2025 SPRAYFOAM Convention & Expo
Daytona Beach, FL February 9-12

Development of an Evaluation Protocol for Closed-Cell SPF

PART I - BACKGROUND, SAMPLE PREP, TESTING, EXOTHERM SUMMARY

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Mary Bogdan
Research Fellow - Honeywell

Mary Bogdan is a Research Fellow for Honeywell and is the Technology Lead for the Blowing Agent Technical Sales and Service Group. She earned a bachelor's degree in Chemistry/Biochemistry and an MBA from Canisius University. Since joining Honeywell in 1989, Mary has held numerous positions in research and development. She currently supports the global fluorine products blowing agent business.

Over her career, she has worked on the introduction of Honeywell's HCFC, HFC and HFO technology across many applications. She is a Six Sigma Black belt. She has more than 30 U.S. patents and has numerous published technical articles on the development and use of fluorocarbons as foam blowing agents. She has co-authored and presented several CPI papers receiving the CPI Best paper awards for 12 of her presentations. She has received a Distinguished leadership award from ACC CPI and a Heroes in Chemistry Award from the ACS.

She is on the Board of Directors for SPFA and actively represents Honeywell on several Trade Association (including ACC- CPI committees), ASTM and Building Code committees.

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Rick Duncan
Technical Consultant - SPFA

Rick brings more than 25 years of experience in technical marketing, building science, and product/business development delivering new materials and applications to the construction market. Drawing from his prior teaching experience, Rick simplifies complex building envelope issues and clearly describes solutions for construction and design professionals. Rick served as technical director of SPFA from 2008-2020, and as executive director from 2020 to 2024. As a technical consultant to SPFA, he oversees all technical activities for the organization. He holds a Ph.D. in Engineering Science and Mechanics Penn State, MSME from Bucknell and a BSME from the University of Maryland. Rick is a Registered Professional Engineer in Pennsylvania.

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Overview

Background
- Requested by Contractors
- History of High-Lift Closed-Cell SPF
- Some Field Issues Reported
- Formation of SPFA Task Group

Evaluation Protocol (Current Research)

Exotherm Data Summary

Conclusions

Next steps

Part II Session 5F

Request by Contractors

As industry has transitioned from 2” lift foams to high-lift foams…

- Contractors reported challenges in the field with high-lift foam
- Not easily characterized by laboratory methods such as ASTM test methods
- ASTM methods are designed to compare properties, not evaluate field performance and application methods
- Develop a straight-forward, inexpensive and accessible means to measure and demonstrate these challenges - that match field observations

HFO Foam History

HFO Foams

- Introduced 2014
- HFC ban initially mandated by EPA 1/1/21 (several states followed)
- HFC ban mandated nationwide by EPA 1/1/25

~ 2017 several manufacturers increased max pass thickness of new HFO foams from 2” to 3”-6”. These are considered ‘high-lift’ foams.

- Field issues reported with some products
- Formation of SPFA High-Lift Task Group in 2022
- Evaluation Protocol (Current Research)

Reported Field Issues

Some field reports indicate shrinkage, poor cell structure, odors when applied to manufacturers pass limits of 3-6”

Delamination, cracking observed > costly removal and replacement

SOME high lift foams show:

- Increased shrinkage (poor dimensional stability)
- Reduced core density
- Reduced compressive strength
- Differences in yield

