High Heat Sink Fuels Program

Patricia Pearce

Wright-Patterson AFB

937-255-6918

Patricia.Pearce@wpafb.af.mil

HHSF Program

- **Demonstrate Approaches to Increased Fuel Heat Sink in JP-8 Fuels**
- **In-House Team Includes Government, Military, UDRI, UTC**

HHSF Approach

- Feasibility Studies – Complete June 2002
- Additive Demonstration
- Deoxygenation
- Coatings
- Cooled Cooling Air
- Components
- Modeling

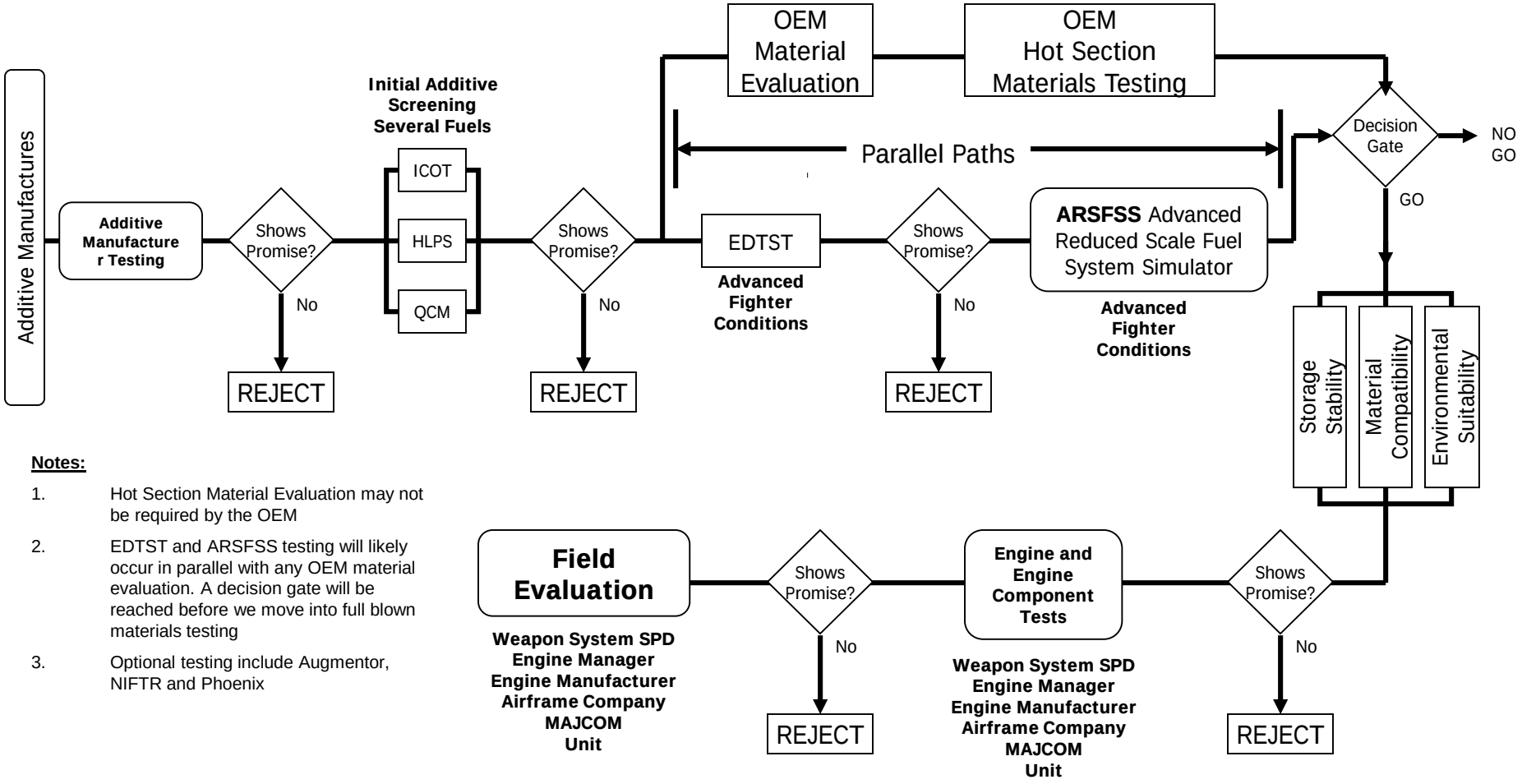
Additive Demonstration Background

- JP-8+100 Program
  - SPEC AID 8Q462
  - AeroShell Performance Additive 101
- Qualification of Second Additive
- JP-8+225

