Tab C

Technical Rationale Report for the CPSC Staff's 2005 Revised Draft Standard for the Flammability of Upholstered Furniture

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Rohit Khanna
Division of Combustion and Fire Sciences
Directorate for Engineering Sciences
U.S. Consumer Product Safety Commission
Washington, DC 20207

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1.0 Introduction

In October 2003, the U.S. Consumer Product Safety Commission (CPSC) published an advance notice of proposed rulemaking (ANPR) in the Federal Register, announcing the agency's intent to consider a proposed rule addressing the risk of residential fires associated with cigarette and small open flame ignitions of upholstered furniture. This ANPR expanded the scope of an ongoing regulatory proceeding initiated under a previous ANPR published by the Commission in 1994. The CPSC staff has developed a draft flammability standard containing test procedures and performance requirements to address the risk of deaths and injuries to consumers caused by upholstered furniture fires. The CPSC Staff's 2005 Revised Draft Standard ("draft standard") takes into consideration a number of technical recommendations submitted by stakeholders in response to the 2003 ANPR and subsequent public meetings.

This report contains the basis for the requirements in the draft standard, discusses major comments received on technical issues, and details areas where additional research is planned.

The draft furniture standard contains a series of flammability tests for materials used in upholstered furniture construction with respect to both smoldering and open flame ignition. These flammability tests use a bench-scale approach to construct mockups that represent the seating area configuration of furniture. The materials evaluated by the standard include upholstery fabrics, filling materials, and fire-barriers. Each material to be evaluated is assembled in a mockup in conjunction with standard test materials. An ignition source is placed in the intersection of the vertical and horizontal surfaces, i.e., the crevice location of the mockup. Observations and measurements of mass loss are recorded during the test duration. The acceptable performance of upholstery materials is demonstrated by the resulting mass loss being below specified limits.

2.0 Objective

The objective of the draft standard is to reduce the likelihood of deaths and injuries from upholstered furniture fires that typically result from careless smoking, children playing with matches/lighters, and accidental contact with small open flames. This will be accomplished by increasing the ignition resistance and slowing the burning rate of materials used in upholstered furniture manufacture, i.e. cover fabrics and fillings. The requirements in the draft standard establish test procedures and acceptance criteria designed to increase the ignition resistance and reduce the burning rate of materials that contribute to upholstered furniture flammability with respect to both smoldering and open flame ignition.

3.0 Upholstered Furniture Fire Hazard Data

Of the products within the CPSC's jurisdiction, ignitions of upholstered furniture are a leading cause of residential fire-related deaths, injuries and property damage. From 1999 through 2002 the total annual average fire losses for this 4-year period were 9,000 fires, 520 deaths, 1,040 injuries and $242 million in property damage[1].

Some of the reported residential upholstered furniture fires involved ignition sources such as larger flames or electrical sparks/arcs that are not within the scope of the draft standard, or where the involvement of the furniture is not clear. These fires are not considered addressable by the draft standard. About 53% of estimated fires that occurred during the 1999 through 2002 period would, however, be addressable by a flammability standard. Estimated addressable fire losses are shown in Table 1.

Table 1
Residential Upholstered Furniture:
Estimated Average Annual Addressable Fire Losses 1999-2002

	Smoking Materials	Small Open Flame	Total
Fires	3,600	1,300	4,800*
Deaths	300	60	360
Injuries	480	260	740
Property Damage	$91 million	$42 million	$133 million

*All estimates within categories are rounded; totals are based on un-rounded estimates; property loss estimates are unadjusted[1].

The table shows that ignitions from smoking materials (primarily cigarettes) account for about 80% of estimated deaths and about 65-70% of estimated injuries and property damage.

4.0 Development of the Draft Standard

During development of the draft standard, CPSC staff analyzed available hazard data, reviewed existing domestic and international flammability standards, visited upholstered furniture and textile manufacturing facilities, and held discussions with interested stakeholders/industry representatives. In addition, laboratory experiments were conducted to support the general approach, and to demonstrate the technical and commercial feasibility of the draft standard.

During this process, interested stakeholders provided useful data and suggestions pertaining to technical requirements and test procedures of the draft standard. The major comments on the draft standard communicated to staff in the form of written submissions and in discussions during public meetings are detailed in applicable sections in this report.

4.1 General Approach

Staff reviewed existing flammability standards and built upon research conducted following the 1994 ANPR to serve as guidance for a national standard. The primary standards applicable to the development of the draft standard include: the Upholstered Furniture Action Council

(UFAC) voluntary guidelines [2]; British Standards Institute (BSI) BS 5852[3]; and current and developmental California Bureau of Home Furnishings and Thermal Insulation (CBHFTI) Technical Bulletins 117[4,5]. Test methods from these standards are incorporated in national voluntary and international consensus organizations such as ASTM International, the National Fire Protection Association (NFPA), and the International Organization for Standardization (ISO).

