptable) to "high" ventilation/pool fire criteria
      ii. Acceptably tested through all challenges
2. NDIR indications affirmed valid use of the Statham-derivative
3. Observed smoke/flame releases to test bay through the atmospheric gap of the FAATC NFS; spawned a need for additional tests

Review / Recent MPSHRe Project

Recommendation for certification, based on MPSHRe rev04 testing, is *30.6%v/v Blend A for ½ sec* throughout the fire zone

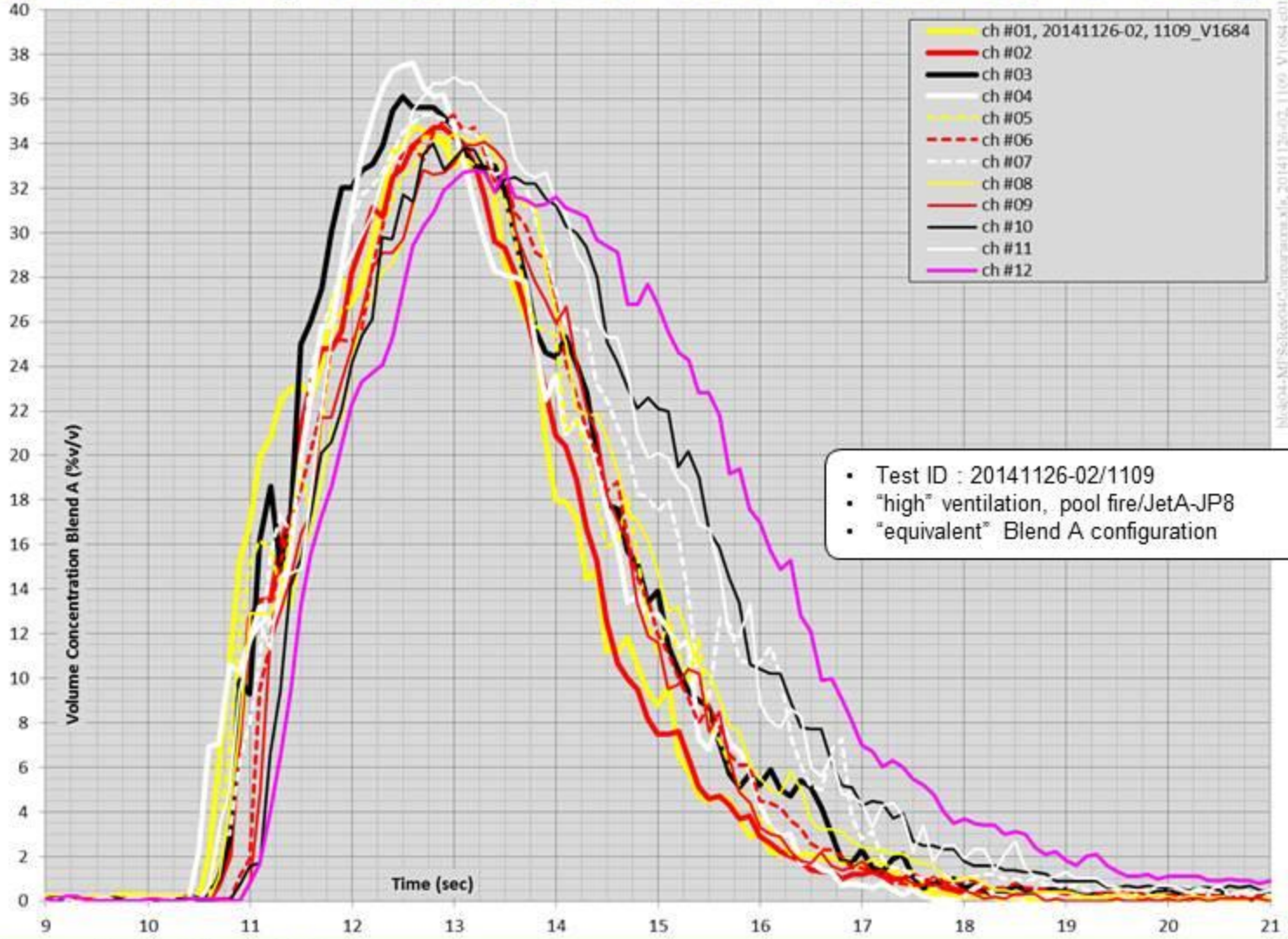


Standard deviations, volume concentrations.

