SSC Project Recommendation for FY 2023

Evaluation of Fire-Damaged Composite Materials with Commercially Available Flame Retardants

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1.0 OBJECTIVE.

1.1 The purpose of this project is to understand the in-plane tension, compression, and shear mechanical property knock downs for E-glass and carbon fiber composite material specimens after various durations of burning damage with commercial, off the shelf flame retardant gel coats.

2.0 BACKGROUND.

2.1 It was discovered that glass reinforced polymer composite material mechanical properties degrade when exposed to intense heat from fire. The use of phenolic resins, while more thermally stable, does not provide enough protection from heat to maintain mechanical properties after burning losing more than 70% of its tensile stiffness after 30 minutes of exposure to a heat flux of 50 kW/m^2. Specifications from the U.S. Navy simply state that structures must maintain adequate stiffness after a 30-minute fire event to meet recommended structural specifications. [8.1]

2.2 Degradation of composite materials begins with pyrolysis of the matrix material then transitions to oxidation of the char developed on the material and finally oxidation of the fiber material in the composite structure. [8.2] By limiting the amount of char formation on the matrix material, it can be theorized that the composite material system will still maintain a significant percentage of its original mechanical properties.

2.3 The American Bureau of Shipping (ABS) is working to address expanded use of fiber reinforced composites in offshore structures, noting that the largest restrictions for adoption of FRP materials are a lack of specifications to conduct material testing and many non-suitable materials. [8.3]

2.4 The U.S. Navy Zumwalt-class destroyer utilizes a phenolic resin infused composite material laminate design citing that the original carbon fiber and vinyl ester resin material system used to construct the superstructure did not offer enough fire protection for its roof. [8.4]

2.5 This project would address the need for vessel light-weighting and the use of composite materials in ship structure.

3.0 REQUIREMENTS.

3.1 Scope

3.1.1 The Contractor will conduct an assessment of current issues with fire protection on ship structures constructed from composite materials. This will be achieved through a literature review with emphasis on innovative naval material systems and steps taken to validate these structures with ABS.

3.1.2 The Contractor will fabricate representative test coupons for material testing utilizing various off the shelf flame retardant gel coats for the purpose of test specimen creation.

3.1.3 The Contractor will collect material data on the mechanical properties of a composite material system utilizing commercial flame retardant gel coats to evaluate mechanical performance after fire events of various durations.

3.1.4 The Contractor will use the data collected from the material tests to quantify the knockdowns to the mechanical properties of the material systems tested. This information will be valuable for future use for design engineers when sizing structures to withstand extreme operating conditions.

3.2 Tasks. (Identify the tasks to carry out the scope of the project).

3.2.1 The Contractor will conduct a comprehensive literature review to fully understand the scope of the problem proposed.

3.2.2 The Contractor will fabricate representative test coupons utilizing various off the shelf flame retardant gel coats.

3.2.3 The Contractor will conduct tensile, compressive, and flexural strength tests per ASTM standards for each type of test on specimens made from the test coupons fabricated for baseline data.

3.2.4 The Contractor will damage test specimens by burning for various durations per ASTM standards and procedures.

3.2.5 The Contractor will conduct tensile, compressive, and flexural strength tests per ASTM standards for each type of test on specimens made from the test coupons fabricated after burning for various durations.

3.2.6 The Contractor shall compile findings from material tests performed on intact specimens and burned specimens in a technical report to document the degradation of mechanical properties, if any.

3.3 Project Timeline.

3.3.1 Scope 3.1.1
Task 3.2.1: Months 1-3
3.3.2 Scope 3.1.2
Task 3.2.2: Months 3-5
3.3.3 Scope 3.1.3
Task 3.2.3: Months 6
Task 3.2.4: Months 7-8
Task 3.2.5: Months 9
3.3.4 Scope 3.1.4
Task 3.2.6: Months 10-12
3.3.5 Progress Reports: Months 3, 6, 9, 12

4.0 GOVERNMENT FURNISHED INFORMATION.

4.1 Standards for the Preparation and Publication of SSC Technical Reports.

5.0 DELIVERY REQUIREMENTS. (Identify the deliverables of the project).

5.1 The Contractor shall provide quarterly progress reports to the Project Technical Committee, the Ship Structure Committee Executive Director, and the Contract Specialist.

5.2 The Contractor shall provide all raw data and analysis generated in the project.

5.3 The Contractor shall provide a print ready master final report and an electronic copy, including the above deliverables, formatted as per the SSC Report Style Manual.

6.0 PERIOD OF PERFORMANCE.

6.1 Project Initiation Date: date of award.

6.2 Project Completion Date: 12 months from the date of award.

7.0 GOVERNMENT ESTIMATE. These contractor direct costs are based on previous project participation expenses.

7.1 Project Duration: 12 months.

7.2 Total Estimate: $100,000

7.3 The Independent Government Cost Estimate is attached as enclosure (*x*).

8.0 REFERENCES.

8.1 A.P Mouritz, Z Mathys, Post-fire mechanical properties of marine polymer composites, Composite Structures, Volume 47, Issues 1–4, 1999

8.2 A. Brown, A. B. Dodd, and K. L. Erickson, "The behavior of carbon fiber-epoxy based aircraft composite materials in unmitigated fires," Sandia National Lab, Albuquerque, NM, SAND2012-, May 2012.

8.3 American Bureau of Shipping (ABS) Eagle.org. (2022, December 19). ABS Chairs Industry Group Addressing the Expanded Use of FRP Composites in Offshore Oil and Gas Projects. Retrieved February 7, 2023, from https://ww2.eagle.org/en/news/abs-news/frp-composites-offshore-gas-projects.html

8.4 Black, Sara. "Destroyer Deckhouse Roof Meets U.S. Navy Fire Code with Phenolic Composite." CompositesWorld, CompositesWorld, 4 Sept. 2017, https://www.compositesworld .com/articles /destroyer-deckhouse-roof-meets-us-navy-fire-code-with-phenolic-composite.

9.0 SUGGESTED CONTRACTING STRATEGY.

9.1 It is suggested that the project will be led by a research team at the Advanced Composites Institute at Mississippi State University collaborating with commercial partners that the ACI has developed through other research opportunities.