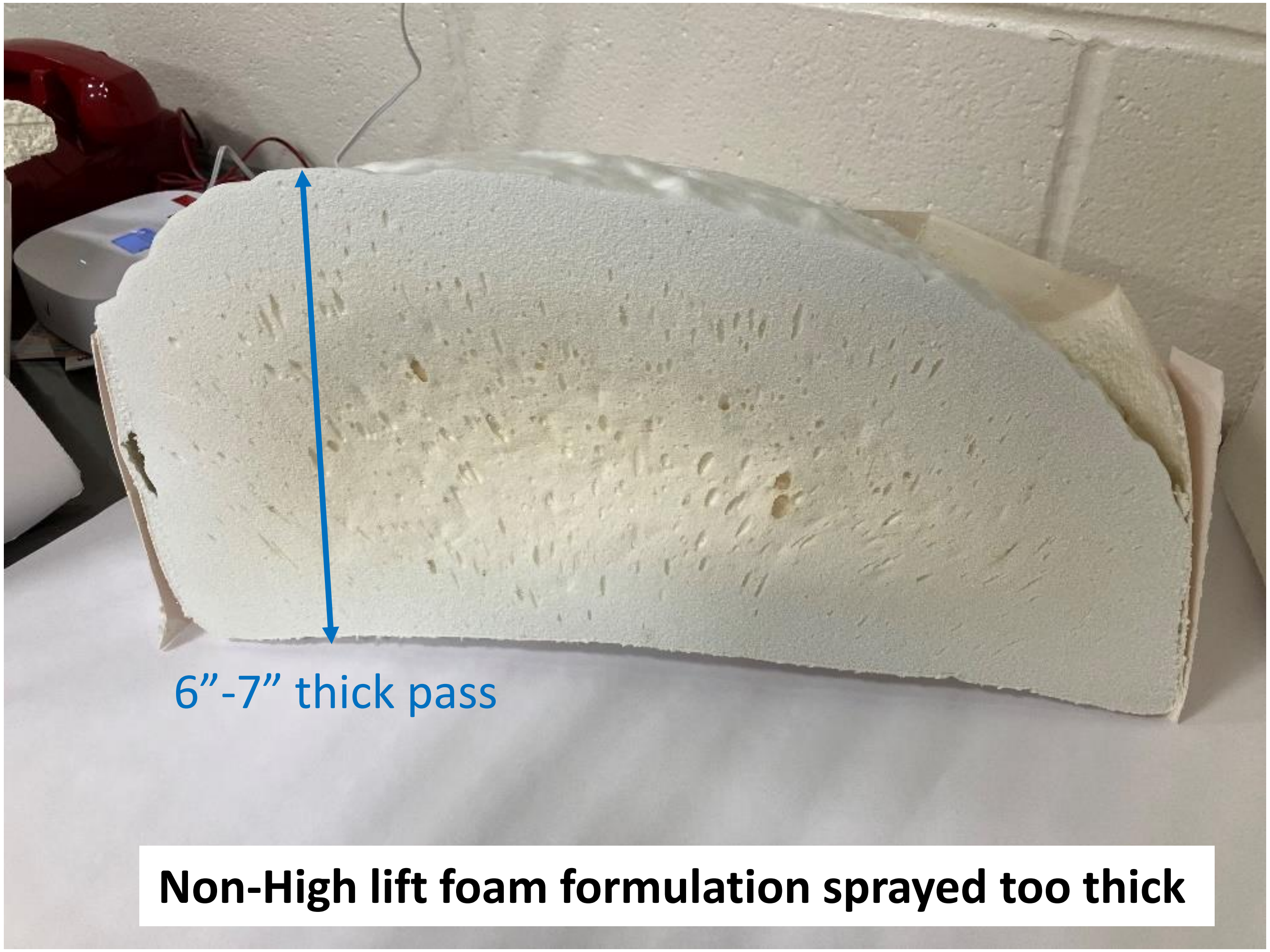
Inconsistencies in **SOME** manufacturer’s installation instructions (MII) reported by contractors