4.2 Bench-Scale Test Methods

Most of the standards mentioned above use bench-scale test methods to evaluate the flammability performance of materials. These tests involve measuring the response of either individual materials or bench-scale test assemblies (i.e. mockups) of a combination of materials to a standardized ignition source.

Bench-scale tests evaluate the response of materials to an ignition source under controlled conditions, but due to smaller scale and simplified geometry, do not fully characterize finished products under actual fire conditions. The materials used and the geometry of mockups are significant factors in the extent to which the data obtained from bench-scale tests reflects the performance of finished products.

For purposes of this report, the term "composite tests" refers to bench-scale tests that evaluate the performance of a combination of two or more materials. "Component tests" are tests in which the material to be evaluated is tested alone. Composite tests can provide a predictable relationship to real-world performance when appropriate standard materials are used with good approximation to end use geometries as demonstrated by CBHFTI and discussed in the next section[6].

In the draft standard, materials to be used in furniture construction are evaluated in consistent bench-scale tests using mockups of materials to be tested in conjunction with standard test materials. The standard test materials are selected to exhibit appropriate flammability properties and reduce the introduction of variability in test results. For each test, materials are assembled in layers as they would be found in real furniture. Each upholstery material subject to the

standard is tested as part of a composite assembly, where the material's flammability performance is evaluated in conjunction with other standard test materials or with actual materials used in the furniture item's construction. For example, **see Figure 1 and Figure 2.**

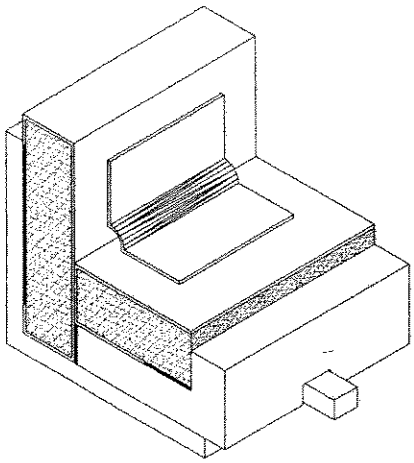


Figure 1 - Smoldering Test Mockup Assembly.

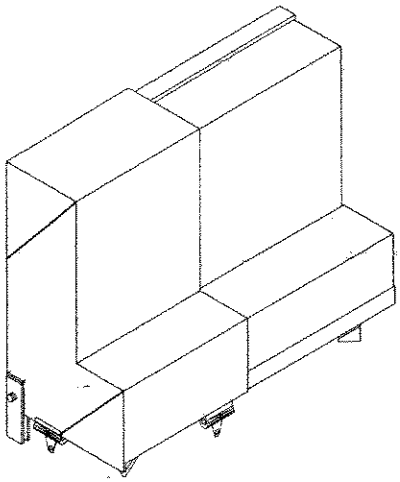


Figure 2 - Open Flame Test Mockup Assembly.

Discussion of Comments on Bench-Scale/Large Scale Testing

Throughout this rulemaking proceeding, the staff has been aware of the need to estimate the real-world effectiveness of the draft standard in reducing the risk of deaths or injuries from upholstered furniture fires. The staff recognizes that the flammability performance of upholstered furniture is most accurately evaluated in full-scale fire testing. Due to the variety of materials, geometries, and constructions used in the upholstered

furniture industry, a flammability standard requiring full-scale testing would be cost prohibitive. The test requirements in the draft standard comprise a reasonable system to evaluate the primary materials that contribute to furniture flammability. The application of bench-scale tests, consistent with current industry standards, was determined to be a reasonable alternative to full-scale testing.

Commenters have expressed a concern about relating bench-scale fire test data to full-scale furniture performance. Previous bench-scale furniture test approaches have been shown in laboratory tests to provide good approximation to real-world performance. Data [7], [8] that was collected during the development of the 2001 CPSC Draft Standard showed an 81% correlation of bench-scale to large scale test results. In support of the 2001 draft standard using a combustion time performance measure, 27 upholstered chairs manufactured in the United Kingdom (UK) were tested to evaluate the relationship between full-scale and bench-scale mockup tests where the primary performance measure was combustion time (limiting flaming to 2 minutes and smoldering to 15 minutes) after removal of the test flame. More recently, limited tests[9] conducted by CBHFTI and the Alliance for the Polyurethanes Industry (API)[10] on fabrics evaluated over a variety of filling materials showed good correlation between the bench-scale fabric test method contained in the draft TB-117 (2002) standard (TB-117+) and larger scale tests. The CBHFTI attributes the improved correlation of its fabric test to the application of a standard substrate during evaluation of fabrics as opposed to component testing of the fabric alone. The staff agrees with CBHFTI's assessment that evaluating composite assemblies of upholstery materials in bench-scale tests can be adequately representative of the fire performance of actual furniture.

