

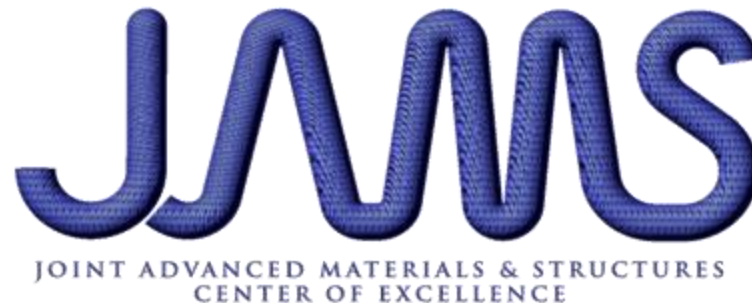


NATIONAL INSTITUTE FOR AVIATION RESEARCH

WICHITA STATE UNIVERSITY

Material Qualification Testing of Hexcel HexWeb[®] HRH-10 Aramid Fiber/Phenolic Resin Honeycomb Core

John Tomblin, Rachael Andrulonis, Royal Lovingfoss, Nicole Stahl, Caleb Saathoff & Tomas Lorik



Federal Aviation
Administration

TARGETED OUTCOMES FROM PRESENTATION

1. Provide an understanding of NIARs material qualification of Hexcel HexWeb® HRH-10 Aramid Fiber/Phenolic Resin Honeycomb Core.
2. Highlight lessons learned during prequalification activities and how these influenced the framework for material qualification activities.
3. Demonstrate use of the developed qualification framework for honeycomb core through generation of material properties.



RESEARCH TEAM & OBJECTIVES



John Tomblin, PhD
Executive Vice President, Research,
Industry and Defense Programs,
WSU-NIAR Executive Director



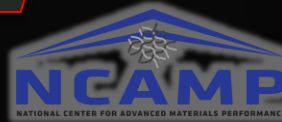
Rachael Andrulonis
Director of Advanced Materials
Research



Royal Lovingfoss
Director of Composites & Advanced
Materials



Caleb Saathoff
Senior Engineering Manager,
Advanced Materials Research



Tomas Lorik
Senior Research Engineer, Advanced
Materials Research



Nicole Stahl
Research Engineer, NCAMP



Cindy Ashforth
Senior Technical Specialist for
Advanced Composite Materials



Larry Ilcewicz, PhD
Chief Scientific and Technical Advisor
for Advanced Composite Materials

Ahmet Oztekin, PhD
Advanced Materials Research Program
Manager, JAMS Program Manager

Lynn Pham
Technical Monitor



PROJECT OVERVIEW

INDUSTRY PARTNERS

Jake Gibbs
Technical Sales Engineer, HEXCEL



RESEARCH OBJECTIVES

- Develop a **framework for the qualification** of core materials including guidelines and recommendations for their testing and characterization within the aerospace industry.
- To transition the test data and guidelines generated in this program into shared databases, such as **CMH-17**.

CMH-17
COMPOSITE MATERIALS HANDBOOK

Project Objectives

- Develop a **framework for the qualification** of core materials including guidelines and recommendations for their testing and characterization within the aerospace industry.
- Transition the test data and guidelines generated in this program into shared databases, such as **CMH-17**.

CMH-17
COMPOSITE MATERIALS HANDBOOK

Research Outputs

- **Trial test results** that provide valuable lessons learned regarding test methods best suited for core materials
- **Qualification framework for core materials**
 - Material and process specifications
 - Test matrix and subsequent test plan including required physical and mechanical test methods. Mechanical test plan inclusive of relevant environments for these materials and applications.
- Lessons learned, guidelines, and data made available to **CMH-17**

Establishment of Industry Steering Committee



Trial Testing & DRAFT Framework Development

- Industry Survey
- Material Selection
- Material Acquisition and Fabrication
- Testing, Data Reduction and Data Analysis
- Steering Committee Review



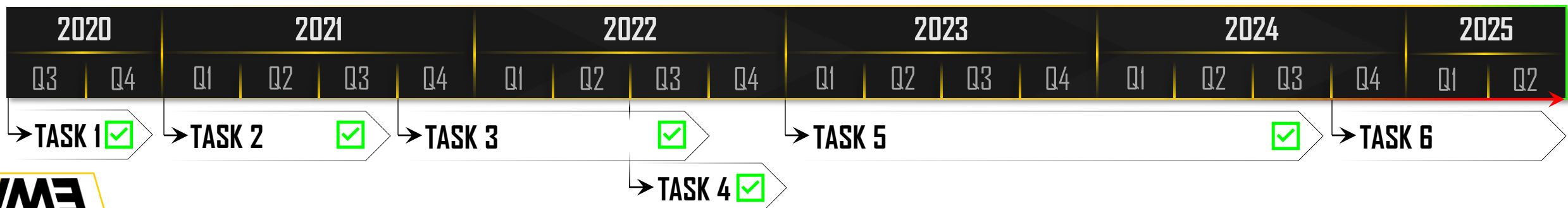
Qualification Program

- Test Plan & Specification Development
- Material Acquisition & Panel Fabrication
- Testing & Data Reduction
- **Data Review (Statistical Analysis)**
- Reports and Specifications Published



PROJECT PLAN & TIMELINE

- 1 COORDINATION** Establishment of an Industry Steering Committee (ISC).
- 2 MATERIAL & PROCESS SELECTION** Selection of materials and manufacturing process of interest to the ISC.
- 3 QUAL. FRAMEWORK DEVELOPMENT** Development of qualification framework leveraging lessons learned ensuring challenges and critical process parameters established on Task 2 are reflected and evaluated via trial testing.
- 4 MATERIAL & PROCESS SPECs** Development of base material specification and process specification for fabricating panels for qualification program.
- 5 MATERIAL QUALIFICATION** Performance of material qualification using framework established.
- 6 MATERIAL DATA & STATISTICS** Statistical analysis overview and guidelines.



TASK 1: COORDINATION – INDUSTRY SURVEY

- **Goal of Survey: *Generate industry driven input on the development of a qualification framework for core materials***
- **48 responses from 23 organizations (50% OEMS, 24% Tier 1 suppliers, others – consultants, government, academia)**
 - Question 5 – Core materials primarily used by respondents:
 - **98% Honeycomb**
 - **80% Foam**
 - **20% Corrugated**
 - Question 6 – Core materials and parts/applications currently in use:
 - Materials: **Nomex honeycomb core** mentioned in nearly every response, but other materials mentioned (fiberglass, closed cell foams)
 - Parts/applications: Secondary structures – control surfaces, access panels, fairings, spoilers
 - Questions 7 – Materials for future aircraft structures (5-10 years):
 - **91% Honeycomb**
 - **72% Foam**
 - **20% Corrugated**

Question	Answer Type
Q1: Company Name	Text box
Q2: What is your company's role in the aviation industry?	Radio buttons with pre-selected options + "other" option and comments box
Q3: Are you familiar with CMH-17 (previously known as MIL-17)?	Yes/No
Q4: Are you familiar with the NCAMP qualification and equivalency program through Wichita State University – NIAR?	Yes/No
Q5: Please identify the core material forms that you are currently utilizing in aircraft structures. Check all that apply.	Select from following general options (multiple selections allowed): <i>Honeycomb, Cross-Banded, Corrugate, Waffle-Type, Foam, Natural (balsa wood and others), Other (please specify)</i>
Q6: Please specify the core materials and parts/applications currently in use- Multiple materials/parts can be listed	Text box
Q7: Please identify the core material forms that are proposed for future aircraft structures (5-10 years). Check all that apply.	Select from following general options (multiple selections allowed): <i>Honeycomb, Cross-Banded, Corrugated, Waffle-Type, Foams, Natural (balsa wood and others), Other (please specify)</i>
Q8: Please specify the core material and parts/applications proposed for future aircraft- Multiple materials can be listed	Text box
Q9: Are there other core materials that you believe are likely to produce structural components in aircraft within the next 5-10 years?	List core type List materials (facesheet/core) List parts/application
Q10: Please rate the following statements for implementing new core materials from Strongly Disagree to Strongly Agree.	<i>Cost, Availability, Producibility, Lack of trained personnel, Lack of design and certification guidelines, Lack of available qualification data, Joint design, Flaw detection by NDI, Reparability</i>
Q11: Are you interested in serving on a peer advisory committee to provide technical expertise on the development of the methodology?	Yes/No If Yes, users directed page to enter contact information
Q12: Is your company interested in contributing materials and/or resources to the development of data for incorporation of results into CMH-17 and other sources for the general public?	Yes/No If Yes, users directed page to enter contact information



TASK 2: MATERIALS & PROCESSING

MATERIAL SELECTION(S)

Material	Description	Selection Support
Honeycomb Core	HexWeb® HRH-10-1/8-3.0	Committee feedback & Survey Commonly used in industry
Facesheet Prepreg	HexPly® AGP193P(NT)/8552S;38%;193AW;50	NCAMP Qualified
Film Adhesive	FM 300-2M	NCAMP Qualification in Progress

NOMENCLATURE & MANUFACTURING

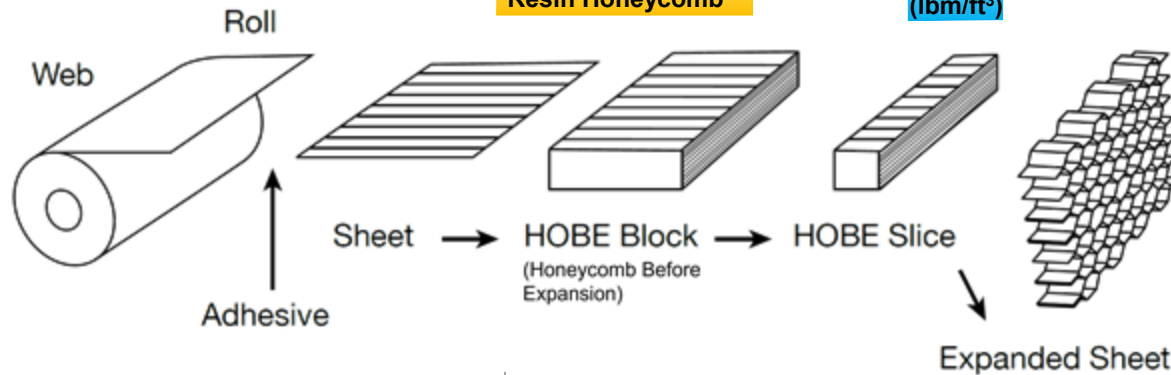
HexWeb® HRH-10-1/8-3.0

Hexcel Product Line

Honeycomb Type:
Aramid Fiber/Phenolic
Resin Honeycomb

Cell Size
(inches)

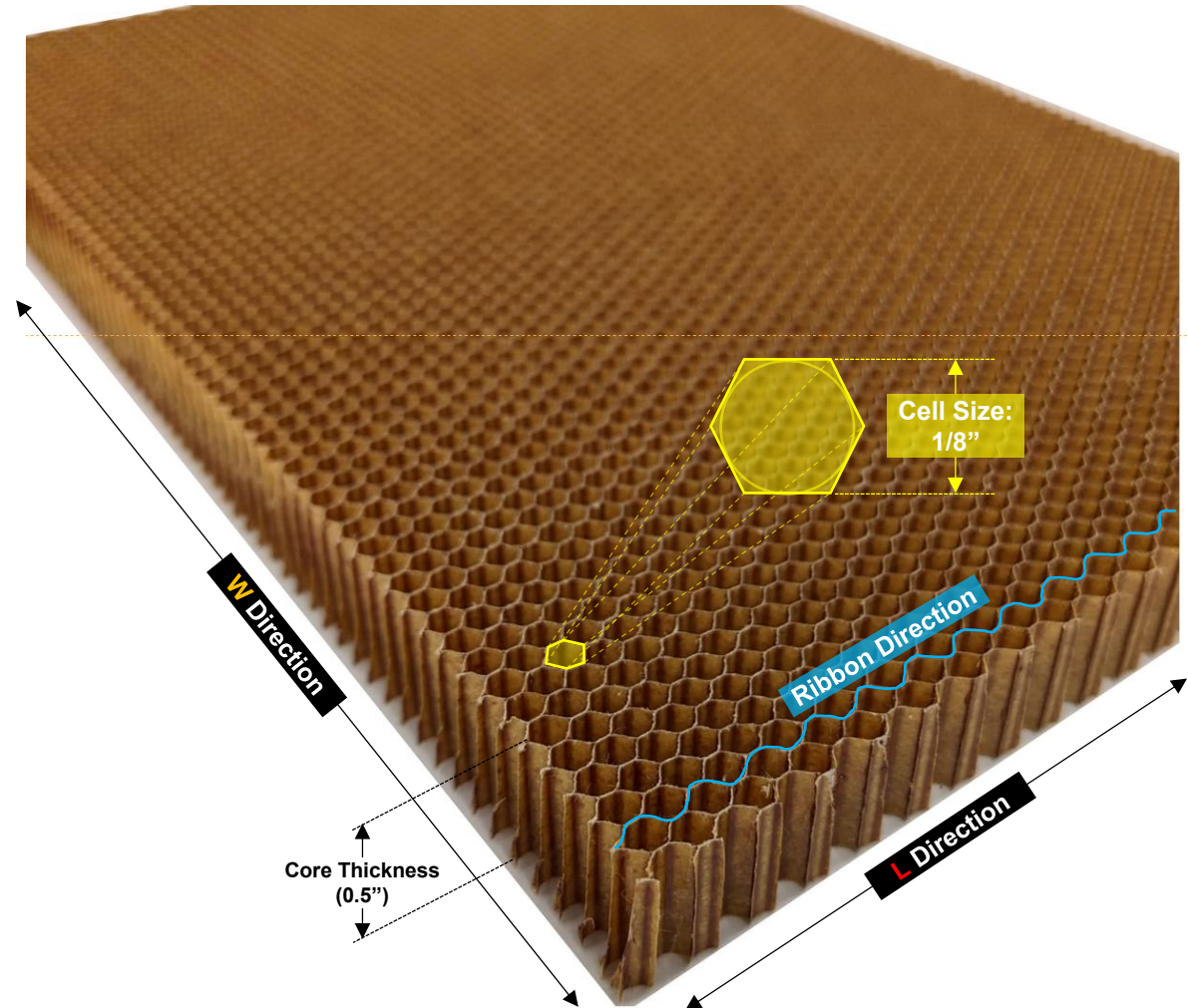
Nominal
Density
(lbm/ft³)



2016, Hexcel, HexWeb® Honeycomb Attributes and Properties

Non-metallic honeycomb is generally expanded before slicing

HONEYCOMB CORE OVERVIEW: Hexcel HexWeb® HRH-10



TASK 3: QUALIFICATION FRAMEWORK DEVELOPMENT

■ TRIAL TESTING OBJECTIVES & MATRICIES

- Properties Evaluated
 - Mechanical and Physical
- General Processing Challenges
 - Identifying variables that need to be controlled.