- Time/temperature for multiple passes
- Spray techniques

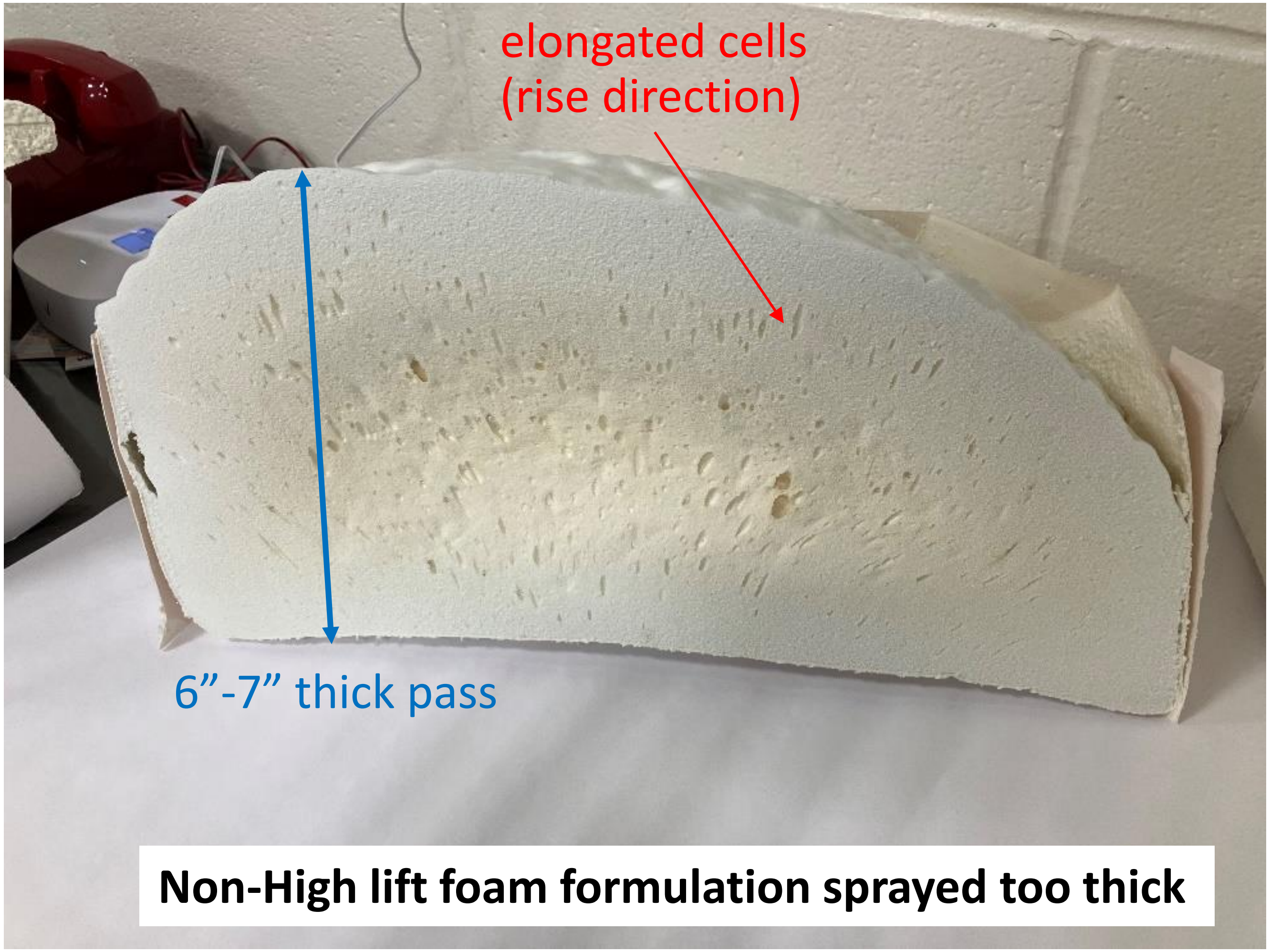
Three 1.5" Lifts
- Core density within mfg. spec.
- No voids
- No shrinkage

One 4.5" Lift
- Core density 10% below mfg. spec.
- Noticeable voids.
- Core is soft
- Shrinkage observed within hours of core sample

Example of Non-High Lift Foam



Example of Non-High Lift Foam



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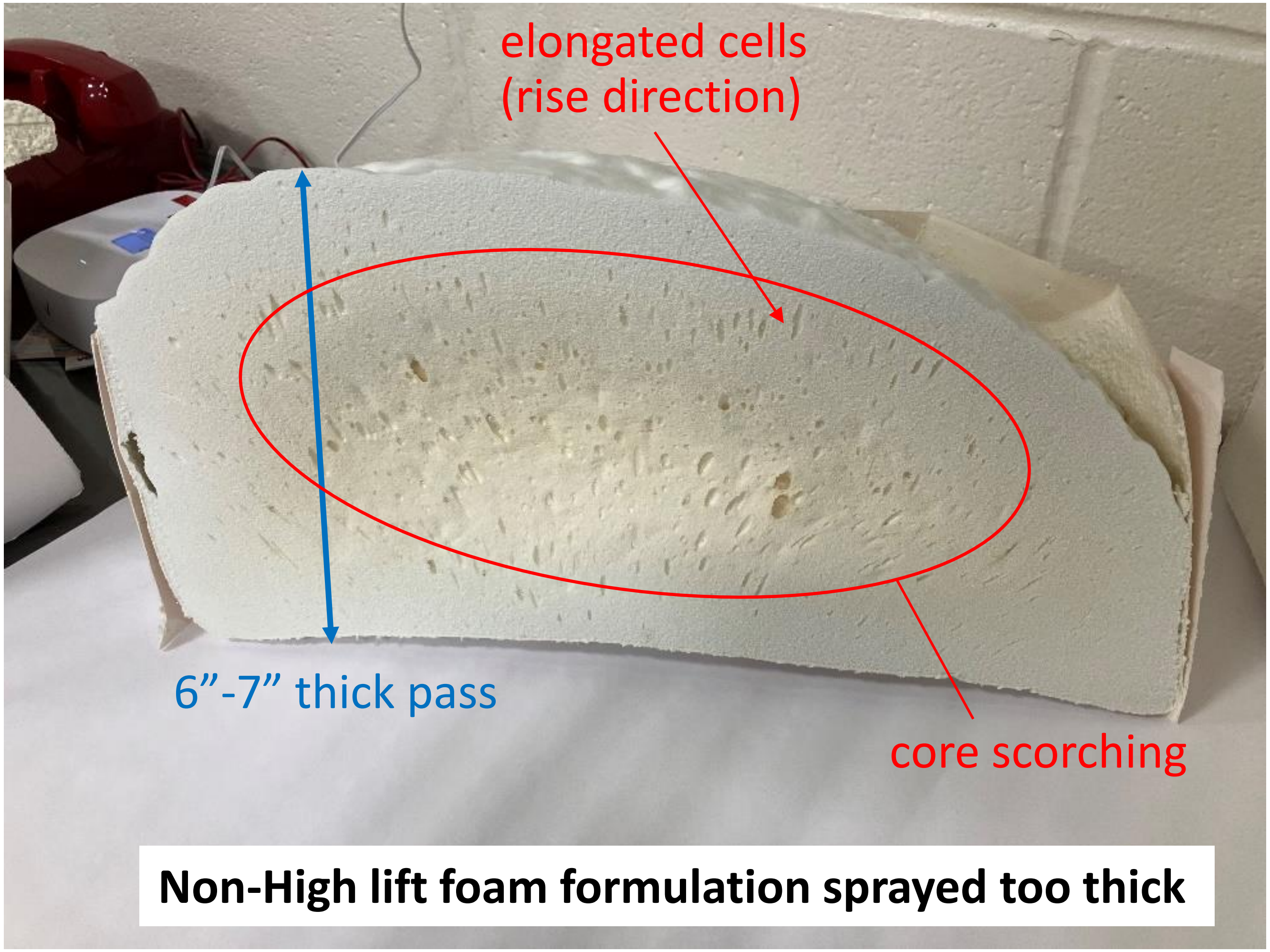
Example of Non-High Lift Foam



