



Flammability Reduction Technologies

Federal Fire Working Group Meeting

June 25, 2015

- **Bill Pitts**
- **Doug Fox**
- **Egidio Mortella**
- **Michelle Gervasio**
- **Morgan Bruns**
- **Mauro Zammarano**
- **Randy Shields**
- **Shonali Nazare**
- **Szabolcs Matko**
- **Valeria Cazzaetta**
- **Yeon Seok Kim**
- **Yu-Chin Li**

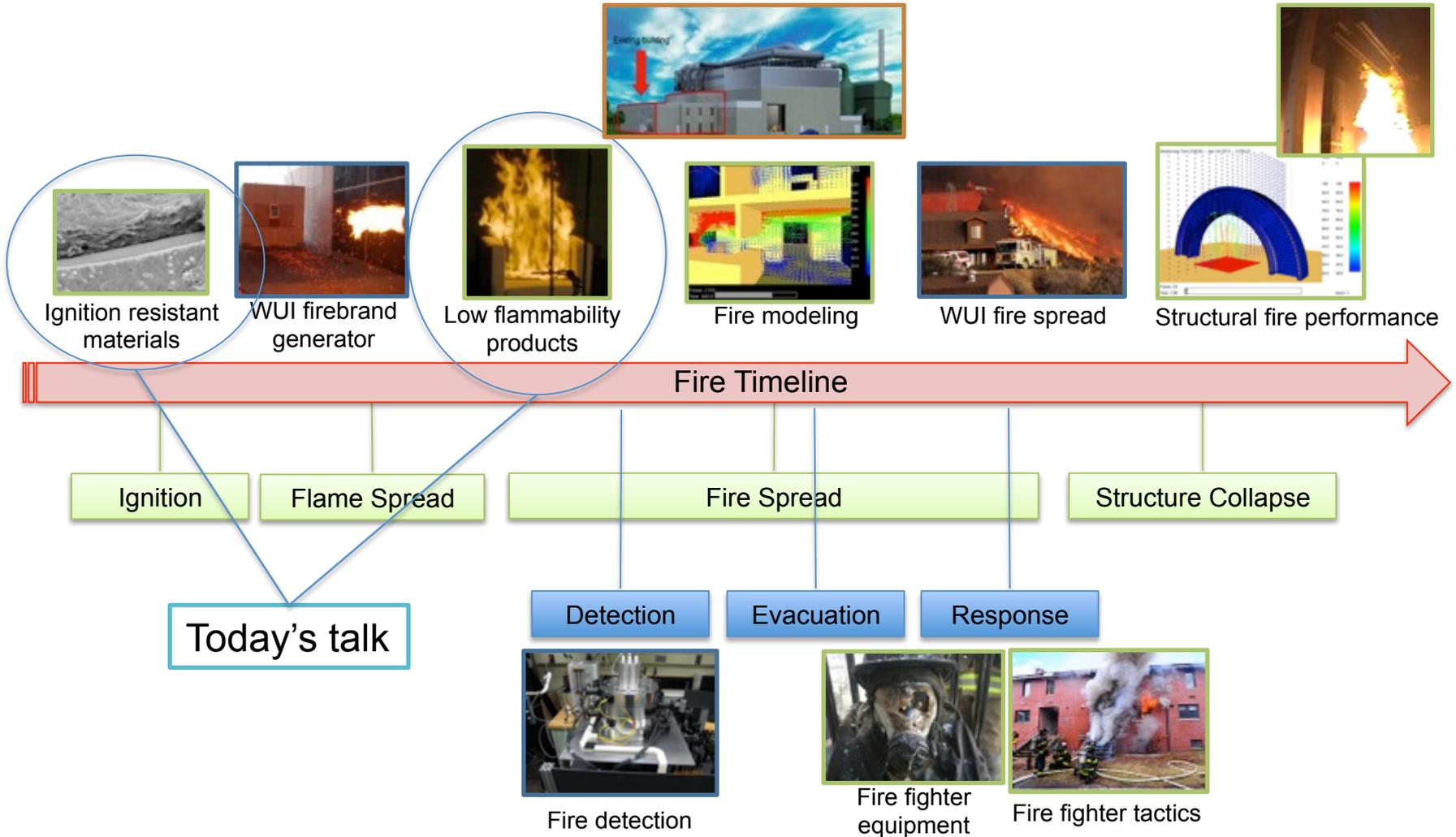
Rick Davis – Group Leader and Program Manager
Engineering Laboratory
Fire Research Division

NIST Fire Research

Reducing fire losses and costs by

- 1) enabling cost-effective fire protection of people, buildings, and communities
- 2) improving the safety and effectiveness of firefighters

National Fire Research Laboratory



Fire Safe Furniture

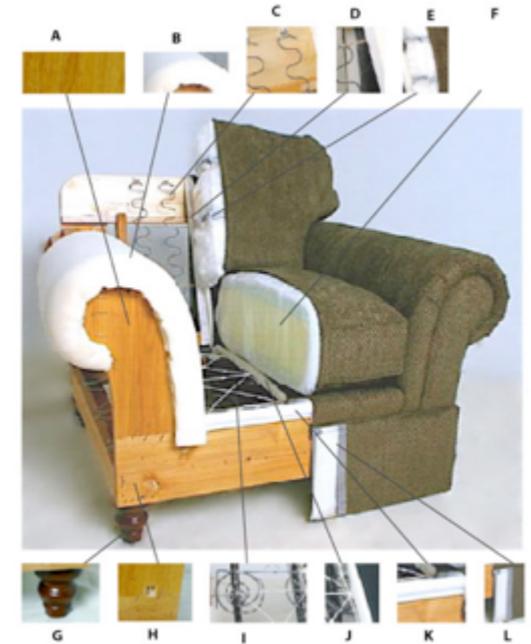
Why Residential Upholstered Furniture (RUF)?

