COMPOSITE MATERIAL FIRE FIGHTING

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Overview of Presentation

- **Summary of Past Work**
- **Development of Standardized Test Method**
- **Evaluating the Fire Performance of GLARE**

Summary of Past Work

Findings

- Characterized the fire performance of both CFRP and GLARE materials using small-scale test apparatus (ASTM E1354 cone calorimeter)
- Identified oriented strand board (OSB) as a representative, cost-effective surrogate for the composite material
- Determined that neither CFRP or OSB will burn for any extended period of time in the absence of an external heat flux (i.e., exposure fire)

Action Items

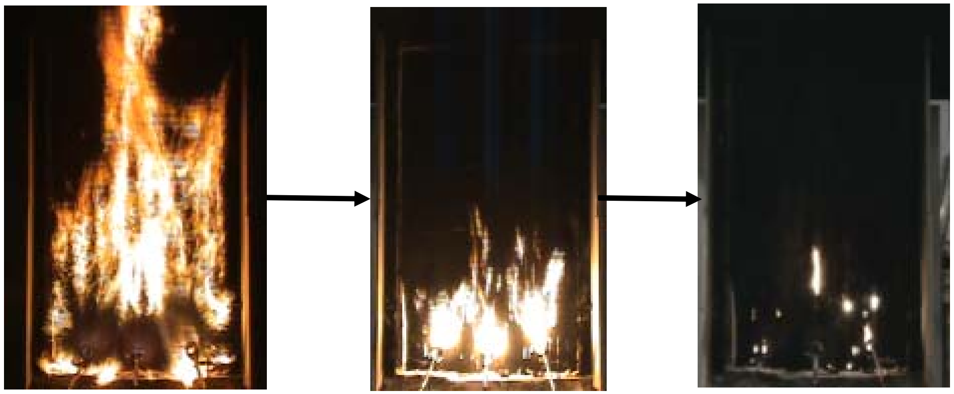
- Procure OSB material that is more comparable in thickness to that of the composites being evaluated to better simulate burning duration
- Identify under what condition/configuration, if any, the CFRP/OSB materials will continue to burn in the absence of an exposure fire
- Develop standardized test method to evaluate suppressability of composite
- Further characterize GLARE material at both small- and intermediate-scales

Summary of Test Materials

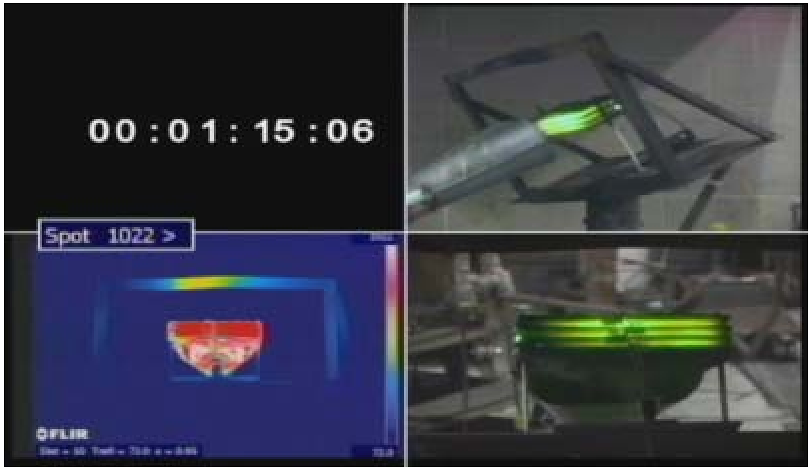
- **Carbon Fiber Reinforced Plastic (CFRP)**
  - Unidirectional T-800/350^{o}F cure epoxy, 16 ply quasi-isotropic [0,-45,45,90]S2, nominal thickness of 3.2 mm (0.126 inch) Finished 60/40 fiber-resin
- **Glass Fiber Reinforced Aluminum (GLARE)**
  - GLARE 3-5/4-.3, 2.5 mm (0.098 inch) total thickness
- **Oriented Strand Board (OSB)**
  - Norbord Trubord - nominal thickness of 6.25 mm (0.25 in.)
  - Small-scale calorimetery testing performed to validate similarity to composites
    - Time to ignition and peak HRR characteristics comparable between OSB and CFRP
    - Burning duration and total heat release of OSB slightly higher than CFRP – primarily an artifact of OSB being thicker than the composite samples tested

