

Large-Scale Standards Testing (LST) Mattresses, Upholstered Furniture and Barrier Fabrics

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General Benefits of Furniture and Bedding Fire Standards

- Delay of Onset of Ignition
- Slow Fire Growth after Ignition
- Allow Occupant (s) increased Time to Recognize Fire, Call 911 and Escape
- Delay or Prevent onset of FLASHOVER fires, which typically results in Deaths, Serious Injury and massive Property Losses





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Three Classes of Furnishings Barrier Technology Can Address

1. **UPHOLSTERED FURNITURE**
2. **MATTRESSES, MATTRESS SETS AND FUTONS**
3. **FILLED BED CLOTHING**

Note: Use of Barrier-type Materials may also improve Fire Resistance of flat materials (bed sheets, pillowcases, non-filled pillow shams and mattress pads, furniture skirts, blankets and other textile fabrics not covered by mandatory or voluntary regulations)

Upholstered Furniture



Mattresses and Mattress Sets



Futons and Day-beds



Filled Bed Clothing (Comforters, Pillows and Mattress Pads)



Guiding Principles – Flame Resistant Barrier Use

- Barriers must reduce actual, recognized hazard (smoldering or flaming sources or both) and improve Fire Resistance vs. “traditional” constructions
- Empirical test data should demonstrate improved fire resistance performance
- Use of Barrier systems and incorporation into product (labor) must be technically and economically feasible.
- Final product must be saleable and meet all aesthetic criteria of the market.
- No New Health, Safety and Environmental (S.H.E.) Hazards can be introduced.

Hazard Addressed by Barriers

- Best case barrier systems address smoldering AND flaming potential of furnishings products (Focus of this discussion will be Flaming)
- Flashover occurs in typical bedroom or living room when ceiling temperature reaches 1000 °F, smoke and toxic gas layer moves towards floor, and peak Heat Release Rate (pHRR) reaches 1000 KW.
- “Point of No Return” typically reached when HRR is 500- 600 kW in typical bedroom or living room
- Barrier must reduce product’s tendency to burn rapidly and exceed this level of thermal power, to allow reasonable time for detection or escape
- Fires involving Flaming Ignition may reach Untenability Level in 2- 4 minutes vs. 30 – 40 minutes for Smoldering Fires
- Fire Department Response Times vary widely (based on urban vs. rural location, size of municipality, etc.)

LS Fire Test Standards Typically Employing Barrier Systems

- **California Technical Bulletins 121 and 129 (ASTM E1590-07) – Flame Resistance of Prison and Institutional Mattresses**
- **California Technical Bulletin 133 (ASTM E1537-07) – Flame Resistance of Public Occupancy Furniture**
- **CPSC 16 CFR 1633 – Flame Resistance of Residential Mattresses and Futons**
- **CPSC 16 CFR 1632 – Smolder Resistance of Mattresses and Futons**
- **California Technical Bulletin 116 (Finished Furniture Smoldering) and UFAC (Bench Scale Furniture Standards for Smoldering)**
- **Boston Fire Code, BFD IX-10 (Furniture Flame Resistance) and BFD IX-11 (Flame Resistance of Mattresses with Bed Clothing)**

Thermal Insults to Barrier-Protected Upholstered Furniture

California TB 133 Furniture Test – 18 kW Propane Square Gas Burner Flame applied (seat surface) for 80 seconds (1 hour test).

Failure Criteria:

- 1. Peak Heat Release Rate exceeding 80 kW in 1 hour or**
- 2. Total Heat Release exceeding 25 megajoules in first 10 minutes or**
- 3. > 75% Smoke Opacity at or above 4 ft level or**
- 4. CO Concentration > 1000 ppm for more than 5 seconds**

Note: Only Criteria 1. and 2. applied if Open Calorimeter used



Thermal Insults to Barrier-Protected Mattresses - Institutional

California TB129 Mattress Test – 17 kW T-Shaped Gas Burner Flame applied (to Border) for 180 sec (1 hour test).