Additive Demonstration

- Establish Process
- Establish Baseline Fuels for Each Test
- Follow Process for Each Candidate
- Test Database
- Provide Continuing Feedback to Additive Manufacturer

Additive Evaluation Process



Notes:

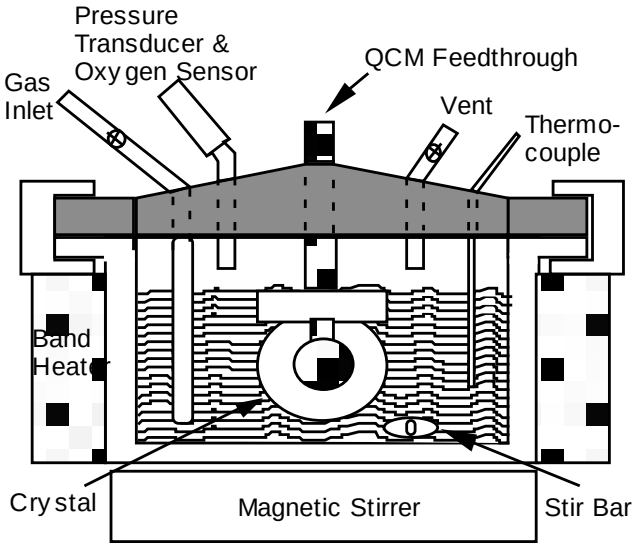
1. Hot Section Material Evaluation may not be required by the OEM
2. EDTST and ARSFSS testing will likely occur in parallel with any OEM material evaluation. A decision gate will be reached before we move into full blown materials testing
3. Optional testing include Augmentor, NIFTR and Phoenix

ICOT

- Isothermal Corrosion Oxidation Tester
- Apparatus - ASTM D4871
- Test Conditions (+100)
  - 180°C
  - 5 hours
  - 100 mL
- Monitor
  - Filtered Solids

QCM

- Quartz Crystal Microbalance
- Formation of Surface Deposits
- Test Conditions (+100)
  - 140°C
  - 15 hours
  - 60 mL
- Monitor
  - Surface Deposit (micrograms /cm^2 vs time)
  - Oxidation Process



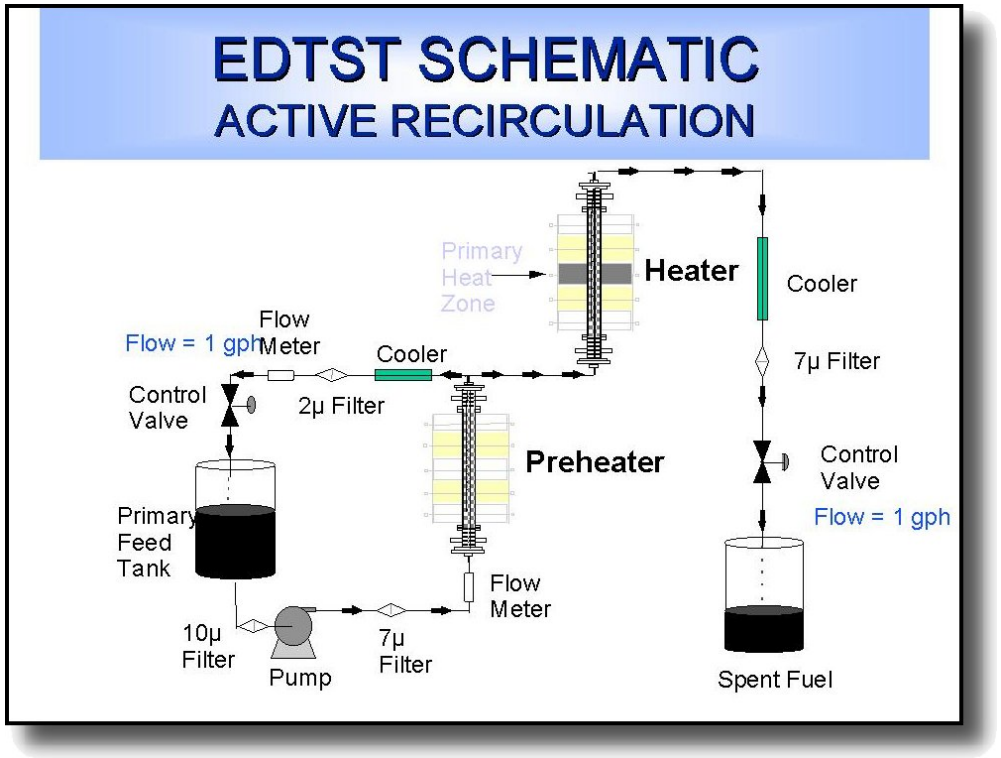
HLPS

- Hot Liquid Process Simulator
- Apparatus - ASTM D3241
- Test Conditions (+100)
  - 335°C
  - 300 minutes
  - 900 mL fuel sample
- Monitored
  - Deposits via Carbon Burn Off