Identifying ‘Worst Case’ Configuration

- Initial intermediate-scale testing showed inability of CFRP to sustain combustion in the absence of an external exposure fire
- Scoping testing conducted at FAA showed that CFRP panels in parallel plate configuration could potentially sustain combustion in the absence of a source
- Parallel plate configuration ‘worst-case’ from a radiant exposure standpoint with adjacent panels irradiating one another even after the exposure fire is suppressed



With external fire exposure | **Immediately after exposure** | **~30s after exposure**



Test Method Development

Requirements

- Parallel plate sample configuration
- Fixed suppression nozzle
- Controlled fire exposure
- Repeatable

Variables

- Sample size
- Flue spacing
- Exposure fire size
- Exposure duration

- Optimization testing performed to identify key variables

Test Method Development

Test Parameters

- **Sample Size:** 4 - 1ft x 4 ft panels
- **Flue Spacing:** 2 inches
- **Exposure Fire**: 60kW (20 kW/flue)
- **Exposure Duration:** 90 seconds
- **Free-Burning Duration:** 60 seconds (followed by activation of suppression)
- **Suppression Nozzle Spray Pattern:** 90^{o} Full-cone
- **Nozzle Position:** 7 inches above sample array

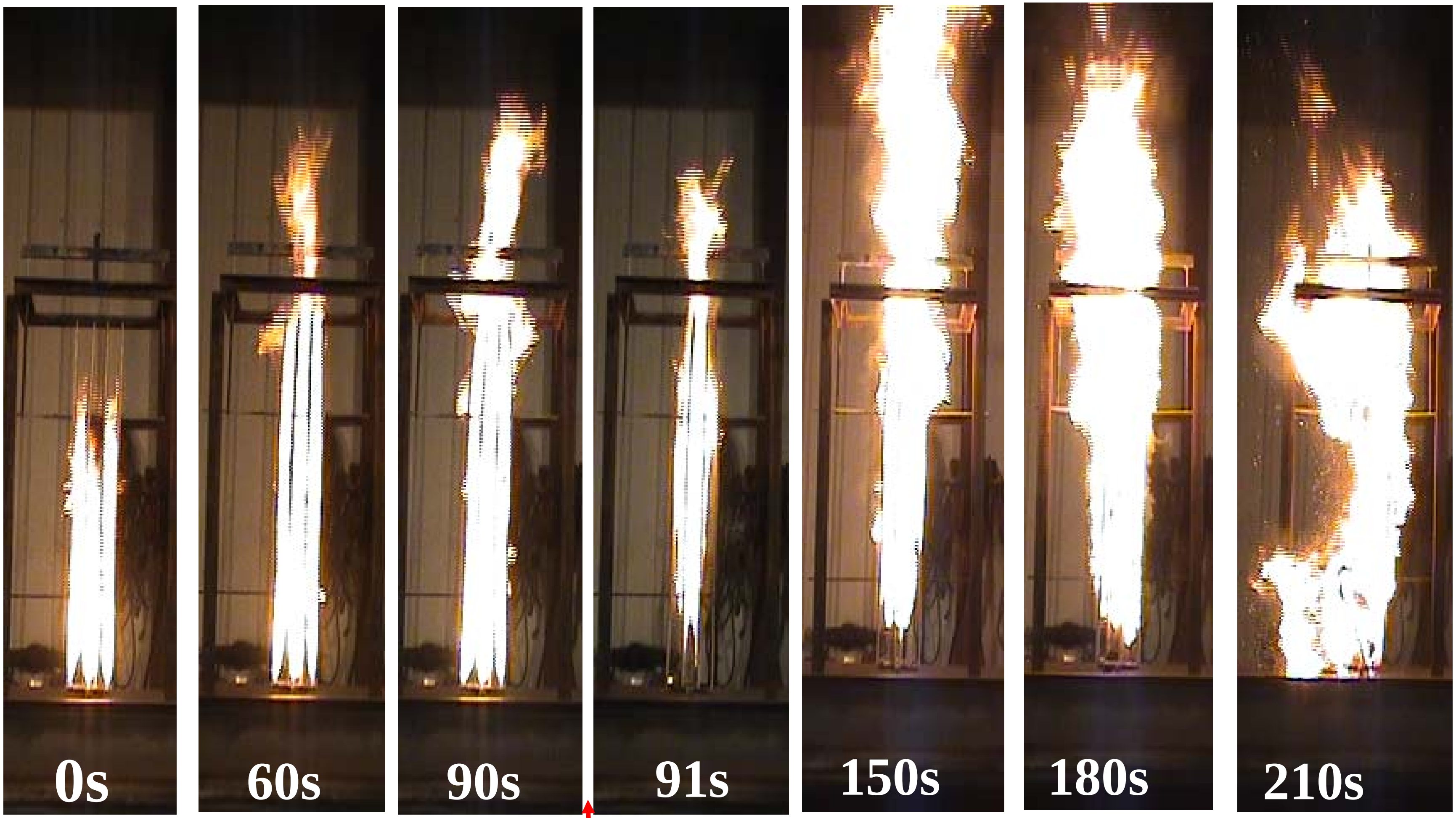
- Parameters based on series of tests conducted with OSB panels
- CFRP panels recently tested using standardized method