Superior	0.61
Inferior	0.56
Equivalent	1.01
Acceptable	1.08

pres20151022.xls, RTDnCONC comparisons c01

Review / Recent MPSHRe Project



- Test ID : 20141126-02/1109
- "high" ventilation, pool fire/JetA-JP8
- "equivalent" Blend A configuration

Numerical data provided by Meggitt Safety Systems Inc.

Review / Recent MPSHRe Project

Additional Investigations / Duct Interface

1. Typically, aerosol or aerosol/flame escaped from internal flow path through the atmospheric gap to the test bay during spray fire extinguishment testing, independent of ventilation rate
   A. No audible cues were detected
   B. Escaping "whitish" aerosol & "bright" flames (color difficult to determine)
   C. Sporadic "bluish" flames observed within FAATC NFS flow path
2. Effluent escaping through this gap is "abnormal" behavior; "normal" is defined in this fixture by halon 1301 (nothing escapes)
3. Conducted tests to investigate, January – February 2015
4. Such testing "quantifies" overpressure behavior based on the disposition of 4 aluminum foil seals when the gap is closed

Review / Recent MPSHRe Project

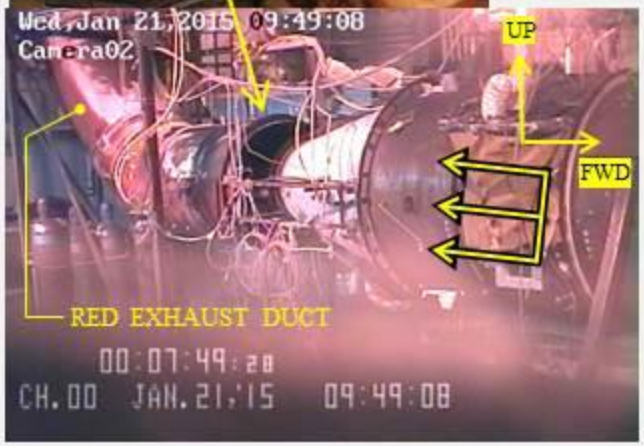
Additional Investigations / Duct Interface

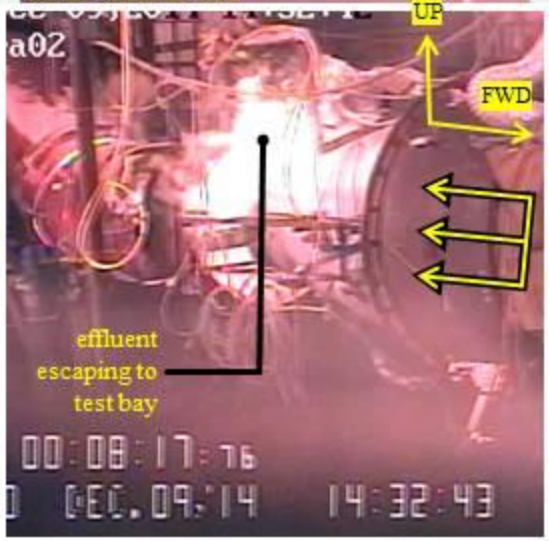
4. The FAATC NFS atmospheric gap was closed during this testing.
   A. The gap was purposely included in the FAATC NFS to relieve inadvertent internal overpressures (instead of using frangible panels, etc.)
   B. This behavior was observed for a different condition to learn more
      i. Additional enclosing structure is placed; eliminates the atmospheric gap
      ii. 4 seals are included; made from 0.001 inch-thick aluminum foil
      iii. Each seal covers a right-triangular vent hole; area of 839 cm^2 (130 in^2)
      iv. Foil is affixed to the enclosing structure with fiberglass tape
      v. The vent holes are covered by foil alone (no tape reinforcement…)
   C. Closing the atmospheric gap alters flow through the FAATC NFS
      i. Exhaust suction penetrates abnormally further upstream; alters flow character
      ii. As a result, the FAATC NFS is altered somewhat to alleviate this perturbation
      iii. Normally-closed louvers in the exhaust duct are opened to relieve suction