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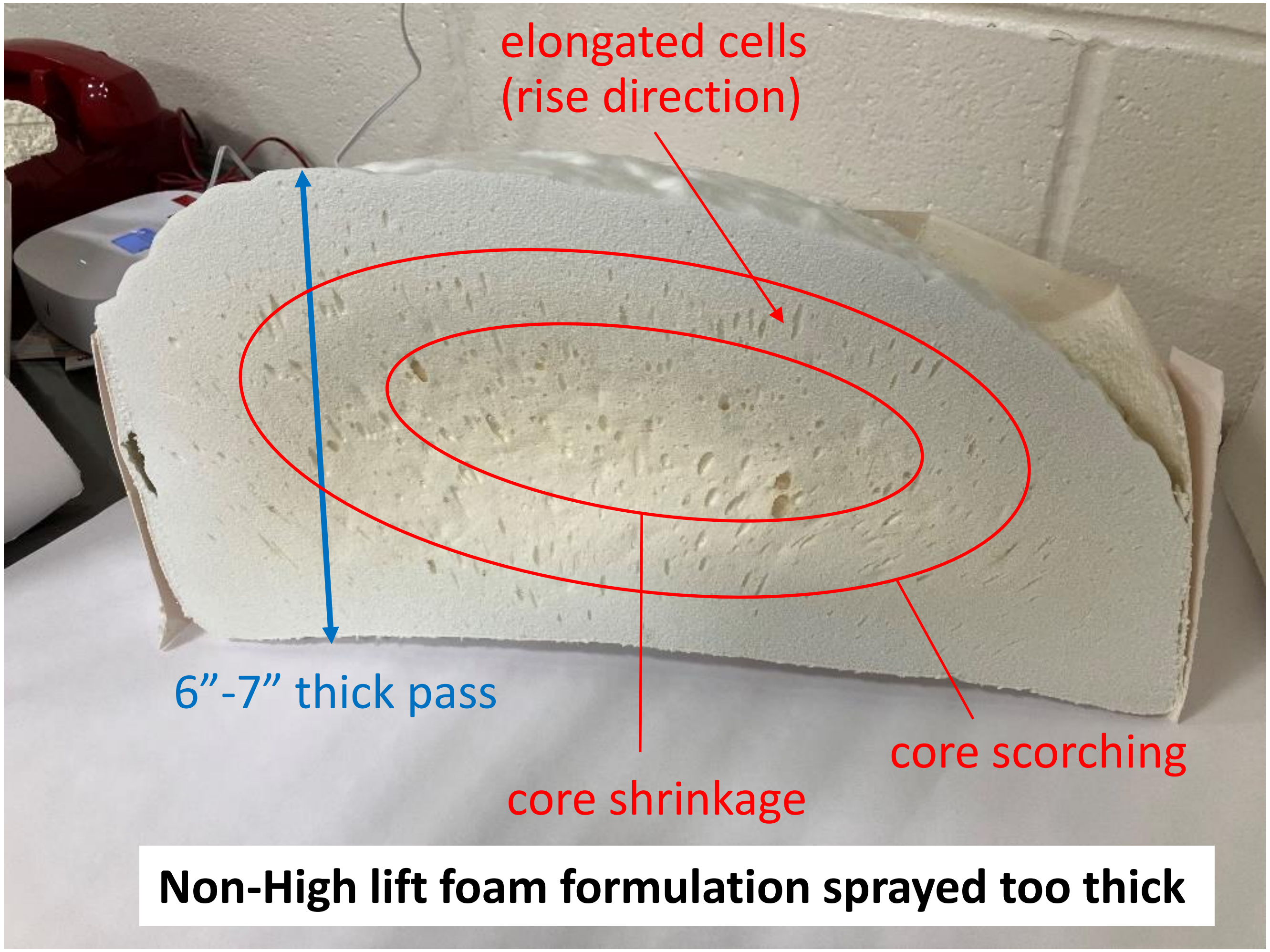
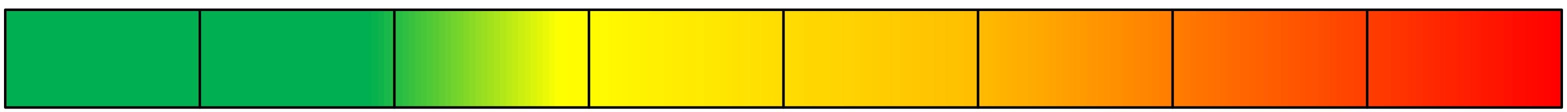


