COMPOSITE MATERIAL FIRE FIGHTING

Presented to: International Aircraft Materials Fire Test Working Group
Pooler, GA, USA

Presented by: John C. Hode
SRA International

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Development of a Fire Test Method

Purpose:

- Create a repeatable test method to quantitatively assess the amount of fire fighting agent necessary to extinguish aircraft structural materials.

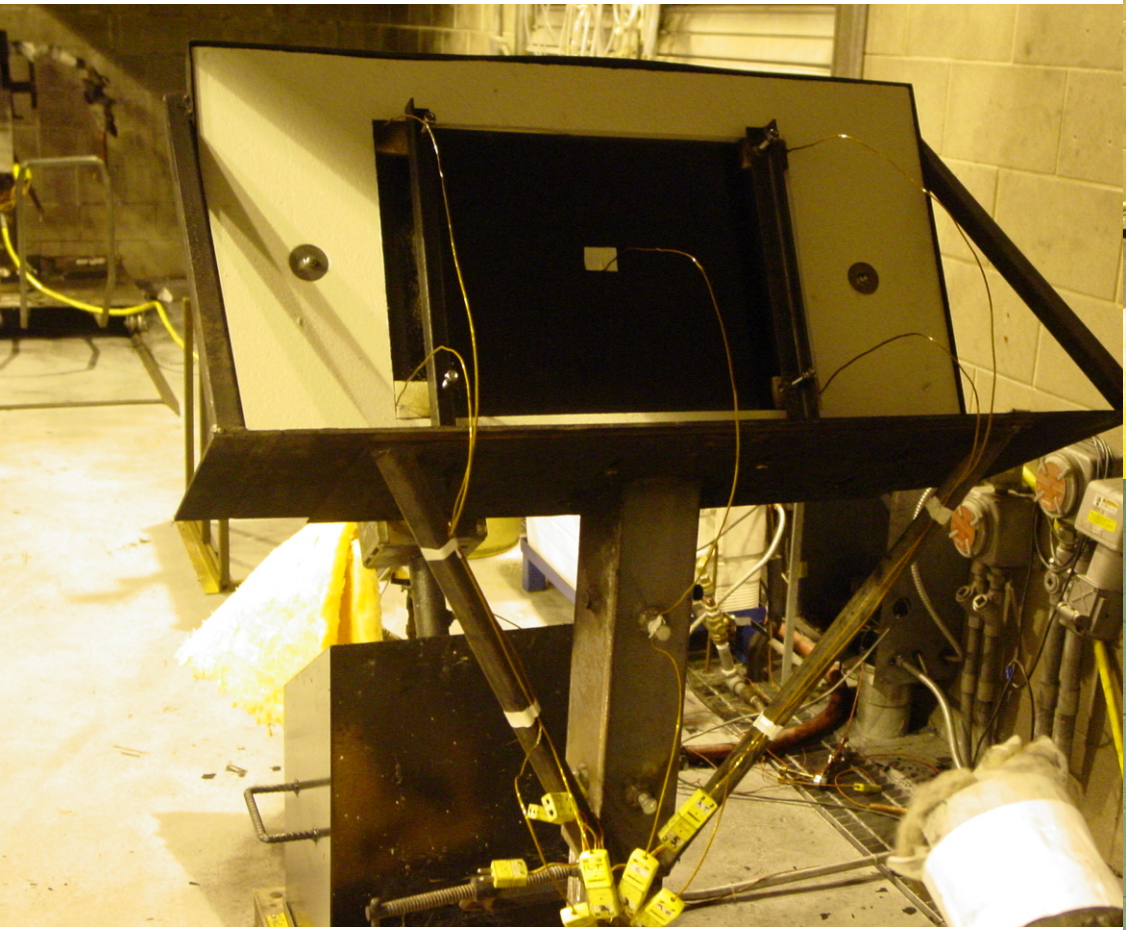
First objective:

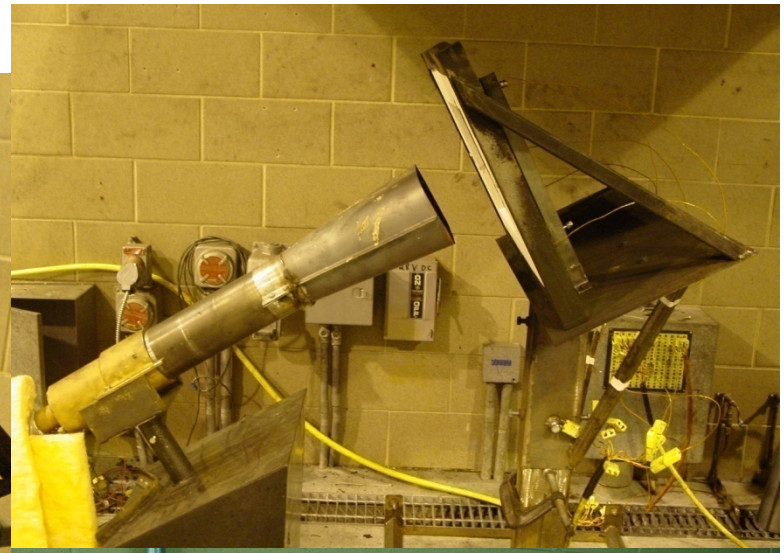
- **Determine the conditions for self-sustained fire.**

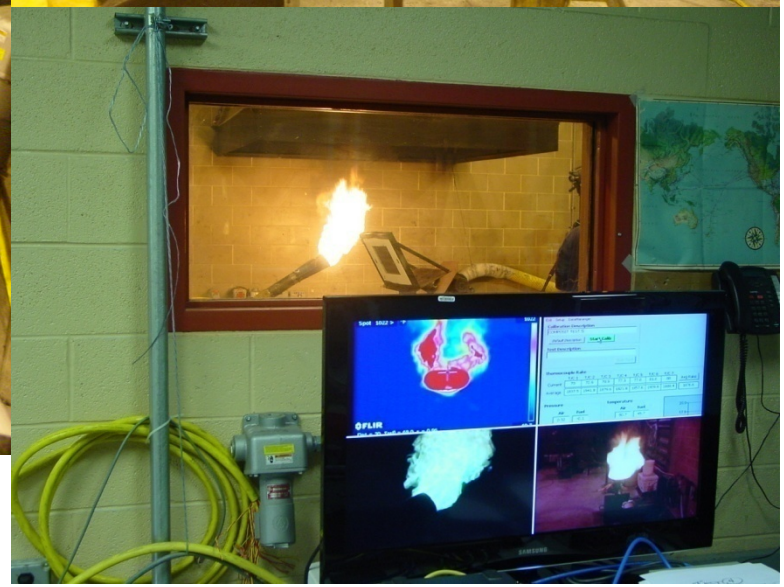
Second objective:

- **Develop a method to apply various fire suppression agents.**
- **Establish the quantity of agent (water & foam)necessary to extinguish a self-sustaining aircraft fire.**
- **Determine the effectiveness of various agents.**

Initial Test Set-up







Small & Intermediate Scale Testing

- Baseline intermediate scale tests conducted to see if results from initial test design are repeatable.

- **Small scale tests**
  - ASTM E1354 Cone Calorimeter
    - Data to support exterior fuselage flame propagation/spread modeling
  - ASTM E1321 Lateral Flame Spread Testing (Lateral flame spread)