- Single largest source of deaths and injuries in residential fires.
- Foam is the single largest fuel source (solid gasoline)² and dictates the severity of a fire.
- Increased pressure to restrict use of FR in RUF

Approach

Enable commercialization of inexpensive, fire, and environmental safe residential upholstered furniture (RUF) by

- **Fire Resistant Coatings (research solution)** – developing a new FR technology
- **Fire Blocking Barrier Fabrics (commercial solution)** – developing methodology and guidance for regulatory compliance
- **Standardized Foam for Smolder Ignition Testing** – developing a standardized materials for a regulation
- **Smolder Ignition Testing (standardized test method)** – developing methodology for a regulation



Ignition Source



Foam Morphology



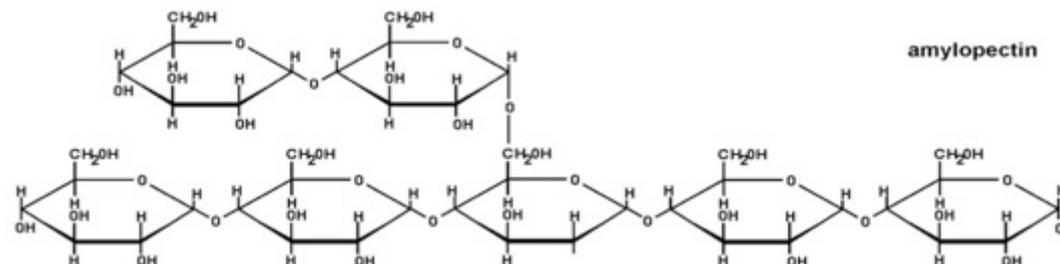
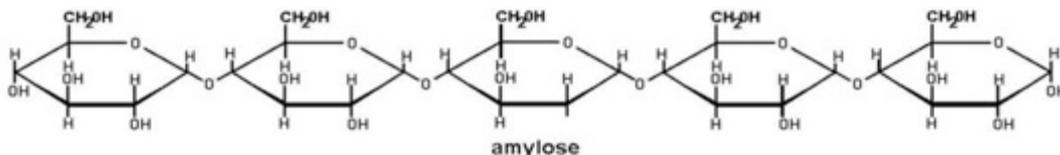
Fire Resistant Coatings

on flexible foam and fabrics in furniture

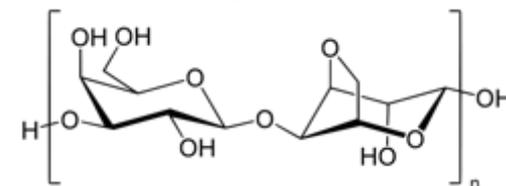
Fire Safe FPUF – Bucket Coatings

US 15/0017856 A1

Potato Starch

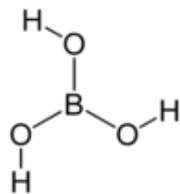


Agar

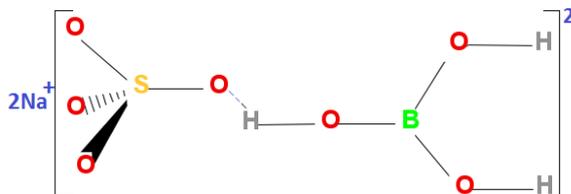


BINDER

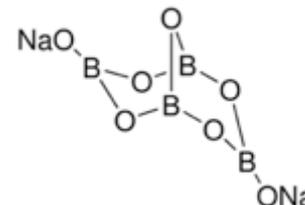
Boric Acid



Sodium Polyborate (Boron-10)



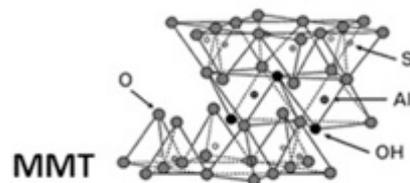
Borax



FR

Extremely effective FR formulation that never could be used for foam

Sodium Montmorillonite Clay



CHAR FORMER

Fire Safe FPUF – Open Flame Full Scale

PP/PE Fabric

- Playing at 20X speed

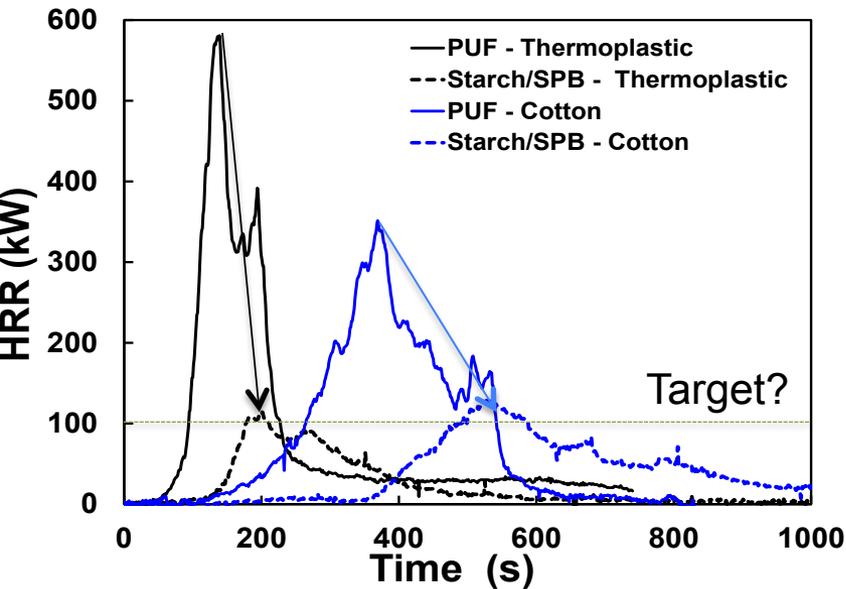
Avg. Reductions of both CF

PHRR = 70%

AHRR = 55%

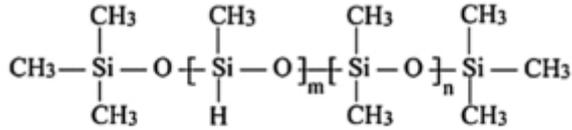
THR = 65%

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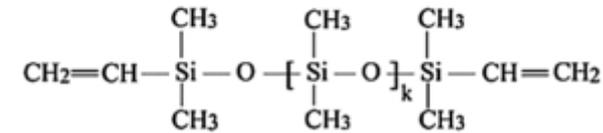
H-PDMS

Hydrogen-functional
polydimethylsiloxane



+

C=C-PDMS

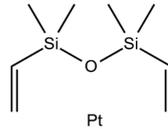


Vinyl-functional
polydimethylsiloxane

Pt (0)