Fixed Suppression Nozzle

Parallel Plate Sample Mount

Exposure Fire

Results for OSB (60s Intervals w/o Suppression)

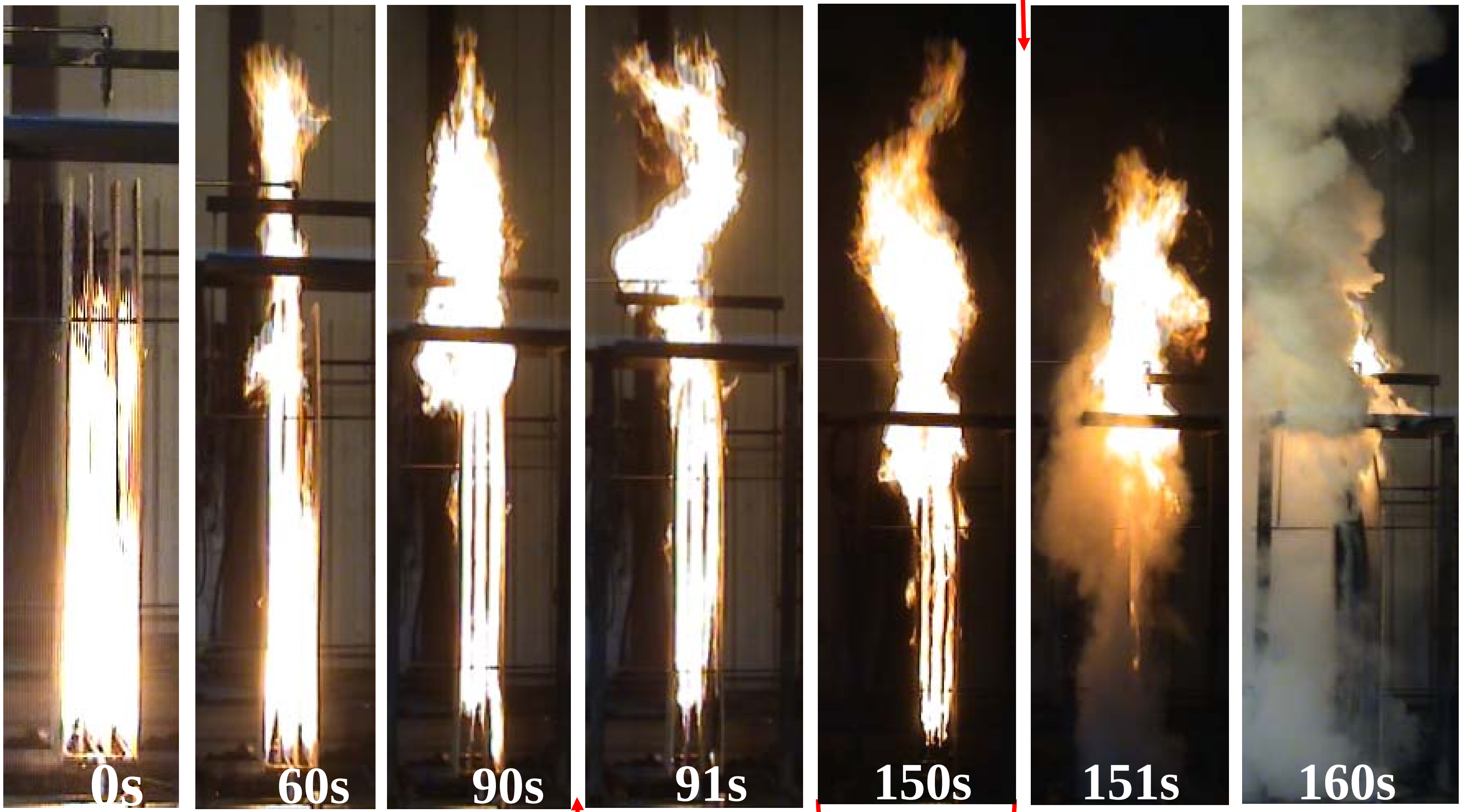


Burner Secured @ 90s

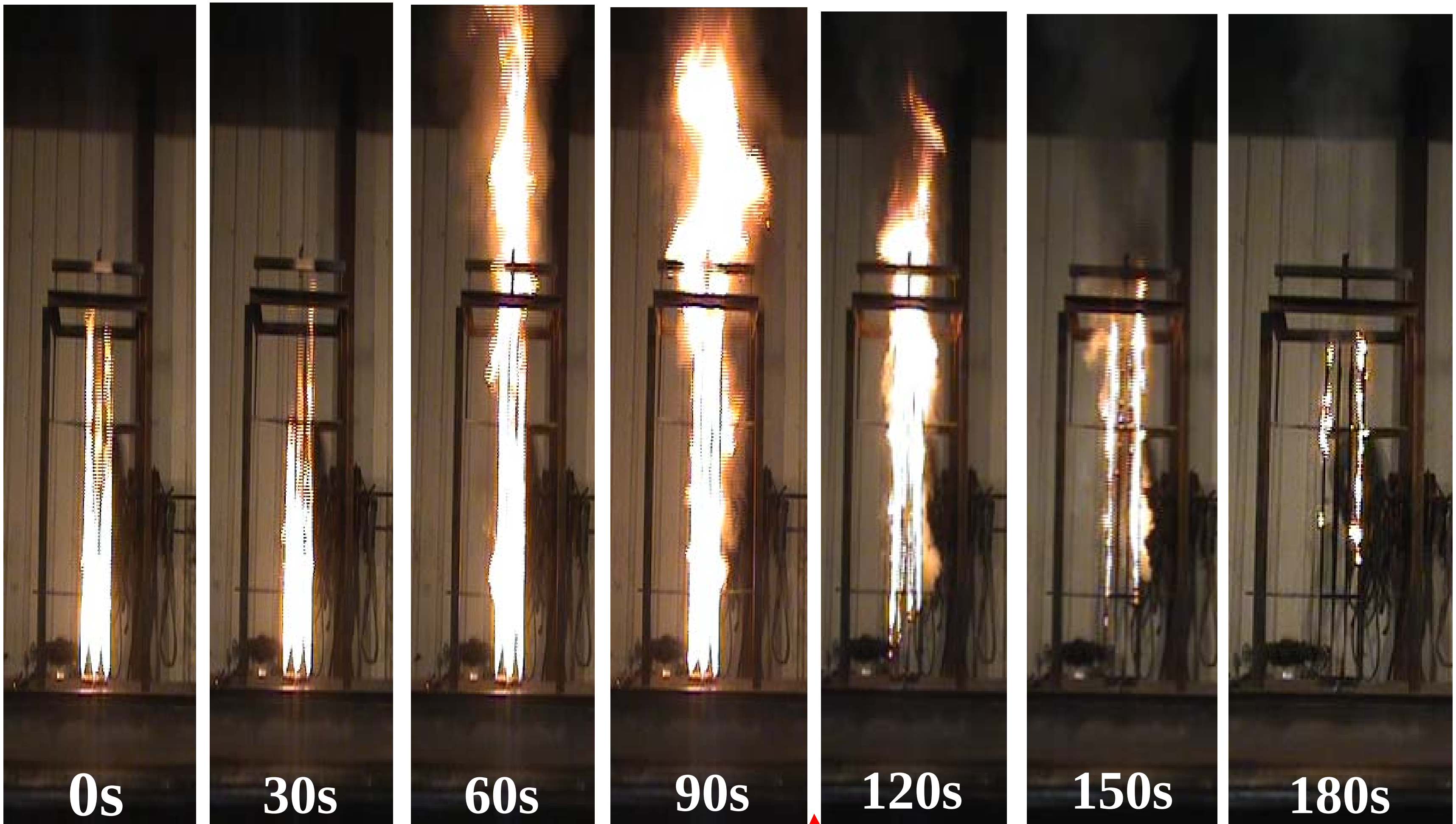
Peak HRR

Material consumed

Results for OSB (60s Intervals w/ Suppression)



Results for CFRP (30s Intervals w/o Suppression)



Burner Secured @ 90s　　*Self-Extinguishment @ 210s*

Summary of Intermediate-Scale Results

- OSB used to optimize test variables
- Self-sustained combustion of OSB observed after 90s exposure
- Peak burning observed 60s after exposure secured
- Suppression required (i.e., no self-extinguishment)
- Required discharge density to achieve suppression between 0.025 – 0.050 gpm/ft^2

- CFRP tested using 90s exposure / 60s free-burn as developed
- CFRP, in parallel plate configuration, self-extinguished approximately 2 minutes after securing exposure fire
- Suppression not needed on intermediate-scale test rig

- Scoping tests examining the burning characteristics of ‘fuel-soaked’ CFRP panels recently conducted to explore if ‘wicking’ or prolonged combustion of panels would be observed