Reported Field Issues

Some new HFO foams permit pass thickness maximums of 3” to 6”

Traditional consensus opinion is that maximum closed-cell SPF pass thickness should be about 1.5”-2.0”



Reported Field Issues

SPFA Responses

- December 2020: SPFA issued TechTip I-7
- January 2022: SPFA formed high-lift foam task group
- SPFA issued HFO Foam Transition Letter in June-October 2024 reminding contractors to get trained by manufacturers and distributors on HFO foam application

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SPFA High-Lift Foam Task Group

Formed under the SPFA BEC

Small group of SPFA Consultants, Suppliers, and Contractors only

Initially to evaluate installation performance of high-lift foams

Correlate application techniques with foam quality

Members:

- Mary Bogdan, Honeywell
- Tom Harris, Tom Harris PUR Consulting
- Mac Sheldon, Sheldon Consulting
- Shawn Wate, TruTeam
- George Spanos, SPI
- Rick Duncan, SPFA
- Patrick Stehley, Honeywell

SPFA High-Lift Foam Task Group

Honeywell Buffalo Research Lab Staff

Recognized for the work and dedication to completing this project

<table>
<tr><th>Commercial</th><th>TSS Foam Lab</th><th>Refrigeration Lab</th><th>Site Services</th></tr>
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Test Protocol Variables

METHOD	
Pass Thickness x Number	Time Between Passes
1” x 6	30 sec
2” x 3 non-vertical	30 sec
2” x 3 vertical	30 sec, plus <100°F surface, 30 min*
3” x 2	30 sec
5” x 1	N/A