Extended Duration Thermal Stability Tests - EDTST

Capabilities/Special Features

- Small-scale simulation of major fuel system components minimizes fuel resource requirements
- Steady-State testing, low fuel resource requirements and short test time allows use as a screening device
- 24-Hour operation minimizes program duration
- Modular design of plant and control system allows “plug-n-play” upgrades and enhancements
- Sophisticated computer control for consistent operation and reliable data acquisition



55 gallons fuel

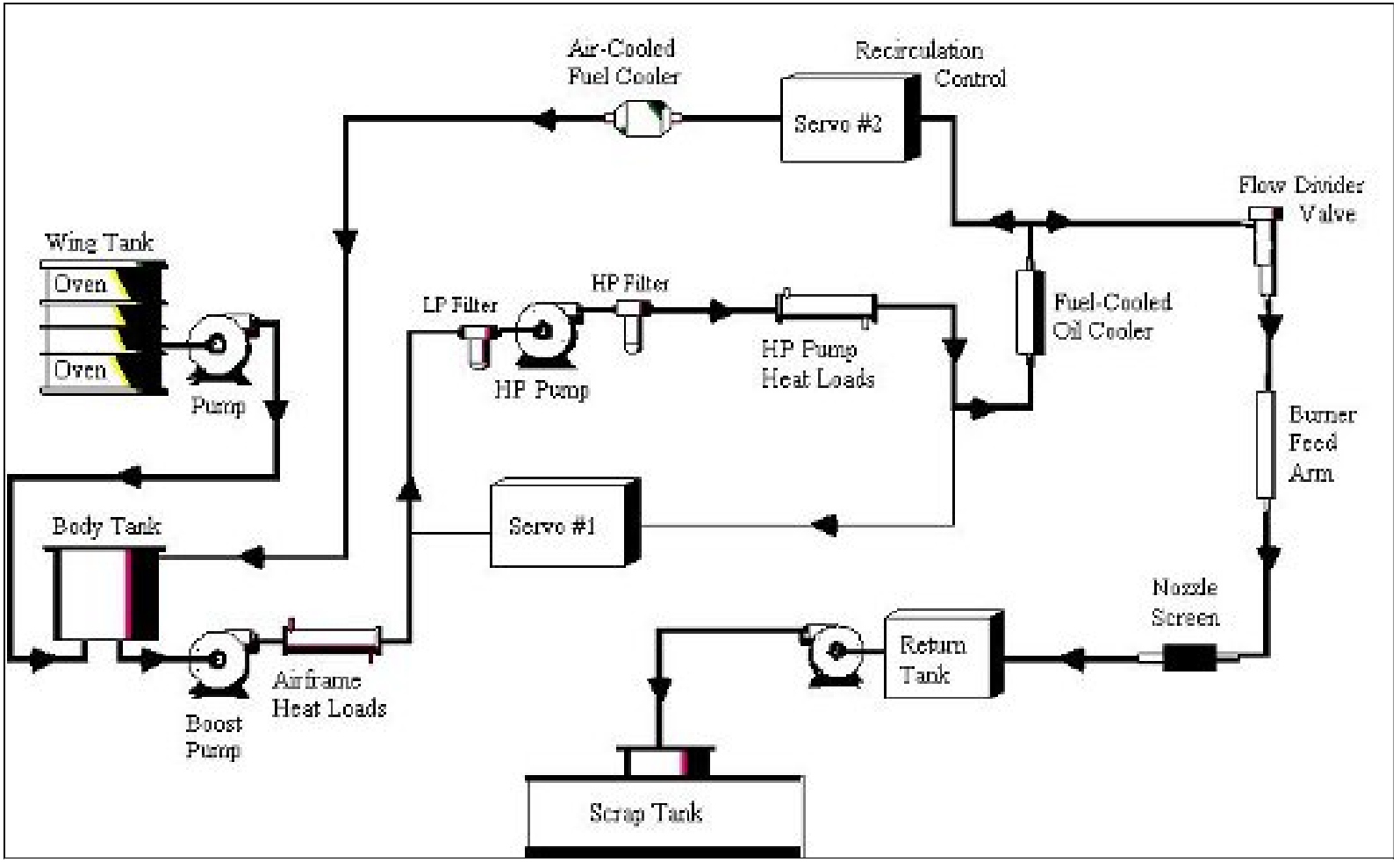
96 hours

375°C Bulk

500°C Wetted Wall

