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Novel Room Temperature Filler for Honeycomb Repairs

2024 JCAMS Annual Meeting

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MATERIALS / STRUCTURES / COMPOSITES

FOR PUBLIC RELEASE



TRANSFORMING THE MATERIAL CHALLENGES OF TODAY INTO THE SOLUTIONS OF TOMORROW

COMPANY PROFILE

Materials Sciences LLC (MSC) is a small business headquartered in a 25,000 ft² combined engineering, laboratory, and prototyping facility in Southeastern PA

- 15,000ft² advanced textile production facility and a 30,000ft² composite manufacturing facility in Greenville, SC
- 12,000ft² engineering and manufacturing facility in Huntsville, AL
- Large scale composites production capability in Gulfport, MS via parent organization Seemann Composites LLC

MATERIAL CHARACTERIZATION

- Test planning, specimen design, data reduction and analysis, material qualification
- Standard coupon (e.g. ASTM, SACMA) and large-scale specialty element/component testing
- Static and fatigue testing - Servohydraulic and electro-mechanical
- Dynamic-modal analysis, DMA, creep, random vibration, shock, system identification
- Environmental conditioning
- Dimensional analysis/3D inspection
- Non-destructive testing

DESIGN AND ANALYSIS

- Computer aided design and solid modeling software:
 - (RHINO, SolidWorks)
- Commercial and in-house finite element programs
 - (ABAQUS, LS-DYNA, ANSYS, FEMAP)
- Proprietary materials analysis and design software
- Topology optimization for additive manufacturing

PROTOTYPE & PRODUCTION MANUFACTURING

- Fabrication of fiber reinforced composite parts
- Out-of-Autoclave (OoA) manufacturing via resin transfer molding (RTM), resin film infusion (RFI)
- Compression molding
- Injection molding
- Textile production

PRODUCT DEVELOPMENT AREAS

MSC has led design, analysis, manufacturing and testing of advanced composite materials and structures for a broad range of product applications for both government and corporate clients. These have included aviation and missile systems, marine and transportation systems, ground vehicle, unmanned systems and high-performance sporting goods.

- **AVIATION AND MISSILE SYSTEMS**
- **MARINE AND TRANSPORTATION SYSTEMS**
- **PRODUCT TEXTILES AND COMPOSITE PARTS**

COMPOSITE DAMAGE MODELS

- **MAT 161/162:** Progressive failure model for LS-DYNA and ANSYS
- **NDBILIN:** Stress-based failure modeling for ABAQUS
- **DDSHM:** Fractured-based failure modeling for ABAQUS