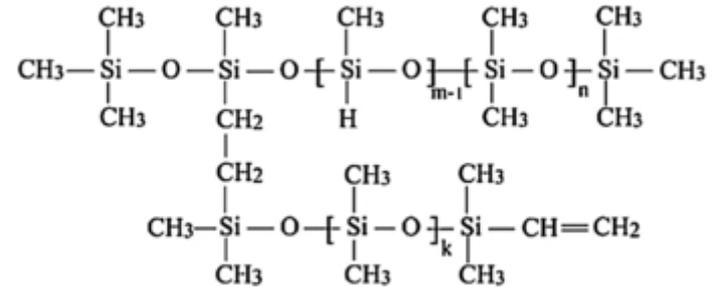


10 ppm



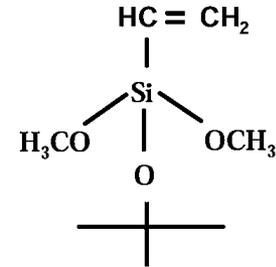
PLATINUM-DIVINYLTETRAMETHYLDISILOXANE

Cross-linked silicone
rubber



72 wt. % filler

Vinyl-functionalized nanosilica and ATH



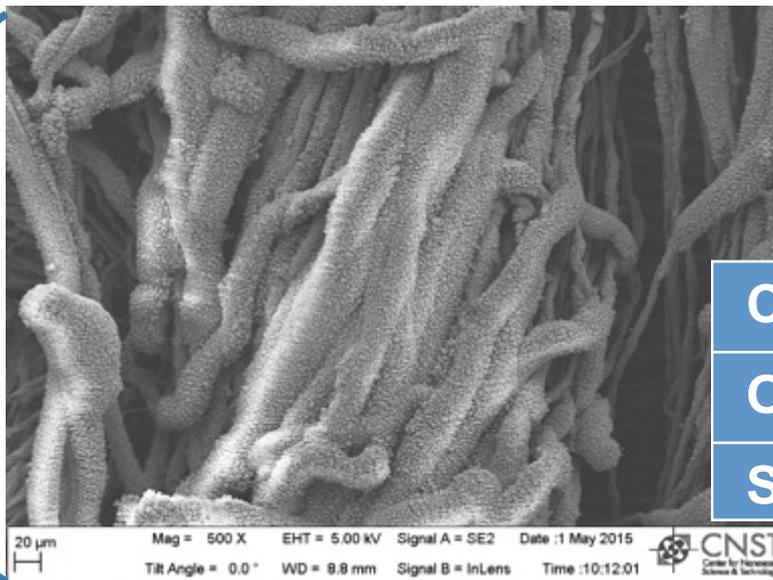
Hydroxide/silica

**Uncoated Fabric
(4x speed)**

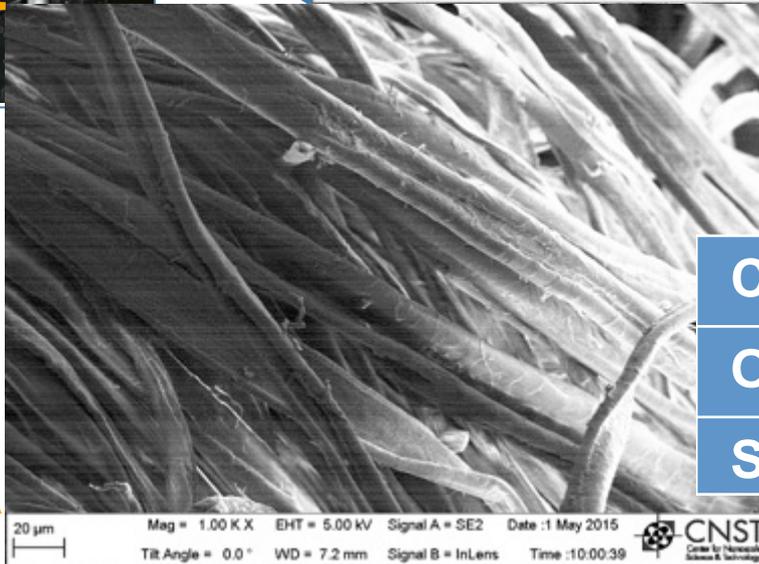
**Coated Fabric
(8x speed)**

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Fire Safe Fabrics



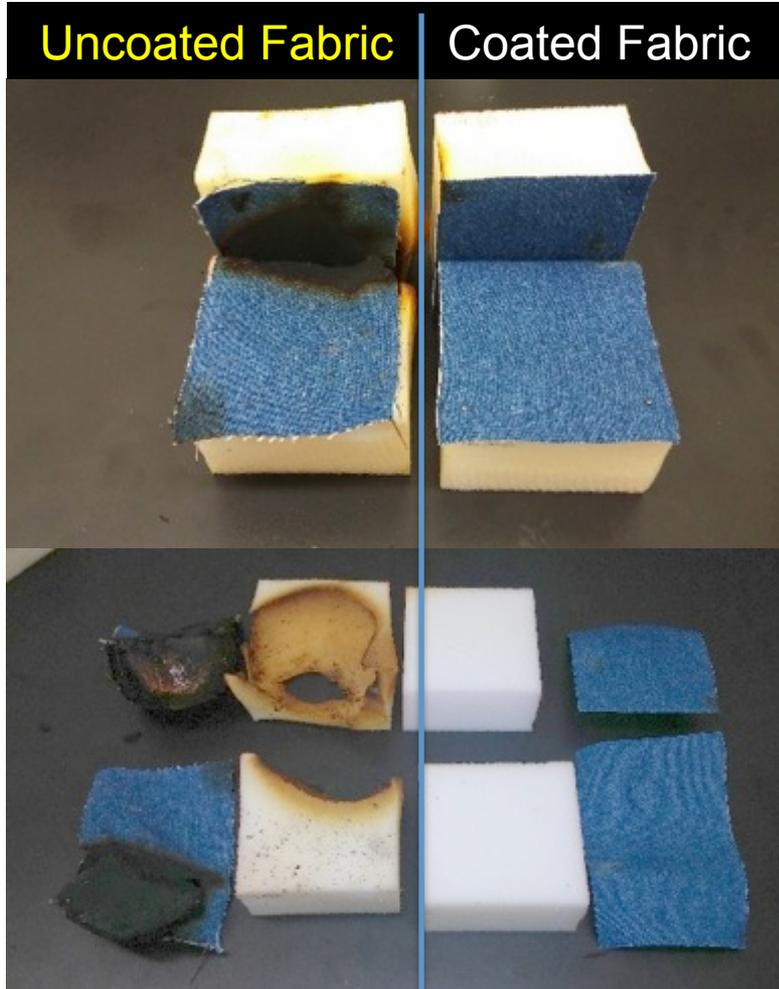
C (%)	5.7
O (%)	60.5
Si (%)	33.8



C (%)	73.0
O (%)	26.2
Si (%)	0.8

Fire Safe Fabrics

Post-Test Mock-ups



Baby Mock-ups

- High smoldering Cal 117-2013 foam
- NIST SRM 1196 Cigarette
- Cellulosic cover fabric (445 g/m²)
- Cover sheet

Cigarette extinguishes in < 1 min



Very promising fire retardant coating for fabrics

- Open flame and smolder resistant
- Flexible
- Easy to apply
- Versatile

Fire Blocking Barrier Fabrics

**guidance for furniture regulatory fire test and manufacturer
compliance**

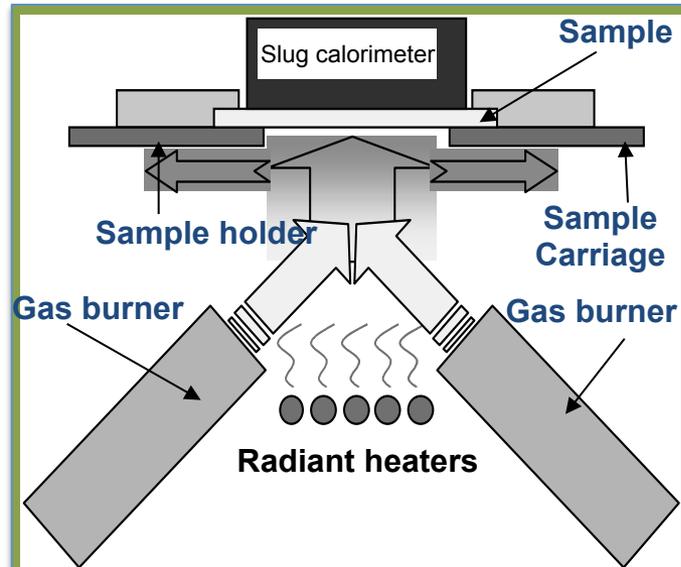
Collaborating with California Bureau and Consumer Product
Safety Commission

Barrier Fabrics

Ideal BF attributes – no thermal transfer, low combustibility, low gas permeability, high structural integrity char, no fire retardants (not reality!!!)

Need a suite of bench scale tools to guide BF development and usage in fire niter flammability regulatory compliance.