In support of the current draft standard, CPSC staff is conducting a test program to evaluate the bench-scale to larger scale correlation of upholstery materials using mass loss as performance measure. This program is discussed in more detail later in this report.

4.3 Fire-Barriers and Interliners Option

CPSC staff and stakeholders agree that manufacturers and suppliers should have flexibility in the methods of

compliance with a standard. The development of flammability standards has led to technical advances in the textile industry with the development of fire-barrier materials. These fire-resistant materials can be in the form of upholstery fabrics, interlining fabrics, or interior materials located in furniture to reduce the spread of fire when subjected to an ignition source.

In cases where upholstery fabrics or filling materials may not comply with requirements of the draft standard, there are allowances for the use of fire-resistant materials that protect interior materials from significant involvement in a fire. The draft standard contains provisions for the use of fire-barriers that can include high loft battings, and interior or upholstery cover fabrics that provide resistance to smoldering and small open flame ignition. The allowance for the use of barriers and interliners provides greater flexibility for manufacturers and choices for consumers, especially for higher-end furniture using decorative fabrics.

4.4 Furniture Classification: Type I, II, III/III-B, and IV

In the draft standard, upholstered furniture materials are subject to applicable bench-scale smoldering and open flame test requirements based on the classification chosen by the manufacturer: Type I, Type II, Type III, or Type IV.

Type I furniture is defined in the draft standard as furniture that is produced with an interior fire barrier that is located between the upholstery cover fabric and the filling materials. The interior fire barrier must comply with the applicable smoldering and open flame bench-scale test methods specified in the draft standard. There are no additional requirements for any upholstery cover fabrics, resilient, fibrous or loose filling materials in Type I furniture.

Type II furniture is defined in the draft standard as furniture that is produced with a cover barrier (e.g., leather, wool, or FR fabrics) as the outermost upholstery material. Cover barriers must comply with the applicable smoldering and open flame bench-scale test methods specified in the draft standard. There are no additional requirements for any resilient, fibrous or loose filling materials in Type II furniture.

Type III furniture is defined in the draft standard as furniture that is produced with upholstery materials that individually comply with applicable smoldering and open flame bench-scale tests specified in the standard. Cover fabrics are required to only meet a smoldering ignition test. If loose filling material is present and qualified with an interliner, it is designated as "Type III-B".

Type IV furniture is defined in the draft standard as furniture where the actual combinations of materials intended to be used in a finished piece of furniture are tested to applicable smoldering and open flame bench-scale tests. This testing approach may be advantageous for certain furniture where the use of the combination of actual materials provides better flammability performance than indicated when individual materials are tested with standard materials as in Type III tests.

4.5 Mass Loss Performance Measure

4.5.1 Mass Loss Application in Smoldering Tests

Most furniture flammability standards that evaluate smoldering behavior use char length measurement to assess performance of materials. Char length measurement in the UFAC and ASTM standards is recorded only in the upward vertical direction. However, upward vertical char does not account for the progression of downward smoldering that has been observed in CPSC laboratory testing [11]. Upward vertical char often occurs in materials with poor smoldering ignition resistance

Full-scale and bench-scale tests show that smoldering can progress in any direction from the ignition source, including downward and/or into the interior materials. Since smoldering is a 3-dimensional phenomenon, a 1-dimensional char length measurement is not a sufficient parameter to determine smoldering behavior. Since mass loss better characterizes the three-dimensional progression of smoldering, it has been selected as the performance criteria. This approach is generally supported by stakeholders.

4.5.2 Mass Loss Application in Open Flame Tests

As mentioned above, current open flame furniture standards use a variety of parameters to assess

flammability behavior. These parameters include flame spread, combustion duration, heat release rate (HRR), and mass loss. Flame spread measurements have traditionally been used to evaluate the burning behavior of apparel fabrics and automobile upholstery. The utility of flame spread to assess burning behavior in upholstered furniture is limited since it is a one-dimensional measurement, and does not account for burning progression into interior materials. The duration of smoldering and flaming combustion is used in some flammability standards [3,4] as a performance measure to evaluate ignition hazard, but does not by itself constitute an adequate performance measure. The severity of burning is not accounted for when using combustion duration measure to assess material flammability. In addition, there is a level of subjectivity in determining combustion duration.

Heat Release Rate and Mass Loss

The HRR is the amount of heat generated during burning per unit of time and is recognized as an important parameter when assessing the fire hazard of a material or product. HRR is usually measured in units of kilowatts (kW). After ignition, current upholstered furniture is capable of producing a HRR ranging from 1 to 3 megawatts (MW), which can result in a flashover condition of a normal size room. Limiting and controlling HRR is important to reduce the severity of upholstered furniture fires. The measurement of HRR in complex assemblies such as upholstered furniture requires full-scale testing and advanced laboratory equipment to obtain accurate results.

