# Soft Furniture Flammability Regulations and Development of Test Methods

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# Overview

- Residential fires: US scenario.
- Mattress flammability regulation: a success story.
- Current and proposed residential furniture regulations.
- Development of Test Methods.
- Standard Reference Materials.
- Final Remarks.

# Residential Fires: US Scenario

- **Larger houses**
  - Open floor plans
  - High ceilings
  - Large void spaces
- **Changing building materials**
  - Vinyl frames
  - Composite doors
  - PUF in rigid thermal insulatio
  - Gypsum board
- **New technologies**
  - Photovoltaic systems
  - Battery storage systems etc.

- Faster fire propagation.
- Shorter time to flashover.

- Shorter time to collapse.
- Shorter escape time.
- Multiple fatalities.

- Rapid changes in fire dynamics.
- More fire fighter injuries.

# The US Fire Problem (Residential ) (2009-2011)

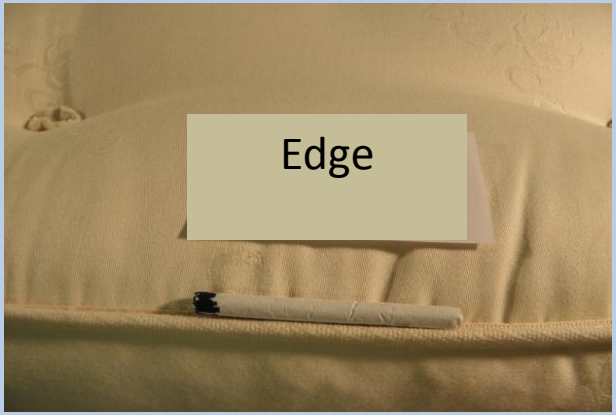
- 1,600 fatal fires in residential buildings.
- 2,495 deaths ( ie each fire claiming more than 1 .5 civilian).
- 79% of fatal fires extended beyond the room of fire origin. …leading to multiple fire fatalities.
- Leading areas of fire origin in fatal fires: bedrooms (26 %) and living and family rooms (23 %). …where you expect to find upholstered furniture items.
- Smoldering cigarette is common cause of fatal fires in residential buildings.