Failure Criteria:

- 1. Weight loss in first 10 minutes equal to or greater than 3 lbs or**
- 2. Peak Heat Release Rate exceeding 100 kW in 1 hour or**
- 3. Total Heat Release exceeding 25 megajoules in first 10 minutes**

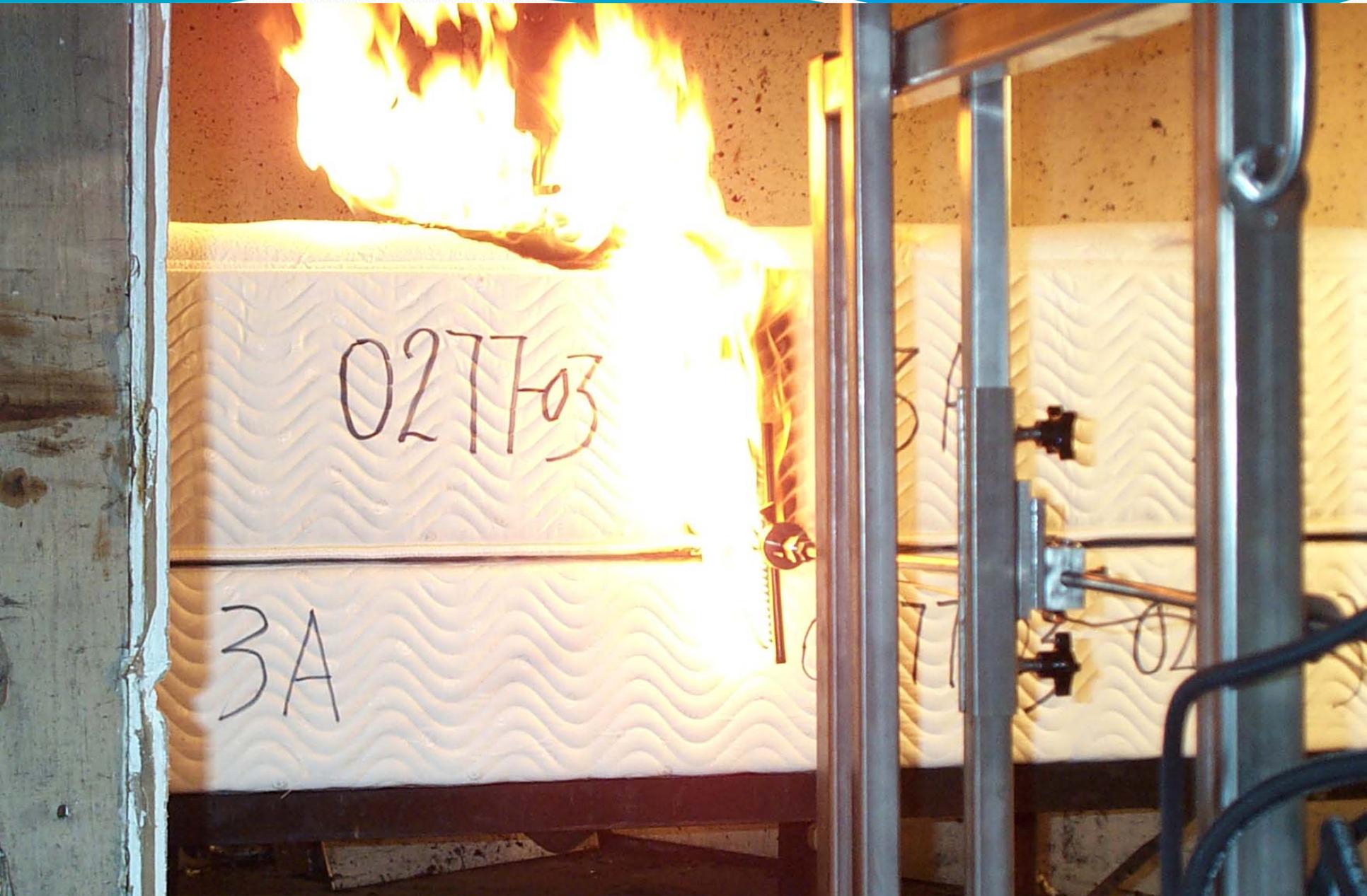
Thermal Insults to Barrier-Protected Mattresses – Residential

CPSC 16 CFR 1633 - 29 kW heat release rate for 50 sec (border flame) and 70 sec (top flame) (30 minute test).