TPP test



**Heat transfer through
BF**

Thermal protective performance

Cone Calorimeter



Heat release rate of BF

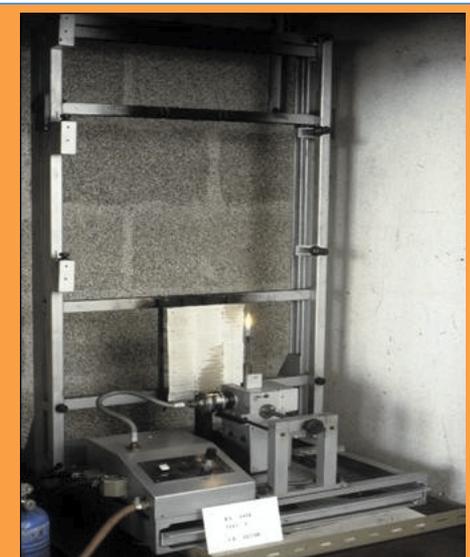
Ignitability

Heat release

Flammable content

Rate of fire spread

Mydrin test



**Composite Flame
Test**

FPUF/BF/CF

Fire protection of BF

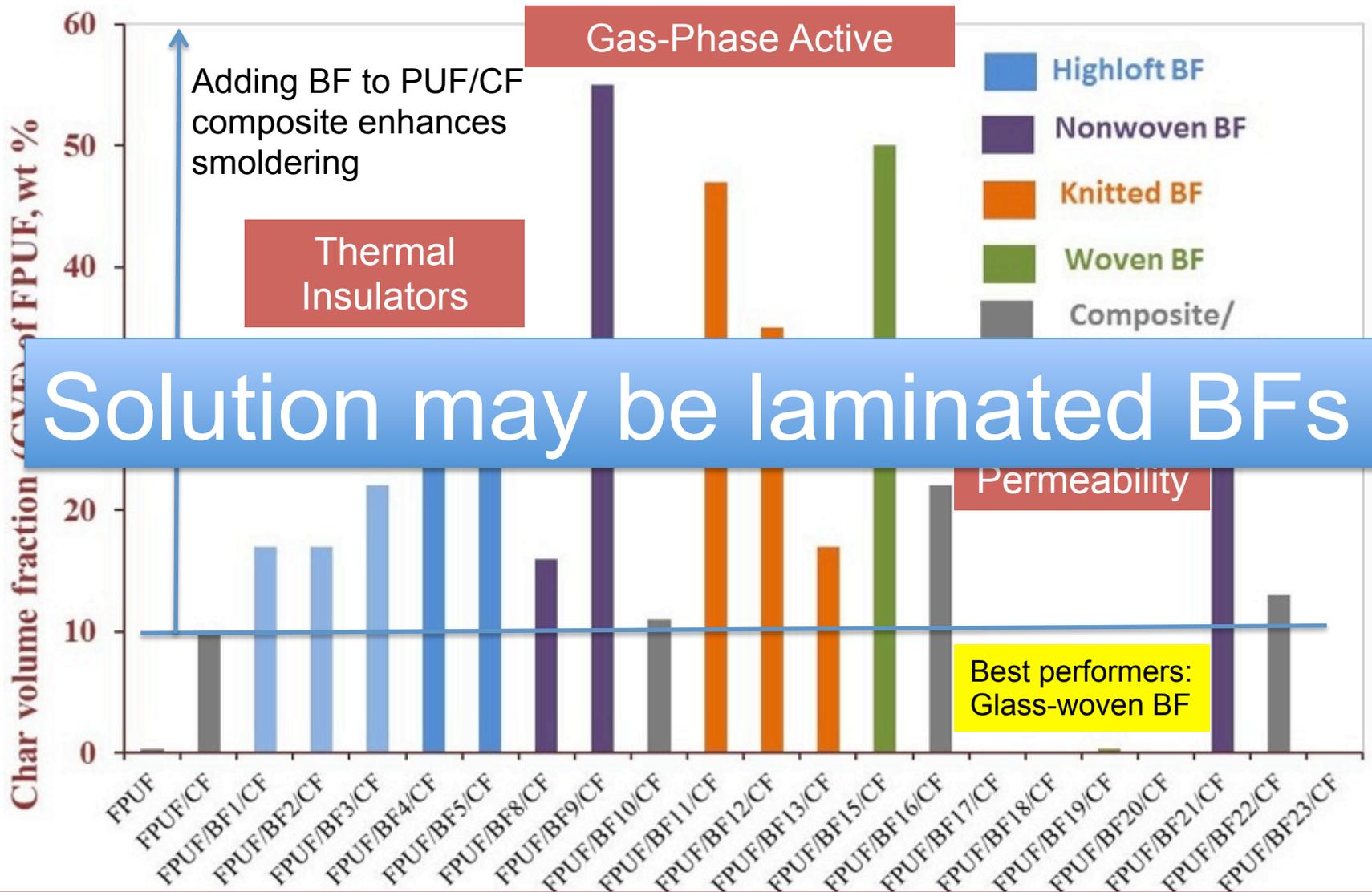
Barrier Fabrics

Fiber blend	Structure	Area density	Thickness mm	Type of BF	Application
FR rayon/polyester	Highloft	155	4	Passive	Residential Mattress
FR rayon/polyester	Highloft	230	7	Passive	Residential Mattress
Boric acid treated cotton/ FR rayon/polyester	Highloft	230	6	Passive	Residential Mattress
Boric acid treated cotton	Highloft	230	7	Passive	Residential Mattress
FR rayon/polyester	Needlepunched	237	4	Passive	Residential Mattress
FR rayon/polyester	Needlepunched	240	2	Passive	Residential Mattress
FR polyester /FR rayon	Needlepunched	240	2	Passive	Residential Mattress
Glass fiber core fiber sheath	Needlepunched	240	2	Passive	Residential Mattress
Glass fiber core fiber	Needlepunched	240	2	Passive	Residential Mattress
FR rayon/glass fiber/ poly lactic acid (PLA) fiber	Knitted	185	1	Passive	Upholstered seating (Cal 133)
FR rayon/crystalline silica fiber/poly lactic acid (PLA) fiber	Nonwoven	290	3	Passive	Upholstered seating (Cal 133)
Glass fiber	Woven	320	0.3	Passive	Upholstered seating (Cal 133)
Carbon fiber	Nonwoven felt	500	4	Passive	Upholstered seating Aircraft
Carbon fiber	Knitted	250	1	Passive	Upholstered seating Aircraft

BFs perform well in open flame tests:
Gas-Phase Active >> Thermal Insulation > Low Gas Permeability

Problem:
Most BF accelerate smoldering

Barrier Fabrics – Smoldering Ignition Testing



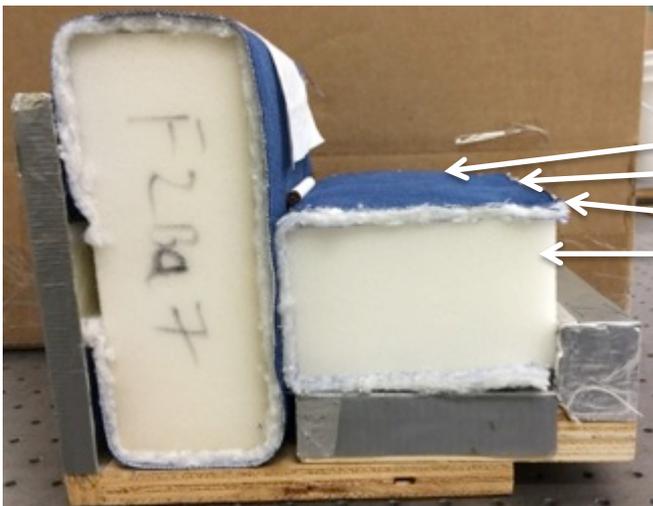
SMOLDERING: Low Gas Permeability >> Thermal Insulation > Gas-Phase Active