Review / Recent MPSHRe Project

Additional Investigations / Duct Interface

DUCT INTERFACE OPEN





DUCT INTERFACE CLOSED

Review / Recent MPSHRe Project

Additional Investigations / Duct Interface

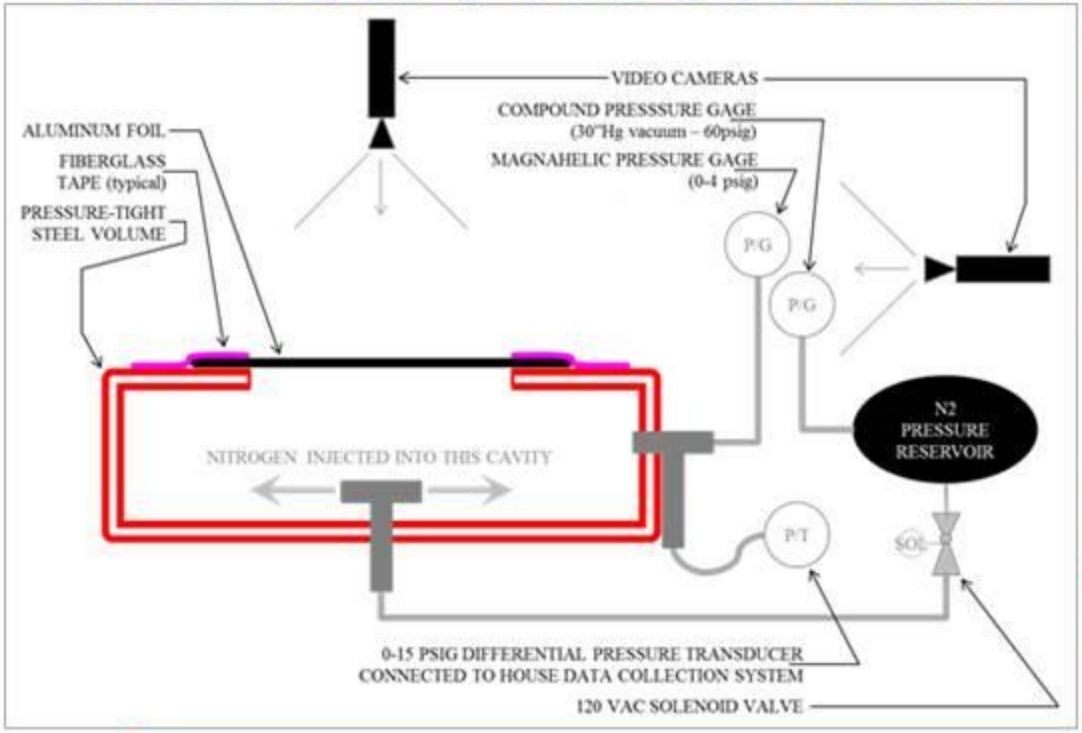
1. Completed 6 tests at limit conditions during this project
   A. Challenged by "high" & "low" ventilation, turbine-fueled, spray fires
   B. 2 tests each @ inferior, equivalent, & acceptable
2. Outcome/Observations
   A. Foil seals remained intact throughout
   B. Foil seals were observed to fluctuate indicating events of :
      i. Initial fire ignition at test commencement
      ii. Candidate injection
      iii. Reignition following Blend A-induced fire extinguishment
   C. Effluent escaping to test bay relocated further downstream in exhaust duct; in "smaller" observed intensity/quantity
   D. No audible cues detected