X

SPRAY DIRECTION
Vertical
Horizontal

X

SPRAY TECHNIQUE
Picture Frame
No Picture Frame

= 22

Test Protocol Constant

MANPOWER
Applicator: Jeremy Ramer - TruTeam
Honeywell Lab Personnel

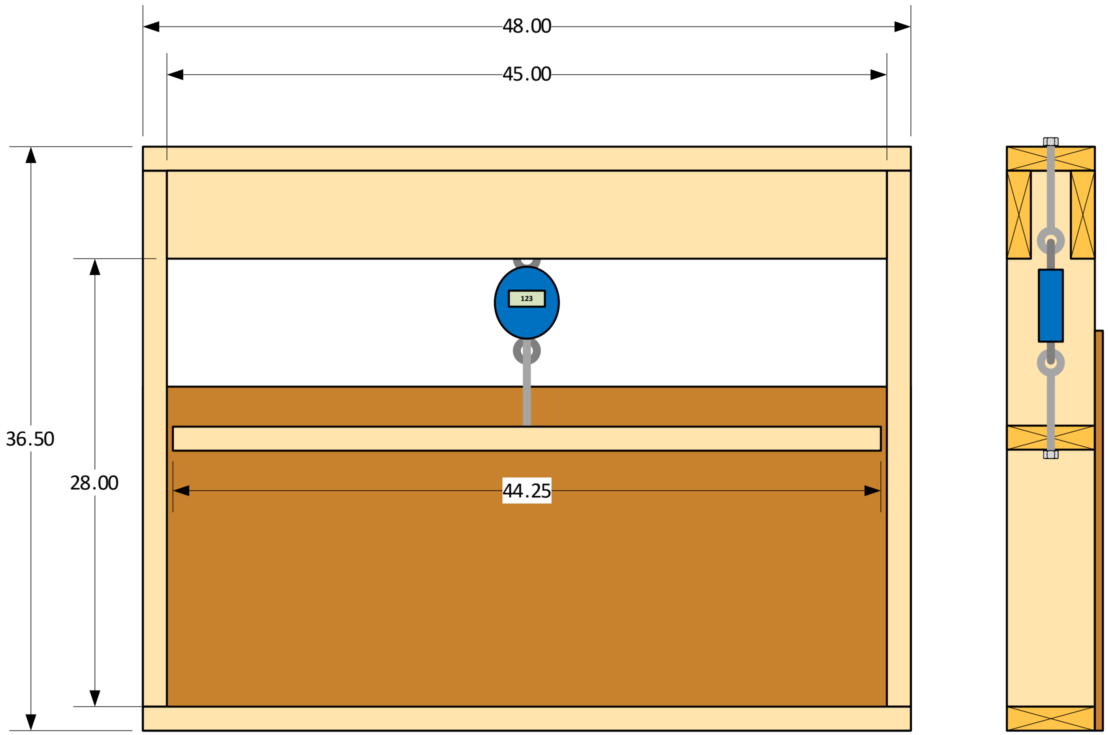
MATERIALS
HFO Medium Density ccSPF (non-high lift)
Wood Frames
Cardboard Liner

MACHINE
Material Temperature = 80°F
Graco H40, 10/50 ft hose
AP Fusion Gun with 4242 Mixing Chamber
Temperature A/B = 120°F
Pressure = 1200 psi

METHODS
30 sec between passes (except two controls)
Substrate Moisture Probe/ Temperature Heat Gage
Crane Digital Load Gage
Frame Release Time = 30 min
Wood Moisture – Pin Gage
Ambient Temperature/Humidity - Standard

MEASUREMENT
Frame Moisture
Room Temperature / Humidity
Exotherm – 3 pts using TC @ 10 sec intervals for 48h
Frame Load (15 min first hour, then hourly for 24h+
Foam Property Testing
Frame Testing

Test Fixture

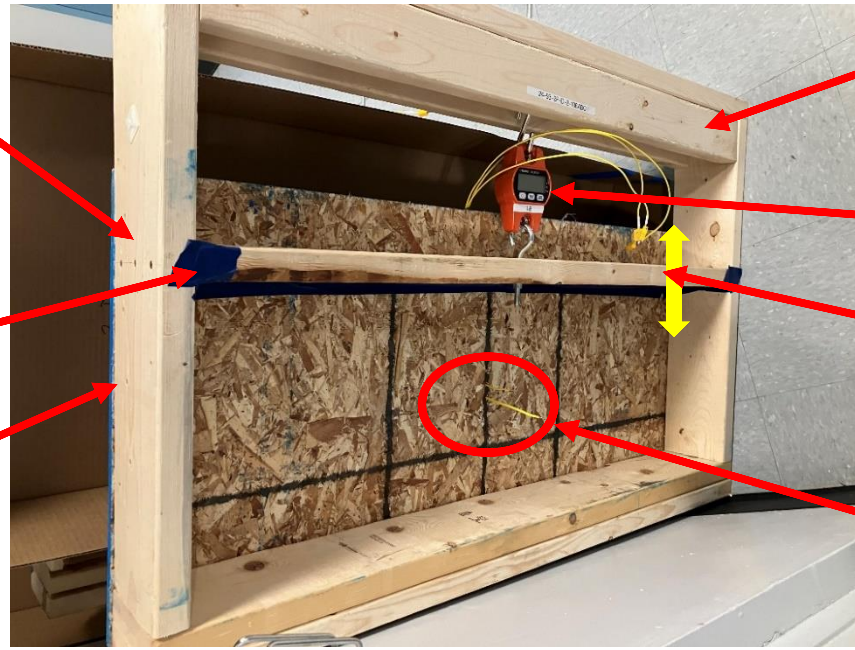


Test Fixture

Screws for release after peak exothermic temperature is reached. 30-minute wait to allow foam to continue to expand

Tape to prevent foam leakage

½” OSB fastened to frame



2”x6” framing

Digital load cell

Floating stud

Three thermocouples in center of cavity (substrate surface, mid-thickness and free surface)

Credits to George Spanos of SPF for the initial design of this test fixture and initial testing protocol

Program Timeline

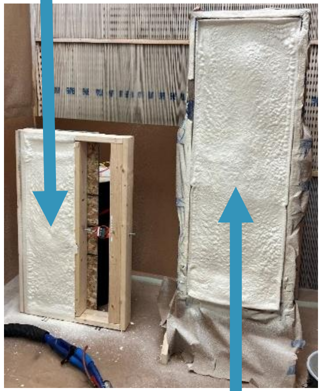
Setting Up the Tests
Thermocouples attached to frame