OPEN FLAME: Gas-Phase Active >> Thermal Insulation > Low Gas Permeability

Standardized Foam for Smolder Ignition Testing

for furniture regulatory tests

Guidance to California Bureau and Consumer Product Safety Commission

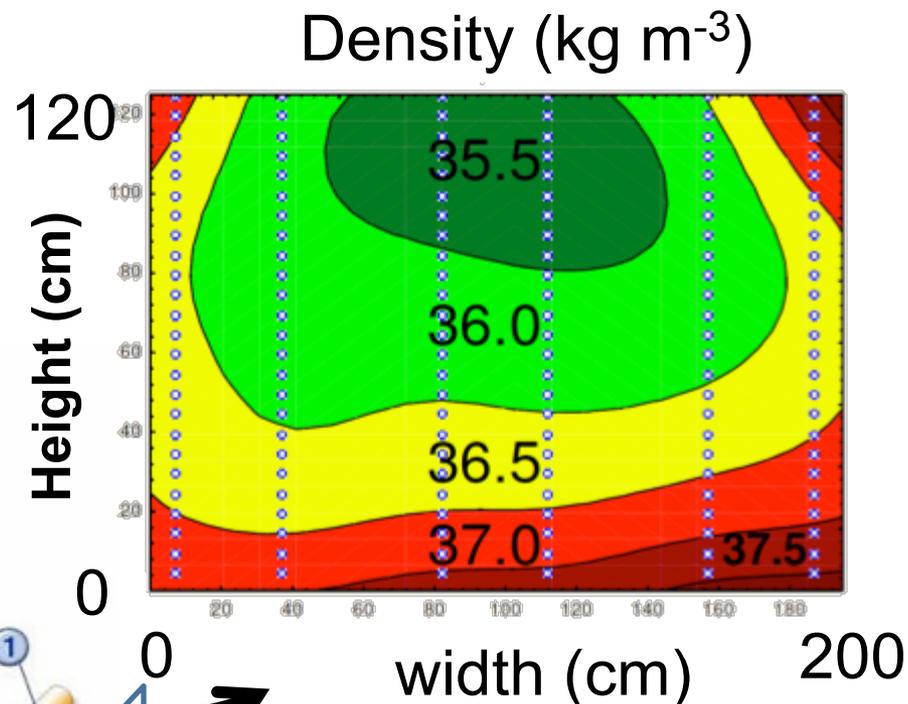
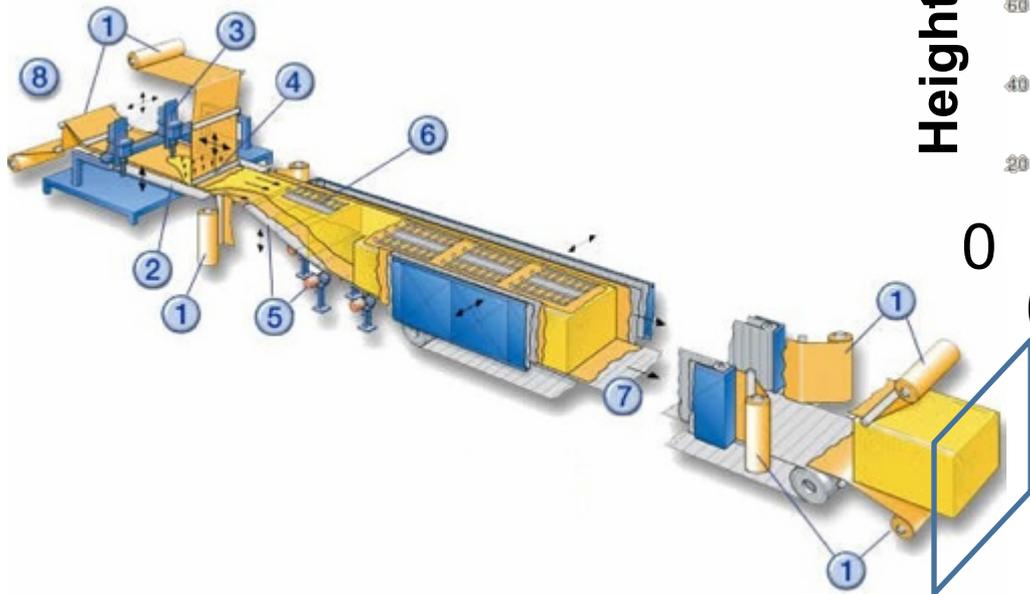


NIST SRM cigarette
Cover fabric (blue cotton)
Fire barrier (white)
Reference foam

Standard Foam for Smoldering Ignition Testing

Challenge: High variability of foam attributes that impact smoldering.

Foam production line:

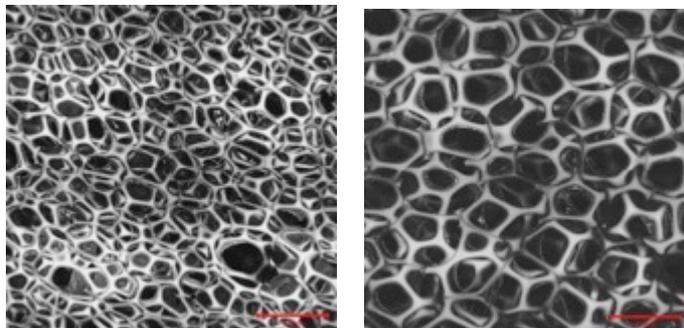


Factors studied: Density, air permeability, catalyst type and concentration, water concentration, and head pressure

Standard Foam for Smoldering Ignition Testing

- Issued NIST SRM 1202 – polyurethane foam and testing guidelines for assessing the smoldering ignition resistance of covering fabric for RUF.
 - SRM was manufactured to meet NIST specification on density and air permeability
 - Difficult to manufacture – NIST began looking for an alternative
 - Specifications used to defined foam in California’s TB 117 RUF regulation
- NIST defined a new parameter critical to smoldering - Specific Surface Area

Cell Size



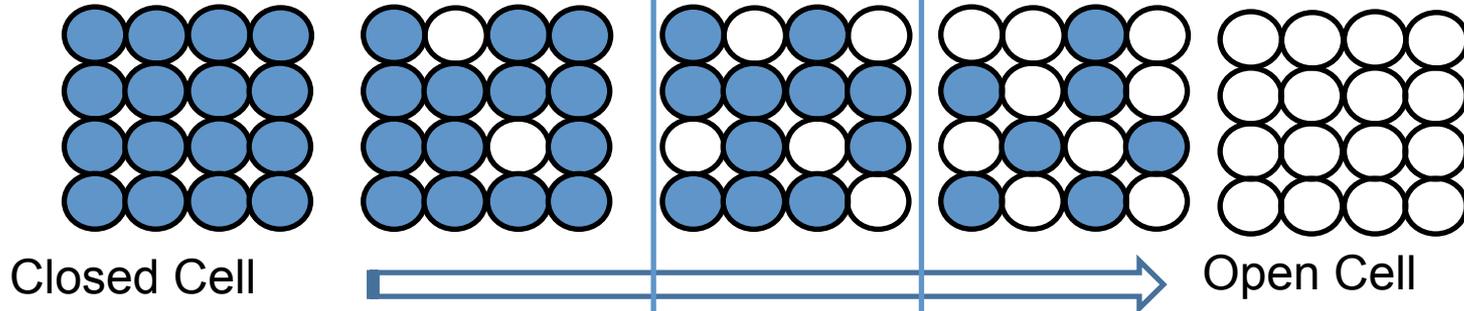
Cell Structure



Standard Foam for Smoldering Ignition Testing

Low permeability range (closed cell foam)