# The Mattress Flammability Regulations

Smoldering Ignition resistance

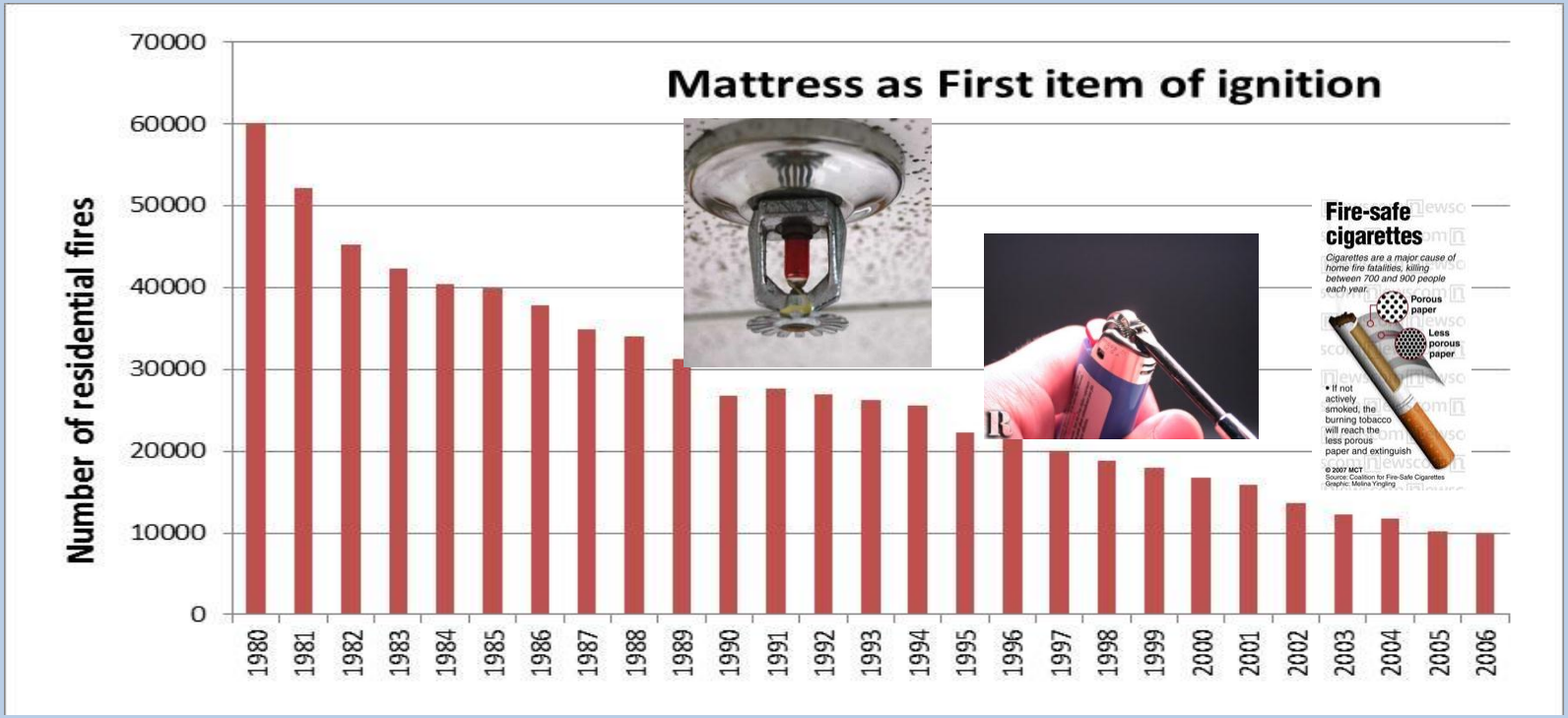
- Cal TB 106 (1970).
- 16 CFR 1632 The Standard for the Flammability of Mattress and Mattress Pads (1972).






- 18 cigarette test ( 9 on bare mattress and 9 with two-sheet test).
- Char length criterion of 2 inches maximum from the cigarette.
- Provision for prototyping and pooling.
- Includes component test for ticking and tape edge.