The HRR depends on many factors such as the size of the room, ventilation, and the efficiency of the combustion process. In the case of complete combustion of a material, the HRR is related mathematically to the mass loss rate by the following equation:

$$Q = \Delta h_c * \dot{m}$$

Where
Q = HRR
Δh_c = heat of combustion
$\dot{m}$ = mass loss rate

The effective heat of combustion is not constant throughout the combustion process of composite materials;

therefore the use of mass loss data in the calculation of HHR requires validation with laboratory testing. Mass loss provides a good performance measure of burning rate to distinguish between materials that ignite and burn readily and those that resist ignition and burn slowly. Mass loss is an accurate parameter that reduces the introduction of data error and subjectivity associated with other flammability parameters. Flammability parameters such as char progression, flame height, or combustion duration observations require a higher degree of interpretation by test operators during data recording that is not present with mass loss measurements. In addition, mass loss data requires no specialized equipment and can be conducted in most laboratories. There is potential for bench-scale mass loss data of materials to be translated to estimate HRR of full-scale furniture and in fire modeling.

Comments on Mass Loss Measurement in Open Flame Testing

Some commenters stated that mass loss is a superior performance measure that should be used in a national flammability standard for reasons that mass loss is a relatively simple, accurate measurement. Mass loss has been used to establish the precision and bias of other flammability test methods. Most commenters agreed with the application of mass loss measurement for the open flame requirements in the draft standard.

4.6 Standard Cover Fabric

A standard cover fabric is used for evaluation of the flammability performance of filling materials, interliner fabrics, and interior fire barriers. The standard cover fabric represents the outermost layer of upholstered furniture constructions, which is typically the first material to be exposed to an ignition source. The use of a standard cover fabric during the evaluation of upholstery materials (e.g. filling, interliner, and interior fire barriers) in a composite mockup provides a better indication of real world fire performance than a component test.

CPSC staff tested several fabrics for potential use as a standard cover fabric. The criteria for a suitable standard cover fabric was smolder propensity, open flame ignition propensity, consistency, fabric construction, and commercial availability. To ensure repeatability of the

standard cover fabric's combustion behavior, there are specific smoldering and open flame test performance requirements for the standard cover fabric to meet.

In smoldering ignition tests, CPSC data [11,12] suggests that a fabric with these properties (referenced as Fabric 24 in the CPSC tests) is a reasonable choice as a standard fabric due to its relatively high smolder propensity. In addition, Fabric 24 has been specified in CBHFTI TB-117 as a standard test fabric for smoldering ignition performance. In small open flame ignition tests conducted by CPSC in 2004, [13] Fabric 24 exhibited consistent burning behavior and provided an adequate level of heat output for the evaluation of underlying upholstery materials. Upholstery filling materials that exhibited acceptable open flame results when tested with Fabric 24 typically contained some level of FR treatment. See **Figure 3.**

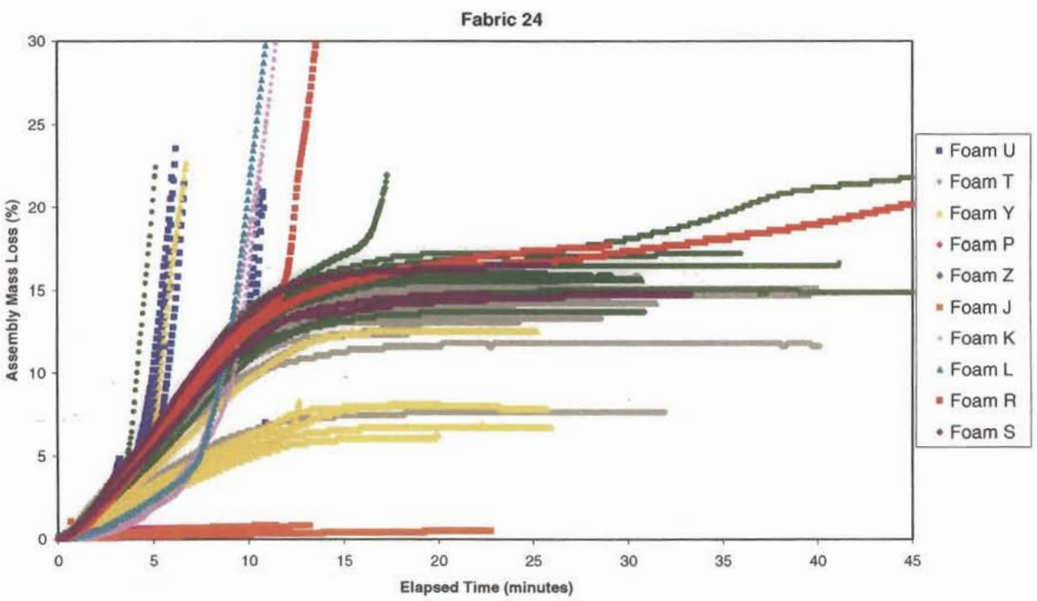


Figure 3 - Assembly mass loss versus elapsed time for Fabric 24 with various foams.