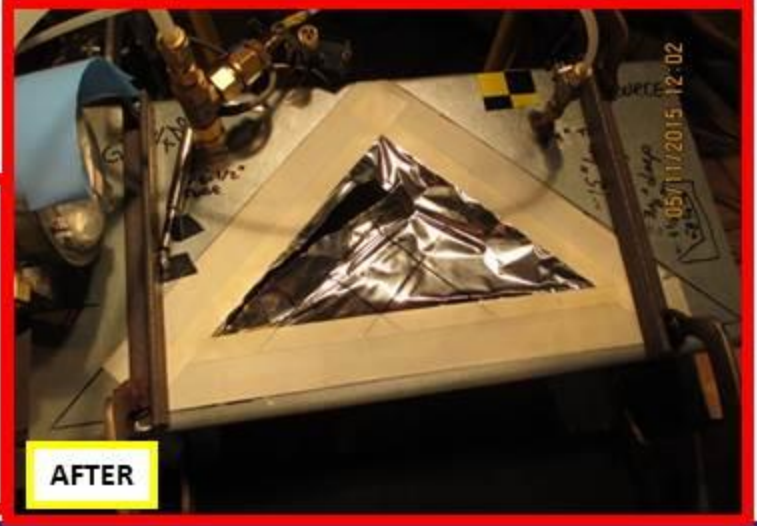
Review / Recent MPSHRe Project

Additional Investigations / Foil Failure Pressure

1. So, what is a pressure limit of 0.001 inch-thick aluminum foil ?
2. Performed testing May 2015 to develop a "feel" for such a pressure
   A. Performed with a steel test assembly instrumented with visual and numerical data collection capabilities
   B. Installed aluminum foil seals directly analogous to use on the FAATC NFS
   C. Accomplished 3 tests
3. Foil seals failed at $P < 13.8$ kPa gage (2 psig)
   A. Maximum measured failure pressure $\approx$ 9.6 kPa gage (1.4 psig)
   B. Average failure pressure $\approx$ 8.3 kPa gage (1.2 psig)
   C. Estimated "maximum attainable" failure pressure $\approx$12.4 kPa gage (1.8 psig)

Review / Recent MPSHRe Project





TEST 20150511-03/1159

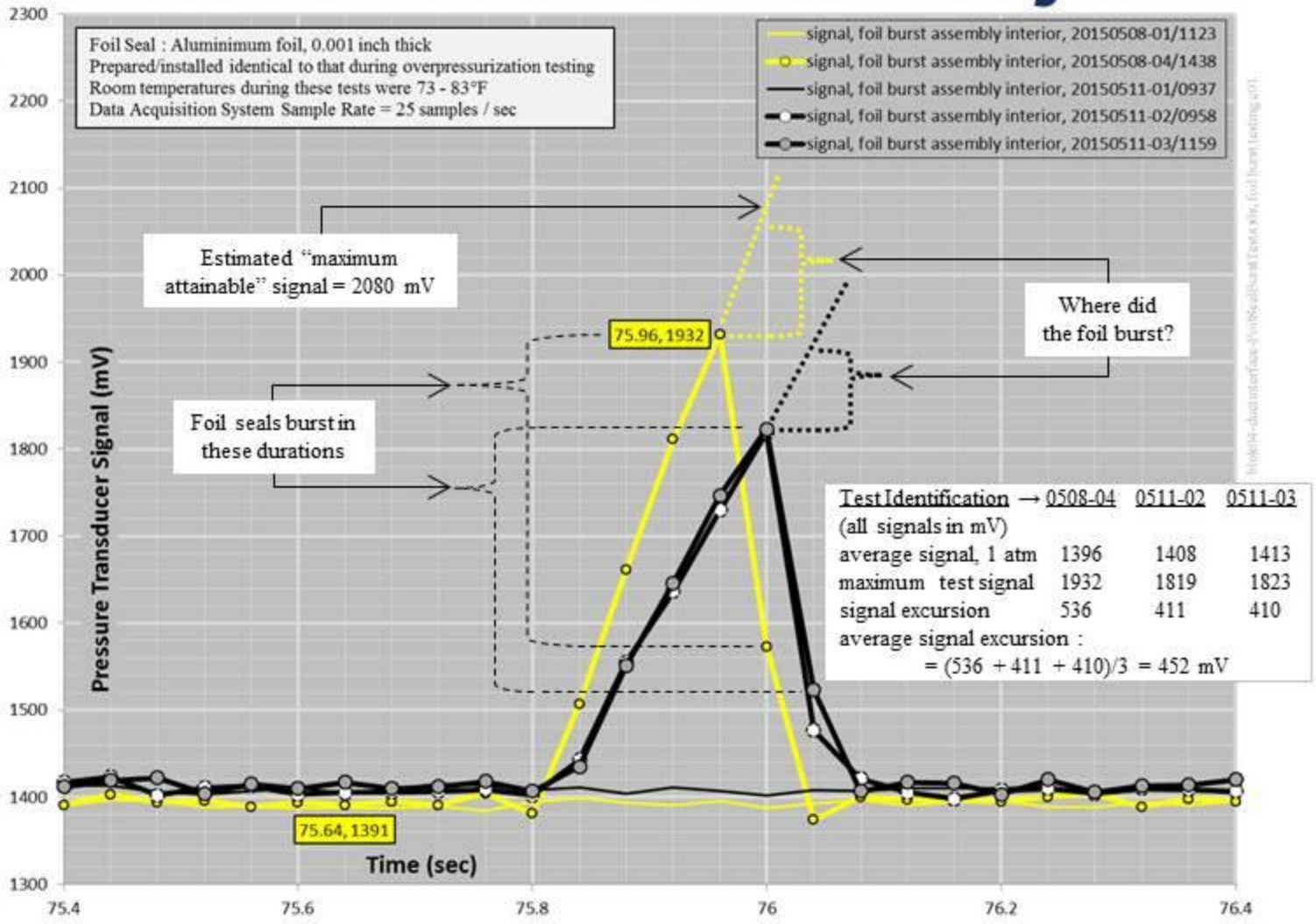
1. Initial failure in the foil is away from the tape seams.
2. Failure propagated by tearing through the foil.
3. The other tests accomplished were similar to this one.