# The Mattress Flammability Regulations

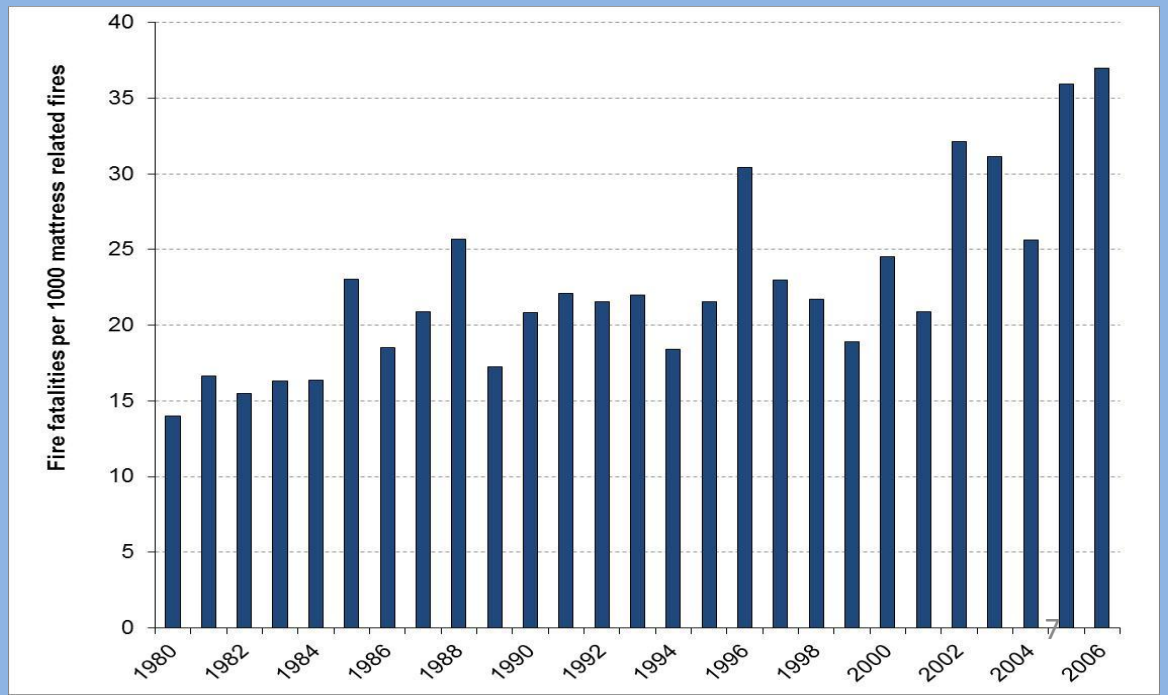



- NFPA Fire Sprinkler Initiative.
  - **Risk of dying decreases by 83%.**
- 16 CFR 1210 Safety Standard for Cigarette Lighters (2000).
  - **CPSC study showed reduction of 58% fires due to child safe lighters.**
- Introduction of reduced ignition propensity (RIP) cigarettes (2004).
  - **About 30% reduction due to RIP cigarettes.**
- Decline in percentage of population who smoke.

# The Mattress Flammability Regulations

## The need for open-flame standard

- Huge fuel load (mattress+ bed clothes).
- Smoldering fires transition into flaming fires.
- Thermoplastic fibers/battings/fillings burn vigorously when ignited.
- Potential for room flashover.
- Open-flame ignitions provide short time window for detection, escape and fire response.



# The Mattress Flammability Regulations

- 16 CFR 1633 The Standard for the Flammability (Open-flame) of Mattress Sets (2007).
- Performance based standard.
- Main objective was to reduce fuel load in mattresses and increase egress time.

# The Mattress Flammability Regulations

- Heat release capped: Max PHRR at 200 kW (30 mins) and THR of 15 MJ at 10 min.
- The 16 CFR 1633 standard is similar to Cal TB 603.
- The ignition source simulates heat flux of burning bedclothes.
- Challenges due to variations in:
    - Size
    - Geometry
    - Construction
    - Materials
- Right solution that is :
  - Cost effective
  - Does not impact comfort/durability
  - Passes the open-flame test.

# The Mattress Flammability Regulations: A Success Story

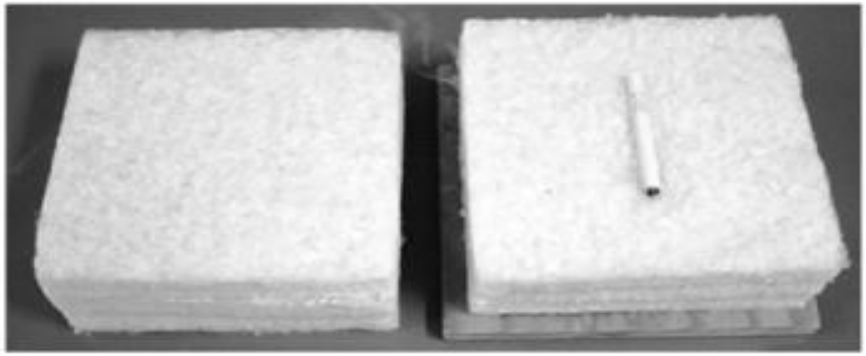
**Role of fire blocking barrier fabric is to prevent or minimize contribution of foam to fire.**

BF should

- be instrumental in extinguishing flames from burning cover fabric/ticking.
- provide adequate insulation to reduce heat transfer.
- not get involved in burning.
- have low permeability to limit pyrolysis underneath the barrier.
- have good structural integrity when exposed to heat and/or flames.