Fabric 24 is a cotton velvet fabric with a pile that CPSC staff has found to meet the standard cover fabric performance criteria. To ensure that the orientation of

the pile does not introduce variability in tests, staff has specified the orientation of the standard cover fabric during assembly of mockups. Care must be taken during preparation of the vertical and horizontal test panels to orient the fabric as specified in the draft standard. The standard cover fabric pieces are cut with the long direction being in the warp direction of the fabric and the top edge is defined such that the pile lays smooth when brushed from top to bottom.

Discussion of Comments on the Standard Cover Fabric

Some stakeholders have expressed concerns about the use of the cotton velvet fabric as a standard cover fabric in open flame testing due to the complexity of velvet fabrics. In recent testing [14] conducted by CPSC staff, variability of fire performance was observed of the cotton velvet fabric. CPSC staff is currently working with the manufacturer of this fabric to identify physical properties that affect the flammability performance. A suggestion was made for the development of a non-woven fabric that would be easier to manufacture to specifications. The CPSC staff is currently looking into the feasibility of specifying a non-woven or other standard textile fabric.

5.0 Smoldering Ignition Resistance Tests

Overview of Test Procedures

The smoldering ignition resistance test methods use a bench-scale mockup approach and are based on the Upholstered Furniture Action Council (UFAC) voluntary industry standard and the CBHFTI TB-117 mandatory standard. The mockups are constructed with the sample of material to be evaluated in conjunction with standard materials to represent the seating area configuration of furniture. A standard cigarette ignition source is lit, placed in the crevice location formed by the intersection of vertical and horizontal panels of each test assembly, and covered with cotton sheeting material. Test observations and measurements are recorded during the 30-minute test duration. The pass/fail requirements for all smoldering ignition resistance tests are a maximum of 10% mass loss of the standard substrate or filling material at the end of the 30 minute test duration, or if transition to flaming occurs prior to the end of the 30 minute test duration.

Acceptance Criteria Discussion

The development of the acceptance criteria for smoldering ignition performance was established after a comprehensive bench-scale test program. In this program, a wide range of upholstery materials was tested using a test apparatus similar to the UFAC standard. Parameters including char length measure in any direction from the test cigarette and post-test mass loss were recorded to determine if other parameters could provide a better characterization of smoldering behavior.

Basis for Modification to Mockup Thickness

An important observation made during the smoldering ignition test program was the progression of downward smoldering through the thickness of the mockup, which would char the specimen holder and resulted in greater variability in test results. Additional tests were conducted to evaluate increasing the specimen (or substrate) thickness to avoid involvement of the specimen holder. The results showed that increasing from 2.0 in. to 3.0 in. thickness provided an improved evaluation of smoldering ignition performance of upholstery materials by eliminating the heat-sink effect introduced by the specimen holder.

Time Limit

Another important observation made during the smoldering ignition test program was the need for a time limit. The open-ended nature of the UFAC test procedure is not practical, as it is sometimes difficult for the test operator to determine when an ignition occurs and smoldering combustion ceases. This can lead to variability in test results. The draft standard limits the test duration to 30 minutes. The 30 minute test duration provides ample time for the smoldering cigarette ignition source to consume itself and to observe smoldering behavior. Specifying test duration also allows for better comparison of test results.

10% Mass Loss Limit

The 10% maximum allowable post-test mass loss limit was developed based on smoldering ignition tests [11,12] conducted on numerous combinations of upholstery cover

fabrics, fillings, and fire-barrier materials. The data suggests that acceptable performance in mockup tests can be defined as limiting the mass loss of the foam to 10% or less when tested in a 3-inch thick mockup configuration using standard fire-retardant foam during the 30-minute test duration.

Apparatus and Materials

Draft Enclosure

Smoldering ignition tests are conducted in a draft enclosure. **See Figure 4.** The draft enclosure is used to limit extreme changes in surface ventilation rate. The tests are performed inside a draft enclosure measuring 711 mm (28 in.) long, 711 mm (28 in.) deep and 457 mm (18 inches) high, without a bottom. The enclosure is designed such that up to three individual specimen holders may be positioned inside simultaneously.