PREQUALIFICATION: METHODS W/REMARKABLE FINDINGS

■ CORE SHEAR: METHOD SELECTION

- ASTM C273: *Standard Test method for Shear Properties of Sandwich Core Materials*
- ASTM C393: *Standard Test Method for Core Shear Properties of Sandwich Construction by Beam Flexure*

■ NODE TENSION

- ASTM C363: *Standard Test Method for Delamination Strength of Honeycomb Core Materials*

■ EDGEWISE COMPRESSION

- ASTM C364: *Standard Test Method for Edgewise Compressive Strength of Sandwich Constructions*

PREQUALIFICATION TESTING: TRIAL TEST MATRIX

Layup	Test Type and Direction	Standard	Material Property	Number of Batches x Number of Panels x Number of Test Specimens		
				Test Temperature/Moisture Condition		
				RTD	ETD1 180°F	ETW1 180°F
-	Core Shear (L)	ASTM C273	Strength and Modulus	1x1x5	1x1x5	1x1x5
-	Core Shear (W)	ASTM C273	Strength and Modulus	1x1x5	1x1x5	1x1x5
-	Bare Compression	ASTM C365	Strength	1x1x5	-	-
6 core 6*	Stabilized Compression	ASTM C365	Strength and Modulus	1x1x5	1x1x5	1x1x5
-	Node Tensile Strength of Honeycomb Core Materials	ASTM C363	Strength	1x1x5	-	-
6 core 6*	Flatwise Tension	ASTM C297	Strength	1x1x5	1x1x5	1x1x5
6 core 6*	Edgewise Compression	ASTM C364	Strength and Modulus	1x1x5	-	-
2 core 6*	Climbing Drum Peel	ASTM D1781	Strength	1x1x5	-	-
6 core 6*	Core Shear Stress	ASTM C393	Strength and Modulus	1x1x5	1x1x5	1x1x5
6 core 6*	Long Beam Flex	ASTM D7249	Strength and Modulus	1x1x5	-	-

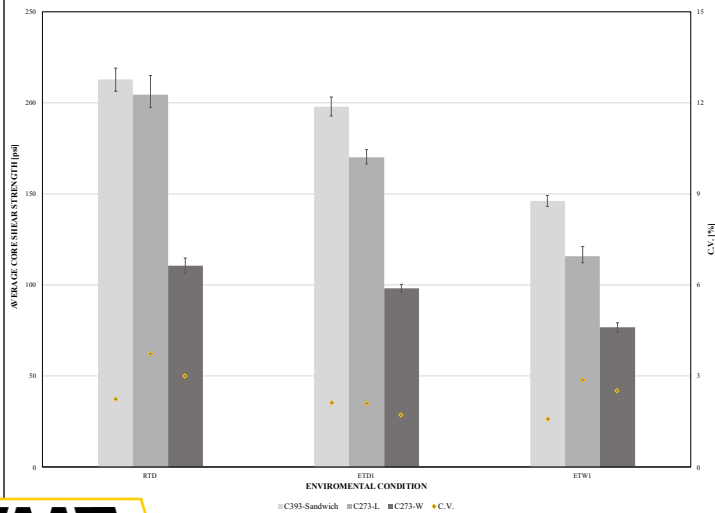
* 6 core 6 corresponds to 6 plies for top facesheet bonded to core with 2 plies of film adhesive and 6 plies for the bottom facesheet bonded to the core with 2 plies of film adhesive. Facesheet layup will be [0, 90, 0, 0, 90, 0].

TASK 3: QUALIFICATION FRAMEWORK DEVELOPMENT

TESTING SETUP: LEFT) ASTM C273; RIGHT) ASTM C393



TESTING RESULTS & PATH FORWARD



KEY OBSERVATIONS

- Flexural method only captures strength, no modulus.
- Elevated temperature testing drove larger discrepancy – likely a result of skin-to-core interaction change.
- Recommended that only ASTM C273 be used during qualification.

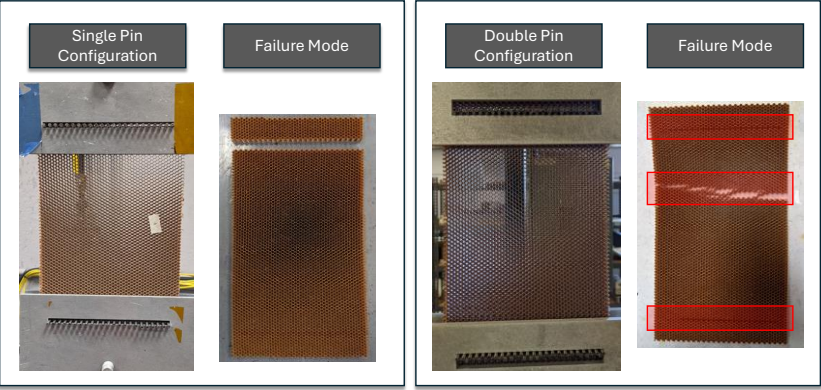
PREQUALIFICATION TESTING: TRIAL TEST MATRIX

Layup	Test Type and Direction	Standard	Material Property	Number of Batches x Number of Panels x Number of Test Specimens		
				Test Temperature/Moisture Condition		
				RTD	ETD1 180°F	ETW1 180°F
-	Core Shear (L)	ASTM C273	Strength and Modulus	1x1x5	1x1x5	1x1x5
-	Core Shear (W)	ASTM C273	Strength and Modulus	1x1x5	1x1x5	1x1x5
-	Bare Compression	ASTM C365	Strength	1x1x5	-	-
6 core 6*	Stabilized Compression	ASTM C365	Strength and Modulus	1x1x5	1x1x5	1x1x5
-	Node Tensile Strength of Honeycomb Core Materials	ASTM C363	Strength	1x1x5	-	-
6 core 6*	Flatwise Tension	ASTM C297	Strength	1x1x5	1x1x5	1x1x5
6 core 6*	Edgewise Compression	ASTM C364	Strength and Modulus	1x1x5	-	-
2 core 6*	Climbing Drum Peel	ASTM D1781	Strength	1x1x5	-	-
6 core 6*	Core Shear Stress	ASTM C393	Strength and Modulus	1x1x5	1x1x5	1x1x5
6 core 6*	Long Beam Flex	ASTM D7249	Strength and Modulus	1x1x5	-	-

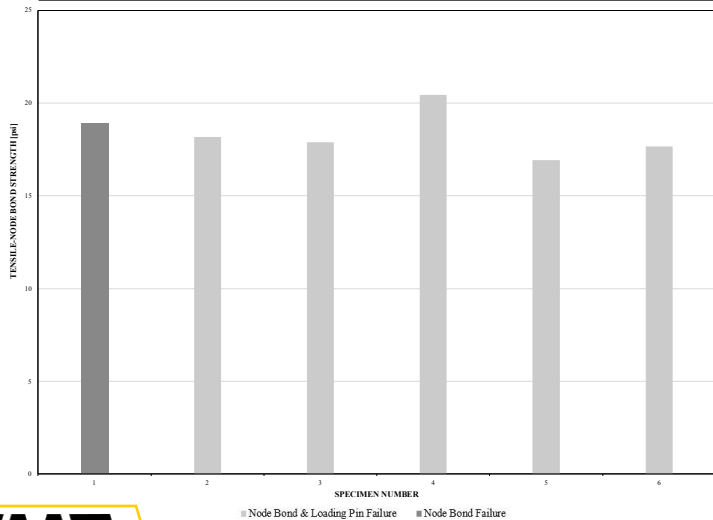
* 6 core 6 corresponds to 6 plies for top facesheet bonded to core with 2 plies of film adhesive and 6 plies for the bottom facesheet bonded to the core with 2 plies of film adhesive. Facesheet layup will be [0, 90, 0, 0, 90, 0].

TASK 3: QUALIFICATION FRAMEWORK DEVELOPMENT

TESTING SETUP: ASTM C363



TESTING RESULTS & PATH FORWARD



KEY OBSERVATIONS

- Evaluated single row, double row, and staggered pin configurations.
- 6 of 11 tests from the double row configuration specimens had valid failure modes (results at left).
- Due to inconsistent failure modes observed, researchers recommend removal from qualification testing.

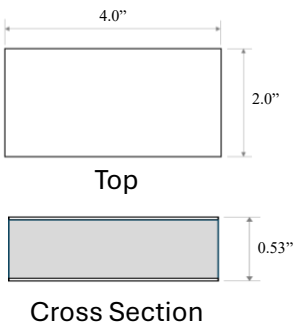
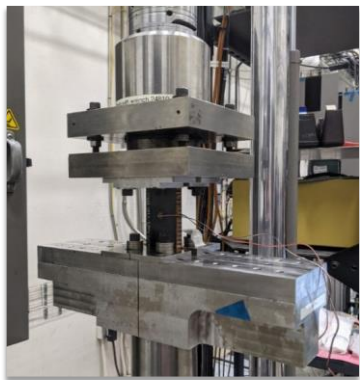
PREQUALIFICATION TESTING: TRIAL TEST MATRIX

Layup	Test Type and Direction	Standard	Material Property	Number of Batches x Number of Panels x Number of Test Specimens		
				Test Temperature/Moisture Condition		
				RTD	ETD1 180°F	ETW1 180°F
-	Core Shear (L)	ASTM C273	Strength and Modulus	1x1x5	1x1x5	1x1x5
-	Core Shear (W)	ASTM C273	Strength and Modulus	1x1x5	1x1x5	1x1x5
-	Bare Compression	ASTM C365	Strength	1x1x5	-	-
6 core 6*	Stabilized Compression	ASTM C365	Strength and Modulus	1x1x5	1x1x5	1x1x5
-	Node Tensile Strength of Honeycomb Core Materials	ASTM C363	Strength	1x1x5	-	-
6 core 6*	Flatwise Tension	ASTM C297	Strength	1x1x5	1x1x5	1x1x5
6 core 6*	Edgewise Compression	ASTM C364	Strength and Modulus	1x1x5	-	-
2 core 6*	Climbing Drum Peel	ASTM D1781	Strength	1x1x5	-	-
6 core 6*	Core Shear Stress	ASTM C393	Strength and Modulus	1x1x5	1x1x5	1x1x5
6 core 6*	Long Beam Flex	ASTM D7249	Strength and Modulus	1x1x5	-	-

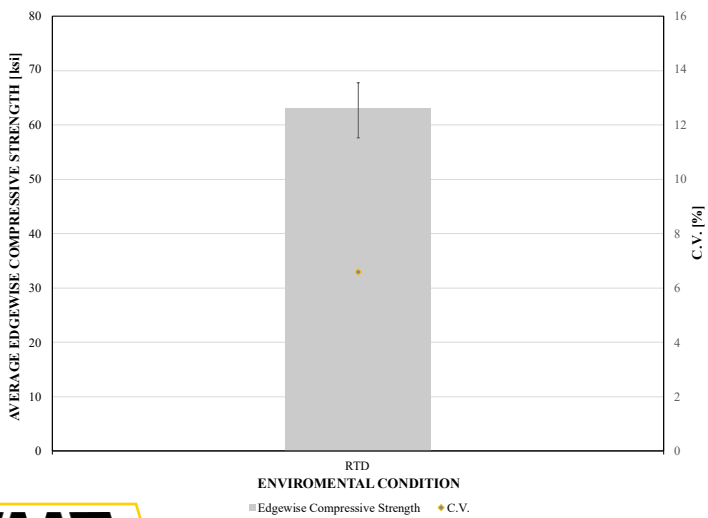
* 6 core 6 corresponds to 6 plies for top facesheet bonded to core with 2 plies of film adhesive and 6 plies for the bottom facesheet bonded to the core with 2 plies of film adhesive. Facesheet layup will be [0, 90, 0, 0, 90, 0].

TASK 3: QUALIFICATION FRAMEWORK DEVELOPMENT

TESTING SETUP: ASTM C364



TESTING RESULTS & PATH FORWARD



KEY OBSERVATIONS

- Edgewise compression testing provides a compressive strength of the sandwich construction.
- Not directly useful for production of a constituent core property.
- Researchers recommended the removal of this from qualification testing.

PREQUALIFICATION TESTING: TRIAL TEST MATRIX

Layup	Test Type and Direction	Standard	Material Property	Number of Batches x Number of Panels x Number of Test Specimens		
				Test Temperature/Moisture Condition		
				RTD	ETD1 180°F	ETW1 180°F
-	Core Shear (L)	ASTM C273	Strength and Modulus	1x1x5	1x1x5	1x1x5
-	Core Shear (W)	ASTM C273	Strength and Modulus	1x1x5	1x1x5	1x1x5
-	Bare Compression	ASTM C365	Strength	1x1x5	-	-
6 core 6*	Stabilized Compression	ASTM C365	Strength and Modulus	1x1x5	1x1x5	1x1x5
-	Node Tensile Strength of Honeycomb Core Materials	ASTM C363	Strength	1x1x5	-	-
6 core 6*	Flatwise Tension	ASTM C297	Strength	1x1x5	1x1x5	1x1x5
6 core 6*	Edgewise Compression	ASTM C364	Strength and Modulus	1x1x5	-	-
2 core 6*	Climbing Drum Peel	ASTM D1781	Strength	1x1x5	-	-
6 core 6*	Core Shear Stress	ASTM C393	Strength and Modulus	1x1x5	1x1x5	1x1x5
6 core 6*	Long Beam Flex	ASTM D7249	Strength and Modulus	1x1x5	-	-

* 6 core 6 corresponds to 6 plies for top facesheet bonded to core with 2 plies of film adhesive and 6 plies for the bottom facesheet bonded to the core with 2 plies of film adhesive. Facesheet layup will be [0, 90, 0, 0, 90, 0].

TASK 4: MATERIAL AND PROCESS SPECIFICATION(S)

NCAMP MATERIAL SPECIFICATION



WICHITA STATE UNIVERSITY
NATIONAL INSTITUTE FOR AVIATION RESEARCH

NMS 100 Rev -
Date: Month, DD 2022



NATIONAL CENTER for ADVANCED MATERIALS PERFORMANCE

Document No.: NMS 100, Revision -, Month XX, 2022

NCAMP Material Specification
This specification is generated and maintained in accordance with NCAMP Standard Operating Procedures, NSP 100

Hexcel HexWeb® HRH-10-1/8-3.0

Prepared by: John Tomblin (NCAMP/NIAR), Rachael Andrulonis (NCAMP/NIAR), Royal Lovingfoss (NCAMP/NIAR), Nicole Stahl (NCAMP/NIAR)

Reviewed by: Jake Gibbs (Hexcel), Frank Monaco (Hexcel), Marcia Tucker (Hexcel), Nick Grapsas (Hexcel), Jessie MacLeod (The Gill Corporation), Ralf Hilgers (Airbus), Nathan Collins (Epic Aircraft)

Distribution Statement A. Approved for public release; distribution is unlimited.

National Center for Advanced Materials Performance
Wichita State University – NIAR
1845 Fairmount Ave., Wichita, KS 67260-0093, USA

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MATERIAL SPEC: REQ'D MECHANICAL PROPERTIES

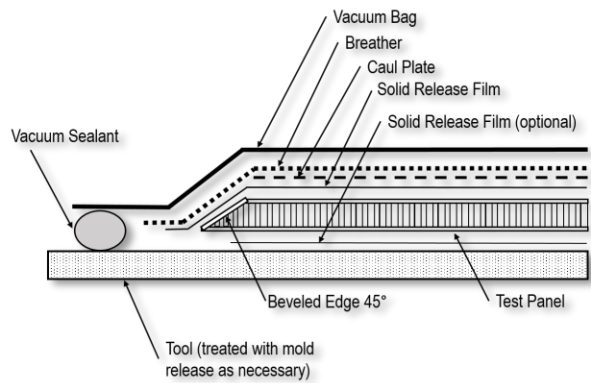
Property	Test Method	Number of Replicates
Bare Compression Strength	ASTM C365	3 per batch
Plate Shear Strength (L)	ASTM C273	3 per batch
Plate Shear Strength (W)	ASTM C273	3 per batch

MATERIAL SPEC: REQ'D PHYSICAL PROPERTIES

Property	Test Method	Number of Replicates
Core Density	ASTM C271	3 per batch
Flame Resistance (1)	DOT/FAA/AR-00/12 Chapter 1	3 per batch

Note 1: Flammability will only be tested as part of the qualification program and will be removed as long as the material passes FAA requirements. The data will be left in the reports to show the material does pass this requirement and provide information for potential users.