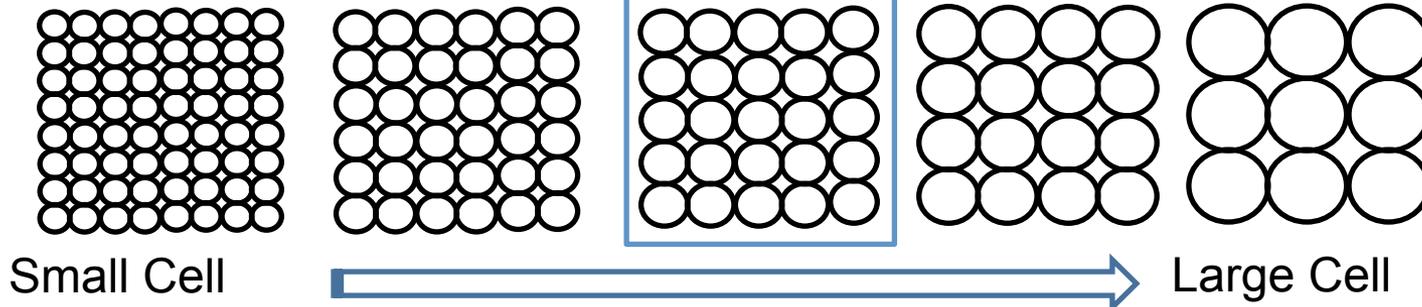
Same density and air permeability
Different specific surface area



Air Permeability \uparrow , Specific Surface Area \downarrow , Smoldering \uparrow

Recommendation – Reticulated Foam (no cell walls)

High permeability range (open cell foam)



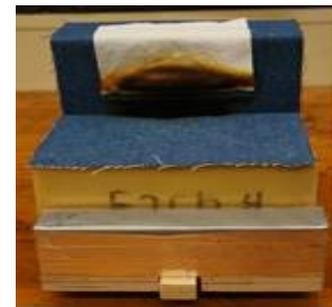
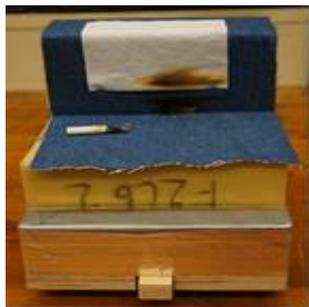
Air Permeability \uparrow , Specific Surface Area \downarrow , Smoldering \downarrow