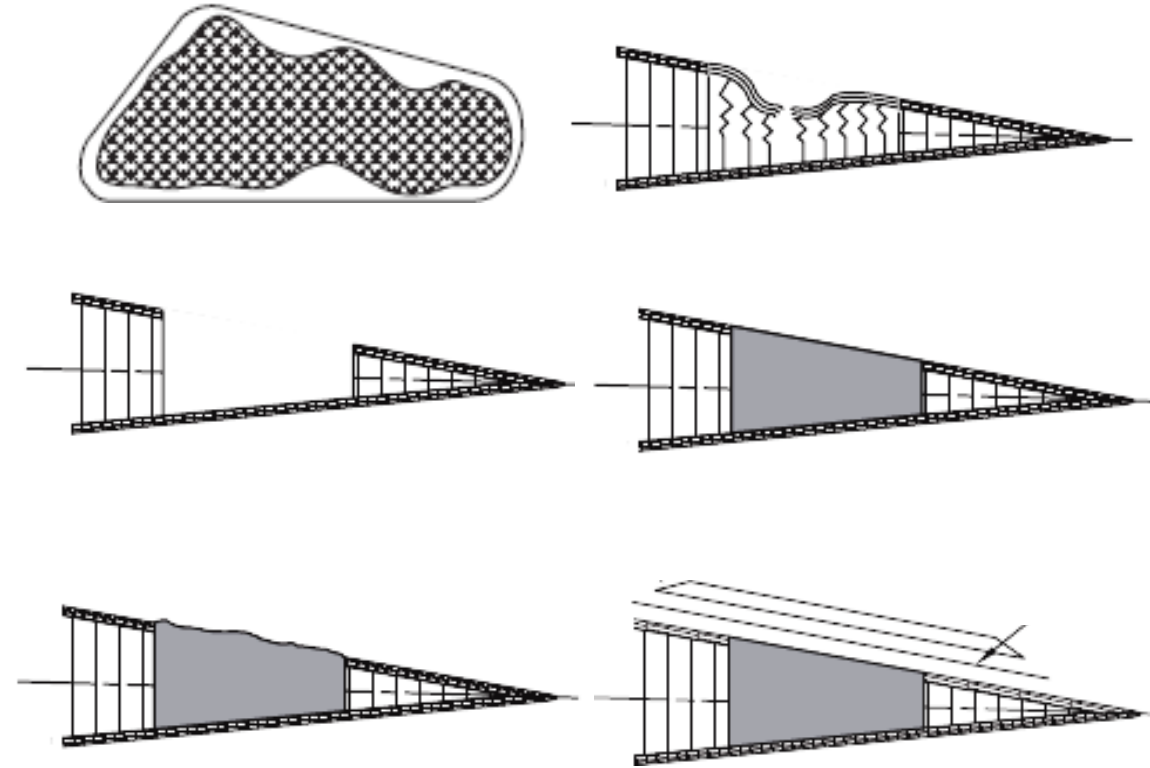
BACKGROUND

■ Opportunity

There are two general repair types for sandwich structures: core fill and honeycomb replacement. For large repairs, replacing the honeycomb is currently the only option due to the weight and structural performance attributes associated with state-of-the-art (SOTA) materials. The Navy is seeking a **novel, light-weight, fast-curing filler material** with enhanced mechanical properties that will facilitate larger potting repairs.

■ Program Details

- Customer: NAVAIR
- Current Funding: Phase II SBIR
- Topic #: N221-006
- PoP: 7/26/23 → 8/4/25



Typical steps to a core fill repair in a sandwich composite

NAVAIR PHI SBIR : PROGRAM GOAL

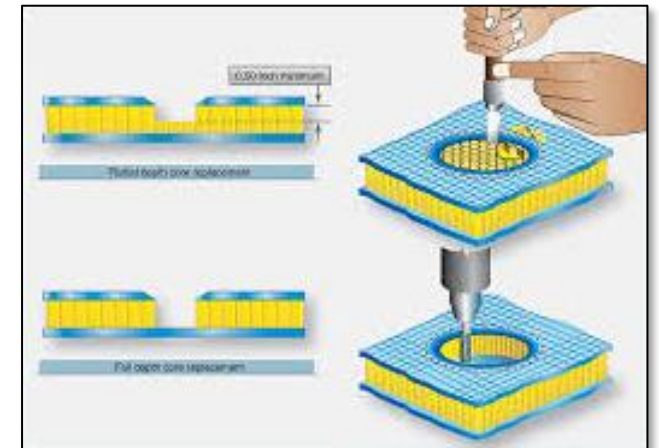
■ **Phase II Objectives:** Demonstrate high-quality repairs that increase operational efficiency

- Optimized Cure Cycle
- Increased Glass Transition Temperature (T_g)
- Reduced Density

■ **Approach:** Formulate blended epoxy system(s) with tuned hardener and filler package(s) to achieve desired cure profile, density, and mechanical performance.

■ **Anticipated Phase II Results:** An innovative low density honeycomb filler that will be useful in a wide range of environments

- Retains compressive strength at elevated temperatures
- Cures rapidly even at very low temperatures
- Agnostic to application method



RESIN DEVELOPMENT

- Develop base epoxy blend and cure package to achieve desired pot life, exotherm temperature, and cure time
- System Optimization
 - Catalyst Concentration for reaction rate control
 - Fire Retardant package
 - Filler for density reduction
 - Elevated temperature properties
- Additional Focus points
 - Handling characteristics such as viscosity and cling
 - Component shelf life