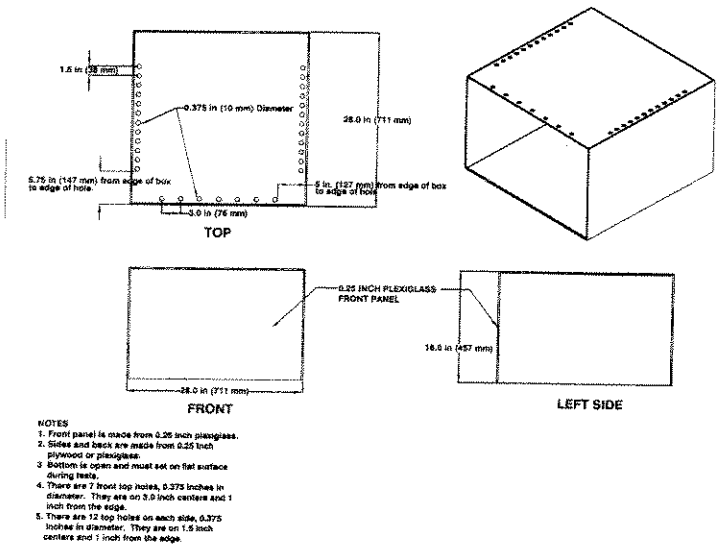


Figure 4 - Draft Enclosure.

The materials used for the construction of the enclosure are not critical, but guidance is provided in the draft standard. It is desirable that the enclosure materials, if opaque, contain an observation window so that tests may be visually monitored.

Specimen Holder

Mockups are assembled on a specimen holder. The specimen holder's base consists of two wooden panels, each nominally 203 x 203 mm (8.0 x 8.0 in) and nominally 19 mm (0.75 in) thickness, joined together at one edge. **See Figure 5.**

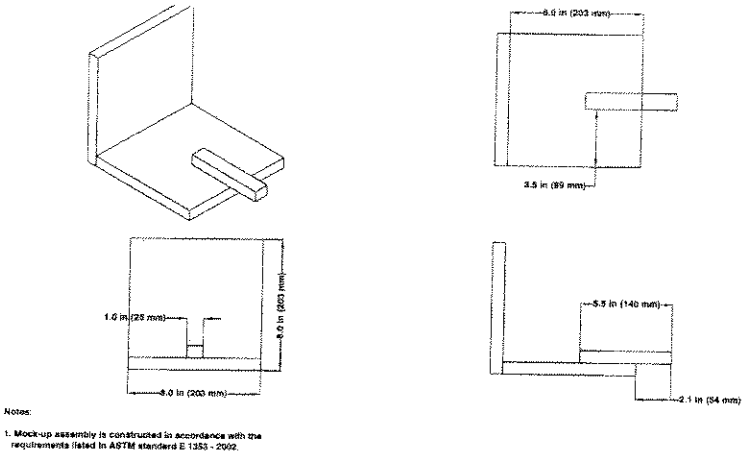


Figure 5 - Specimen Holder Base.

A moveable horizontal panel support is positioned on a centrally located guide **(See Figure 6)**. This bench-scale mockup test apparatus was jointly developed by the National Bureau of Standards/Center for Fire Research and UFAC in 1974 to evaluate smoldering ignition performance of upholstery materials and is specified in UFAC, CBHFTI TB-117, and ASTM voluntary standards.

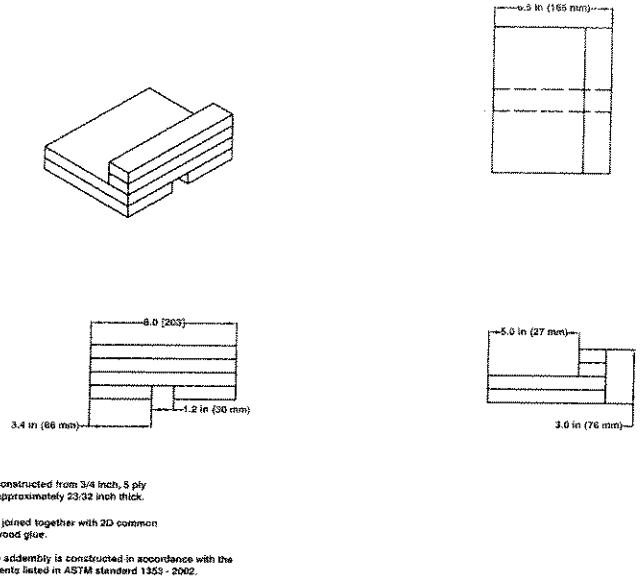


Figure 6 - Horizontal Support.