Failure Criteria:

- 1. Peak Heat Release Rate cannot exceed 200 kW or**
- 2. Total Heat Release cannot exceed 15 megajoules in first 10 minutes**





16 CFR 1633 – Compliant and Non-Compliant Mattress Sets

Pass



Fail



Mattress Flammability Comparison

Both Products Pictured Two Minutes After Start of Fire



Common Mattress

Common Mattress Set Found in Homes Ignites Easily With Small Open Flame and Then Burns Intensely, Filling Room With Heat, Smoke



Improved Mattress

Mattress, Box Spring Set Built to Meet 16 CFR 1633 Standard. Subjected to Test Burner Flames for 70 Seconds, But Resist Fire for 30 Minutes

Thermal Insults to Barrier-Protected Bed Clothing – Residential

- **California Technical Bulletin 604 (Draft) Bed Clothing Flame Standard**
- **TB 604 contains 3 Sections:**
 - **Section 1 - Comforters and Bedspreads**
 - **Section 2 - Pillows and Bed Cushions**
 - **Section 3 - Mattress Pads**

Note: Products may benefit from use of Barrier encapsulation (pillows, bulk items) or F.R.-engineered fillings substituting for conventional fibers, etc. (comforters, bedspreads, mattress pads other flat products)

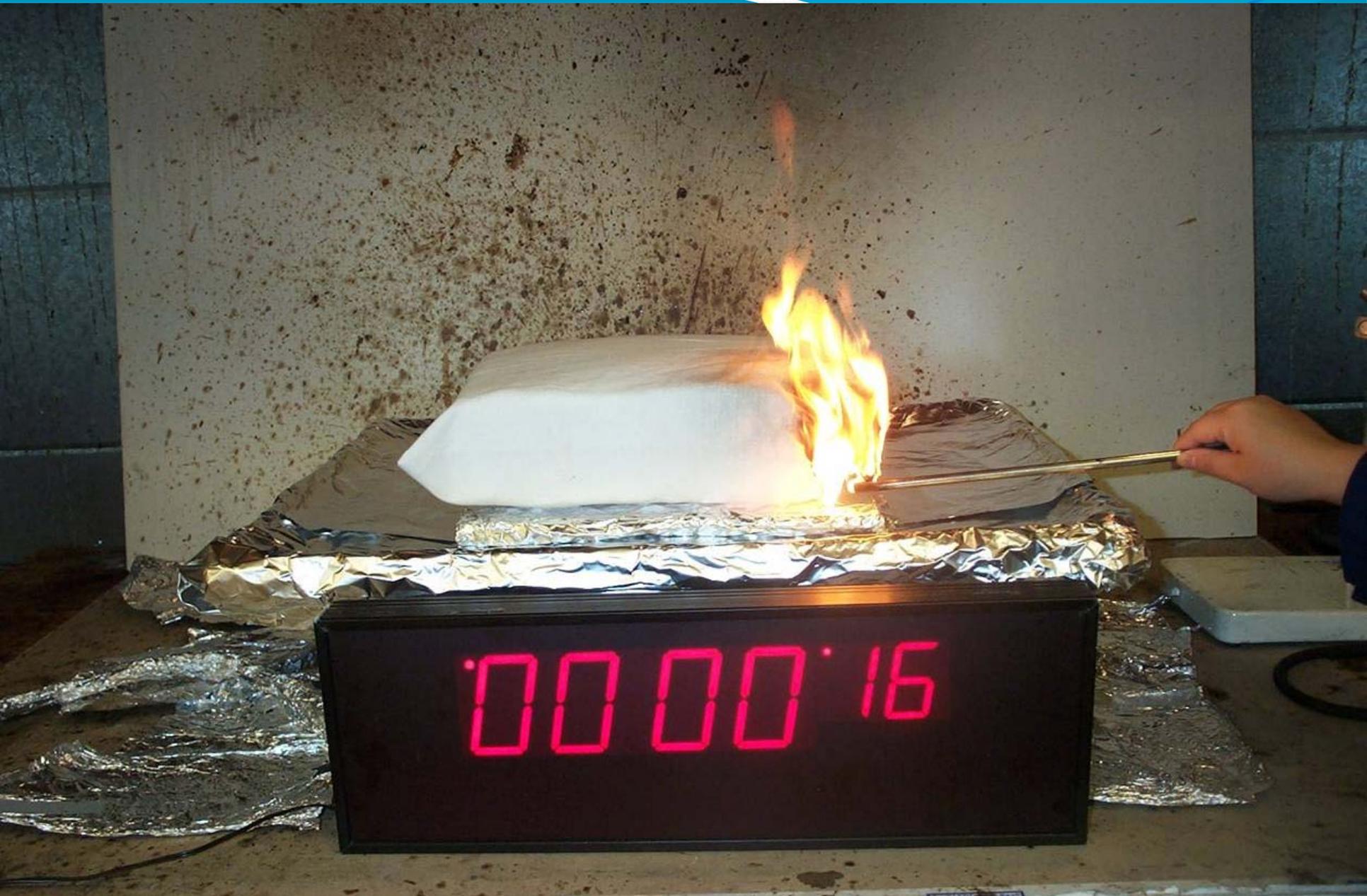


SAFETY INSTRUCTIONS
1. Read the instructions carefully before using the hood.
2. Do not use the hood for storage of chemicals or other materials.
3. Do not use the hood for drying or heating of materials.
4. Do not use the hood for the disposal of waste.
5. Do not use the hood for the storage of flammable or volatile liquids.
6. Do not use the hood for the storage of volatile solids.
7. Do not use the hood for the storage of volatile gases.
8. Do not use the hood for the storage of volatile acids.
9. Do not use the hood for the storage of volatile bases.
10. Do not use the hood for the storage of volatile salts.