PROCESS SPEC: REQ'D PROCESSING DETAILS



NCAMP PROCESS SPECIFICATION



WICHITA STATE UNIVERSITY
NATIONAL INSTITUTE FOR AVIATION RESEARCH

NPS 81018 Rev -
Date: February 23, 2023



NATIONAL CENTER for ADVANCED MATERIALS PERFORMANCE

Document No.: NPS 81018, Revision -, February 23, 2023

NCAMP Process Specification
This specification is generated and maintained in accordance with NCAMP Standard Operating Procedures, NSP 100

Fabrication of NMS 100 Qualification, Equivalency, and Acceptance Test Sandwich Panels
(Hexcel HexWeb® HRH-10-1/8-3.0)

Prepared by: John Tomblin (NCAMP/NIAR), Rachael Andrulonis (NCAMP/NIAR), Royal Lovingfoss (NCAMP/NIAR), Brandon Saathoff (NIAR), Nicole Stahl (NCAMP/NIAR)

Reviewed by: Ed Hooper (NCAMP AER)

Distribution Statement A. Approved for public release; distribution is unlimited.

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TASK 5: MATERIAL QUALIFICATION

- OVERVIEW OF APPROACH

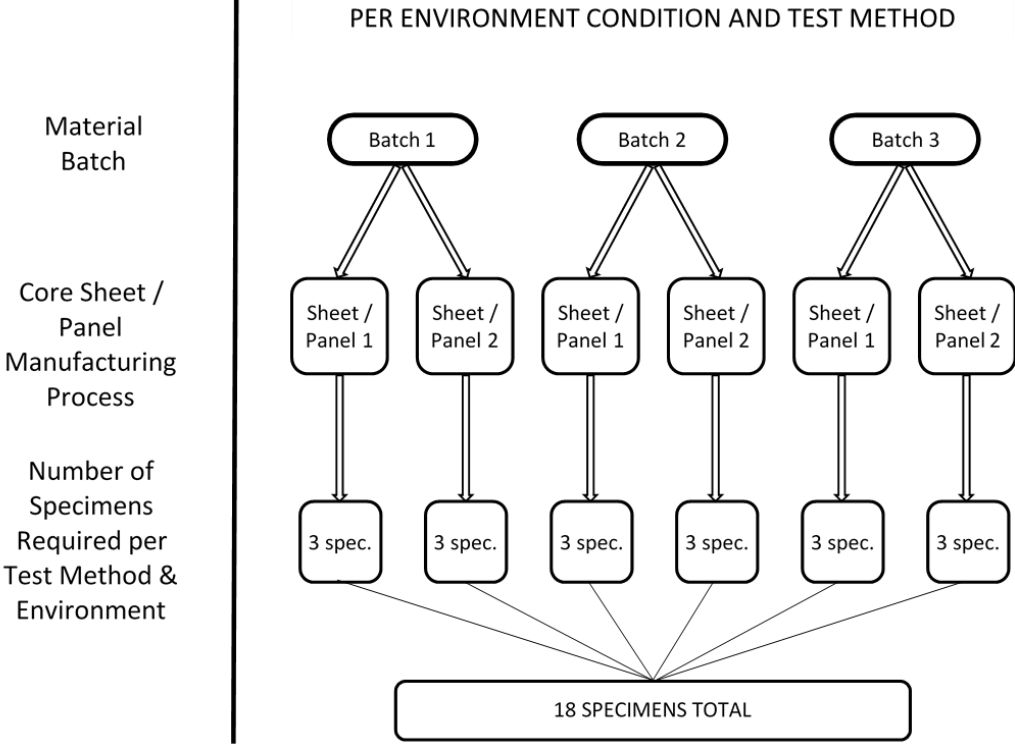
MATERIAL INFORMATION: CORE; FACING; BONDING

Core Name	Description About the Core
Hexcel HexWeb® HRH-10-1/8-3.0	Hexcore Material, Paper: NOMEX® aramid fiber, Thickness: 0.5", Cell Size: 1/8", Density: 3.0 per cubic foot Paper – Hexcel Spec HMS 1009 Resin – Receiving Criteria CX0001-QARI Node Bond Adhesive – Work order instruction 3-WCI-09-130-008
Prepreg Name	Description About the Prepreg
Hexcel 8552S AS4 Plain Weave Prepreg	Resin name: 8552, Reinforcement: AS4, plain weave prepreg, Fiber Areal Weight: 193 gsm, Resin Content: 38%, Spec: NMS 128/3
Adhesive Name	Description About the Adhesive
FM300-2M Film Adhesive	Nominal weight: 0.06 psf, Nominal Thickness: 0.010", Carrier: random mat, Spec: NMS 300/1

BATCH DEFINITION

Core Batch	A	B	C
Paper Lot	Paper Lot 1	Paper Lot 2	Paper Lot 3
Resin Dip Date	MM/DD/YYYY	MM/DD/YYYY	MM/DD/YYYY

SPECIMEN SELECTION METHODOLOGY



TASK 5: MATERIAL QUALIFICATION

TEST MATRIX: MECHANICAL TESTING

Layup (Warp Direction)	Test Type and Direction	Core Thickness	Property	Number of Batches x Number of Sheets x Number of Test Specimens			
				Test Temperature/Moisture Condition			
				CTD	RTD	ETD1	ETW1
N/A	Core Shear (L) ASTM C273	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
N/A	Core Shear (W) ASTM C273	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
N/A	Core Shear (L) ASTM C273	0.25" 0.375" 0.75" 1.0" 1.5"	Strength and Modulus (thickness correction factor)	1x2x4	1x2x4	1x2x4	1x2x4
N/A	Core Shear (W) ASTM C273	0.25" 0.375" 0.75" 1.0" 1.5"	Strength and Modulus (thickness correction factor)	1x2x4	1x2x4	1x2x4	1x2x4
N/A	Bare Flatwise Core Compression ASTM C365	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Stabilized Flatwise Core Compression ASTM C365	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Flatwise Tension ASTM C297	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 2 (1)	Climbing Drum Peel ASTM D1781	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Core Shear Stress ASTM C393	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Long Beam Flex ASTM D7249	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3

Note 1: "4 core 4" corresponds to 4 plies for top facesheet bonded to core with 2 plies of film adhesive and 4 plies for the bottom facesheet bonded to the core with 2 plies of film adhesive. Facesheet layup will be [0,90,90,0] for 4 ply facesheets and [0,90] for 2 ply facesheets.

TEST MATRIX: TOP) PHYSICAL TESTING; BOTTOM) FLUID SENSITIVITY

Property	Condition/Method	Min Replicates per Test Type	
Core Thickness	ASTM C366	All data from mechanical test specimens	
Core Density	ASTM C271	Density to be taken from each sheet of core material used with 10 replicates per sheet.	

Extended Contact:	Exposure	Test Condition	Code
ASTM D1655 Jet A Fuel (other jet fuel may be used but its type must be reported)	90 days min. @ 70°F±10°F	70°F	FS12RT
	90 days min. @ 70°F±10°F	180°F	FS12ET
MIL-PRF-5606 Hydraulic Oil	90 days min. @ 70°F±10°F	70°F	FS13RT
	90 days min. @ 70°F±10°F	180°F	FS13ET
MIL-PRF-83282 Hydraulic Oil	90 days min. @ 70°F±10°F	70°F	FS14RT
	90 days min. @ 70°F±10°F	180°F	FS14ET
MIL-PRF-7808 Engine Oil	90 days min. @ 70°F±10°F	70°F	FS15RT
	90 days min. @ 70°F±10°F	180°F	FS15ET
MIL-PRF-23699, Class STD Engine Oil	90 days min. @ 70°F±10°F	70°F	FS16RT
	90 days min. @ 70°F±10°F	180°F	FS16ET
Sea Water (ASTM D1141 or equiv.)	90 days min. @ 70°F±10°F	70°F	FS17RT
	90 days min. @ 70°F±10°F	180°F	FS17ET
Skydrol LD-4 (SAE AS1241, Type IV, Class 1)	90 days min. @ 70°F±10°F	70°F	FS18RT
	90 days min. @ 70°F±10°F	180°F	FS18ET
50% Water with 50% Skydrol LD-4 (SAE AS1241, Type IV, Class 1)	90 days min. @ 70°F±10°F	70°F	FS19RT
	90 days min. @ 70°F±10°F	180°F	FS19ET

Short Duration Contact:			
MEK washing fluid. ASTM D740	90 minutes min. @ 70°F±10°F	70°F	FS21RT
	90 minutes min. @ 70°F±10°F	180°F	FS21ET
Polypropylene Glycol Deicer (Type I) SAE AMS 1424	90 minutes min. @ 70°F±10°F	70°F	FS22RT
	90 minutes min. @ 70°F±10°F	180°F	FS22ET
Isopropyl Alcohol Deicing Agent (TT-I-735)	48±4 hours @70°F±10°F	70°F	FS23RT
	48±4 hours @70°F±10°F	180°F	FS23ET

Control Tests:			
Distilled Water	90 days min. at 70°F±10°F	70°F	FS31RT
	90 days min. at 70°F±10°F	180°F	FS31ET
Dry	Dry per section 6.1	70°F	FS32RT
	Dry per section 6.1	180°F	FS32ET
85% Relative Humidity	Per section 6.1	70°F	FS33RT
	Per section 6.1	180°F	FS33ET

TASK 5: MATERIAL QUALIFICATION

TEST MATRIX: MECHANICAL TESTING

Layup (Warp Direction)	Test Type and Direction	Core Thickness	Property	Number of Batches x Number of Sheets x Number of Test Specimens			
				Test Temperature/Moisture Condition			
				CTD	RTD	ETD1	ETW1
N/A	Core Shear (L) ASTM C273	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
N/A	Core Shear (W) ASTM C273	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
N/A	Core Shear (L) ASTM C273	0.25" 0.375" 0.75" 1.0" 1.5"	Strength and Modulus (thickness correction factor)	1x2x4	1x2x4	1x2x4	1x2x4
N/A	Core Shear (W) ASTM C273	0.25" 0.375" 0.75" 1.0" 1.5"	Strength and Modulus (thickness correction factor)	1x2x4	1x2x4	1x2x4	1x2x4
N/A	Bare Flatwise Core Compression ASTM C365	0.5"	Strength				1x2x3
4 core 4 (1)	Stabilized Flatwise Core Compression ASTM C365	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Flatwise Tension ASTM C297	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 2 (1)	Climbing Drum Peel ASTM D1781	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Core Shear Stress ASTM C393	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Long Beam Flex ASTM D7249	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3

Note 1: "4 core 4" corresponds to 4 plies for top facesheet bonded to core with 2 plies of film adhesive and 4 plies for the bottom facesheet bonded to the core with 2 plies of film adhesive. Facesheet layup will be [0,90,90,0] for 4 ply facesheets and [0,90] for 2 ply facesheets.

TEST MATRIX: TOP) PHYSICAL TESTING; BOTTOM) FLUID SENSITIVITY

FLUID SENSITIVITY TESTING MAKES USE OF ASTM C365 [BARE COMPRESSION]			
Material used with 10 replicates per sheet.			
Extended Contact:	Exposure	Test Condition	Code
ASTM D1655 Jet A Fuel (other jet fuel may be used but its type must be reported)	90 days min. @ 70°F±10°F	70°F	FS12RT
	90 days min. @ 70°F±10°F	180°F	FS12ET
MIL-PRF-5606 Hydraulic Oil	90 days min. @ 70°F±10°F	70°F	FS13RT
	90 days min. @ 70°F±10°F	180°F	FS13ET
MIL-PRF-83282 Hydraulic Oil	90 days min. @ 70°F±10°F	70°F	FS14RT
	90 days min. @ 70°F±10°F	180°F	FS14ET
MIL-PRF-7808 Engine Oil	90 days min. @ 70°F±10°F	70°F	FS15RT
	90 days min. @ 70°F±10°F	180°F	FS15ET
MIL-PRF-23699, Class STD Engine Oil	90 days min. @ 70°F±10°F	70°F	FS16RT
	90 days min. @ 70°F±10°F	180°F	FS16ET
Sea Water (ASTM D1141 or equiv.)	90 days min. @ 70°F±10°F	70°F	FS17RT
	90 days min. @ 70°F±10°F	180°F	FS17ET
Skydrol LD-4 (SAE AS1241, Type IV, Class 1)	90 days min. @ 70°F±10°F	70°F	FS18RT
	90 days min. @ 70°F±10°F	180°F	FS18ET
50% Water with 50% Skydrol LD-4 (SAE AS1241, Type IV, Class 1)	90 days min. @ 70°F±10°F	70°F	FS19RT
	90 days min. @ 70°F±10°F	180°F	FS19ET
Short Duration Contact:			
MEK washing fluid. ASTM D740	90 minutes min. @ 70°F±10°F	70°F	FS21RT
	90 minutes min. @ 70°F±10°F	180°F	FS21ET
Polypropylene Glycol Deicer (Type I) SAE AMS 1424	90 minutes min. @ 70°F±10°F	70°F	FS22RT
	90 minutes min. @ 70°F±10°F	180°F	FS22ET
Isopropyl Alcohol Deicing Agent (TT-I-735)	48±4 hours @70°F±10°F	70°F	FS23RT
	48±4 hours @70°F±10°F	180°F	FS23ET
Control Tests:			
Distilled Water	90 days min. at 70°F±10°F	70°F	FS31RT
	90 days min. at 70°F±10°F	180°F	FS31ET
Dry	Dry per section 6.1	70°F	FS32RT
	Dry per section 6.1	180°F	FS32ET
85% Relative Humidity	Per section 6.1	70°F	FS33RT
	Per section 6.1	180°F	FS33ET