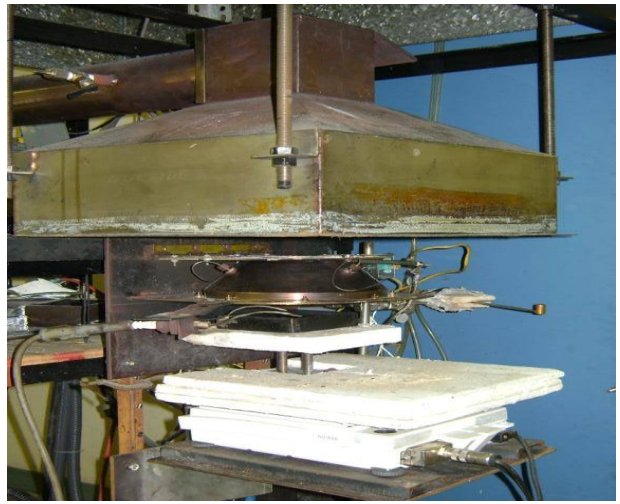
Small & Intermediate Scale Materials

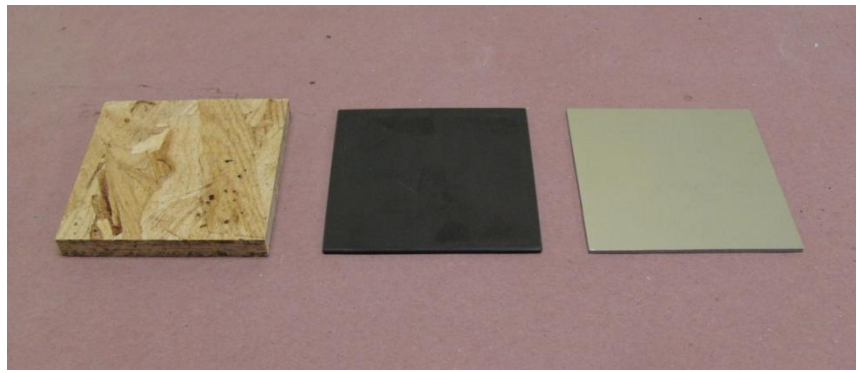
- **Carbon Fiber Reinforced Plastic (CFRP)**
  - Unidirectional T-800/350ºF cure epoxy, 16 ply quasi-isotropic [0,-45,45,90]S2, nominal thickness of 3.2 mm (0.126 inch) Finished 60/40 fiber-resin
- **Glass Fiber Reinforced Aluminum (GLARE)**
  - GLARE 3-5/4-.3, 2.5 mm (0.098 inch) total thickness
- **Oriented Strand Board (OSB)**
  - Georgia Pacific Blue Ribbon®, nominal thickness of 14.7 mm (0.578 inches)
  - Flame spread rating of 150-200

Composite Skin Fire Characteristics and Suppression

- **Approach**
  - Small scale materials testing

    ⇩
  - Results feed into fire model of combustion and propagation
  - Intermediate scale tests
    - Reduce reliance on large tests
  - Materials
    - Carbon/Epoxy (CFRP -B787)
    - Aluminum/Glass (GLARE – A380)
    - Surrogate – (wood board)





ASTM E1321 Lateral Ignition & Flame Spread

- **Wood was the only material in which lateral flame spread was observed**
- **CFRP and GLARE – some burning at seams**

OSB

CFRP

GLARE

Small Scale Tests - Combustibility

- **Composite Skin Materials Have Similar or Lower Combustible Properties compared to "Ordinary" Combustibles**
- **Compared to wood, composites:**
  - Require more imposed energy to ignite
  - Ignite slower
  - Have a shorter duration of burning(due to smaller thickness)

Sample	Minimum Heat Flux for Ignition (kW/m^2)	For 100 kW/m^2 Exposure		
		Tim to Ignition (sec)	Burning Duration (sec)	Avg. HRR (kW/m^2)
OSB	12	8	490	172
CFRP	16	29	113	153
GLARE	25	82.5	129	66.5