Smolder Ignition Testing

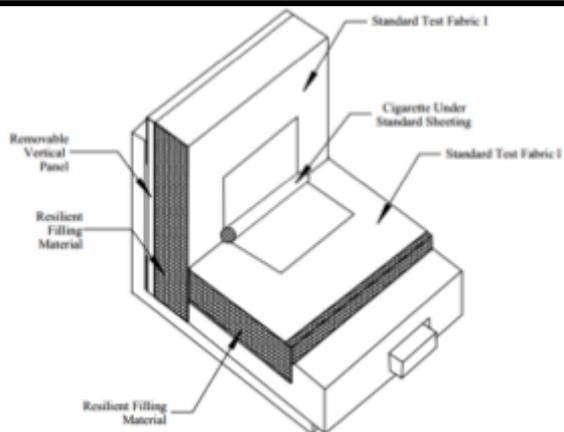
guidance for furniture regulatory tests

Smoldering Ignition Testing

Mock-up
with FPUF/
CF



FPUF after
removal of
char

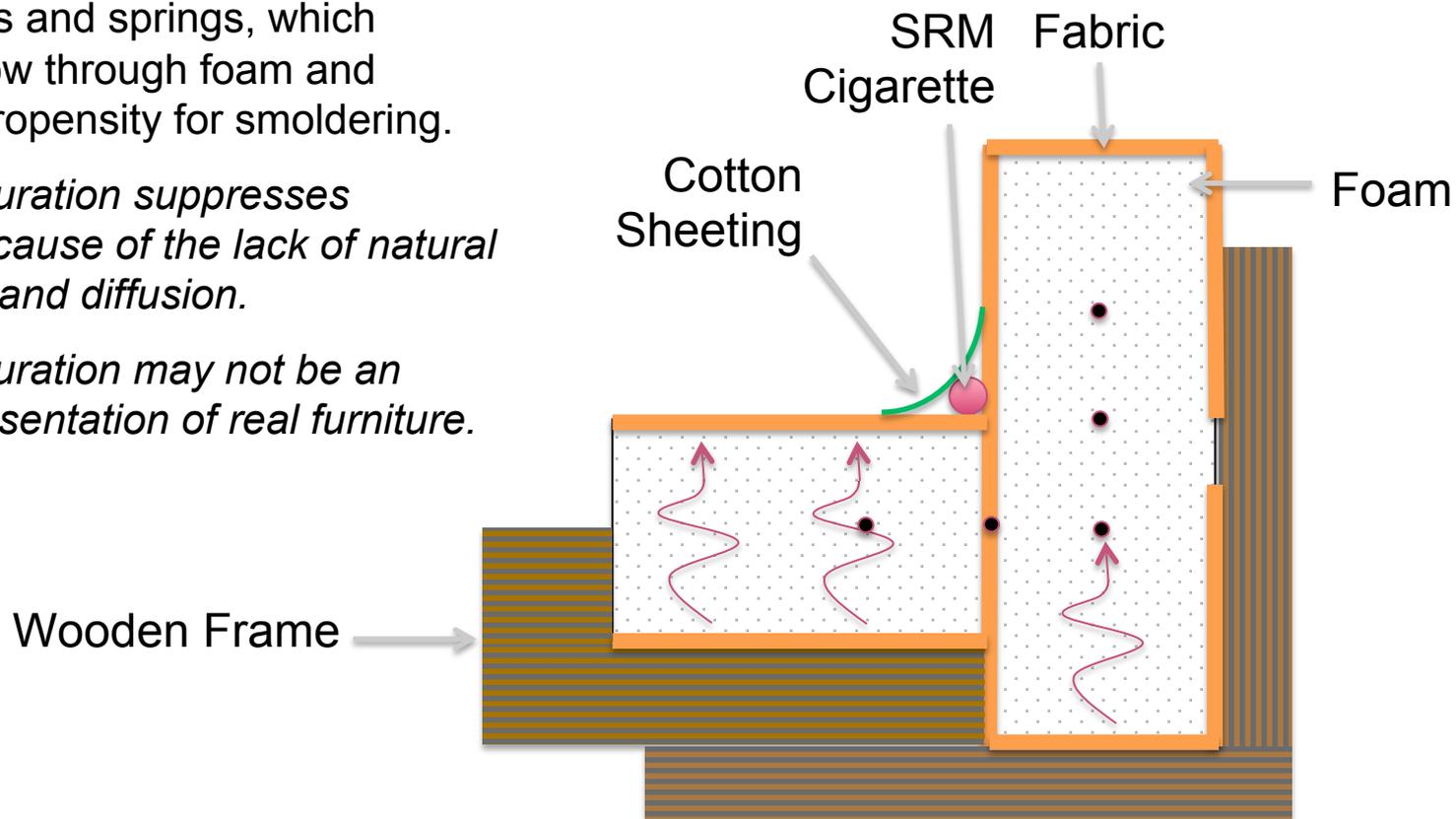


Mass loss is based on
mass after removing
char from foam.

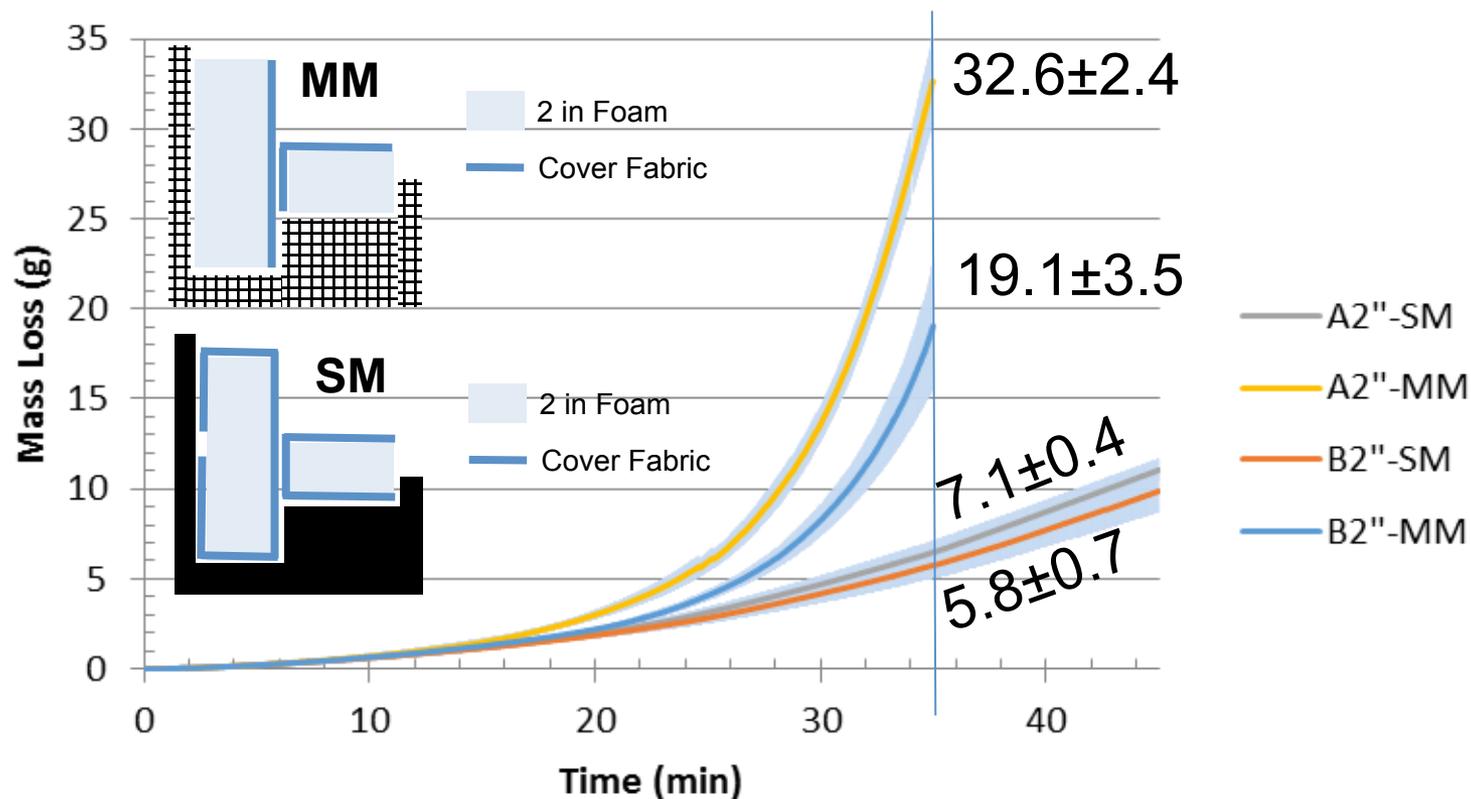


Smoldering Ignition Testing: Impact of Configuration

- Current standard mockup tests (TB117-2013 and ASTM E1353) mimics a scenario where furniture foam sits on a non-air-permeable substrate (e.g. the wooden frame).
- Household furniture typically includes open wooden frames and springs, which enhance air flow through foam and increase the propensity for smoldering.
- *Current configuration suppresses smoldering because of the lack of natural air convection and diffusion.*
- *Current configuration may not be an accurate representation of real furniture.*



Smoldering Ignition Testing: Impact of Configuration



- 3x to 5x higher mass loss with modified setup
- Concern: standard configuration may allow smolder prone fabrics

Summary

- FR coatings show great promise as “universal-like” technology for reducing the flammability of products
- FR coatings are EHS friendly and out perform existing commercial technologies (open flame and smoldering of RUF)
- NIST guidelines and understanding of barrier fabrics and smoldering
 - is enabling the development of RUF flammability regulations, and
 - helping manufacturers with a more immediate path to compliance (open flame and smoldering of RUF)
- Research is driven by strong stakeholder collaborations and input.
 - Consumer Product Safety Commission
 - California Bureau of Electronic and Appliance Repair, Home Furnishings and Thermal Insulation
 - Foam and Barrier Fabric manufacturers

QUESTIONS