TASK 5: MATERIAL QUALIFICATION

TEST MATRIX: MECHANICAL TESTING

Core Batch	Core Thickness	Sheet	Test Type	Geometry (0"x90")	Test Method	CTD -65°F	RTD 70°F	ETD 180°F	ETW 180°F	Core Panel Size (0"x90")	Panel Name	
Batch A NA34151	0.5"	1	Stabilized Compression (SFWC)	2"x2"	ASTM C365	5	5	5	5	15"x13"	NTP1018Q1-HXL-H21-NIAR-SFWC-A-S1-C1-1	
			Flatwise Tension (FWT)	2"x2"	ASTM C297	5	5	5	5	15"x13"	NTP1018Q1-HXL-H21-NIAR-FWT-A-S1-C1-1	
			Long Beam Flex (LBF)	24"x3"	ASTM D7249	2	2	3	3	29"x36"	NTP1018Q1-HXL-H21-NIAR-LBF-A-S1-C1-1	
			Core Shear (CSL)	6"x2"	ASTM C273	5	5	5	5	N/A	N/A	
			Core Shear (CSW)	2"x6"	ASTM C273	5	5	5	5	N/A	N/A	
			Bare Flatwise Core Compression (BFWC)	2"x2"	ASTM C365	5	5	5	5	N/A	N/A	
			Bare Flatwise Core Compression - Fluids	2"x2"	ASTM C365		35		35	N/A	N/A	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		2	Stabilized Compression (SFWC)	2"x2"	ASTM C365	5	5	5	5	15"x13"	NTP1018Q1-HXL-H21-NIAR-SFWC-A-S2-C1-1	
			Flatwise Tension (FWT)	2"x2"	ASTM C297	5	5	5	5	15"x13"	NTP1018Q1-HXL-H21-NIAR-FWT-B-S2-C1-1	
			Long Beam Flex (LBF)	24"x3"	ASTM D7249	2	2	3	3	29"x36"	NTP1018Q1-HXL-H21-NIAR-LBF-A-S2-C1-1	
			Core Shear (CSL)	6"x2"	ASTM C273	5	5	5	5	N/A	N/A	
			Core Shear (CSW)	2"x6"	ASTM C273	5	5	5	5	N/A	N/A	
			Bare Flatwise Core Compression (BFWC)	2"x2"	ASTM C365	5	5	5	5	N/A	N/A	
			Bare Flatwise Core Compression - Fluids	2"x2"	ASTM C365		35		35	N/A	N/A	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		3	Climbing Drum Peel (CDP)	14"x3"	ASTM D1781	5	5	5	5	33"x36"	NTP1018Q1-HXL-H21-NIAR-CDP-A-S3-C1-1	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		4	Climbing Drum Peel (CDP)	14"x3"	ASTM D1781	5	5	5	5	33"x36"	NTP1018Q1-HXL-H21-NIAR-CDP-A-S4-C1-1	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		5	Long Beam Flex (LBF)	24"x3"	ASTM D7249	3	3	2	2	29"x36"	NTP1018Q1-HXL-H21-NIAR-LBF-A-S5-C1-1	
			Core Shear Stress (CSS)	8"x3"	ASTM C393	5	5	5	5	37"x20"	NTP1018Q1-HXL-H21-NIAR-CSS-A-S5-C1-1	
		6	Core Density	12"x12"	ASTM C271		10			N/A	N/A	
			Long Beam Flex (LBF)	24"x3"	ASTM D7249	3	3	2	2	29"x36"	NTP1018Q1-HXL-H21-NIAR-LBF-A-S6-C1-1	
		7	Core Shear Stress (CSS)	8"x3"	ASTM C393	5	5	5	5	37"x20"	NTP1018Q1-HXL-H21-NIAR-CSS-A-S6-C1-1	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		0.25"	1	N/A	N/A	N/A					N/A	N/A
				Core Shear (CSL)	3"x2"	ASTM C273	6	6	6	6	N/A	N/A
	Core Shear (CSW)			2"x3"	ASTM C273	6	6	6	6	N/A	N/A	
	0.375"	1	Core Density	12"x12"	ASTM C271		10			N/A	N/A	
			Core Shear (CSL)	4.5"x2"	ASTM C273	6	6	6	6	N/A	N/A	
			Core Shear (CSW)	2"x4.5"	ASTM C273	6	6	6	6	N/A	N/A	
	0.75"	1	Core Density	12"x12"	ASTM C271		10			N/A	N/A	
			Core Shear (CSL)	9"x2"	ASTM C273	6	6	6	6	N/A	N/A	
			Core Shear (CSW)	2"x9"	ASTM C273	6	6	6	6	N/A	N/A	
	1.0"	1	Core Density	12"x12"	ASTM C271		10			N/A	N/A	
			Core Shear (CSL)	12"x2"	ASTM C273	6	6	6	6	N/A	N/A	
			Core Shear (CSW)	2"x12"	ASTM C273	6	6	6	6	N/A	N/A	
	1.5"	1	Core Density	12"x12"	ASTM C271		10			N/A	N/A	
			Core Shear (CSL)	18"x2"	ASTM C273	6	6	6	6	N/A	N/A	
			Core Shear (CSW)	2"x18"	ASTM C273	6	6	6	6	N/A	N/A	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
Batch B NA34469	0.5"	1	Stabilized Compression (SFWC)	2"x2"	ASTM C365	5	5	5	5	15"x13"	NTP1018Q1-HXL-H21-NIAR-SFWC-B-S1-C1-1	
			Flatwise Tension (FWT)	2"x2"	ASTM C297	5	5	5	5	15"x13"	NTP1018Q1-HXL-H21-NIAR-FWT-B-S1-C1-1	
			Long Beam Flex (LBF)	24"x3"	ASTM D7249	3	3	4	4	29"x36"	NTP1018Q1-HXL-H21-NIAR-LBF-B-S1-C1-1	
			Core Shear (CSL)	6"x2"	ASTM C273	5	5	5	5	N/A	N/A	
			Core Shear (CSW)	2"x6"	ASTM C273	5	5	5	5	N/A	N/A	
			Bare Flatwise Core Compression (BFWC)	2"x2"	ASTM C365	5	5	5	5	N/A	N/A	
			Bare Flatwise Core Compression - Fluids	2"x2"	ASTM C365		35		35	N/A	N/A	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		2	Stabilized Compression (SFWC)	2"x2"	ASTM C365	5	5	5	5	15"x13"	NTP1018Q1-HXL-H21-NIAR-SFWC-B-S2-C1-1	
			Flatwise Tension (FWT)	2"x2"	ASTM C297	5	5	5	5	15"x13"	NTP1018Q1-HXL-H21-NIAR-FWT-B-S2-C1-1	
			Long Beam Flex (LBF)	24"x3"	ASTM D7249	3	3	4	4	29"x36"	NTP1018Q1-HXL-H21-NIAR-LBF-B-S2-C1-1	
			Core Shear (CSL)	6"x2"	ASTM C273	5	5	5	5	N/A	N/A	
			Core Shear (CSW)	2"x6"	ASTM C273	5	5	5	5	N/A	N/A	
			Bare Flatwise Core Compression (BFWC)	2"x2"	ASTM C365	5	5	5	5	N/A	N/A	
			Bare Flatwise Core Compression - Fluids	2"x2"	ASTM C365		35		35	N/A	N/A	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		3	Climbing Drum Peel (CDP)	14"x3"	ASTM D1781	5	5	5	5	33"x36"	NTP1018Q1-HXL-H21-NIAR-CDP-B-S3-C1-1	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		4	Climbing Drum Peel (CDP)	14"x3"	ASTM D1781	5	5	5	5	33"x36"	NTP1018Q1-HXL-H21-NIAR-CDP-B-S4-C1-1	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		5	Long Beam Flex (LBF)	24"x3"	ASTM D7249	3	4	3	3	29"x36"	NTP1018Q1-HXL-H21-NIAR-LBF-B-S5-C1-1	
			Core Shear Stress (CSS)	8"x3"	ASTM C393	5	5	5	5	37"x20"	NTP1018Q1-HXL-H21-NIAR-CSS-B-S5-C1-1	
		6	Core Density	12"x12"	ASTM C271		10			N/A	N/A	
			Long Beam Flex (LBF)	24"x3"	ASTM D7249	3	4	3	3	29"x36"	NTP1018Q1-HXL-H21-NIAR-LBF-B-S6-C1-1	
		7	Core Shear Stress (CSS)	8"x3"	ASTM C393	5	5	5	5	37"x20"	NTP1018Q1-HXL-H21-NIAR-CSS-B-S6-C1-1	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		0.25"	1	N/A	N/A	N/A					N/A	N/A
				Core Shear (CSL)	3"x2"	ASTM C273	6	6	6	6	N/A	N/A
	Core Shear (CSW)			2"x3"	ASTM C273	6	6	6	6	N/A	N/A	
	0.375"	1	Core Density	12"x12"	ASTM C271		10			N/A	N/A	
			Core Shear (CSL)	4.5"x2"	ASTM C273	6	6	6	6	N/A	N/A	
			Core Shear (CSW)	2"x4.5"	ASTM C273	6	6	6	6	N/A	N/A	
	0.75"	1	Core Density	12"x12"	ASTM C271		10			N/A	N/A	
			Core Shear (CSL)	9"x2"	ASTM C273	6	6	6	6	N/A	N/A	
			Core Shear (CSW)	2"x9"	ASTM C273	6	6	6	6	N/A	N/A	
	1.0"	1	Core Density	12"x12"	ASTM C271		10			N/A	N/A	
			Core Shear (CSL)	12"x2"	ASTM C273	6	6	6	6	N/A	N/A	
			Core Shear (CSW)	2"x12"	ASTM C273	6	6	6	6	N/A	N/A	
	1.5"	1	Core Density	12"x12"	ASTM C271		10			N/A	N/A	
			Core Shear (CSL)	18"x2"	ASTM C273	6	6	6	6	N/A	N/A	
			Core Shear (CSW)	2"x18"	ASTM C273	6	6	6	6	N/A	N/A	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
Batch C NA34523	0.5"	1	Stabilized Compression (SFWC)	2"x2"	ASTM C365	5	5	5	5	15"x13"	NTP1018Q1-HXL-H21-NIAR-SFWC-C-S1-C1-1	
			Flatwise Tension (FWT)	2"x2"	ASTM C297	5	5	5	5	15"x13"	NTP1018Q1-HXL-H21-NIAR-FWT-C-S1-C1-1	
			Long Beam Flex (LBF)	24"x3"	ASTM D7249	3	3	4	4	29"x36"	NTP1018Q1-HXL-H21-NIAR-LBF-C-S1-C1-1	
			Core Shear (CSL)	6"x2"	ASTM C273	5	5	5	5	N/A	N/A	
			Core Shear (CSW)	2"x6"	ASTM C273	5	5	5	5	N/A	N/A	
			Bare Flatwise Core Compression (BFWC)	2"x2"	ASTM C365	5	5	5	5	N/A	N/A	
			Bare Flatwise Core Compression - Fluids	2"x2"	ASTM C365		35		35	N/A	N/A	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		2	Stabilized Compression (SFWC)	2"x2"	ASTM C365	5	5	5	5	15"x13"	NTP1018Q1-HXL-H21-NIAR-SFWC-C-S2-C1-1	
			Flatwise Tension (FWT)	2"x2"	ASTM C297	5	5	5	5	15"x13"	NTP1018Q1-HXL-H21-NIAR-FWT-C-S2-C1-1	
			Long Beam Flex (LBF)	24"x3"	ASTM D7249	3	3	4	4	29"x36"	NTP1018Q1-HXL-H21-NIAR-LBF-C-S2-C1-1	
			Core Shear (CSL)	6"x2"	ASTM C273	5	5	5	5	N/A	N/A	
			Core Shear (CSW)	2"x6"	ASTM C273	5	5	5	5	N/A	N/A	
			Bare Flatwise Core Compression (BFWC)	2"x2"	ASTM C365	5	5	5	5	N/A	N/A	
			Bare Flatwise Core Compression - Fluids	2"x2"	ASTM C365		35		35	N/A	N/A	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		3	Climbing Drum Peel (CDP)	14"x3"	ASTM D1781	5	5	5	5	33"x36"	NTP1018Q1-HXL-H21-NIAR-CDP-C-S3-C1-1	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		4	Climbing Drum Peel (CDP)	14"x3"	ASTM D1781	5	5	5	5	33"x36"	NTP1018Q1-HXL-H21-NIAR-CDP-C-S4-C1-1	
			Core Density	12"x12"	ASTM C271		10			N/A	N/A	
		5	Long Beam Flex (LBF)	24"x3"	ASTM D7249	3	4	3	3	29"x36"	NTP1018Q1-HXL-H21-NIAR-LBF-C-S5-C1-1	
6	Core Shear Stress (CSS)	8"x3"	ASTM C393	5	5	5	5	37"x20"	NTP1018Q1-HXL-H21-NIAR-CSS-C-S5-C1-1			
7	Core Density	12"x12"	ASTM C271		10			N/A	N/A			
8	Long Beam Flex (LBF)	24"x3"	ASTM D7249	3	4	3	3	29"x36"	NTP1018Q1-HXL-H21-NIAR-LBF-C-S6-C1-1			
9	Core Shear Stress (CSS)	8"x3"	ASTM C393	5	5	5	5	37"x20"	NTP1018Q1-HXL-H21-NIAR-CSS-C-S6-C1-1			
10	Core Density	12"x12"	ASTM C271		10			N/A	N/A			

Sheet Definition

3 Batches

TASK 5: MATERIAL QUALIFICATION

TEST MATRIX: MECHANICAL TESTING

Layup (Warp Direction)	Test Type and Direction	Core Thickness	Property	Number of Batches x Number of Sheets x Number of Test Specimens			
				Test Temperature/Moisture Condition			
				CTD	RTD	ETD1	ETW1
N/A	Core Shear (L) ASTM C273	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
N/A	Core Shear (W) ASTM C273	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
N/A	Core Shear (L) ASTM C273	0.25" 0.375" 0.75" 1.0" 1.5"	Strength and Modulus (thickness correction factor)	1x2x4	1x2x4	1x2x4	1x2x4
N/A	Core Shear (W) ASTM C273	0.25" 0.375" 0.75" 1.0" 1.5"	Strength and Modulus (thickness correction factor)	1x2x4	1x2x4	1x2x4	1x2x4
N/A	Bare Flatwise Core Compression ASTM C365	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Stabilized Flatwise Core Compression ASTM C365	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Flatwise Tension ASTM C297	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 2 (1)	Climbing Drum Peel ASTM D1781	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Core Shear Stress ASTM C393	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Long Beam Flex ASTM D7249	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3

Note 1: "4 core 4" corresponds to 4 plies for top facesheet bonded to core with 2 plies of film adhesive and 4 plies for the bottom facesheet bonded to the core with 2 plies of film adhesive. Facesheet layup will be [0,90,90,0] for 4 ply facesheets and [0,90] for 2 ply facesheets.