Secure pressure gauges to frames
Torque to 5 psi reading

Preparing for testing
Measure environment conditions, wood frame moisture, and spray surface temperature.
Attach thermocouples to card readers and begin recording
Zero frame pressure gauges

Spray Test Fixture
Follow correct pattern and pass method
30 sec between each pass
Foam thickness is measured between each pass
After final pass a 15 minute timer starts before moving frame out of room

After 15 Min



Spray Box
Follow correct pattern and pass method
30 seconds between each pass
Foam Thickness is measured between each pass
Box is moved to curing room

After 2-14 days

What We Sprayed

Spray Technique/Lift Configurations			A	B	C	D	Control
	Picture Frame	Spray Direction	6 @ 1”	3 @ 2”	2 @ 3”	1 @ 5”	3 @ 2”
1	Yes	Side-side	✓	✓	✓	✓	
2	No	Side-side	✓	✓	✓	✓	
3	Yes	Vertical	✓	✓	✓	✓	
4	No	Vertical	✓	✓	✓	✓	
5	Yes	Rising Foam		✓	✓		
6	No	Rising Foam		✓	✓		
7	No	Vertical					(1)
8	No	Vertical					(2)

- **Non-High Lift HFO medium-density closed-cell foam applied**
- Lift configuration D was limited to 5” to avoid exothermic scorching
- Control Foam – Sprayed without Picture Frame in Vertical Direction

  (1) Waiting until surface temperature reaches 100F before next pass

  (2) Waiting 30 minutes between each pass

22 Frame & Box Samples Prepared

Frame Testing Timeline

PROPERTY	TEST METHOD	TIMELINE
Exothermic Temperatures	Thermocouples with automated data acquisition	10 second intervals for up to 48 hours after spraying
Frame Load	Fixture with load cell (manually recorded)	<1 hour: 15-min intervals after release 1-8 hours: 1-hr intervals 24 hours 2, 3, 4, 5, 7 or 30 days after release
Change in Thickness	Pin Probe	8, 24 and 45 days after spraying

Testing on 22 Sample Frames

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Box Testing Timeline

PROPERTY	TEST METHOD/ CONDITIONS	FREQUENCY	TIMELINE
Density - Core - Top - Middle - Bottom - Cylinder	ASTM D1622	Once	2-5 days after spraying
% Closed Cell - Top - Middle - Bottom	ASTM D6226	Once	19-27 days after spraying
Dimensional Stability - Top - Middle - Bottom	ASTM D2126 Hot (90°C) Cold (-40°C) Hot and Humid (70°C/90% RH)	Initial, 1,7,14 days	3-5 days after spraying
Dimensional Stability - Cylinder see bottom photo on slide 9	Hot (90°C) Cold (-40°C) Hot and Humid (70°C/90% RH)	Initial, 1,7,14 days	3-5 days after spraying

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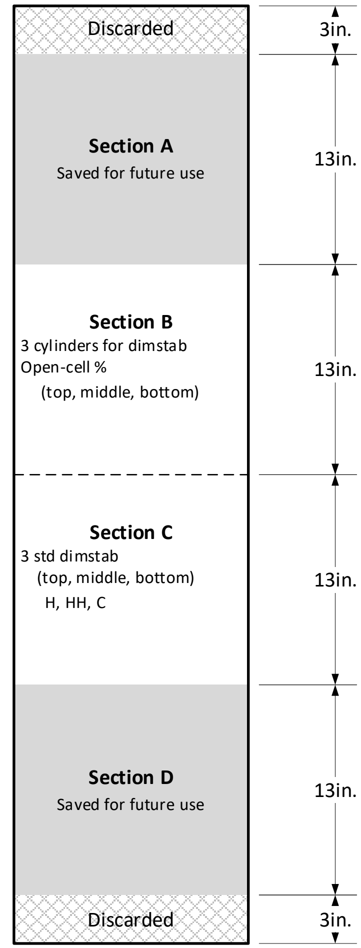
Box Testing Diagram