The lines on the foil in the BEFORE image were drawn with an indelible, felt-tipped, black marker. These lines did NOT score the foil, possibly promoting failure along any drawn line. The lines were used to attempt to identify failure propagation in the visual record.

Review / Recent MPSHRe Project

1. Two significant data points from pressure transducer's calibration relationship
   A. (0 mV, 0 psig)
   B. (1502 mV, 4 psig)
2. Slope of the transducer's pressure/signal relationship :
   = (4 – 0) / (1502 - 0)
   = 4/1502 psig/mV
   = 2.663(10^{-3}) psig/mV
3. Maximum measured failure pressure of the 3 tests
   = 2.663(10^{-3}) * 536
   = 1.43 psig
   = 1.4 psig
4. Average measured failure pressure of the 3 tests
   = 2.663(10^{-3}) * 452
   = 1.20 psig
5. Estimated "maximum attainable" failure pressure
   = 2080 – 1396 = 684 mV
   = 2.663(10^{-3}) * 684
   = 1.82 psig
   = 1.8 psig

(1 psig = 6.895 kPa)



Review / Recent MPSHRe Project

Summary Comments

1. Airbus/MSSI requested MPSHRe assessment of MSSI Blend A & the FAA supported the project
2. The species of Blend A are not individually identifiable by a Statham derivative gas analyzer when mixed
3. Completed MPSHRe (rev04) test project with MSSI Blend A
   A. Affirmed validity of Statham-derivative during MPSHRe assessment with additional grab-sample collection and NDIR concentration analysis
   B. Observed escaping effluent from the FAATC NFS atmospheric gap
   C. Phenomena did not burst foil seals with a closed atmospheric gap
   D. Recommendation for certification = 30.6%v/v Blend A for ½ sec
4. Foil seals tested for failure pressure; P < 13.8 kPa gage (2 psig)

Recognizing those supporting…

Airbus :

Mssrs. Thibault Pelletier, Stephane Pugliese, Pierre-Emmanuel Arnaud

MSSI :

Dr. Ian Campbell, Mr. Cris Sevilla, Mr. Kurt Mills

FAA :

Ms. Louise Speitel, Mr. Rick Whedbee, Mr. Tom Carmen, Mr. Wayne Eichner, Mr. Larry Fitzgerald, Mr. Tim Smith, Mr. Steve Happenny

Technology and Management International, LLC :

Mr. Paul Scrofani, Mr. Mark Materio, Mr. Mike Donio

Thank you.