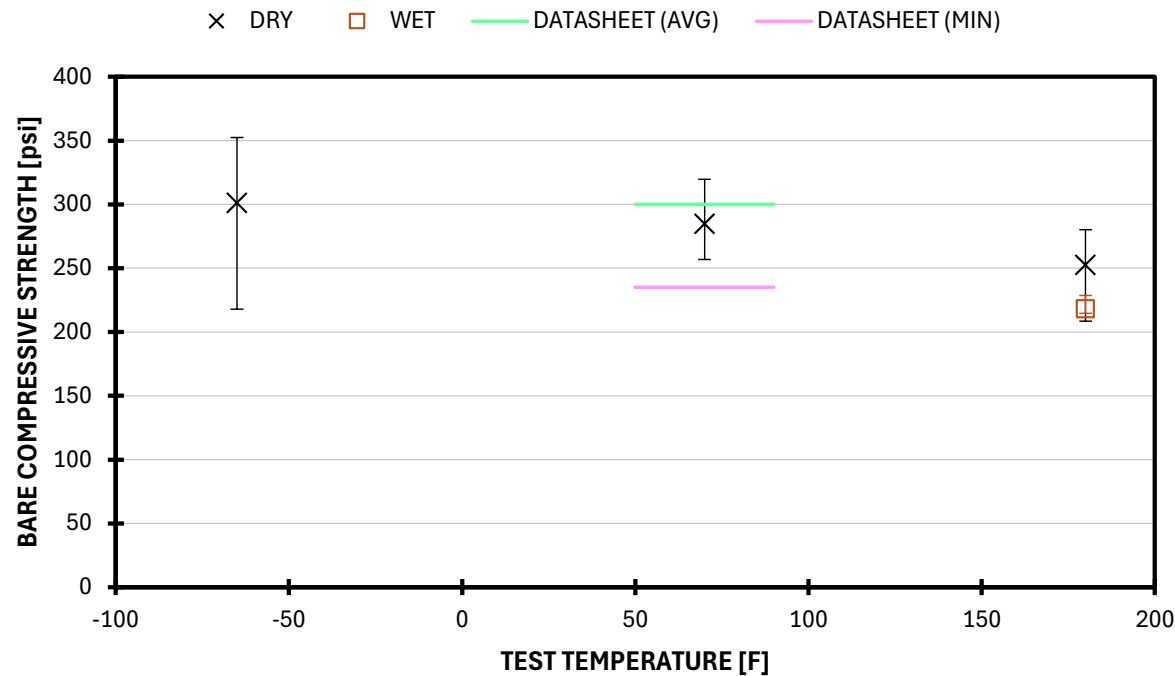
TEST MATRIX: TOP) PHYSICAL TESTING; BOTTOM) FLUID SENSITIVITY

Property	Condition/Method	Min Replicates per Test Type	
Core Thickness	ASTM C366	All data from mechanical test specimens	
Core Density	ASTM C271	Density to be taken from each sheet of core material used with 10 replicates per sheet.	

Extended Contact:	Exposure	Test Condition	Code
ASTM D1655 Jet A Fuel (other jet fuel may be used but its type must be reported)	90 days min. @ 70°F±10°F	70°F	FS12RT
	90 days min. @ 70°F±10°F	180°F	FS12ET
MIL-PRF-5606 Hydraulic Oil	90 days min. @ 70°F±10°F	70°F	FS13RT
	90 days min. @ 70°F±10°F	180°F	FS13ET
MIL-PRF-83282 Hydraulic Oil	90 days min. @ 70°F±10°F	70°F	FS14RT
	90 days min. @ 70°F±10°F	180°F	FS14ET
MIL-PRF-7808 Engine Oil	90 days min. @ 70°F±10°F	70°F	FS15RT
	90 days min. @ 70°F±10°F	180°F	FS15ET
MIL-PRF-23699, Class STD Engine Oil	90 days min. @ 70°F±10°F	70°F	FS16RT
	90 days min. @ 70°F±10°F	180°F	FS16ET
Sea Water (ASTM D1141 or equiv.)	90 days min. @ 70°F±10°F	70°F	FS17RT
	90 days min. @ 70°F±10°F	180°F	FS17ET
Skydrol LD-4 (SAE AS1241, Type IV, Class 1)	90 days min. @ 70°F±10°F	70°F	FS18RT
	90 days min. @ 70°F±10°F	180°F	FS18ET
50% Water with 50% Skydrol LD-4 (SAE AS1241, Type IV, Class 1)	90 days min. @ 70°F±10°F	70°F	FS19RT
	90 days min. @ 70°F±10°F	180°F	FS19ET
Short Duration Contact:			
MEK washing fluid. ASTM D740	90 minutes min. @ 70°F±10°F	70°F	FS21RT
	90 minutes min. @ 70°F±10°F	180°F	FS21ET
Polypropylene Glycol Deicer (Type I) SAE AMS 1424	90 minutes min. @ 70°F±10°F	70°F	FS22RT
	90 minutes min. @ 70°F±10°F	180°F	FS22ET
Isopropyl Alcohol Deicing Agent (TT-I-735)	48±4 hours @70°F±10°F	70°F	FS23RT
	48±4 hours @70°F±10°F	180°F	FS23ET
Control Tests:			
Distilled Water	90 days min. at 70°F±10°F	70°F	FS31RT
	90 days min. at 70°F±10°F	180°F	FS31ET
Dry	Dry per section 6.1	70°F	FS32RT
	Dry per section 6.1	180°F	FS32ET
85% Relative Humidity	Per section 6.1	70°F	FS33RT
	Per section 6.1	180°F	FS33ET

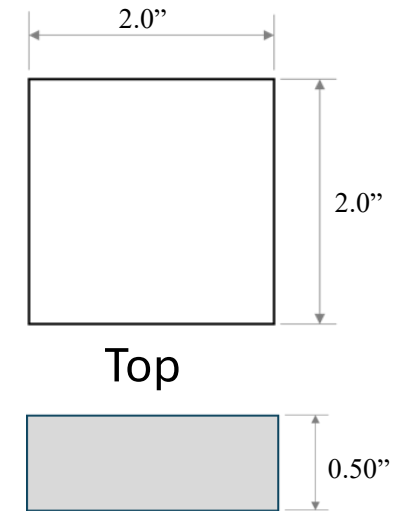
TASK 5: MATERIAL QUALIFICATION

BARE COMPRESSION: STRENGTH



- **STRENGTH vs TEMPERATURE:** Observed decrease in strength with increase in test temp.
- **MEASURED vs DATASHEET:** Measured AVG below TYP; Measured MIN greater than datasheet.
- **ELEVATED TEMP TESTING:** ETW testing produced a decrease in compressive strength (MIN from ETD dipped below MIN for ETW).

BARE COMPRESSION: TEST SETUP & SPECIMEN GEOMETRY



Cross Section

TASK 5: MATERIAL QUALIFICATION

TEST MATRIX: MECHANICAL TESTING

Layup (Warp Direction)	Test Type and Direction	Core Thickness	Property	Number of Batches x Number of Sheets x Number of Test Specimens			
				Test Temperature/Moisture Condition			
				CTD	RTD	ETD1	ETW1
N/A	Core Shear (L) ASTM C273	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
N/A	Core Shear (W) ASTM C273	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
N/A	Core Shear (L) ASTM C273	0.25" 0.375" 0.75" 1.0" 1.5"	Strength and Modulus (thickness correction factor)	1x2x4	1x2x4	1x2x4	1x2x4
N/A	Core Shear (W) ASTM C273	0.25" 0.375" 0.75" 1.0" 1.5"	Strength and Modulus (thickness correction factor)	1x2x4	1x2x4	1x2x4	1x2x4
N/A	Bare Flatwise Core Compression ASTM C365	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Stabilized Flatwise Core Compression ASTM C365	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Flatwise Tension ASTM C297	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 2 (1)	Climbing Drum Peel ASTM D1781	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Core Shear Stress ASTM C393	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Long Beam Flex ASTM D7249	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3

Note 1: "4 core 4" corresponds to 4 plies for top facesheet bonded to core with 2 plies of film adhesive and 4 plies for the bottom facesheet bonded to the core with 2 plies of film adhesive. Facesheet layup will be [0,90,90,0] for 4 ply facesheets and [0,90] for 2 ply facesheets.

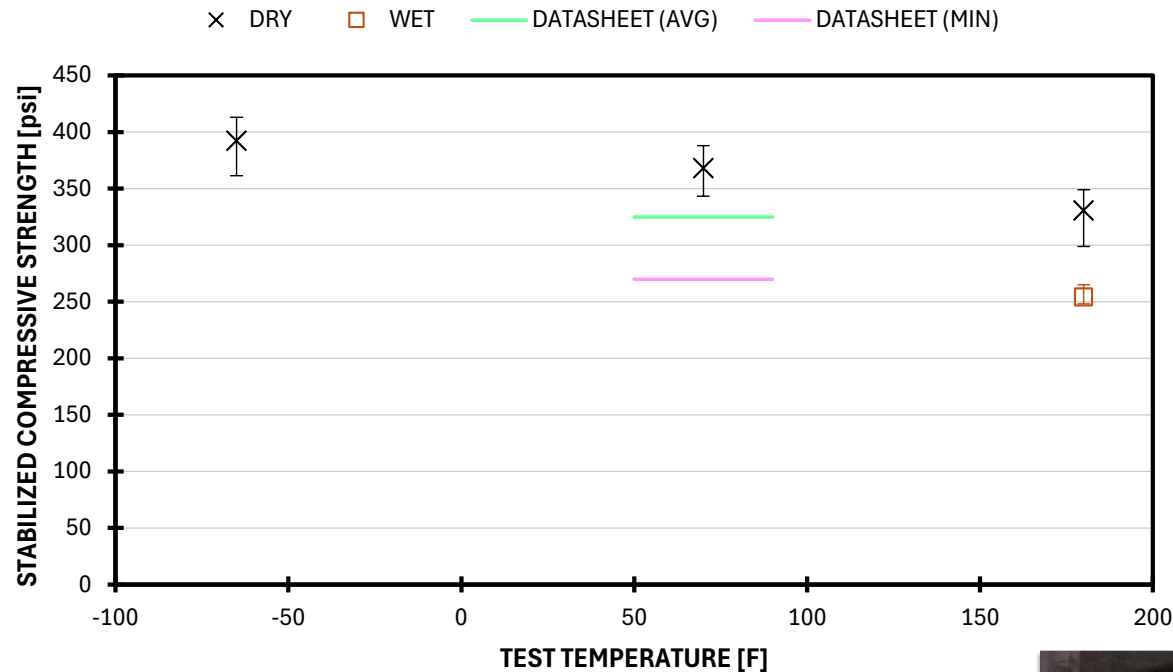
TEST MATRIX: TOP) PHYSICAL TESTING; BOTTOM) FLUID SENSITIVITY

Property	Condition/Method	Min Replicates per Test Type	
Core Thickness	ASTM C366	All data from mechanical test specimens	
Core Density	ASTM C271	Density to be taken from each sheet of core material used with 10 replicates per sheet.	

Extended Contact:	Exposure	Test Condition	Code
ASTM D1655 Jet A Fuel (other jet fuel may be used but its type must be reported)	90 days min. @ 70°F±10°F	70°F	FS12RT
	90 days min. @ 70°F±10°F	180°F	FS12ET
MIL-PRF-5606 Hydraulic Oil	90 days min. @ 70°F±10°F	70°F	FS13RT
	90 days min. @ 70°F±10°F	180°F	FS13ET
MIL-PRF-83282 Hydraulic Oil	90 days min. @ 70°F±10°F	70°F	FS14RT
	90 days min. @ 70°F±10°F	180°F	FS14ET
MIL-PRF-7808 Engine Oil	90 days min. @ 70°F±10°F	70°F	FS15RT
	90 days min. @ 70°F±10°F	180°F	FS15ET
MIL-PRF-23699, Class STD Engine Oil	90 days min. @ 70°F±10°F	70°F	FS16RT
	90 days min. @ 70°F±10°F	180°F	FS16ET
Sea Water (ASTM D1141 or equiv.)	90 days min. @ 70°F±10°F	70°F	FS17RT
	90 days min. @ 70°F±10°F	180°F	FS17ET
Skydrol LD-4 (SAE AS1241, Type IV, Class 1)	90 days min. @ 70°F±10°F	70°F	FS18RT
	90 days min. @ 70°F±10°F	180°F	FS18ET
50% Water with 50% Skydrol LD-4 (SAE AS1241, Type IV, Class 1)	90 days min. @ 70°F±10°F	70°F	FS19RT
	90 days min. @ 70°F±10°F	180°F	FS19ET
Short Duration Contact:			
MEK washing fluid. ASTM D740	90 minutes min. @ 70°F±10°F	70°F	FS21RT
	90 minutes min. @ 70°F±10°F	180°F	FS21ET
Polypropylene Glycol Deicer (Type I) SAE AMS 1424	90 minutes min. @ 70°F±10°F	70°F	FS22RT
	90 minutes min. @ 70°F±10°F	180°F	FS22ET
Isopropyl Alcohol Deicing Agent (TT-I-735)	48±4 hours @70°F±10°F	70°F	FS23RT
	48±4 hours @70°F±10°F	180°F	FS23ET
Control Tests:			
Distilled Water	90 days min. at 70°F±10°F	70°F	FS31RT
	90 days min. at 70°F±10°F	180°F	FS31ET
Dry	Dry per section 6.1	70°F	FS32RT
	Dry per section 6.1	180°F	FS32ET
85% Relative Humidity	Per section 6.1	70°F	FS33RT
	Per section 6.1	180°F	FS33ET

TASK 5: MATERIAL QUALIFICATION

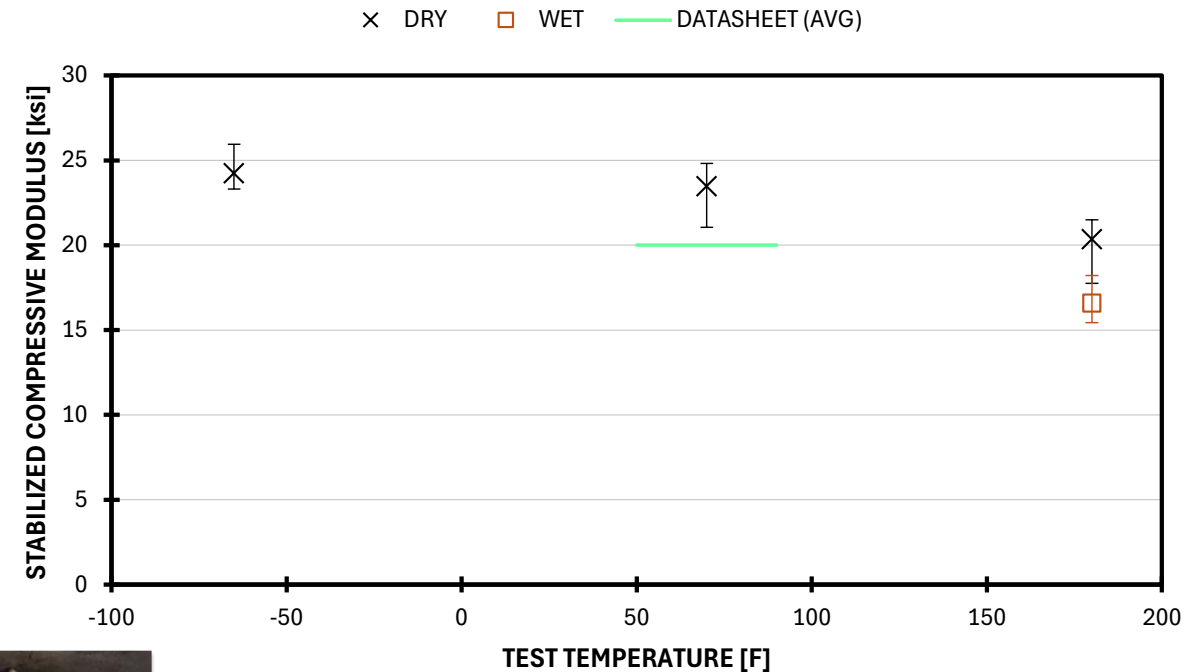
STABILIZED COMPRESSION: STRENGTH



- **STRENGTH vs TEMP:** Observed decrease in strength with increase in test temp.
- **MEASURED vs DATASHEET:** Measured AVG above TYP; Measured MIN greater than TYP.
- **ELEVATED TEMP TESTING:** ETW testing produced a decrease in compressive strength (more observable in stabilized testing).