Heater Tube Deposit Established Through Carbon Burn-off

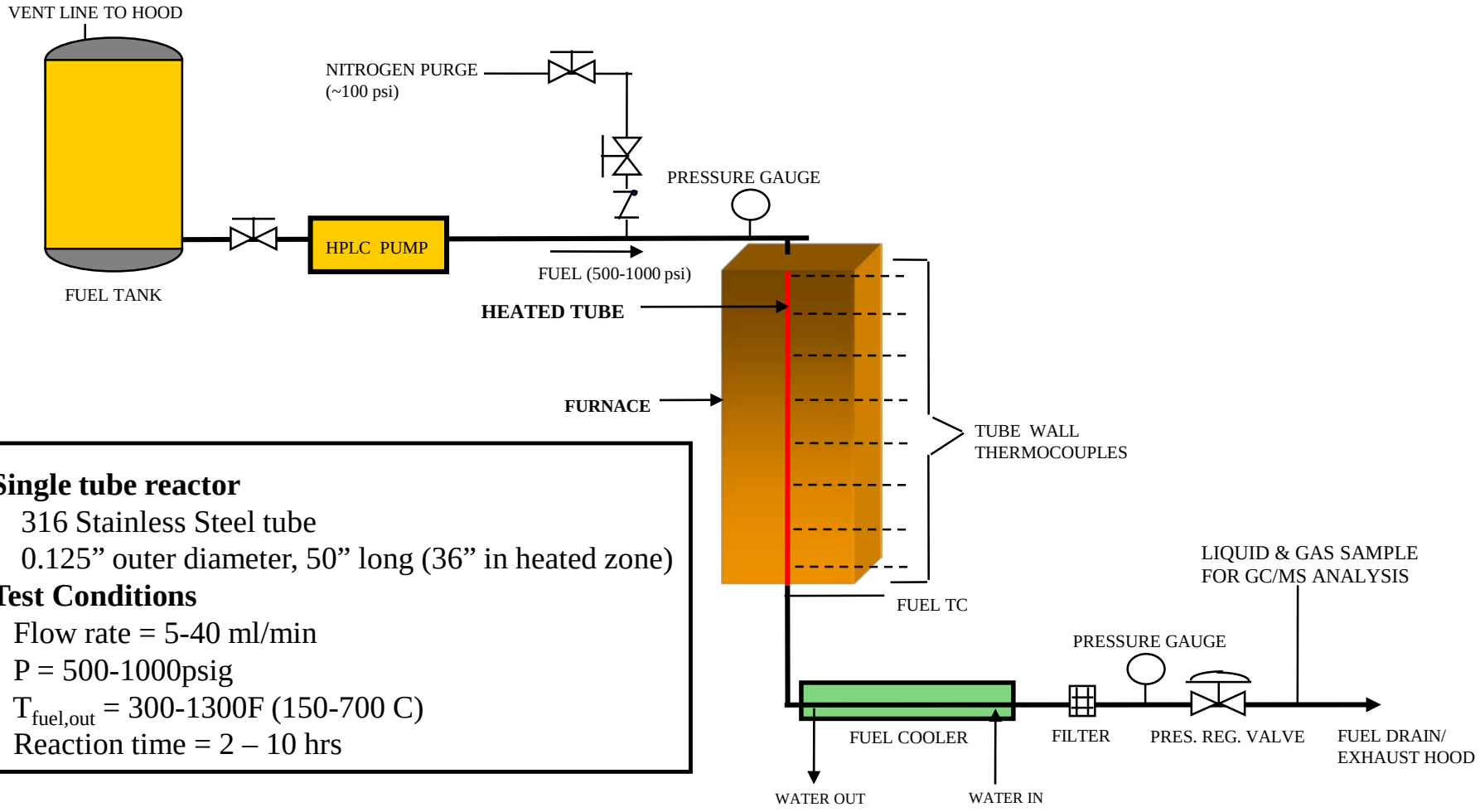
ARSFSS



Schematic of Advanced Reduced Scale Fuel System Simulator (ARSFSS)

Flow Diagram for ECAT -- Reactor System to Evaluate Additives to Inhibit Oxidative and Pyrolytic Deposition of JP-8

SINGLE TUBE SUPERCRITICAL FUEL TEST SETUP



Single tube reactor

316 Stainless Steel tube

0.125” outer diameter, 50” long (36” in heated zone)

Test Conditions

Flow rate = 5-40 ml/min

P = 500-1000psig

$T_{fuel,out}$ = 300-1300F (150-700 C)

Reaction time = 2 – 10 hrs

AF Additive Focal Point

For all high heat sink additives submitted for testing:

Robert Morris

1790 Loop Road N

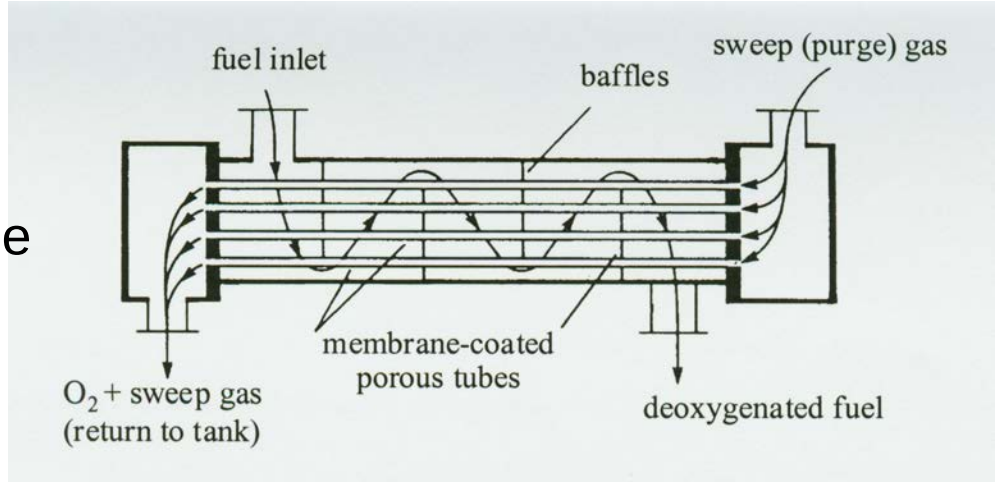
WPAFB OH 45433

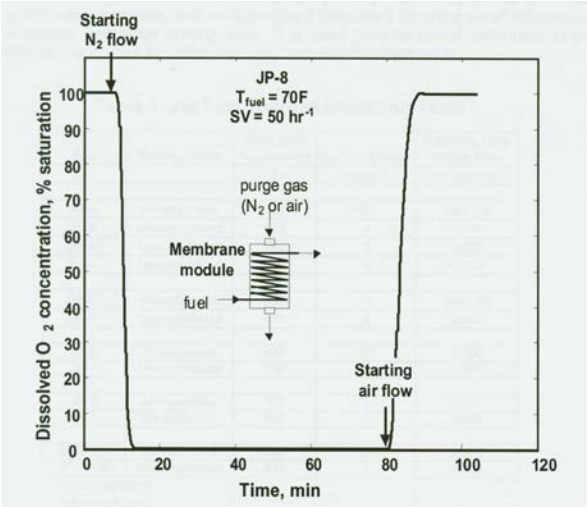
937-255-3527

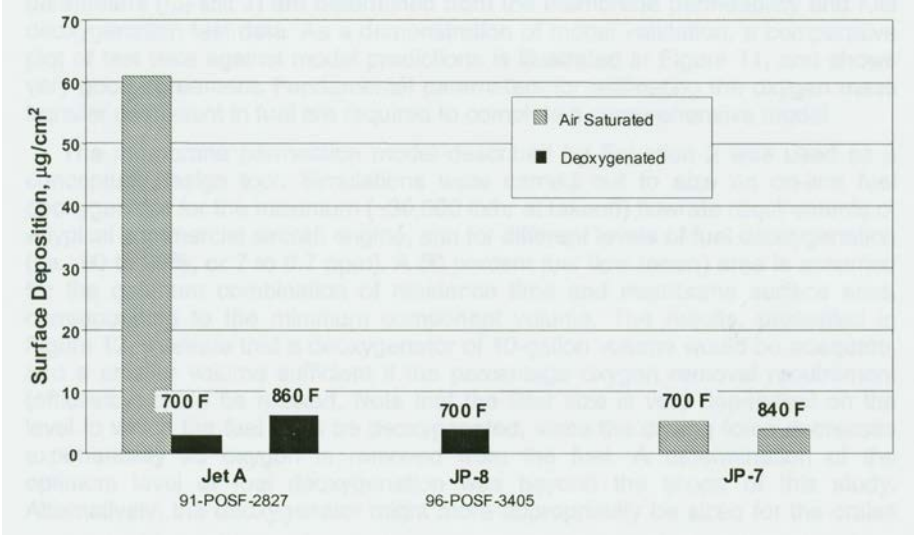
robert.morris@wpafb.af.mil

Deoxygenation

- Fuel deoxygenation could be a key enabler for high heat sink fuels - essentially eliminates oxidative deposition
- In FY01, bench scale membrane device demonstrated JP-7 performance with JP-8
- Follow-on research to engineer larger-scale unit for fuel system simulator demonstration