Frame Test

Exotherm vs Application Technique

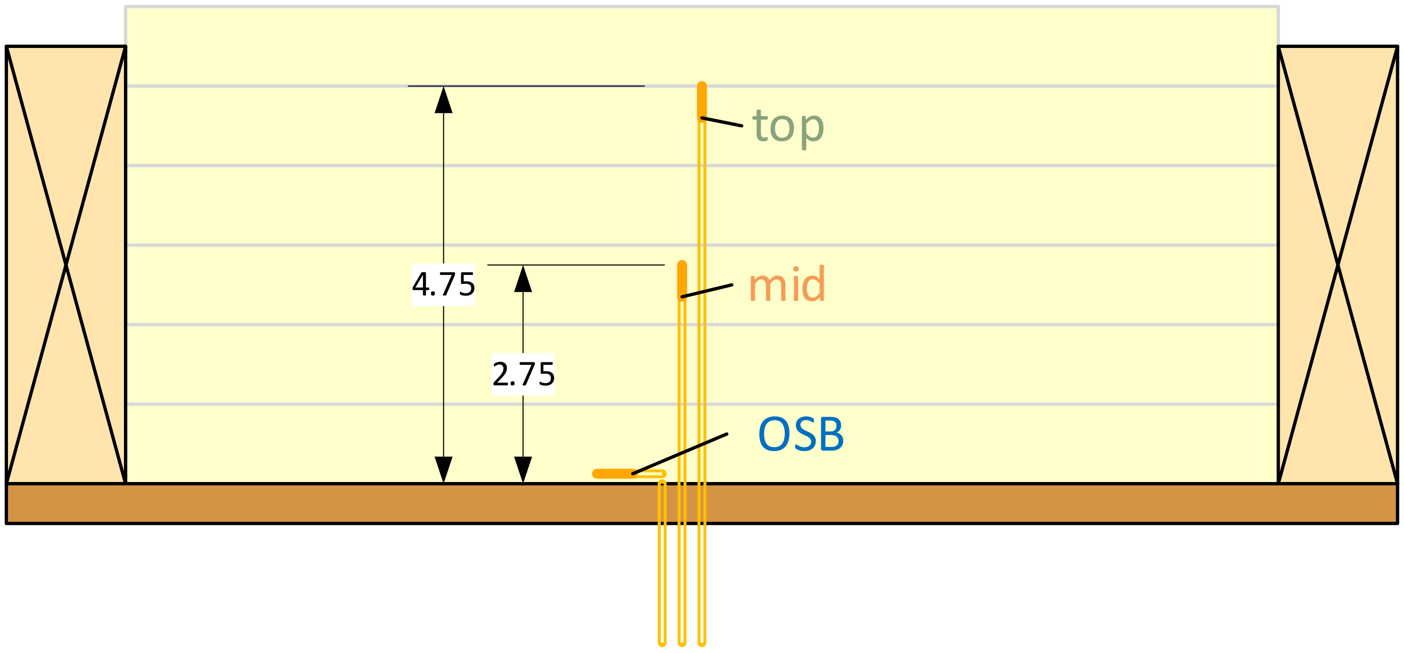
Exothermic Temperature Test

- Data: Exotherm Temperature vs. Time
- Location: top/middle/bottom of frame
- Frequency: 10 second intervals
- Duration: 48 hours

900,000 + Data Points

Thermocouple Placement

Illustration of thermocouple placement in spray frame



Exotherm Data Summary- Peak Temp (°F)

Spray Technique/ Lift Configuration			A	B	C	D	D'
	Picture Frame	Spray Direction	6 @ 1"	3 @ 2"	2 @ 3"	1 @ 5"	3 @ 2"
1	Yes	Side-side	278	298	308	349	
2	No	Side-side	279	299	317	328	
3	Yes	Vertical	284	286	305	315	
4	No	Vertical	285	302	301	320	
5	Yes	Rising Foam		304	321		
6	No	Rising Foam		300	311		
7	No	Vertical (Control 1)					261
8	No	Vertical (Control 2)					229
		Average	**282**	**298**	**311**	**328**	**245**

More Details Stay For Session 5F

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Summary

- Extensive study designed to demonstrate impact application methods have on foam quality
  - two sample types (Box, Frame), total 484 tests, >1M data points
- Limited variables:
  - Spray lifts, spray techniques (side-to-side, vertical, into rising foam, with or without picture framing)
- Control samples meet manufacturer published criteria when sprayed per TDS
- Exotherm Testing
  - Increasing lift thickness dramatically increases exothermic temperatures from 225°F to about 245°F
  - Spray pattern and spray technique no impact on Exotherm

Next steps- Part ll Session 5F

PROPERTY	SPRAY PATTERN	SPRAY TECHNIQUE	LIFT NUMBER AND THICKNESS
Frame Testing			
Exothermic Temperatures	No Significant Impact	No Significant Impact	Increasing lift thickness dramatically increases exothermic temperatures from 225°F to about 245°F
Frame Load, psi			
Change in Thickness, %			
Box Testing			
Density, pcf			
Closed-Cell %			
Dimensional Stability, vol %			

Status Testing Frame and Box Conducted

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