Processing Objectives

- 8 hr. cure < 70°F (21°C)
- Pot Life > 15 minutes
- 1 hour cure to sanding at 70°F (21°C)
- Exotherm < 200°F (93.3°C)

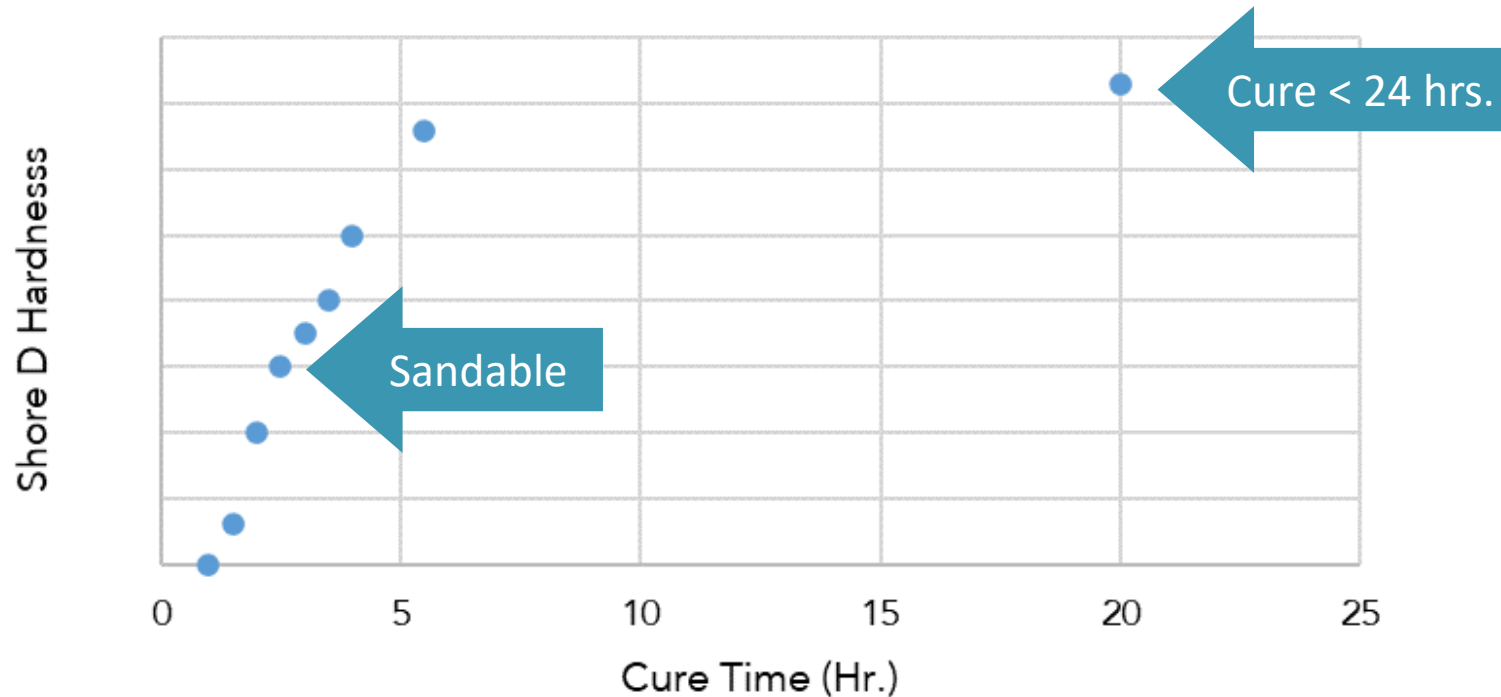
Material Property Targets

- Compression Strength 7-10 ksi
- Density 0.4-0.8 g/cc (25-50lbs/ft³)
- Surface chemistry
- Processability
- Majority property retention at 180 °F