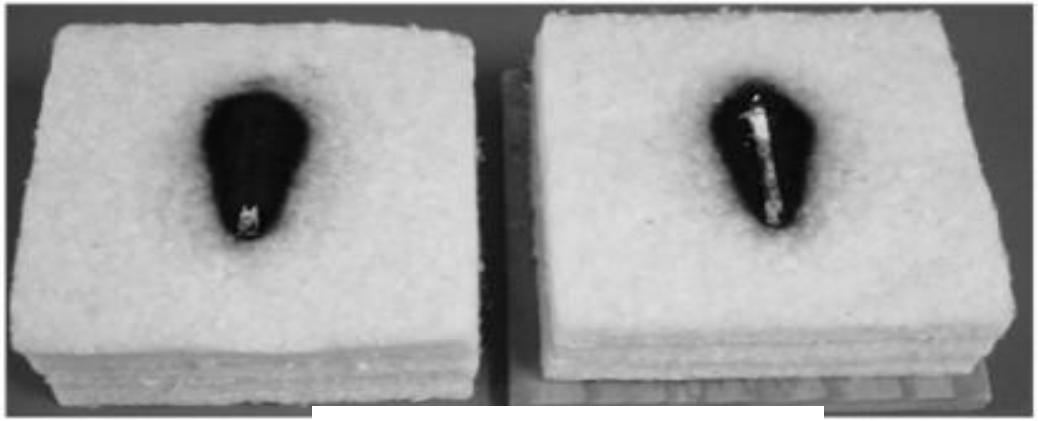
# Evaluation of Protective Performance of Fire Barriers

## Smoldering Ignition Test for Highloft Barriers



Start of ‘Sandwich’ test

Test in progress



End of test

# Evaluation of Protective Performance of Fire Barriers

## Open Flame Ignition Test for Highloft barriers

4” flame

BS Source 3 ( 350 ml/min)

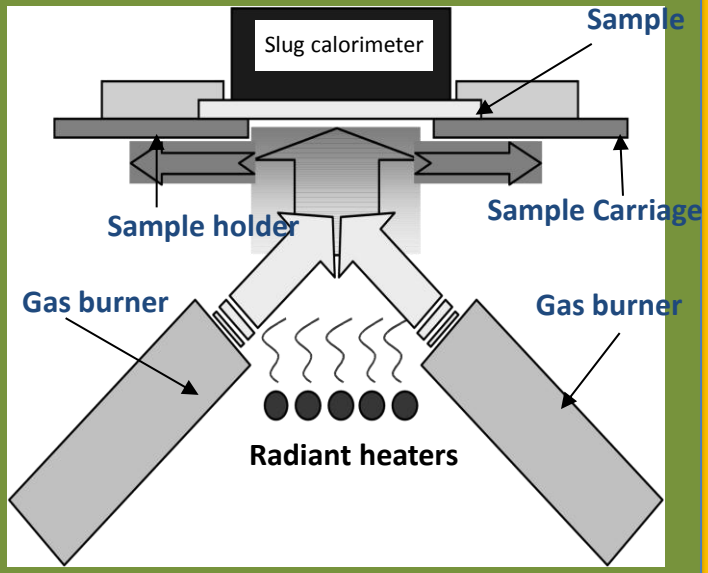
Specimen : 12” x12”
Flame application time: 10 mins
Fails if weight loss < 4%

# Experimental Barrier Fabrics

| Sample | Fiber blend | Structure | Area density, g/m² | Avg.thickness, mm | Application |
|---|---|---|---|---|---|
| BF-1 | FR rayon/polyester | Highloft | 155 | 4. | Residential Mattress |
| BF-2 | FR rayon/polyester | Highloft | 230 | 7 | Residential Mattress |
| BF-3 | FR rayon/polyester | Needle punched | 240 | 8 | Residential Mattress |
| BF-4 | Boric acid treated cotton/ FR rayon/polyester | Needle punched /Stratified | 230 | 6 | Residential Mattress |
| BF-5 | Boric acid treated cotton | Needle punched | 230 | 7 | Residential Mattress |
| BF-6 | Carbon fiber | Nonwoven felt | 500 | 4 | Aircraft seating |
| BF-7 | Carbon fiber | Nonwoven felt | 576 | 7 | Aircraft seating |
| BF-8 | FR rayon/polyester | Needlepunched | 237 | 4 | Institutional Mattress |
| BF-10 | FR polyester /FR rayon | Stitchbond | 165 | 0.7 | Institutional Mattress |
| BF-11 | Glass fiber core/ FR acrylic fiber | Knit Barrier using core yarn technology | 186 | 0.9 | Upholstered Seating |
| BF-13 | FR rayon/glass fiber/ poly lactic acid (PLA) fiber | Knit Barrier | 165 | 1.4 | Upholstered Seating |
| BF-15 | Glass fiber core/ FR acrylic fiber | Woven Barrier | 170 | 0.5 | Upholstered Seatings |
| BF-16 | FR rayon/crystalline silica fiber/poly lactic acid | Nonwoven | 290 | 2.9 | Upholstered Seating |