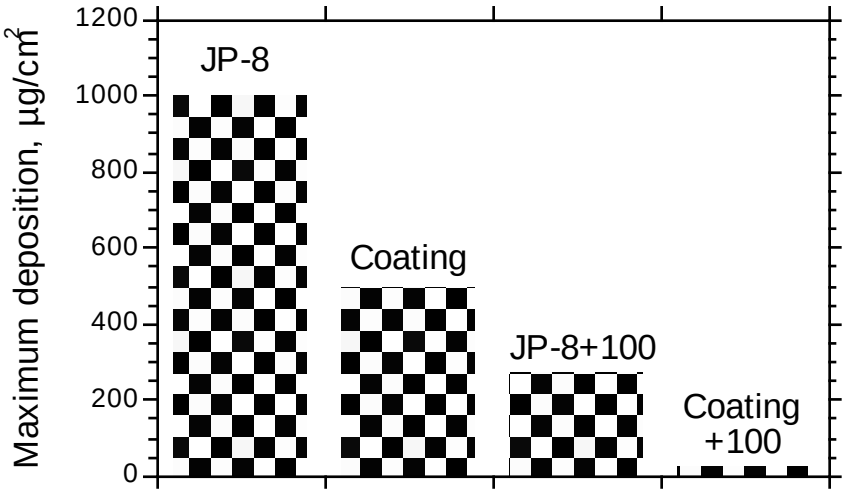






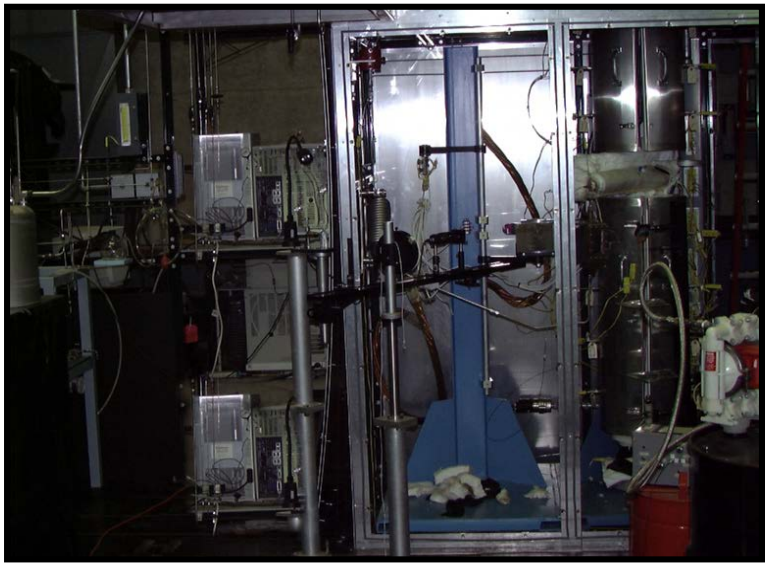
Coatings

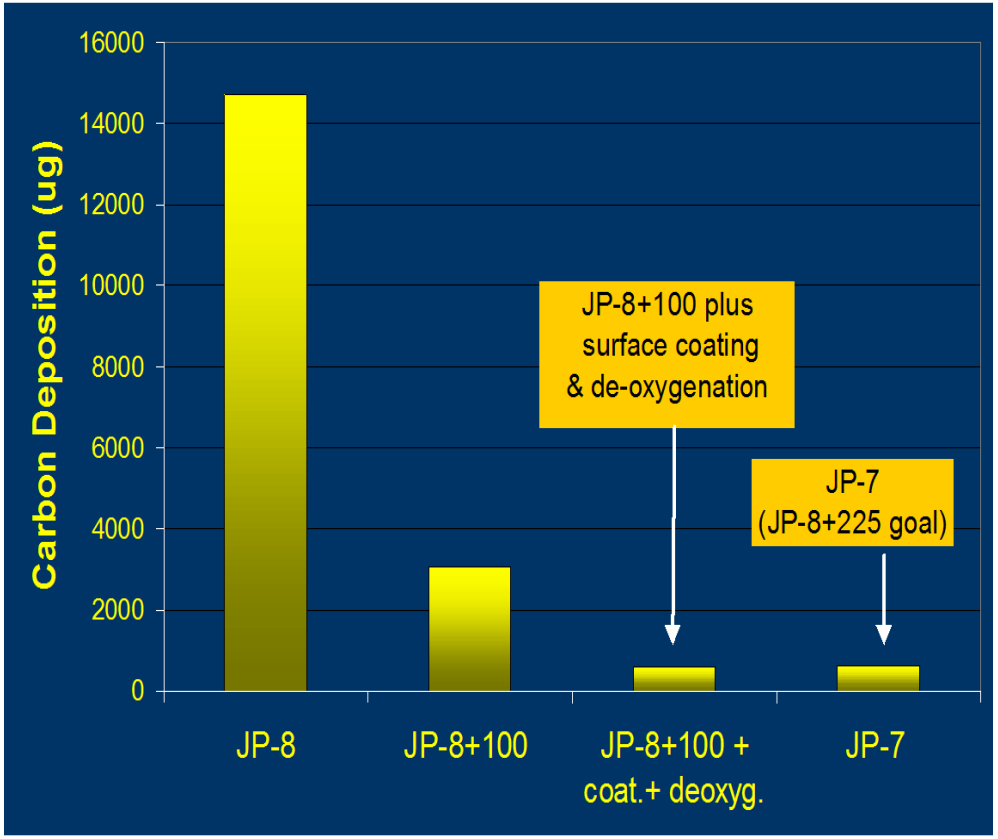
- In-house research with Silcosteel® coating demonstrated significant benefits for fuel heat sink capability
- Deposition reduction synergistic with dispersant additives (+100)