Ignition Source

The ignition source for smoldering ignition tests is a cigarette without filter tips made from natural tobacco, 85 ± 2 mm (3.3 ± 0.1 in) long and with a packing density of 0.27 ± 0.02g/cm^3 (0.16 ± 0.01 oz/in^3) and a total weight of 1.1 ± 0.1 g (0.039 ± 0.004 oz).

Test data [15] evaluating temperatures developed by burning cigarettes show that king-size non-filter tipped cigarettes produce higher smoldering temperatures (worst case) than their filter tip counterparts. Based on the results of this study, the non-filter tip cigarette was selected as the standard ignition source for 16 CFR Part 1632 - Standard for the Flammability of Mattresses and Mattress Pads. This ignition source is also accepted as an appropriate standard smoldering ignition source and is specified in UFAC and ASTM voluntary standards.

Sheeting Material

Sheeting material is used to cover the standard test cigarettes after they are lit and placed in the crevice location of mockups. The cotton sheeting induces smoldering and reduces the likelihood of self-extinguishment of the standard test cigarettes [13]. Covering the test cigarette makes ignition more likely to

occur. A cigarette covering material is necessary in the test to simulate this more severe condition, which can occur in cases of accidentally dropped cigarettes. Sheeting is specified due to its commercial availability.

The sheeting material specified for smoldering ignition tests is white, 100% cotton sheets or sheeting material, not treated with a chemical finish which imparts a characteristic such as permanent press or flame resistance, 19 - 33 threads per square centimeter (120-210 threads per square inch), fabric weight - 125 ± 28 g/m^2 (3.7 ± 0.8 oz/yd^2).

The sheeting is laundered once before use in a residential home washer using the hot water setting and longest normal cycle with the washer manufacturer's recommended quantity of a commercial detergent and dried in an automatic residential tumble dryer. The laundering of the sheeting material is required to remove any finishes on the fabric that may influence test results.

Standard Flame-Retardant Polyurethane Foam (SFRPUF) Substrate

The SFRPUF substrate represents the foam cushioning used in upholstered furniture. The SFRPUF substrate is used in smoldering and some open flame ignition tests and to qualify the standard cover fabric. Although foams are generally smolder-resistant, the chemical formulation of flame retardant foams can result in decreased smolder resistance for certain weight percent ranges of FR chemicals used in the foam. The physical and performance properties of the flame-retardant foam specified in the draft standard provide for a suitable substrate to evaluate the sample of upholstered furniture material being tested with respect to smoldering and open flame ignition.

The specifications of the SFRPUF substrate are as follows:

(1) The flammability performance bands detailed in the draft standard
(2) Density: 1.4 ± 0.1 lb/ft^3
(3) Indentation Load Deflection (ILD): 25 to 30
(4) Air Permeability: greater than 4.0 ft^3/min

To ensure repeatability of the SFRPUF substrate's combustion behavior, there are smoldering and open flame

test performance requirements specified in the draft standard for this standard foam to meet.

Standard Polyester Fiber Fill

The Standard Polyester Fiber Fill is used as the standard substrate in smoldering tests in the assembly of the mockup for evaluation of loose filling interliner fabrics. Although polyester fiber fill is generally smolder-resistant, its use as the standard substrate for interliner fabric tests was selected due to its prevalent use as loose filling material.

The Standard Polyester Fiber Fill must be 100 % Untreated white polyester fiber fill.

Conditioning

All test specimens and standard test materials (including substrates, cigarettes, and sheeting material) are conditioned at a temperature of 21° ± 3° C (70° ± 4° F) and between 50% and 66% relative humidity for at least 24 hours prior to testing. If conditions in the test room do not meet these specifications, then testing must be initiated within 10 minutes after the specimens are removed from the conditioning room. These requirements are necessary to maintain a constant atmosphere for test specimens and standard materials, as the effects of moisture content on heat transfer and ignition characteristics of textile materials are known to affect test results. The conditioning specifications are consistent with the requirements contained in the UFAC, ASTM and other flammability standards.

5.1 Upholstery Cover Fabrics

Scope

This test method is intended to measure the cigarette ignition resistance of upholstery cover fabrics used in upholstered furniture. This test applies to all upholstery cover fabrics. Upholstery cover fabrics that meet the requirements of this test are acceptable for use in Type III furniture.

Smoldering requirements for upholstery cover fabrics are included in the draft standard to reduce the use of

smolder-prone fabrics in upholstered furniture. The requirements apply to cover fabrics that are typically the first layer to be exposed to a smoldering ignition source. Upholstery fabrics that do not meet the requirements of this test can be used in furniture provided they are used with approved fire-barrier materials. This provision allows manufacturers flexibility in selecting upholstery cover fabrics to provide consumers a wide variety of choices without increasing the fire hazard.