11. Do not use the hood for the storage of volatile organic compounds.
12. Do not use the hood for the storage of volatile inorganic compounds.
13. Do not use the hood for the storage of volatile metals.
14. Do not use the hood for the storage of volatile non-metals.
15. Do not use the hood for the storage of volatile metalloids.
16. Do not use the hood for the storage of volatile noble gases.
17. Do not use the hood for the storage of volatile halogens.
18. Do not use the hood for the storage of volatile noble gases.
19. Do not use the hood for the storage of volatile noble gases.
20. Do not use the hood for the storage of volatile noble gases.

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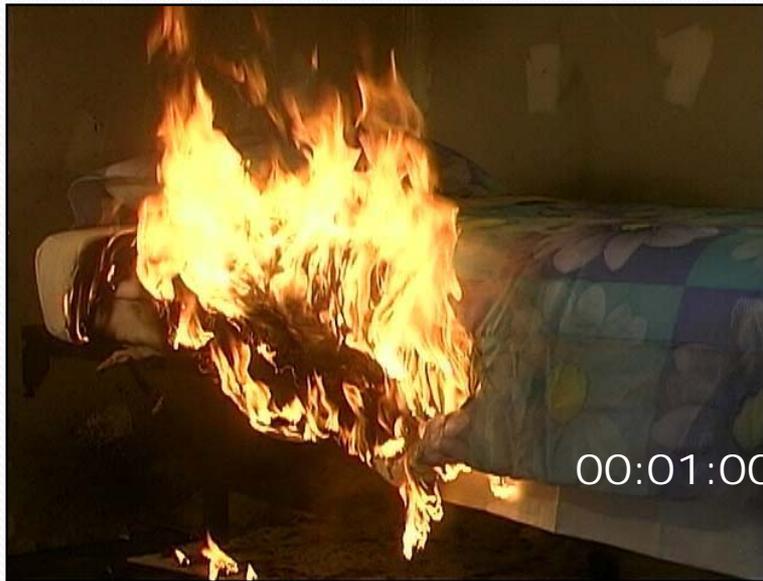
SONY
SONY

Control Knob



Comforter Flammability Comparison

Both Products Pictured One Minute After Start of Fire



Common Comforter

Comforter Commonly Found in Homes Ignites Easily and Burns Rapidly



Improved Comforter

Comforter Built to Meet California's Draft Proposed Safety Std TB 604 Resists Fire

Thermal Insults to Upholstered Furniture Mockups – Examples

- **California Technical Bulletin 117, Section A, part II (Shredded Foam) – must be encased in impermeable barrier insert**
- **California TB 117, Section B, part II (Feathers and Down) – must be encased in impermeable barrier insert**
- **Draft Revised California TB 117 (Feb. 2002), Section 5 – Includes barrier mockup flame test with actual fabric, barrier and filling material to be used in product**



2 27 2001



2.23.2001

Draft Revised CA TB 117 Upholstered Furniture Composite Mockup Test



**Furniture composite tested
without barrier**



**Furniture composite tested
with barrier**

Thermal Insults to Upholstered Furniture Mockups – Examples (2)