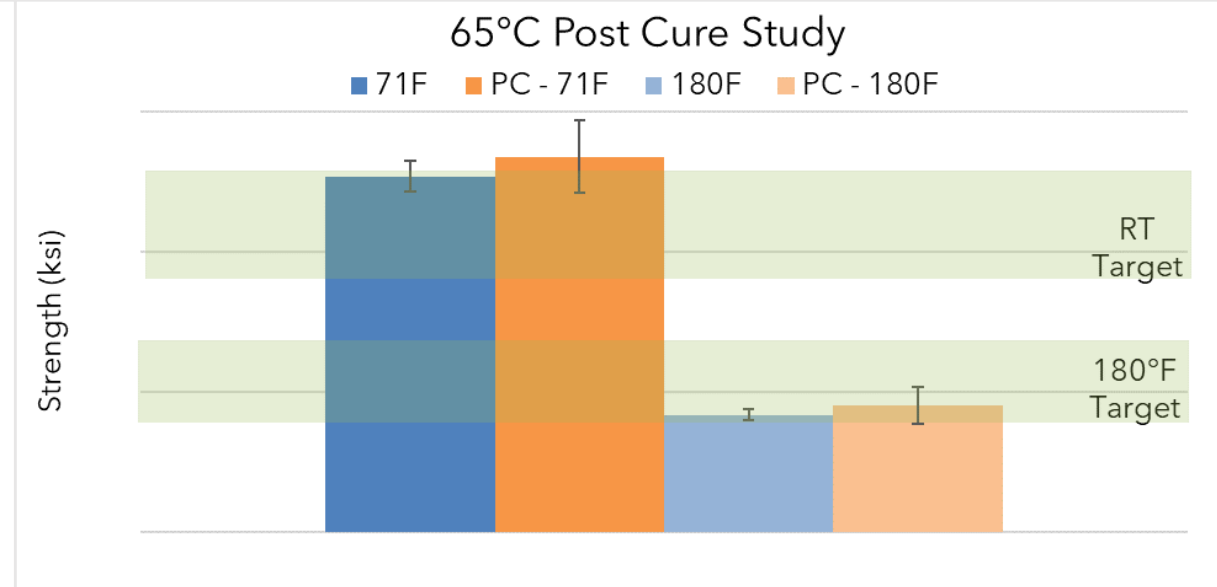
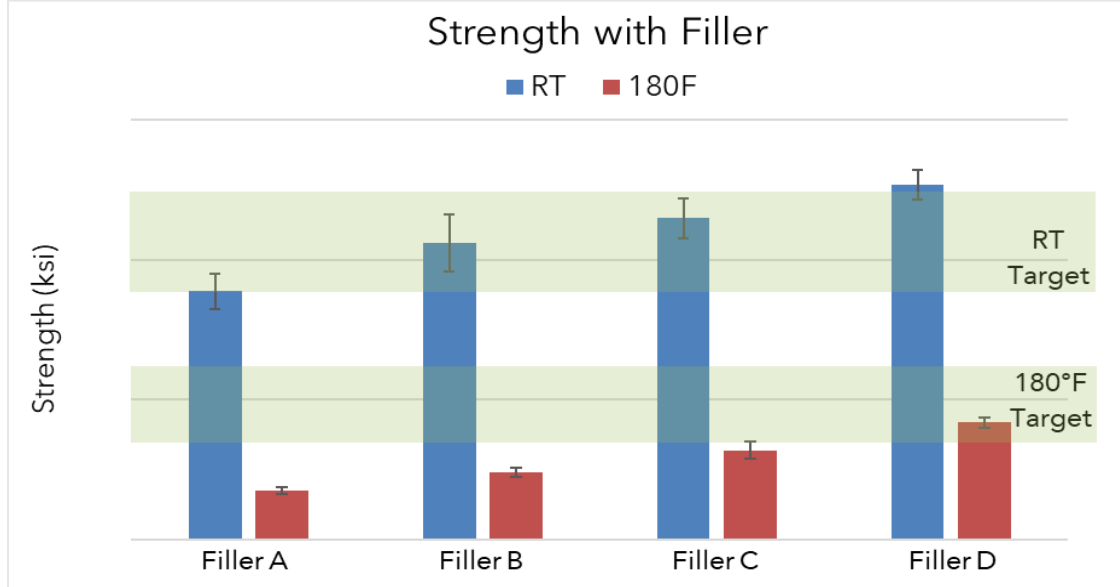
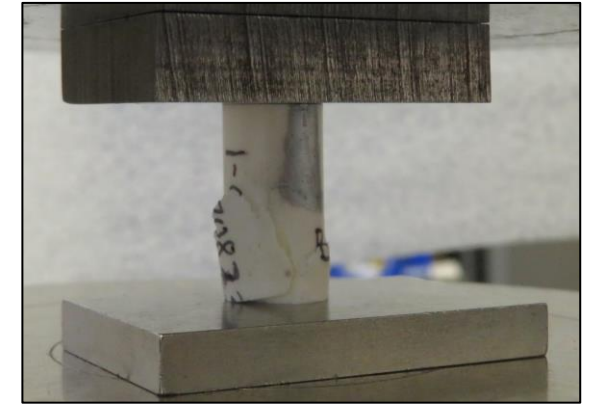