# Performance Evaluation of Barrier Fabrics

## TPP test




Heat transfer

## Cone Calorimeter

Heat release rate

## Mydrin test

Qualitative pass/fail test

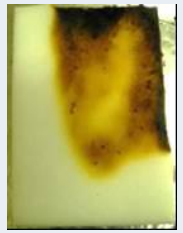
# Performance Evaluation of Barrier Fabrics

| Parameters | Performance Attributes |
|---|---|
| Heat transfer ($J/m^2$) | Thermal protection of cushioning components |
| TTI (s) | Ignitability of BF under burning cover fabric/ticking |
| PHRR ($kW/m^2$) | Maximum heat release to maintain positive feedback mechanism |
| THR ($MJ/m^2$) | Flammable content of BF |
| Char | Protective property of BF after been consumed in fire |
| FIGRA (kW/s) | Fire spread rate |
| Visible damage | Qualitative fire performance under end-use conditions |



Nazare, Davis, Pitts, et al., Guidelines for Evaluating Fire Blocking Barrier Fabrics, NIST Technical Note 1798, April 12, 2013.

# Summary of Results

| Sample | Area density, ($g/m^2$) | Thickness (mm) | Cone Calorimetry pHRR ($KW/m^2$) / FIGRA kW/s) | TPP test HTF (J/g)/TPI | MYDRIN test Ticking/BF/PUF | BF/PUF | PUF |
|---|---|---|---|---|---|---|---|
| Stichbond FR polyester / FR rayon | 165 | 1 | 102± 8 / (9) | 430/2 |  |  |  |
| Highloft FR Rayon/ Polyester | 230 | 7 | 138 ± 3 / (13) | 130/8 |  |  |  |
| Woven Glass fiber | 150 | 0.2 | 6± 0.5 / (1) | 287/4 |  |  |  |

Self-extinguishing

Thermally thick

Low gas-permeability

# The Residential Upholstered Furniture

- Why is the upholstered furniture flammability problem so complex ?
  - Current attempts towards regulating furniture are directed towards components as opposed to full-scale products.
- Why can we not use the same approach to the one used in residential mattresses?
  - Furniture industry is more rigid.
  - Fire barriers have to be resistant to both, smoldering and open-flame ignitions.

# The Residential Upholstered Furniture A Complex Problem

- First item ignited.
- Primary item contributing fire spread.
- 3D geometry
- Comfort/Aesthetics
- Cost
- Durability

# Residential Furniture Flammability
## Timeline of Requirements

- 1975: Cal TB 117 (National de fecto standard) Component tests, includes smoldering ignition and open-flame ignition tests.
- 1979: UFAC voluntary standard ( Cigarette ignition) Component tests.
- 1980: Cal TB 116( Cigarette ignition) Full-scale tests.
- 1991: Cal TB 133 (large open flame ignition) Full-scale test for UF in public occupancies.
- 2005: 16 CFR 1634 CPSC's Proposed rule for residential furniture.
- 2013: Cal TB 117 Component tests, includes smoldering ignition ~~and open-flame ignition~~ tests.