- **CPSC Notice of Proposed Rulemaking 16 CFR 1634 (March, 2008)**
- **Fabrics tested with cigarette over non-FR Foam must protect interior fills from progressive smoldering leading to flaming**
- **If Fabric fails smolder test, Barrier Mockup (w/ Std Fabric and Std Foam Fill) must meet Smoldering cigarette test and Flaming Ignition test (70 second gas flame) and Barrier must be used in product**

Large-Scale vs. Bench-Scale Tests and Barriers

- **Bench-Scale tests may not fully gauge fire performance of finished products containing identical components and barrier enhancements (due to geometry, time constraints and other factors)**
- **Use of a Barrier in Bench-Scale test may not predict Full-Scale performance of Finished Products with Barriers**
- **Establishment of Correlations between Small and Bench-Scale Tests and Large-Scale Tests are Critical to Development and Enforcement of Robust Standards**

Smoldering Thermal Insults to Mattresses and Furniture

- **UFAC furniture and California Technical Bulletin 116-compliant furniture - All cigarettes must self-extinguish (< 2 inch char length)**
- **CPSC 16 CFR 1632 Smoldering Tests for Mattresses/Mattress Pads - All cigarettes must self-extinguish (< 2 inch char length)**
- **Smoldering mitigated by choice of smolder-resistant fabrics or barriers**
- **Barrier issues for Mitigating Smoldering may be different than those for Flaming**



Strategies to Comply with Large Scale Furniture and Bedding Product Tests

- **Use Flame-Blocking Barrier Materials, with Flame-Resistant threads and tape edges to protect Foam and other fills**
- **Thorough Encapsulation of Combustible Fills is Essential**
- **Use Flame-Resistant foams, Cotton Battings and/or other fillings, to supplement barrier protection, when needed**
- **Use Flame-Resistant Barriers, Threads, Tape Edges and other fasteners, if needed**

Barrier Constructions in Finished Furnishings Products

- **Barrier may be incorporated into one component (i.e., encasement for Pillow with feather and down or Shredded Polyurethane Foam in current CA Technical Bulletin 117), leaving Other Parts of product still vulnerable**
- **Barrier can/should completely envelope all vulnerable areas of a finished product to prevent involvement of more combustible filling materials and minimize fire spread (i.e., barriers used in 16 CFR 1633 encase majority of mattress components, except for “sacrificial layers”)**

Barrier - Physical Considerations

- **Barrier must Prevent Thermal Transfer into Product via**
 1. **Conduction (Solids), and/or**
 2. **Convection (Liquid Pool Fires) and/or**
 3. **Radiation (Air Movement)**
- **Conduction is major factor in thermal transfer through Barriers**
- **Barrier Selected must be appropriate for**
 - **Size and Geometry of Product**
 - **Level of Initial Ignition Insult (Flame size, Duration and kW output)**
 - **Amount of Surface Burning above Barrier after Primary Ignition Source removed**
 - **Test Time**
 - **Failure Criteria (Stringency Level)**

Basic Barrier Mechanisms

- **Some Barriers prevent Flame Propagation by Smoldering (i.e., Cellulosic-based barriers for 16 CFR 1633)**
- **Some prevent Smoldering Propagation (i.e., Thermoplastic tickings for use in 16 CFR 1632-compliant mattresses) but may allow Flaming if exposed to Open-Flame Source**
- **Best Barriers minimize both Smoldering and Flaming propagation**
- **Fire Safety Goal is to reduce both Smoldering and Flaming as life-threatening hazards to building occupants**

How Barriers Fail

- **Barrier Degrades, Shrinks from Flame, Melts, Breaks Open (Flame Resistance mechanism or physical integrity compromised), allowing flame or heat penetration before completion of test**
- **Barrier Fastening Connection Points (threads, tape edges, fasteners) Break Open**
- **Barrier allows Pinpoint Flame Penetration or Heat Buildup in core fill, which burns and attacks Barriers from inside (i.e. PU Foam)**
- **Barrier Construction does not protect all Vulnerable (Combustible) Components in product (i.e., Skirts in Upholstered Furniture, Box Springs in Mattress Sets)**
- **Others ?**

Encapsulation of Combustible Components

- **Use of FR Barrier alone may not be sufficient for Compliance with a Standard**
- **All combustible fill components of any significant amount must be encapsulated and fill components must be hermetically sealed**
- **FR sewing threads, tape edge bindings, tufts and other fasteners are critical elements to join barrier edges and seams and prevent flame or smoldering incursion into fillings at vulnerable connection points**
- **Barrier is only as Effective as its Weakest Point especially for fires spreading (by smoldering or flaming) Laterally Across or Down Fabric surfaces**
- **Remember Barrier Protection for Box Springs, Foundations and Bed Platforms as well as Furniture Components which may be Combustible**