Accomplishment

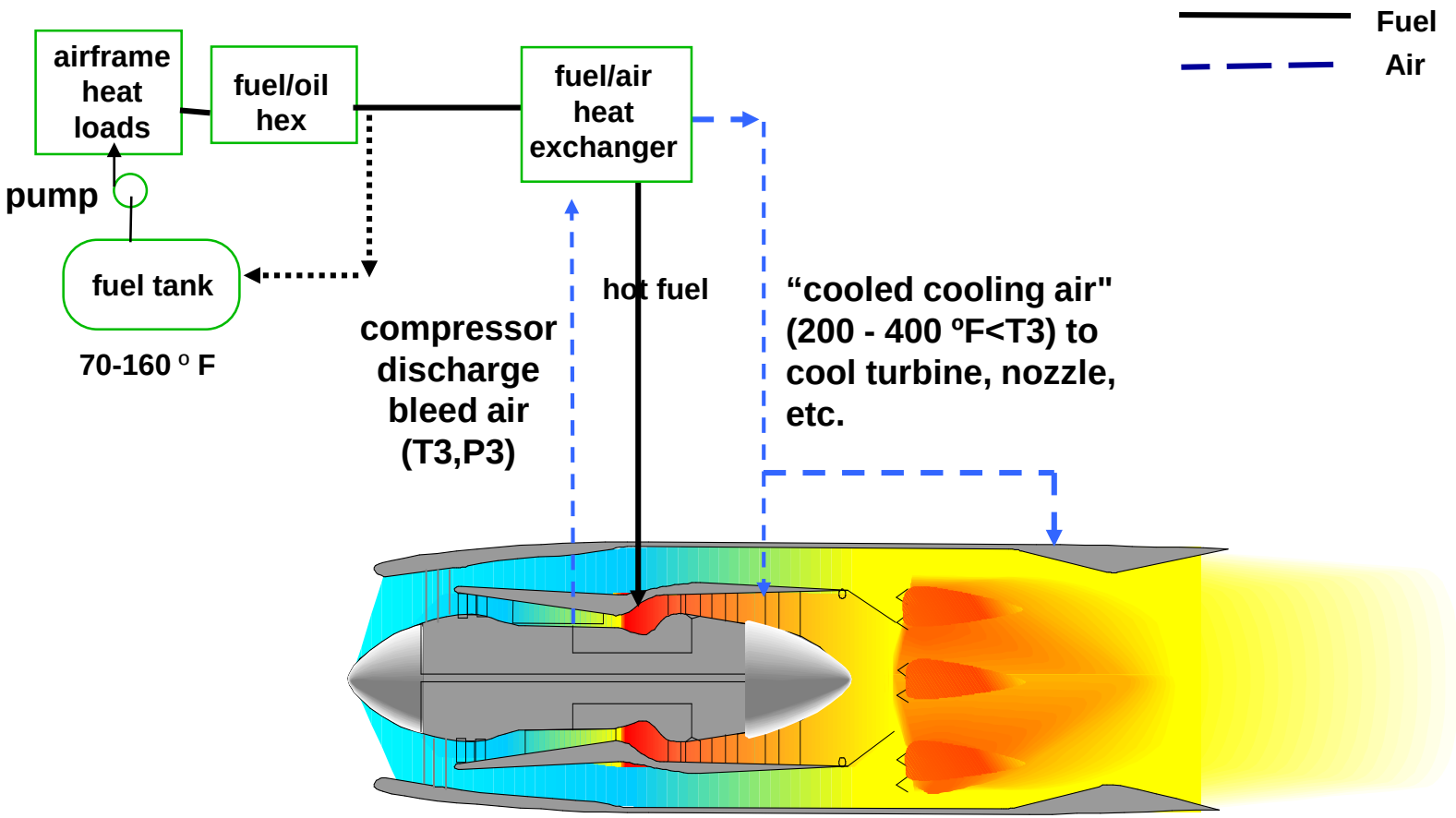
- **Goal**: simulation of advanced fuel systems
- **Research Objectives:** deposition control, component development
- **Analysis:** multi-point T, P, fuel, deposits
- **Capability**: 1300 ºF fuel temp., 1000 psi, 100 hrs demonstrated with JP-8+100