OSB Exposed to Large Area Burner with Insulation Backing

Large Area Burner On

Burner Off – 0 seconds

Burner Off – 30 seconds

Burner Off – 60 seconds

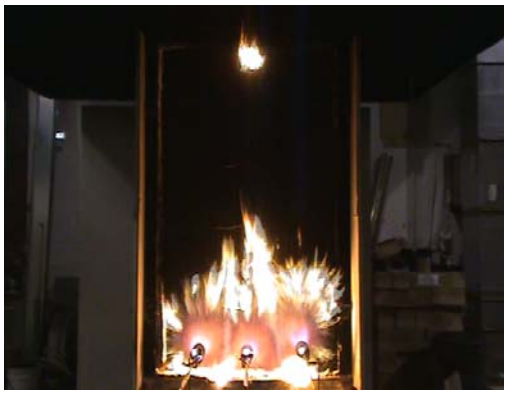
Burner Off – 100 seconds

CFRP Exposed to Torch Burner with Insulation Backing

Torch Ignition

1 minute after ignition

1.5 minutes after ignition

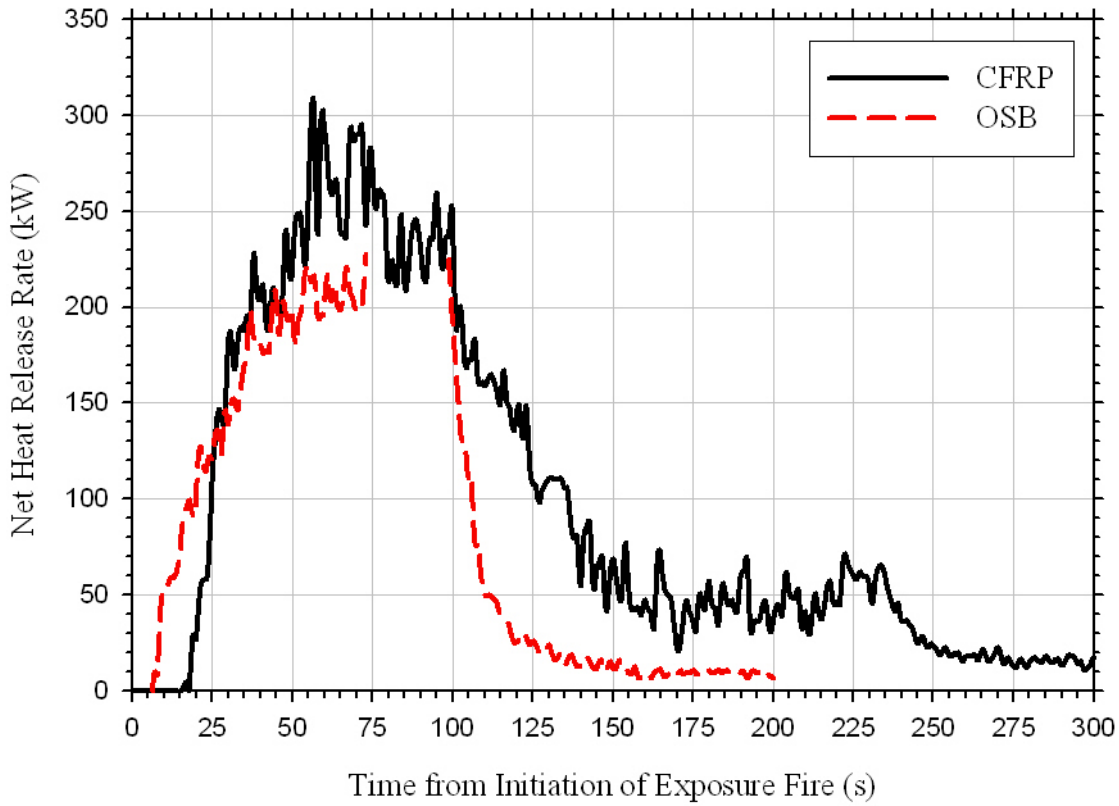


2.5 minutes after ignition

4 minutes after ignition
Torches Out

15 seconds after
torches out

Comparison of CFRP & OSB Heat Release



CFRP Torch Test

- Exposure 180 kW/m2
- Duration 250 seconds (4 min 10 sec)
- Panel Ignition at 16 seconds
- HRR increased after ignition to peak of 300 kW over 60 seconds
- HRR decayed after 90 seconds to steady-state value of 50 kW
- Post-exposure burning for 37 seconds

Intermediate Scale Test Conclusions

- **OSB vs. CFRP**
  - Both materials burn and spread flame when exposed to large fire
  - Heat release rates and ignition times similar
  - The thicker OSB contributed to longer burning
- **Large Scale Implications**
  - OSB might be used as a surrogate for CFRP
  - Flaming and combustion does not appear to continue after exposure is removed
    - Since there was no or very little post exposure combustion, no suppression tests performed as planned
    - Minimal agent for suppression of intact aircraft?

Qualifiers to Intermediate Scale Results

- **Need to check GLARE**
  - No significant surface burning differences anticipated (may be better than CFRP)
- **Verify /check CFRP for thicker areas (longer potential burning duration)**
- **Evaluate edges/separations**
  - Wing control surfaces
  - Engine nacelle
  - Stiffeners
  - Post –crash debris scenario

Can a well established fire develop in a post-crash environment?

Overall Findings from Initial, Small and Intermediate Scale

- **Flame propagation and self-sustained flaming does not significantly occur in the absence of external fire source.**
- **Epoxy off-gas is combustible.**
- **CFRP can smolder.**
- **Epoxy off-gas causes composite to swell through internal pressurization.**
- **OSB is potential surrogate for large scale tests to assess extinguishment test methods to save composites for data collection.**

Scoping tests of parallel configuration

FIRST IDEA FOR COMPLEX GEOMETRY FIRE TEST SETUP

ACTUAL CONFIGURATION USED IN SCOPING TEST

- **0.5 inch Oriented Strand Board (OSB) 9.5in x 24in and spaced 1” apart**
- **Ignition within 30 seconds**
- **Developed after 30-40 seconds then exposing flame secured**
- **Flames grew above rig**
- **Manual extinguishment after 1 minute**
- **Reignition occurred requiring second agent application for longer duration to completely suppress**

Participation welcome

- **Soliciting comments and ideas on:**
  - Potential test configurations
  - Previous testing results and data
  - Sources for aviation-grade carbon fiber composites and FML
  - Other helpful ideas