Early History of Barrier Use in Furniture

- **Original use was in Institutional Furniture and Bedding for Prisons, Hospitals, Nursing Homes, Auditoriums, Theaters, Stadiums and Hotels, etc.**
- **Catastrophic fire losses (MGM Grand - Las Vegas, Puerto Rico DuPont Plaza Hotel fire, etc.) were change drivers in 1980's**
- **Use of Barriers in Residential Furnishings initially considered too expensive and did not meet aesthetic and sales criteria**

Typical Barrier Materials Used in First Generation FR Furniture/Mattresses

- **Aluminized ACA Cotton Ticking (prison mattresses)**
- **Mineral Fiber Battings/Pads**
- **“Densified” Fiber Battings/Pads**
- **Fiberglass Blend Barriers/Pads**
- **FR Vinyl Sheeting**
- **Synthetic Aromatic Polyamides (Aramids)**
- **Fabrics with FR Chemical Additives**

Typical F.R. Core Fill Materials in First Generation Furniture/Mattresses

- **Melamine Foam Pads**
- **Combustion Modified High Resiliency (CMHR) Foams**
- **Polychloroprene (Neoprene) Foam Pads**
- **Hydrophilic Foam Pads**
- **Boric Acid/Borax-Treated Blended Cotton Battings**
- **Other types**

Current Trends in Barrier Use

- **Movement away from stiff, unworkable “First Generation” barriers (used initially in CA TB 133 and TB 129 products)**
- **Increased use of soft, “labor-friendly” and “user-friendly” battings as fire-blocking barriers driven by development of T.B 603/1633, Draft Revised CA TB 117, Draft CA TB 604 and proposed CPSC bed clothing standard and proposed CPSC upholstered furniture standard**
- **Barrier Battings are drop-in substitute for traditional Non-FR Synthetic Battings in current use and may replace several layered components, minimizing labor**
- **Some Barrier Component Tests now in place as QC measures for Manufacturers and Suppliers**

Recent California Bureau Experience with Barriers

- **California Bureau of Home Furnishings has tested 1000's of furniture and bedding products for enforcement and fee-for-service over 35 + Years**
- **For Technical Bulletin 121, 129, 116, 133, 16 CFR 1632, T.B. 603/16 CFR 1633 and other Large-Scale (Finished Product) Tests**
- **Tests included wide mix of products, sizes, brands and SKU's**

Mattress Barrier Analysis Data - California Bureau TB 603 Tests (2005)

- **Data set includes 51 Mattresses and Futons tested to TB 603 in 2005 (first year of enforcement of California standard and before enforcement of 16 CFR 1633)**
- **Data for Chemical Content Analysis of Batting and Pad-Type Barriers generated**
- **Percentages of each Generic type of Barrier tabulated**
- **Study was limited industry “Snapshot” of Barriers used in California Mattress/Futon products in 2005**

Barrier Analysis Information- 51 Mattresses/Futons (TB 603 compliant- 2005)

| | |
|-------------------------|--------------|
| Rayon | 47.1% |
| Cotton | 23.5% |
| Modacrylic/Rayon | 7.8% |
| Cotton/Rayon | 5.9% |
| Melamine | 3.9% |

| | |
|-------------------------------------|-------------|
| No FR Barrier | 3.9% |
| Wool | 2.0% |
| Polyester | 2.0% |
| Fabric Barrier (unknown) | 2.0% |
| FR Foam | 2.0% |

Observed Trends – Barrier Chemical Analysis (2005)

- **76.5 % of barrier materials used were exclusively cellulosic (cotton, rayon or combination).**
- **3.9 % were inherently flame-resistant (No FR Batting Barrier used).**
- **Data excluded any flat Fabrics which may have functioned as Barriers**
- **As Barrier Technology evolves, Barrier types identified in 2005 Subset not representative of current market**

Manufacturer's Quality Control Issues for Barriers

- **Use of Barriers of specific types in Regulated Products must be driven by Real-Life Fire Trends and Accurate and Comprehensive Incident Fire Data**
- **Synergies/Antagonisms between FR Barriers and other Product Components (Fabrics, Fills and Fasteners) should be well-understood.**
- **Furniture and Bedding Manufacturers must include Barrier Performance as an integral part of their Quality Control and Quality Assurance Program and not rely solely on Barrier Supplier's Claims**
- **Industry Quality Assurance Programs should establish Routine Testing of Barriers and other Critical Components**