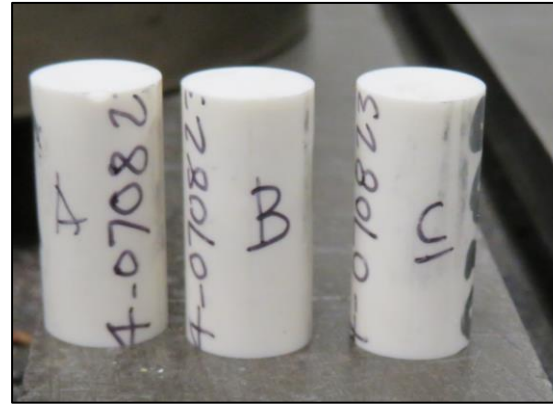
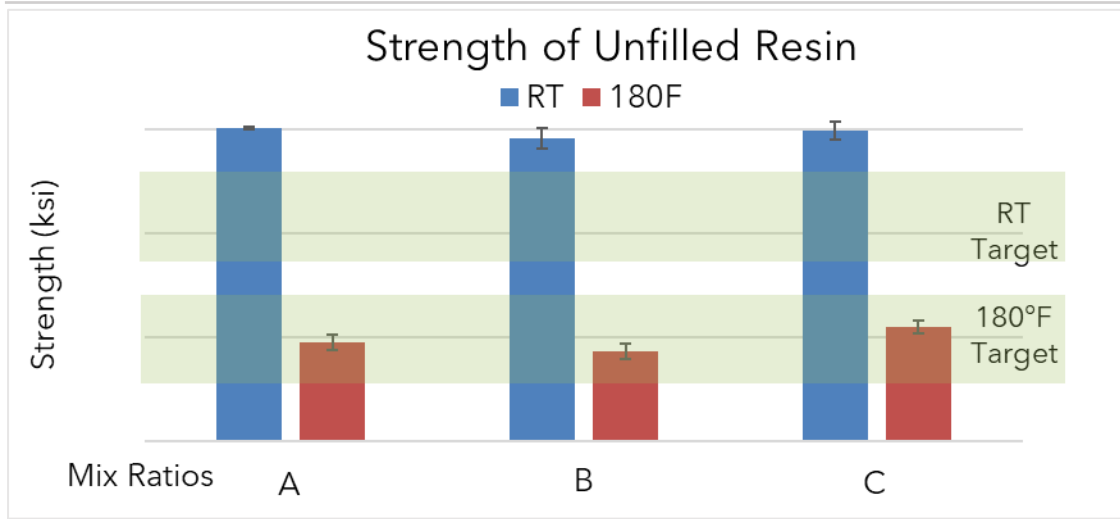