STABILIZED COMPRESSION: MODULUS



- **MODULUS vs TEMP:** Observed decrease in modulus with increase in test temp.
- **MEASURED vs DATASHEET:** Measured AVG above TYP; Measured MIN greater than TYP.
- **ELEVATED TEMP TESTING:** ETW testing produced a decrease in compressive modulus; though max ETW exceeded min ETD.

TASK 5: MATERIAL QUALIFICATION

TEST MATRIX: MECHANICAL TESTING

Layup (Warp Direction)	Test Type and Direction	Core Thickness	Property	Number of Batches x Number of Sheets x Number of Test Specimens			
				Test Temperature/Moisture Condition			
				CTD	RTD	ETD1	ETW1
N/A	Core Shear (L) ASTM C273	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
N/A	Core Shear (W) ASTM C273	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
N/A	Core Shear (L) ASTM C273	0.25" 0.375" 0.75" 1.0" 1.5"	Strength and Modulus (thickness correction factor)	1x2x4	1x2x4	1x2x4	1x2x4
N/A	Core Shear (W) ASTM C273	0.25" 0.375" 0.75" 1.0" 1.5"	Strength and Modulus (thickness correction factor)	1x2x4	1x2x4	1x2x4	1x2x4
N/A	Bare Flatwise Core Compression ASTM C365	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Stabilized Flatwise Core Compression ASTM C365	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Flatwise Tension ASTM C297	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 2 (1)	Climbing Drum Peel ASTM D1781	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Core Shear Stress ASTM C393	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Long Beam Flex ASTM D7249	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3

Note 1: "4 core 4" corresponds to 4 plies for top facesheet bonded to core with 2 plies of film adhesive and 4 plies for the bottom facesheet bonded to the core with 2 plies of film adhesive. Facesheet layup will be [0,90,90,0] for 4 ply facesheets and [0,90] for 2 ply facesheets.

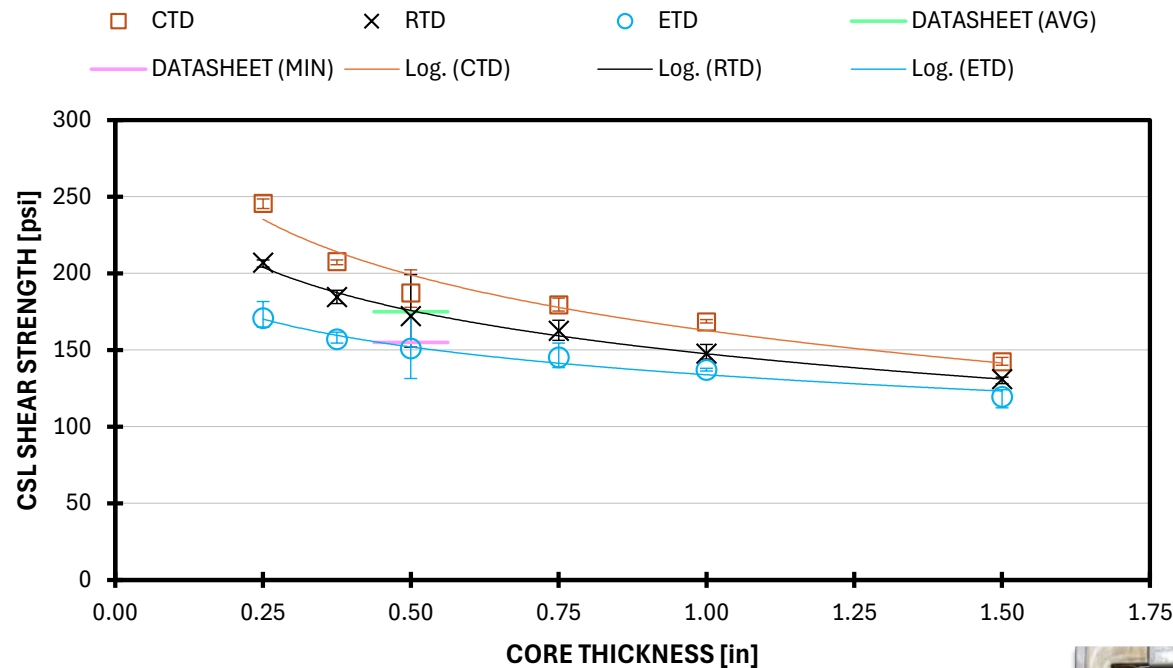
TEST MATRIX: TOP) PHYSICAL TESTING; BOTTOM) FLUID SENSITIVITY

Property	Condition/Method	Min Replicates per Test Type	
Core Thickness	ASTM C366	All data from mechanical test specimens	
Core Density	ASTM C271	Density to be taken from each sheet of core material used with 10 replicates per sheet.	

Extended Contact:	Exposure	Test Condition	Code
ASTM D1655 Jet A Fuel (other jet fuel may be used but its type must be reported)	90 days min. @ 70°F±10°F	70°F	FS12RT
	90 days min. @ 70°F±10°F	180°F	FS12ET
MIL-PRF-5606 Hydraulic Oil	90 days min. @ 70°F±10°F	70°F	FS13RT
	90 days min. @ 70°F±10°F	180°F	FS13ET
MIL-PRF-83282 Hydraulic Oil	90 days min. @ 70°F±10°F	70°F	FS14RT
	90 days min. @ 70°F±10°F	180°F	FS14ET
MIL-PRF-7808 Engine Oil	90 days min. @ 70°F±10°F	70°F	FS15RT
	90 days min. @ 70°F±10°F	180°F	FS15ET
MIL-PRF-23699, Class STD Engine Oil	90 days min. @ 70°F±10°F	70°F	FS16RT
	90 days min. @ 70°F±10°F	180°F	FS16ET
Sea Water (ASTM D1141 or equiv.)	90 days min. @ 70°F±10°F	70°F	FS17RT
	90 days min. @ 70°F±10°F	180°F	FS17ET
Skydrol LD-4 (SAE AS1241, Type IV, Class 1)	90 days min. @ 70°F±10°F	70°F	FS18RT
	90 days min. @ 70°F±10°F	180°F	FS18ET
50% Water with 50% Skydrol LD-4 (SAE AS1241, Type IV, Class 1)	90 days min. @ 70°F±10°F	70°F	FS19RT
	90 days min. @ 70°F±10°F	180°F	FS19ET
Short Duration Contact:			
MEK washing fluid. ASTM D740	90 minutes min. @ 70°F±10°F	70°F	FS21RT
	90 minutes min. @ 70°F±10°F	180°F	FS21ET
Polypropylene Glycol Deicer (Type I) SAE AMS 1424	90 minutes min. @ 70°F±10°F	70°F	FS22RT
	90 minutes min. @ 70°F±10°F	180°F	FS22ET
Isopropyl Alcohol Deicing Agent (TT-I-735)	48±4 hours @70°F±10°F	70°F	FS23RT
	48±4 hours @70°F±10°F	180°F	FS23ET
Control Tests:			
Distilled Water	90 days min. at 70°F±10°F	70°F	FS31RT
	90 days min. at 70°F±10°F	180°F	FS31ET
Dry	Dry per section 6.1	70°F	FS32RT
	Dry per section 6.1	180°F	FS32ET
85% Relative Humidity	Per section 6.1	70°F	FS33RT
	Per section 6.1	180°F	FS33ET

TASK 5: MATERIAL QUALIFICATION

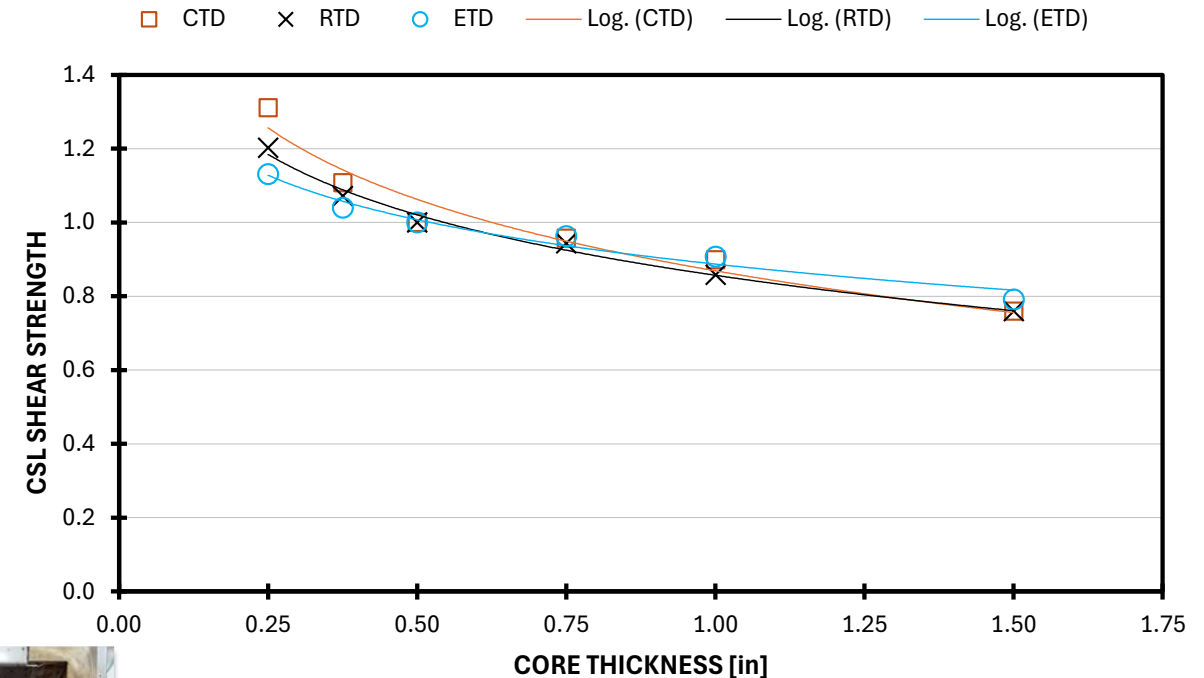
CORE THICKNESS EFFECTS ON SHEAR STRENGTH: L-DIRECTION (MEASURED)



- DATA ONLY PLOTTED FOR DRY TESTING CONDITIONS
- STRENGTH vs THICKNESS:** Observed decrease in strength with increase core thickness.
- MEASURED vs DATASHEET:** Measured AVG below TYP; Measured MIN below datasheet.



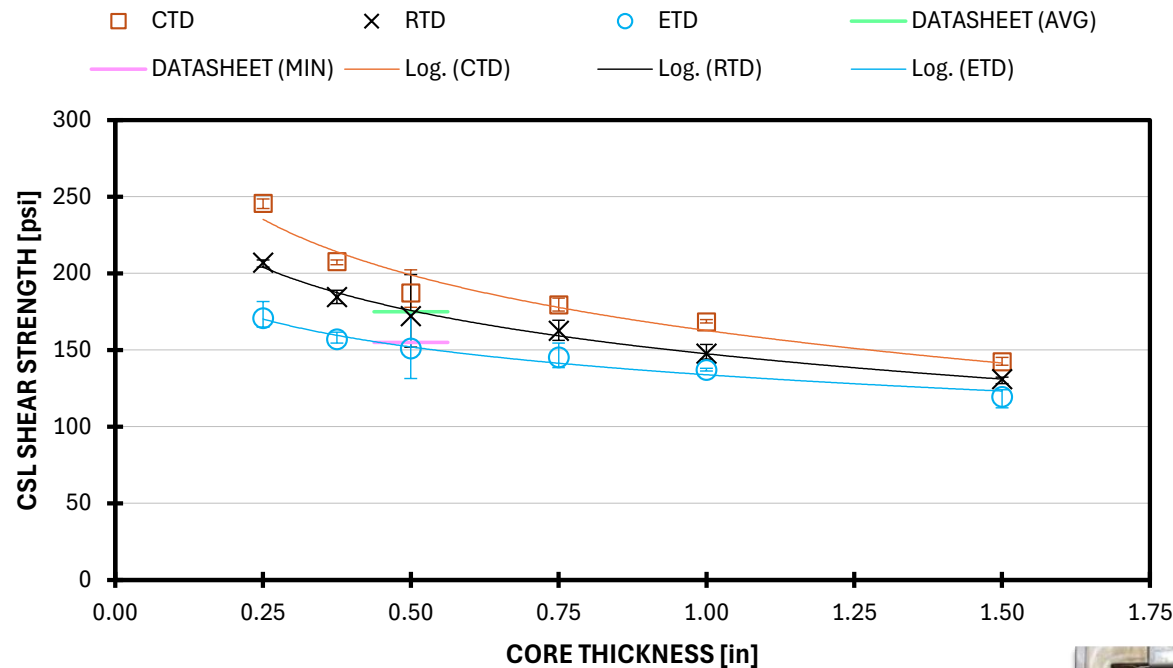
CORE THICKNESS EFFECTS ON SHEAR STRENGTH: L-DIRECTION



- DATA NORMALIZED TO 0.50" tk. CORE SHEAR STRENGTH @ EACH CONDITION
- CURVE-FIT FROM EMPIRICAL DATA
- CORE THICKNESS CORRECTION FACTOR:** Appears to vary at the extremes; thinner core material is observed to produce greater deviation from nominal fit (increased slope).

TASK 5: MATERIAL QUALIFICATION

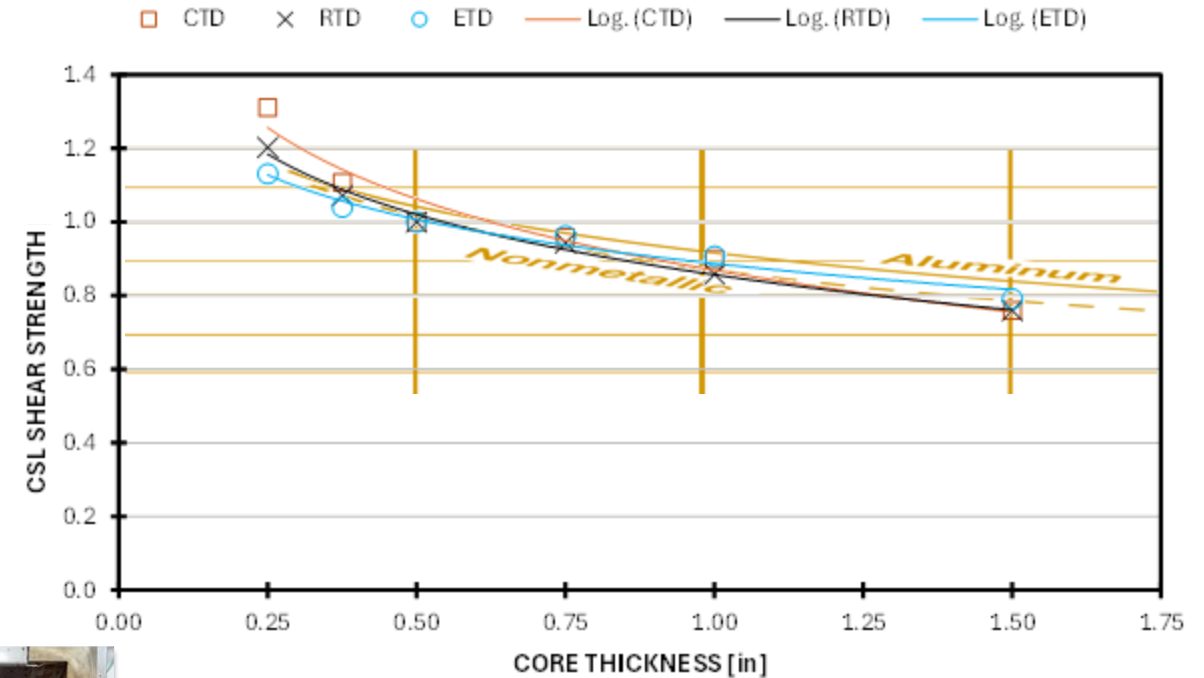
CORE THICKNESS EFFECTS ON SHEAR STRENGTH: L-DIRECTION (MEASURED)



- DATA ONLY PLOTTED FOR DRY TESTING CONDITIONS
- STRENGTH vs THICKNESS:** Observed decrease in strength with increase core thickness.
- MEASURED vs DATASHEET:** Measured AVG below TYP; Measured MIN below datasheet.