Fire-Resistance Tests for Barrier Components

- **Driven by development of Federal and State Standards requiring voluntary or mandatory Quality Control and Best Practices**
- **Barrier Screening Tests Must be Empirically - Correlated to Full-Scale, Finished Product Performance to best extent and have Predictive Power**
- **Must be Economically Viable for Manufacturers by minimizing number of full-scale tests needed to comply with regulations**
- **Drives use of improved FR components and helps to identify Reliable Suppliers of Consistent Products**

ASTM D7140-07 – Test for Resistance to Thermal Transfer through Barrier

- **“Standard Test Method to Measure Heat Transfer Through Textile Thermal Barrier Materials”, (adopted 2007)**
- **Developed for Evaluation of Barrier Components for use in 16 CFR 1633 Mattresses but may have Value for Designing/Testing Fire-Resistant Furniture and Bed Clothing Products**
- **Should be part of any Supplier’s and Manufacturer’s Quality Assurance Program**
- **Is a Component (Screening) Test with Unknown Barrier material**
- **Not a Large-Scale Composite Test and if used to comply with 16 CFR 1633, not a substitute for required CPSC Mattress Prototype Tests**
- **Determines if Heat Transfer (within a specific time) through Textile Barrier material or laminate is sufficient to ignite contiguous core material (level of “Exposure Energy to Thermal End Point”)**
- **Barriers Failing this Test are Suspect for Use in Finished Products requiring Barrier Protection**

ASTM D7016-07 – Test of Edge Binding Components in Mattresses

- **“Standard Test Method to Evaluate Edge Binding Components Used in Mattresses after Exposure to An Open Flame” (adopted 2004)**
- **For evaluation of barrier components for use in California Tech Bulletin 603 (now 16 CFR 1633)**
- **Should be Part of any Supplier’s and Manufacturer’s Quality Assurance Program**
- **Screening test for sewing threads and mattress edge bindings when required for mattresses using barrier fabric**
- **Determines if Mattress Tapes and Sewing Threads support Combustion Afterflame, and/or Retain Structural Integrity after Flame Exposure**
- **Components may be evaluated independently or in specific combinations based on designs targeted**
- **Not a Large-Scale Composite Test and if used to comply with 16 CFR 1633, not a substitute for required CPSC Mattress Prototype Tests**
- **Determines if fastening components will withstand applied heat flux expected in 16 CFR 1633 and not shrink back, break open, melt, etc. exposing mattress fill**
- **Components Failing this Test are Suspect for Use in Finished Products requiring Barrier Protection**

Issues re. Future Use of Barriers

- **Can FR Batting Barriers be used to replace Conventional (Commodity) Fiber Battings (i.e., Polyester) in Upholstered Furniture to Encapsulate and Protect Fills**
- **What Role can FR Barriers play in Construction of Fire-Resistant Bed Clothing?**
- **Can Reliable Barriers allow future use of Non-FR Polyurethane Foam and other Combustible Fill Components, without compromising Fire Safety ?**
- **Can the success of 16 CFR 1633 (Using Flame-Resistant Barriers in Residential Mattresses in the US) become a model for Upholstered Furniture and Bed Clothing Design and Construction and ultimately lead to Effective Federal (CPSC) Standards in all Three Product Classes ?**
- **How is Barrier Use in Upholstered Furniture and Bed Clothing likely to be Different from, or Similar to, its Use in Mattresses?**

Other Barrier Questions

- **Can barriers evolve to be considered “standard” components of upholstered furniture and bedding versus “additional” components which add costs and labor ?**
- **What constitutes a Consumer- Friendly, Well-Understood, Accurate and Transparent Barrier Labeling System ?**
- **How can Supplier’s Proprietary Data re. Barriers be Protected while still using Effective Labeling ?**
- **How will possible FR Toxicity issues re. Barriers be resolved so that Fire Safety AND Environmental Safety are both enhanced for the Benefit of Consumers ?**



DISCLAIMER

The information presented here is solely the opinion of John McCormack, an independent fire consultant and private citizen and does not represent the interest of any company, association, government agency or other party.

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WORKSHOP AGENDA