EXTENT OF CURE

- Shore D is an indicator of the extent of cure
- Highest Shore D value taken at each point



COMPRESSION TESTING



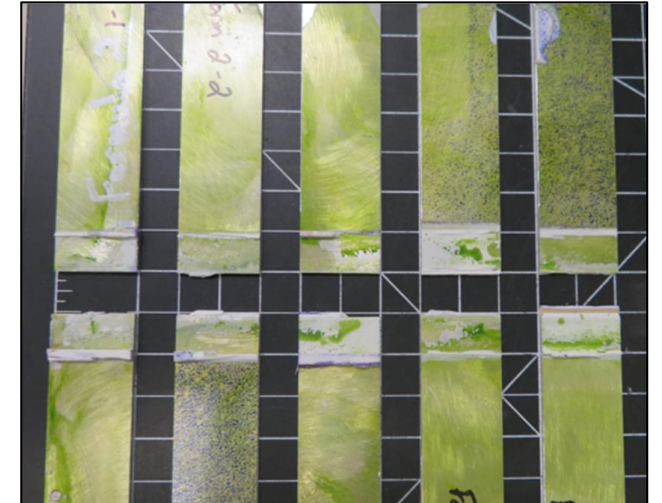
LAP SHEAR TESTING

- Aluminum used as adherend
- Prepared according to ASTM D1002
 - Single lap configuration

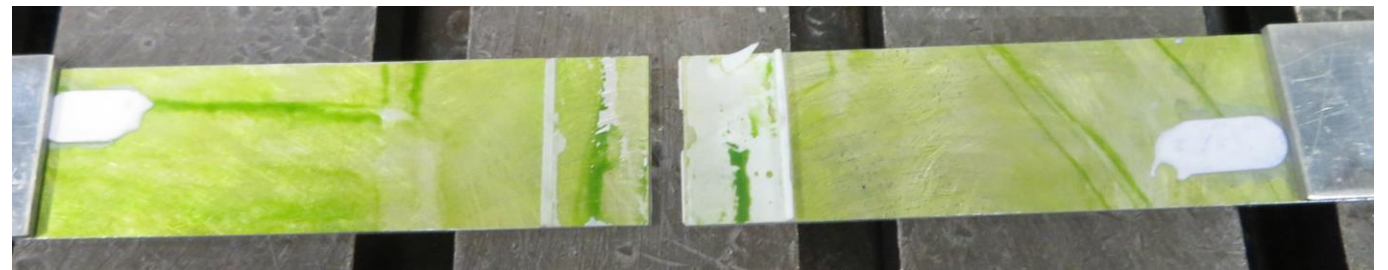
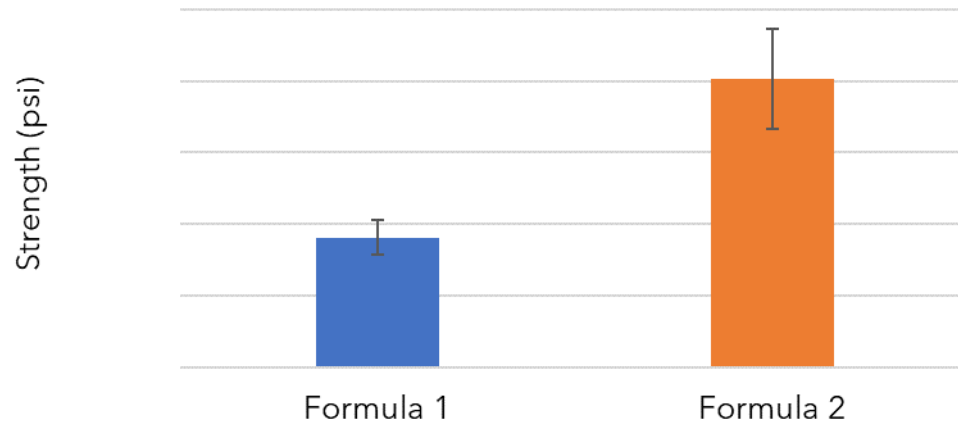
Formula 1