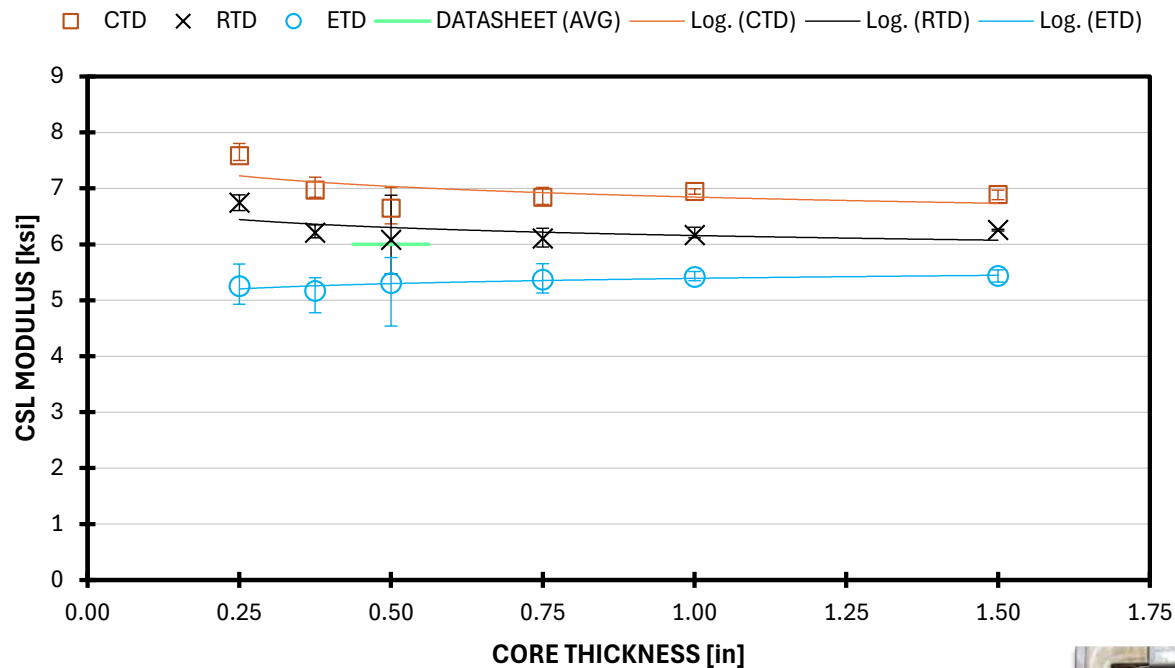
CORE THICKNESS EFFECTS ON SHEAR STRENGTH: L-DIRECTION



- DATA NORMALIZED TO 0.50" tk. CORE SHEAR STRENGTH @ EACH CONDITION
- CURVE-FIT FROM EMPIRICAL DATA
- CORE THICKNESS CORRECTION FACTOR:** Appears to vary at the extremes; thinner core material is observed to produce greater deviation from nominal fit (increased slope).

TASK 5: MATERIAL QUALIFICATION

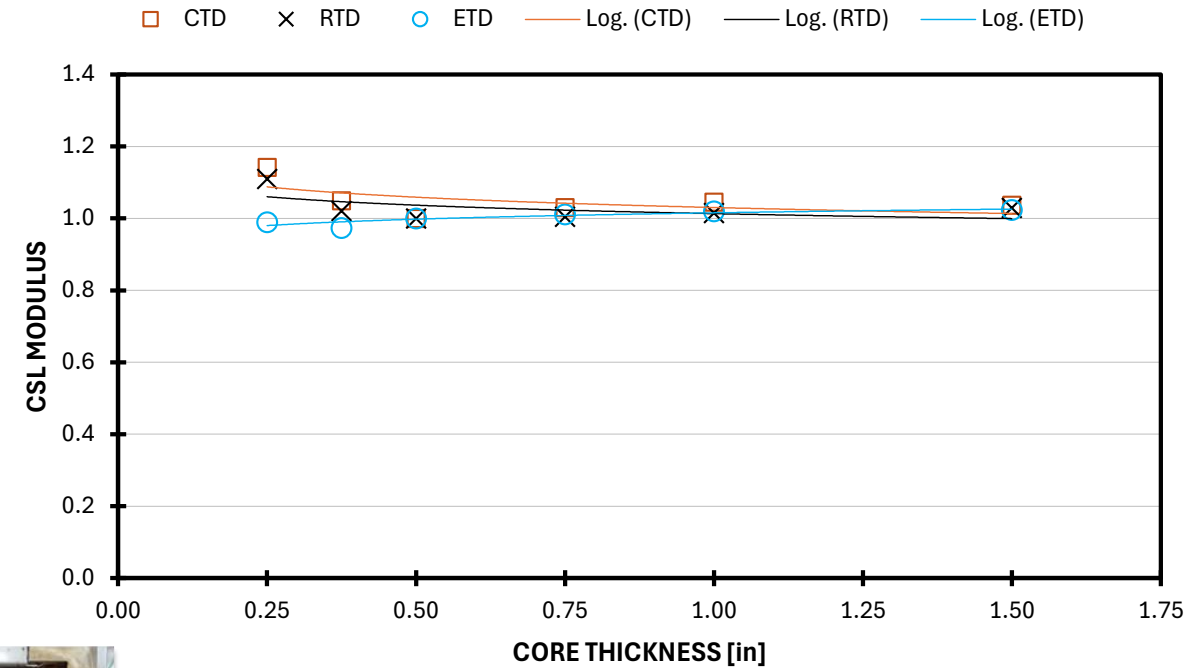
CORE THICKNESS EFFECTS ON SHEAR MODULUS: L-DIRECTION (MEASURED)



- DATA ONLY PLOTTED FOR DRY TESTING CONDITIONS
- MODULUS vs THICKNESS:** No direct correlation between change in modulus and core thickness across all testing conditions.
- MEASURED vs DATASHEET:** Measured AVG above TYP.



CORE THICKNESS EFFECTS ON SHEAR MODULUS: L-DIRECTION



- DATA NORMALIZED TO 0.50" tk. CORE SHEAR MODULUS @ EACH CONDITION
- CURVE-FIT FROM EMPIRICAL DATA**
- CORE THICKNESS CORRECTION FACTOR:** No direct correlation between change in modulus and core thickness across all testing conditions.

TASK 5: MATERIAL QUALIFICATION

TEST MATRIX: MECHANICAL TESTING

Layup (Warp Direction)	Test Type and Direction	Core Thickness	Property	Number of Batches x Number of Sheets x Number of Test Specimens			
				Test Temperature/Moisture Condition			
				CTD	RTD	ETD1	ETW1
N/A	Core Shear (L) ASTM C273	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
N/A	Core Shear (W) ASTM C273	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
N/A	Core Shear (L) ASTM C273	0.25" 0.375" 0.75" 1.0" 1.5"	Strength and Modulus (thickness correction factor)	1x2x4	1x2x4	1x2x4	1x2x4
N/A	Core Shear (W) ASTM C273	0.25" 0.375" 0.75" 1.0" 1.5"	Strength and Modulus (thickness correction factor)	1x2x4	1x2x4	1x2x4	1x2x4
N/A	Bare Flatwise Core Compression ASTM C365	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Stabilized Flatwise Core Compression ASTM C365	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Flatwise Tension ASTM C297	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 2 (1)	Climbing Drum Peel ASTM D1781	0.5"	Strength	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Core Shear Stress ASTM C393	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3
4 core 4 (1)	Long Beam Flex ASTM D7249	0.5"	Strength and Modulus	3x2x3	3x2x3	3x2x3	1x2x3

Note 1: "4 core 4" corresponds to 4 plies for top facesheet bonded to core with 2 plies of film adhesive and 4 plies for the bottom facesheet bonded to the core with 2 plies of film adhesive. Facesheet layup will be [0,90,90,0] for 4 ply facesheets and [0,90] for 2 ply facesheets.

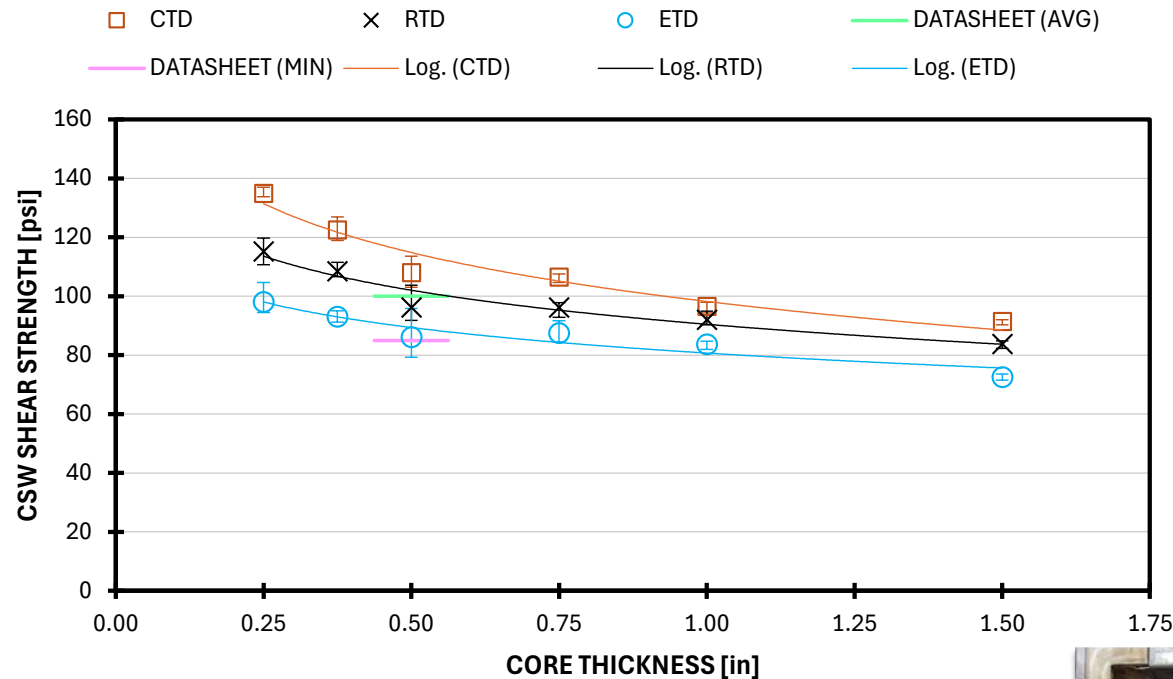
TEST MATRIX: TOP) PHYSICAL TESTING; BOTTOM) FLUID SENSITIVITY

Property	Condition/Method	Min Replicates per Test Type	
Core Thickness	ASTM C366	All data from mechanical test specimens	
Core Density	ASTM C271	Density to be taken from each sheet of core material used with 10 replicates per sheet.	

Extended Contact:	Exposure	Test Condition	Code
ASTM D1655 Jet A Fuel (other jet fuel may be used but its type must be reported)	90 days min. @ 70°F±10°F	70°F	FS12RT
	90 days min. @ 70°F±10°F	180°F	FS12ET
MIL-PRF-5606 Hydraulic Oil	90 days min. @ 70°F±10°F	70°F	FS13RT
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	90 days min. @ 70°F±10°F	180°F	FS15ET
MIL-PRF-23699, Class STD Engine Oil	90 days min. @ 70°F±10°F	70°F	FS16RT
	90 days min. @ 70°F±10°F	180°F	FS16ET
Sea Water (ASTM D1141 or equiv.)	90 days min. @ 70°F±10°F	70°F	FS17RT
	90 days min. @ 70°F±10°F	180°F	FS17ET
Skydrol LD-4 (SAE AS1241, Type IV, Class 1)	90 days min. @ 70°F±10°F	70°F	FS18RT
	90 days min. @ 70°F±10°F	180°F	FS18ET
50% Water with 50% Skydrol LD-4 (SAE AS1241, Type IV, Class 1)	90 days min. @ 70°F±10°F	70°F	FS19RT
	90 days min. @ 70°F±10°F	180°F	FS19ET
Short Duration Contact:			
MEK washing fluid. ASTM D740	90 minutes min. @ 70°F±10°F	70°F	FS21RT
	90 minutes min. @ 70°F±10°F	180°F	FS21ET
Polypropylene Glycol Deicer (Type I) SAE AMS 1424	90 minutes min. @ 70°F±10°F	70°F	FS22RT
	90 minutes min. @ 70°F±10°F	180°F	FS22ET
Isopropyl Alcohol Deicing Agent (TT-I-735)	48±4 hours @70°F±10°F	70°F	FS23RT
	48±4 hours @70°F±10°F	180°F	FS23ET
Control Tests:			
Distilled Water	90 days min. at 70°F±10°F	70°F	FS31RT
	90 days min. at 70°F±10°F	180°F	FS31ET
Dry	Dry per section 6.1	70°F	FS32RT
	Dry per section 6.1	180°F	FS32ET
85% Relative Humidity	Per section 6.1	70°F	FS33RT
	Per section 6.1	180°F	FS33ET

TASK 5: MATERIAL QUALIFICATION

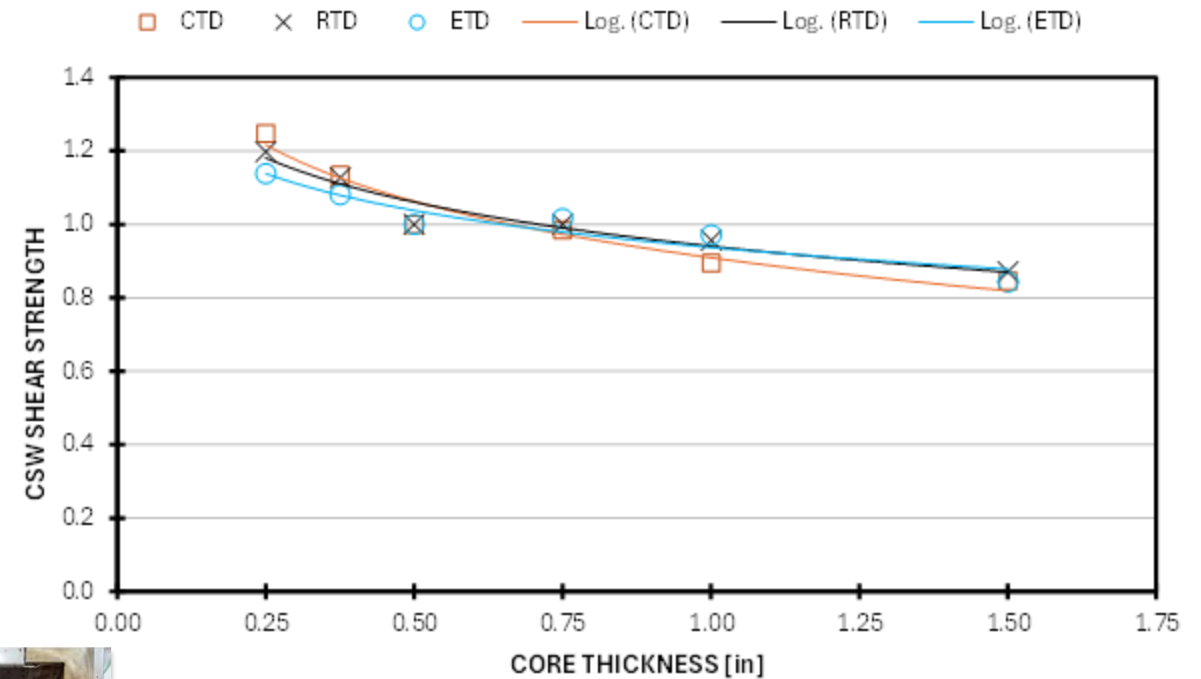
CORE THICKNESS EFFECTS ON SHEAR STRENGTH: W-DIRECTION (MEASURED)



- DATA ONLY PLOTTED FOR DRY TESTING CONDITIONS
- STRENGTH vs THICKNESS:** Observed decrease in strength with increase core thickness.
- MEASURED vs DATASHEET:** Measured AVG below TYP; Measured MIN above datasheet.