- Results indicate that presence of fuel does not change the self-extinguishing nature of the composite material

Small-scale Testing of GLARE

- **Purpose:**
  Compare fire performance of US- and European-made GLARE material

- **Findings**
  - Heat release rate characteristics of both US and European made materials generally comparable, with European material having slightly lower output
  - European material found to be slightly more prone to ignition
  - Burning durations for both materials were comparable

Conclusion:

US- and European-made GLARE material exhibit similar fire performance

Material	Description	Incident Heat Flux (kW/m^2)	Time to Ignition (s)	Burn Duration (s)	Test Avg. HRR (kW/m^2)	Peak HRR (kW/m^2)
GLARE	US	50	239	234	42	128
		75	99	164	57	168
		100	83	129	67	168
	European	50	161	206	39	109
		75	83	171	51	144
		100	45	124	67	157

Intermediate-scale Testing of GLARE

- GLARE panel tested using torch burner exposure to simulate exposure from large liquid pool fire
- Exposed layer of aluminum quickly consumed, exposing resin/glass weave resulting in ignition of resin
- Burn-through over approximately half of the exposed section of the panel observed after approximately 90s of exposure

Potential Paths Forward

- Characterize fire performance of GLARE material using standardized test method
  - Does it behave similarly to CFRP (i.e., self-extinguishing) or require suppression?
- Characterize fire performance of composite materials with fuel soaked insulation
  - Representative of potential crash conditions (i.e., fuel soaked combustible in/around composite material)
- Explore debris pile scenarios to further explore scenarios representative of realistic crash scenarios
- Explore fire spread/development on an intact hull structure
  - Curved structure available at Navy test site currently being used (i.e., NRL Chesapeake Beach Detachment)
  - Liquid fuel pool fire exposure (30 – 60 ft^2)
  - Suppress pool fire and characterize amount of additional agent needed to suppress residual surface flaming