Formula 2



Lap Shear Strength



SUPPLEMENTAL CAPABILITY : FR PERFORMANCE

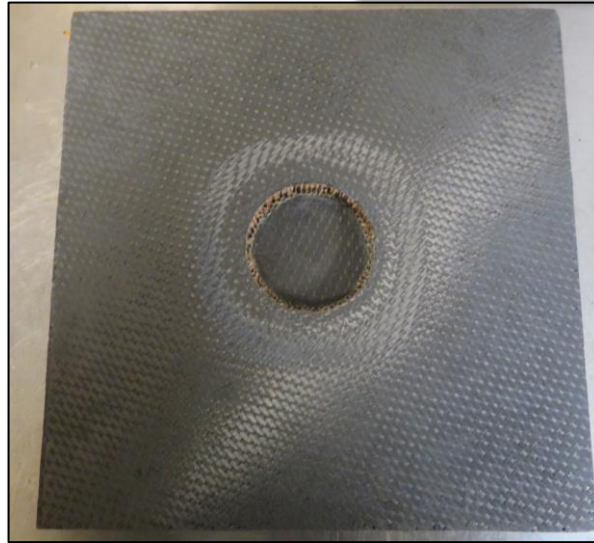
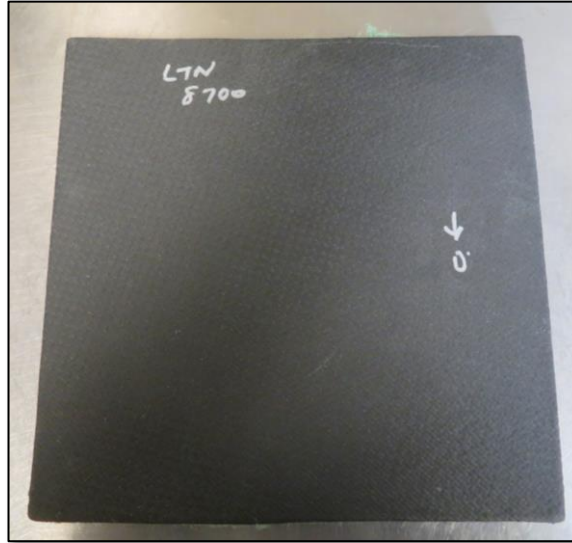
- For large repairs as well as in specific locations, fire retardance is a desirable performance attribute.
 - Filled system is self extinguishing
 - Vertical burn out occurred in 4 seconds
 - No Drips
 - Minimal deformation
 - Very hard char formation

- Corresponds to UL94 Flammability rating of V-0



FOCUS POINT: REPAIR DEMONSTRATION

- Repair shows large efficiency improvement.
 - Rapid application of potting compound
 - Minimal delay to sanding
 - No runaway exothermic reaction
- TRL-4 achieved



PILOT PRODUCTION

- Ross double planetary mixer
 - 2 gallon capacity
 - Fully mixed resin or hardener package
 - Uniform incorporation of fillers



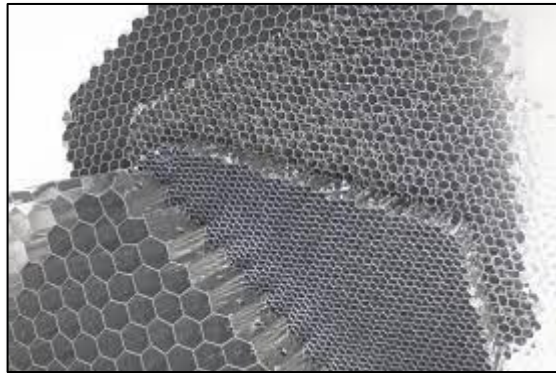
SUMMARY

MSC Solution	Advantages Over Legacy*
	Cost competitive with potential for savings
	Cures at low temperature
	40% weight savings*
	50% reduction in time to sand*
	80% reduction in time to full cure*
	-
	-
	Adds Fire Retardancy



FUTURE WORK

- Higher Temperature Post Curing
- Further Density Reduction
- Evaluation adhesion to other relevant substrates
 - Aramid
 - Aluminum
 - Polymer foams
- Scale up to 40 gallon mix planned



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- Team Members
 - Luke Colone - Chief Technical Officer
 - Elizabeth Andrew - Engineering Manager - andrew@msc-llc.com
 - Dominic Mirto - Testing SME
 - Clifton Garrett - Composite Technician



Questions?