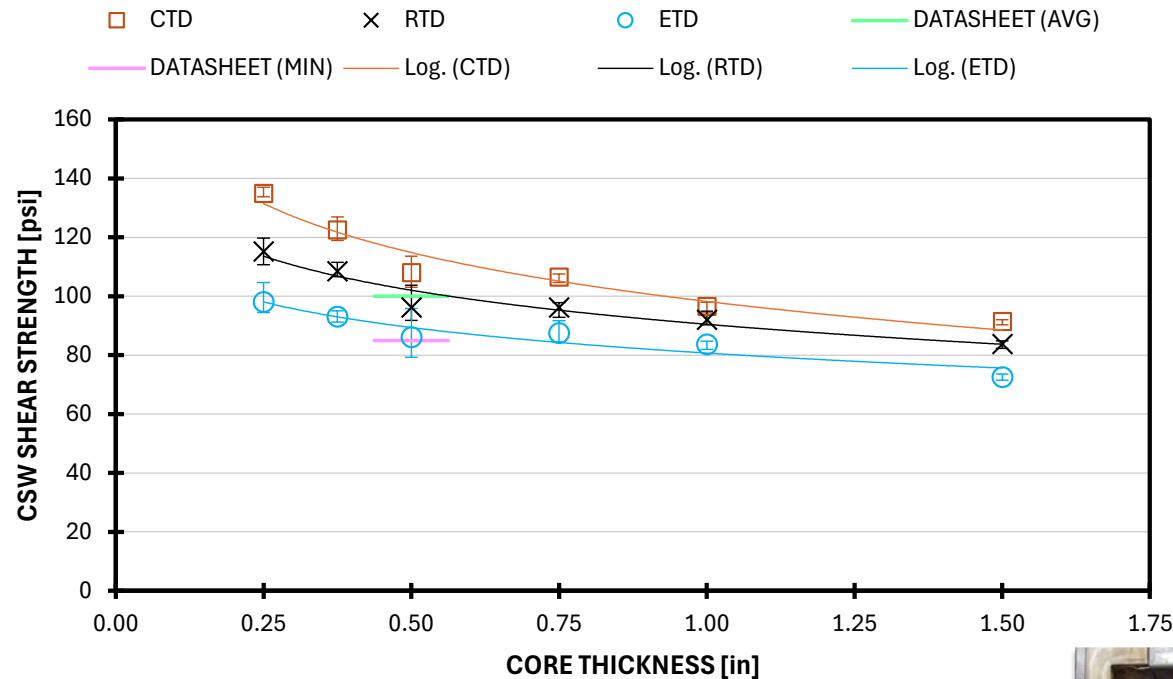
CORE THICKNESS EFFECTS ON SHEAR STRENGTH: W-DIRECTION



- DATA NORMALIZED TO 0.50" tk. CORE SHEAR STRENGTH @ EACH CONDITION
- CURVE-FIT FROM EMPIRICAL DATA
- CORE THICKNESS CORRECTION FACTOR:** Empirical curve-fit appears to over predict shear strength at 0.50" tk. A more in-depth analysis of the data will be conducted to provide guidance to the community.

TASK 5: MATERIAL QUALIFICATION

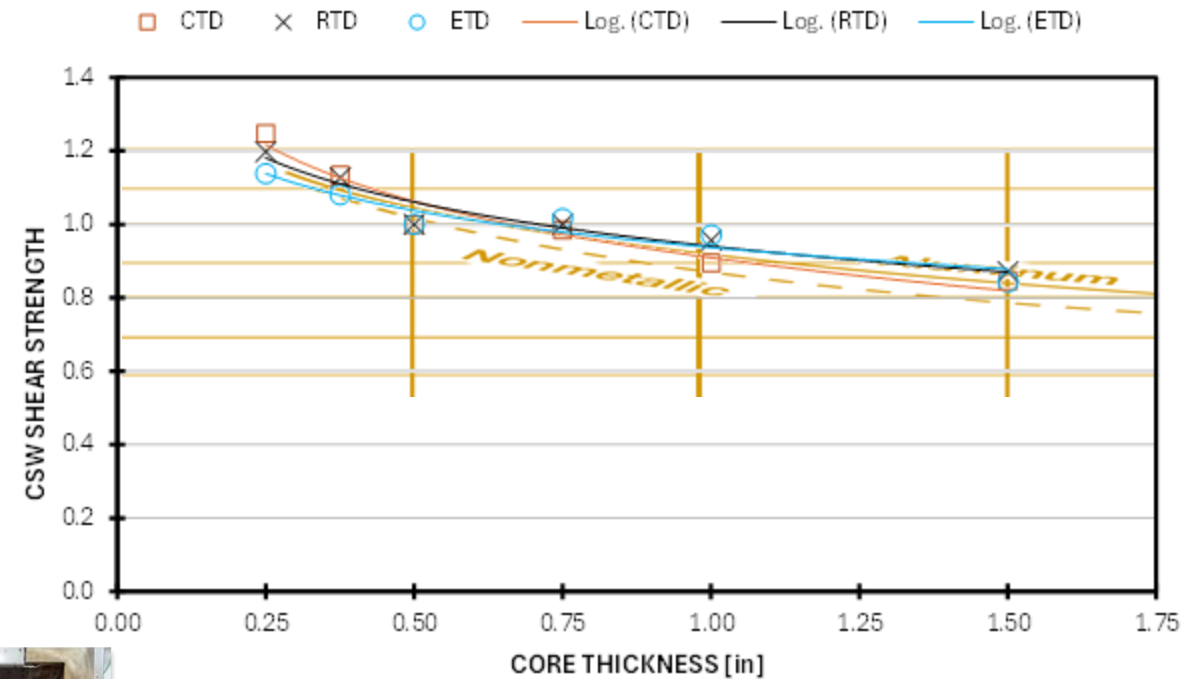
CORE THICKNESS EFFECTS ON SHEAR STRENGTH: W-DIRECTION (MEASURED)



- DATA ONLY PLOTTED FOR DRY TESTING CONDITIONS
- STRENGTH vs THICKNESS:** Observed decrease in strength with increase core thickness.
- MEASURED vs DATASHEET:** Measured AVG below TYP; Measured MIN above datasheet.



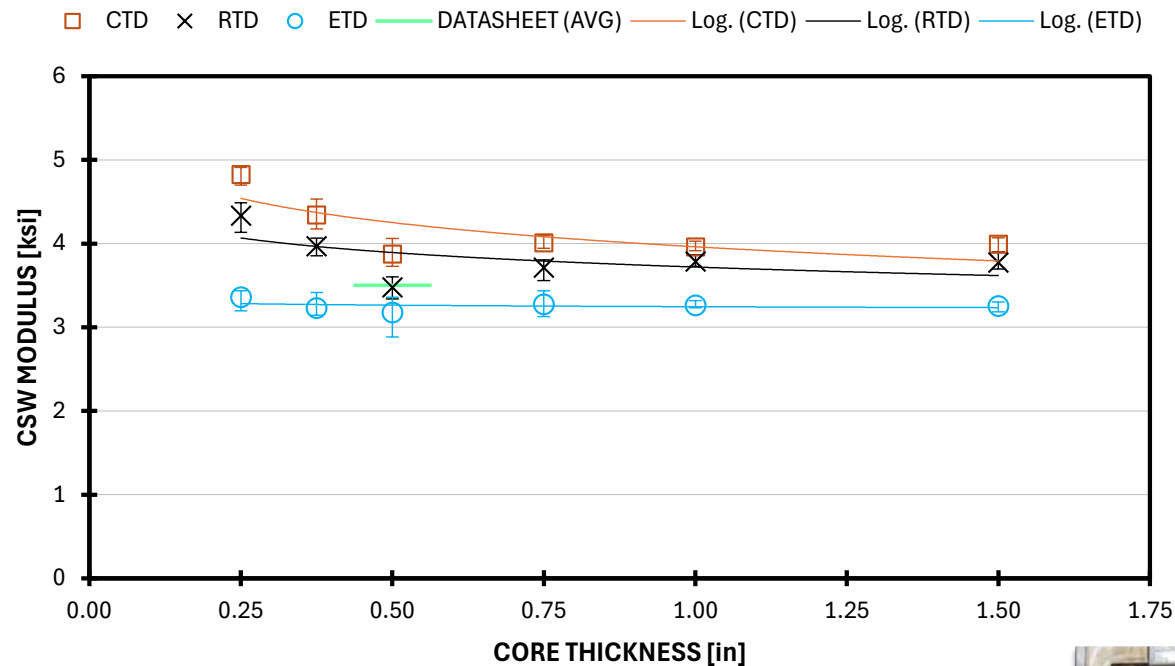
CORE THICKNESS EFFECTS ON SHEAR STRENGTH: W-DIRECTION



- DATA NORMALIZED TO 0.50" tk. CORE SHEAR STRENGTH @ EACH CONDITION
- CURVE-FIT FROM EMPIRICAL DATA
- CORE THICKNESS CORRECTION FACTOR:** Empirical curve-fit appears to over predict shear strength at 0.50" tk. A more in-depth analysis of the data will be conducted to provide guidance to the community.

TASK 5: MATERIAL QUALIFICATION

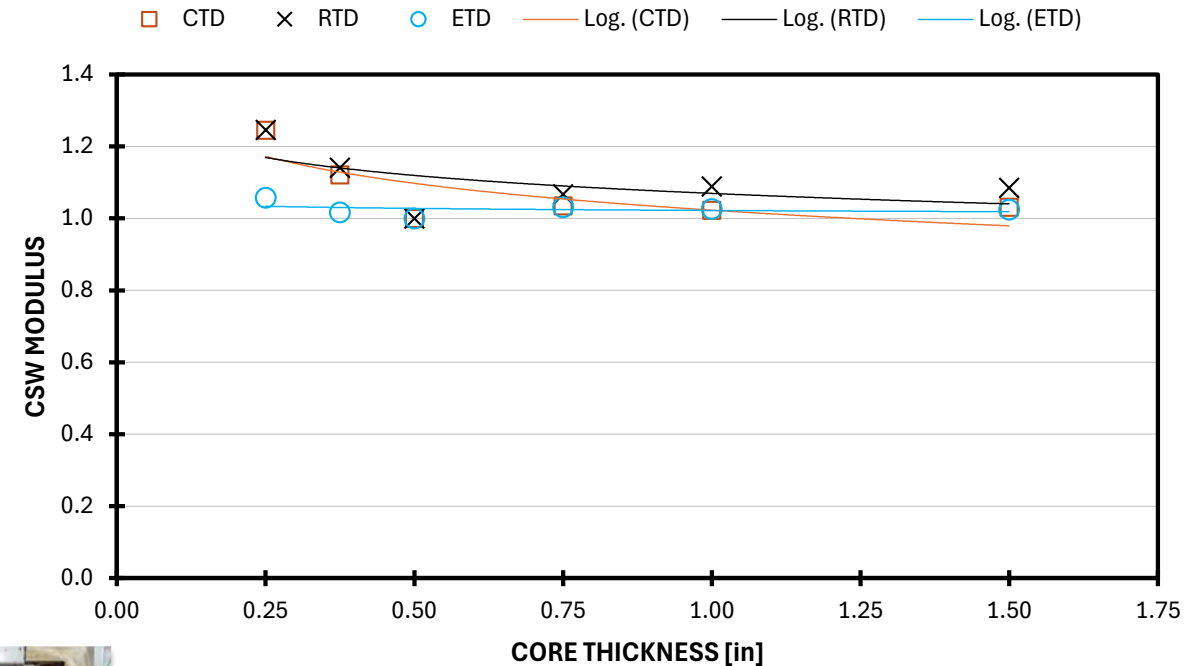
CORE THICKNESS EFFECTS ON SHEAR MODULUS: W-DIRECTION (MEASURED)



- DATA ONLY PLOTTED FOR DRY TESTING CONDITIONS
- MODULUS vs THICKNESS:** No direct correlation between change in modulus and core thickness across all testing conditions.
- MEASURED vs DATASHEET:** Measured AVG at TYP.



CORE THICKNESS EFFECTS ON SHEAR MODULUS: W-DIRECTION



- DATA NORMALIZED TO 0.50" tk. CORE SHEAR MODULUS @ EACH CONDITION
- CURVE-FIT FROM EMPIRICAL DATA
- CORE THICKNESS CORRECTION FACTOR:** No direct correlation between change in modulus and core thickness across all testing conditions – CTD and RTD appear to decrease with thickness while ETD was approximately constant.

- **MATERIAL PROPERTY DATA REPORT & STATISTICAL ANALYSIS REPORTING**

- In-work, expected draft during summer of 2025.

- **REPORTING**

- APRIL 2025 DRAFT:

Core Material Qualification Guidance for Aircraft Design and Certification:
Volume 1 – Qualification Framework

- FUTURE WORK (TARGETED LATE FALL 2025):

Core Material Qualification Guidance for Aircraft Design and Certification:
Volume 2 – Validation of Qualification Framework and Statistical Guidelines.

- **BENEFIT TO AVIATION**

- Publicly available honeycomb core data along with framework for qualifying core materials.
- Guidelines generated in this program will be transitioned into shared databases, such as CMH-17.

DOT/FAA/TC-xx/xx
Federal Aviation Administration
William J. Hughes Technical Center
Aviation Research Division
Atlantic City International Airport
New Jersey 08405

**Core Material Qualification
Guidance for Aircraft Design
and Certification: Volume 1 –
Qualification Framework
Development**

April 2025
Technical Report



U.S. Department of Transportation
Federal Aviation Administration

DRAFT

QUESTIONS?

- **CONTACT:**

- Rachael Andrulonis –
rachael.andrulonis@idp.wichita.edu
- Caleb Saathoff –
caleb.saathoff@idp.wichita.edu



NATIONAL INSTITUTE FOR AVIATION RESEARCH
WICHITA STATE UNIVERSITY