Early results indicate JP-7 performance can be achieved with a JP-8 based fuel with combination of deposition control measures

Cooled Cooling Air



- JP-8+225 will reduce and/or eliminate fuel recirculation
- Need high thermal stability fuel for effective CCA systems

Component Development

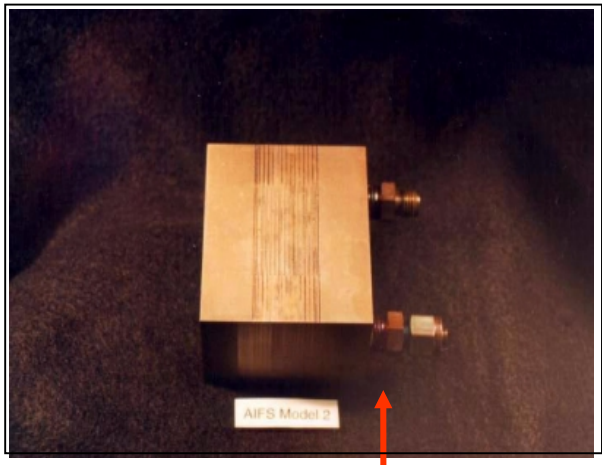
- Subscale bleed air/fuel HX using laminated foil technology, double wall buffered design for safety

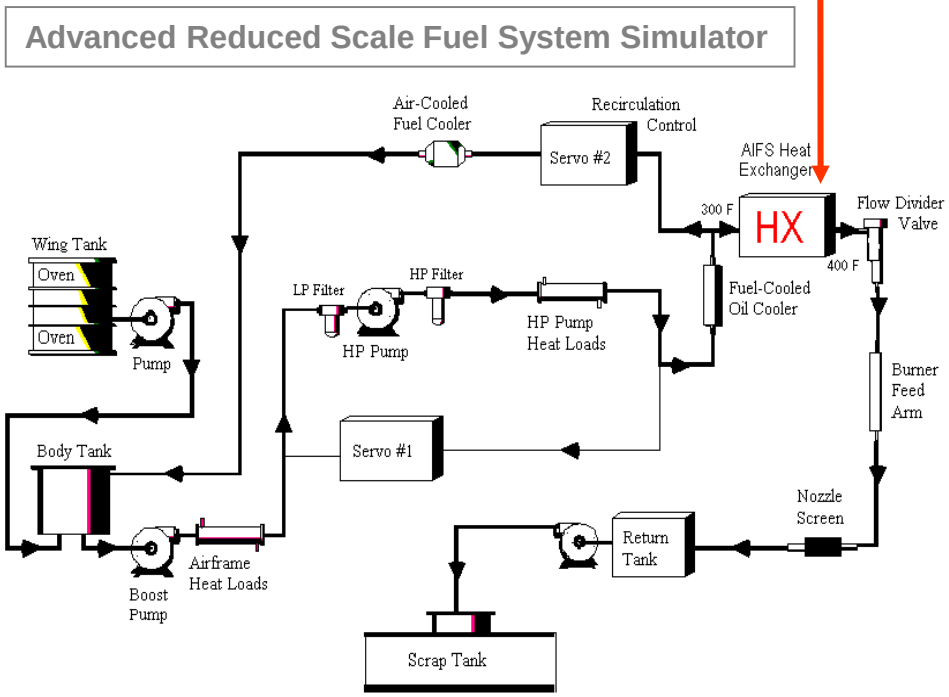
- Demonstrated integrity of the subscale HX model in dynamic cycling pressure test (50,000 thermal/pressure cycles)

- Demonstrated reliable HX operation in fuel system simulator under generic A/C mission for 835 hrs (T_f = 400 ºF / T_{air} = 900 ºF)

- HX coking and performance degradation studies underway

- Two HXs to be tested this year





HHSF Summary

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