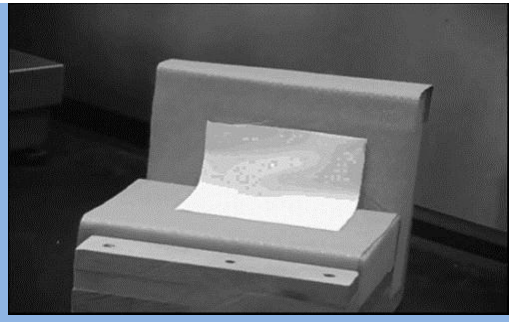
# Impact of Revised Cal TB 177 (2013)

- More thermoplastic cover fabrics,
- Eliminate FR in foams,
- Increased use of thermoplastic fiber battings,
- Increase fuel loads,
- Increase severity of fires,
- Increased smoke and toxic gases,
- Faster fire spread due to melt dripping,
- Reduce egress times.

# Cal TB 117-2000 Component Test
## (Small open-flame)

- Cover Fabric:
  - 45° burn test.
  - Small flame.
  - Almost all furnishing fabrics pass this test.
  - Not predictive of full scale performance.
- Foam:
  - Vertical test.
  - Small flame (12 s).
  - No Afterflame and minimum char length requirement.
  - FR additives required to pass the test.
  - Not predictive of full-scale performance.

# Cal TB 117 Component Test (Smoldering ignition)



- Cover Fabric:
  - 45 min test
  - Pass/fail criteria( char length < 45 mm)
  - Test result influenced by components of mock-up assembly.
  - Not predictive of full scale performance
- Foam:
  - 45 min test
  - Pass/fail criteria (mass loss <20%)
  - Prescribed cover fabric.
  - Not predictive of full-scale performance.

# Cal TB 117 Component Test
## (Smoldering ignition)

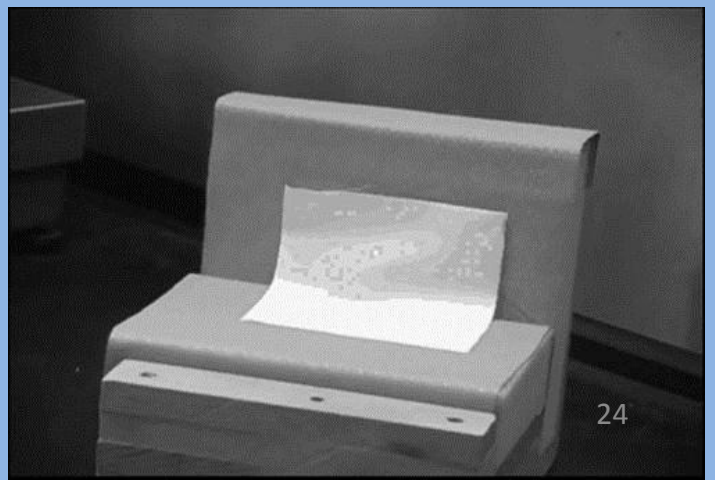
Resilient filling other than Foam

- 45 min test
- Pass/fail criteria (mass loss <20%)
- Prescribed cover fabric.
- Not predictive of full-scale performance.

# Cal TB 117-2013 Component Test (Smoldering ignition)

Barrier Fabric with Class II Cover fabric:

- 45 min test.
- Pass/fail criteria( char length < 50 mm).
- Test result influenced by components of mock-up assembly.
- Not predictive of full scale performance.

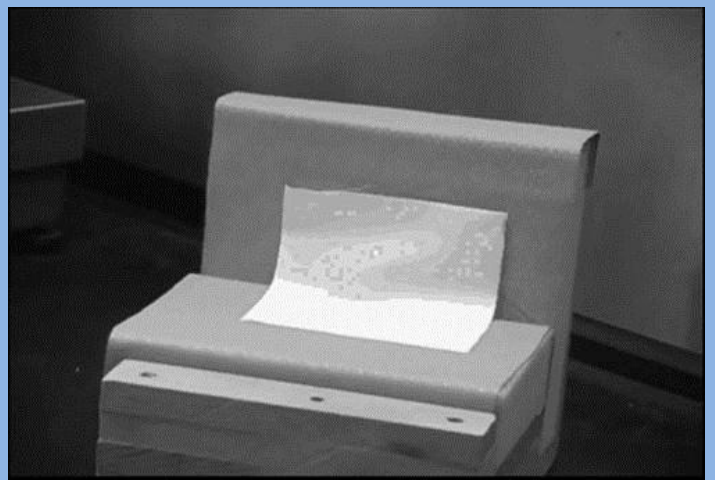


# The UFAC Requirements

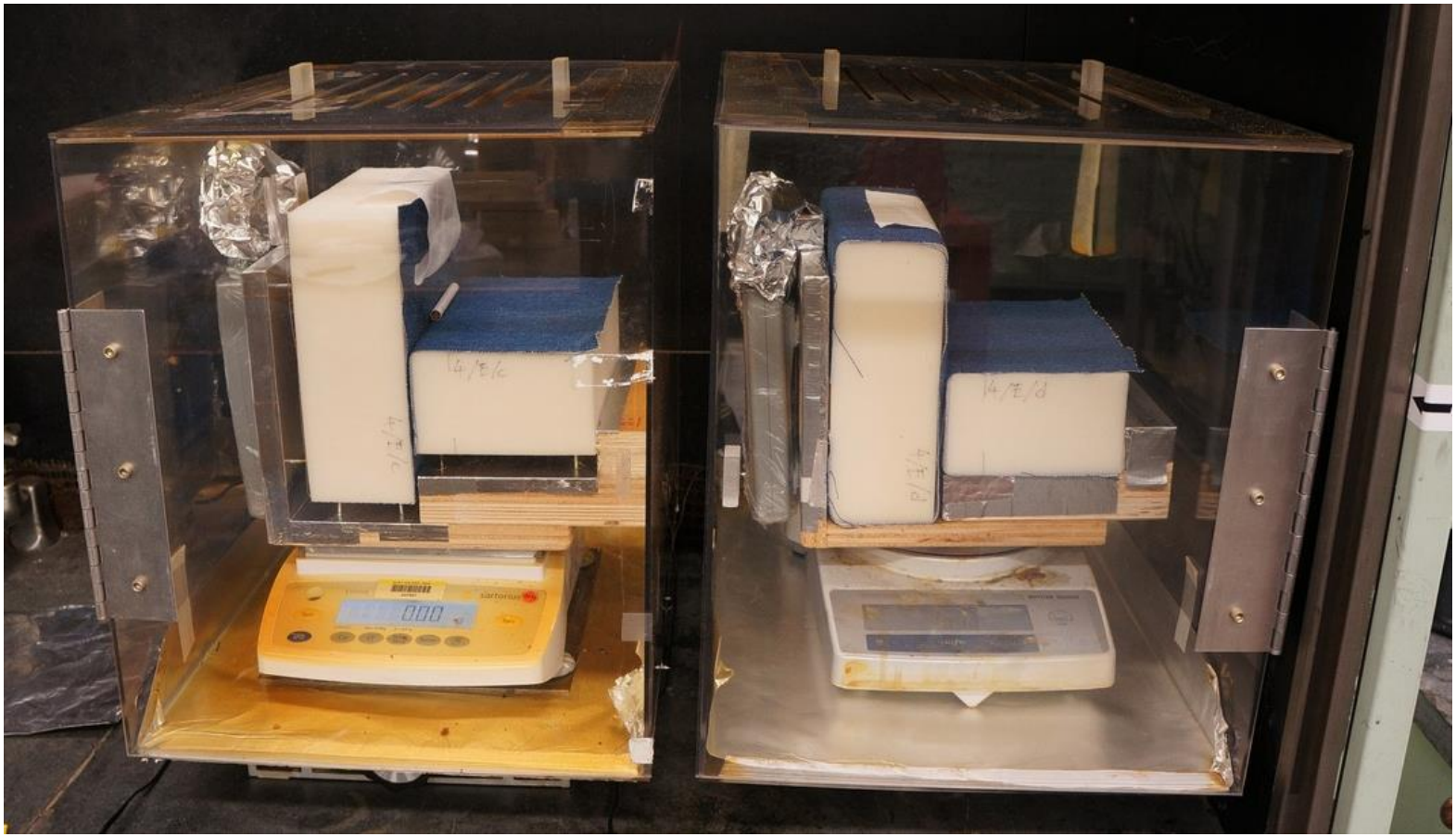
- Smoldering Ignition Test,
- Mock-up test,
- @ 25 mins test duration,
- Pass-fail criteria (Char length).
- Basis for several standard test:
  - ASTM E 1353
  - NFPA 261
  - CPSC's 16 CFR 1634 (Proposed).

Components tested

- ✓ Cover Fabric
- ✓ Barrier Fabrics
- ✓ Foam
- ✓ Loose filling



# Mock-up Configuration to Simulate Real-life Scenario



# Effect of Component Configuration on Smoldering Performance

Cover Fabric/BF/Polyester batting/Foam

Cover Fabric/Polyester Batting/BF/Foam

# Duration of Smoldering Ignition Test

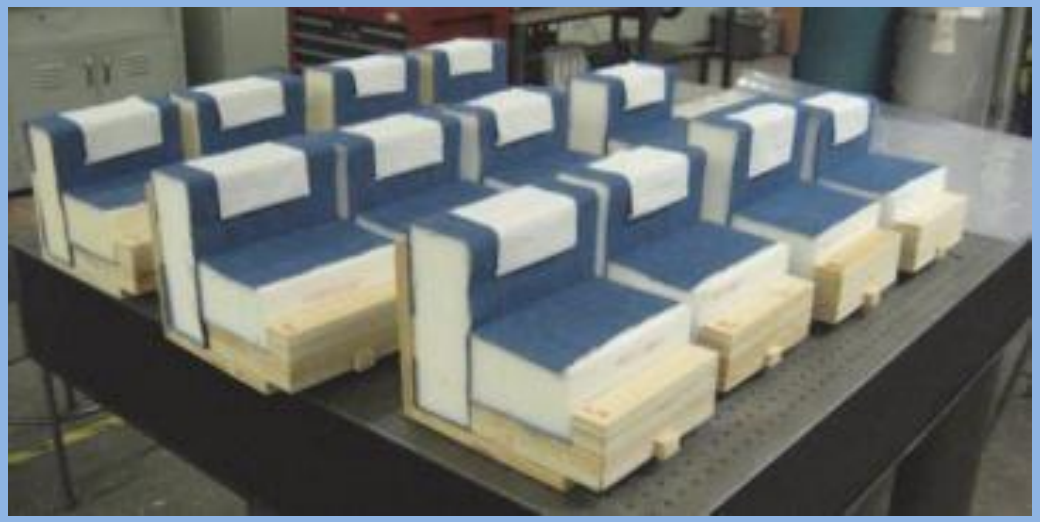
| | UFAC | ASTM 1353 | Cal TB 117 | CPSC |
|---|---|---|---|---|
| **Test duration** | @ 25mins | 45 mins | 45 mins | 45 min |

Remains of mock-up after 1 h

# Vertical Char Length Criterion

# CPSC's Proposed (2008) 16 CFR 1634 Residential Upholstered Furniture Flammability Standard

- Smoldering Ignition test for Cover Fabrics.
- Use of Barrier Fabrics for Class II cover fabrics.
- Smoldering and small open-flame ignition tests for barrier fabrics.



# Residential Upholstered Furnishings

## What needs to be done ?

- Establish regulatory framework based on performance requirements.
- Develop repeatable test methods that accurately predicts fire performance in the real world.
- Develop standard reference materials (SRM) for use in testing.
- Develop better fire barrier materials that will meet the fire safety requirements as well as requirements associated with comfort, durability and cost.
- Develop or implement other solutions such as other types of foam (U.K. model), LbL coated foams etc.

# Engineered Efforts for Reducing Furniture Flammability

- Research in developing Standard Reference Materials
  - SRM Cigarette.
  - Other Surrogate Ignition Sources
    - Ember and Ash
    - Arcing or heat from operating equipment.
  - SRM Foam (density, cell size, and air permeability).
- Improving ignition resistance through selection and design of cover fabrics.
- Development of ignition resistant barrier fabrics.
- Development of new generation flame retardants.

# Furniture Flammability- 4 decades of Unsolved Problem !