Summary of Test Method

Vertical and horizontal panels of a standard polyurethane foam substrate are covered, using the upholstery cover fabric to be tested **(See Figure 7)**. These panels are placed in three specimen holders, and a lighted cigarette is placed in each crevice formed by the intersection of vertical and horizontal panels of each test assembly. Each cigarette is covered with a piece of * sheeting fabric. The cigarettes are allowed to burn their entire length. Test measurements and observations are recorded after the 30-minute test duration. The substrate must not exceed the mass loss limit, or transition to open flaming. Three test specimens are required for the upholstery cover fabric sample.

This test geometry is based on the UFAC and ASTM fabric classification voluntary standards. The significant differences include the use of a standard fire-retardant substrate, test duration of 30 minutes, and the use of mass loss as the performance measure as opposed to vertical char length.

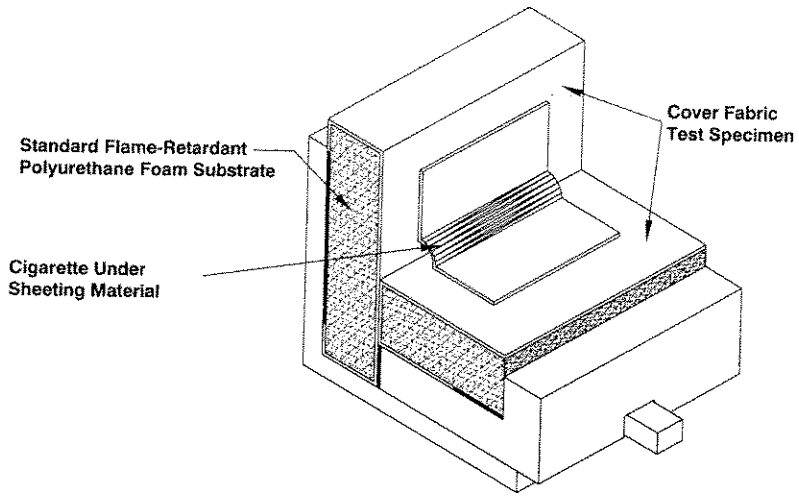


Figure 7 - Mockup Assembly for Upholstery Cover Fabric Smoldering Ignition Resistance Test.

Significance and Use

This test method is designed to measure the response of an upholstery cover fabric to a smoldering ignition source when placed over a specified flame-retardant polyurethane foam substrate. The test method evaluates the smolder propensity of upholstery fabrics and the likelihood of smolder transfer to underlying materials.

5.2 Fibrous Filling Materials

Scope

This test method is intended to measure the cigarette ignition resistance of fibrous filling materials used in upholstered furniture. This test applies to all fibrous filling materials including, but not limited to synthetic and natural textile filling materials that can be carded, garneted, air-layered or otherwise formed into a continuous fiber web for battings, pads, etc.

In addition to complying with this test, fibrous filling materials must also comply with open-flame test requirements specified in the draft standard to be acceptable for use in Type III furniture. Fibrous filling materials that do not meet the requirements of this test can only be used in furniture with complying fire-barrier materials.

Smoldering requirements for fibrous filling materials are included in the draft standard to reduce the use of fibrous materials that can contribute to the smoldering ignition hazard of furniture. Most fibrous filling materials consist of synthetic (polyester blends) and natural (cotton) textile fibers. These materials typically have good smolder resistance due to the non-cellulose fiber content or use of flame-retardant chemicals, as in the case of furniture grade cotton batting. Test requirements are needed to ensure that fibrous filling materials maintain good smolder resistance as they can potentially transfer smoldering to underlying resilient filling materials.

Summary of Test Method

Vertical and horizontal panels of the fibrous filling material to be tested are placed between a standard foam substrate and a standard cover fabric **(See Figure 8)**. *The panels are placed in three specimen holders, and a lighted cigarette is placed in the crevice formed by the intersection of the vertical and horizontal panels in each test assembly. Each cigarette is covered with a piece of sheeting fabric. The cigarettes are allowed to burn their full length. Test measurements and observations are recorded after the 30-minute test duration. The sample must not exceed the mass loss limit, or transition to open flaming. Three test specimens are required for the fibrous filling sample.

This test geometry is based on the UFAC and ASTM fibrous and particulate filling voluntary standards. The significant differences from these standards include the use of a standard fire-retardant foam substrate, test duration of 30 minutes, and the use of mass loss as the performance measure as opposed to vertical char length. In addition, there is a significant difference in the construction of the mockup. In the draft standard, fibrous filling material test specimens are installed on both vertical and horizontal panels of the mockup whereas in the voluntary standards, the test specimens are assembled only in the vertical panels. It is necessary to evaluate the performance of test specimens in both vertical and horizontal panels to better account for the potential progression of smoldering in both vertical and horizontal locations of the seating area, since fibrous filling can be found in the seat and back locations in furniture.

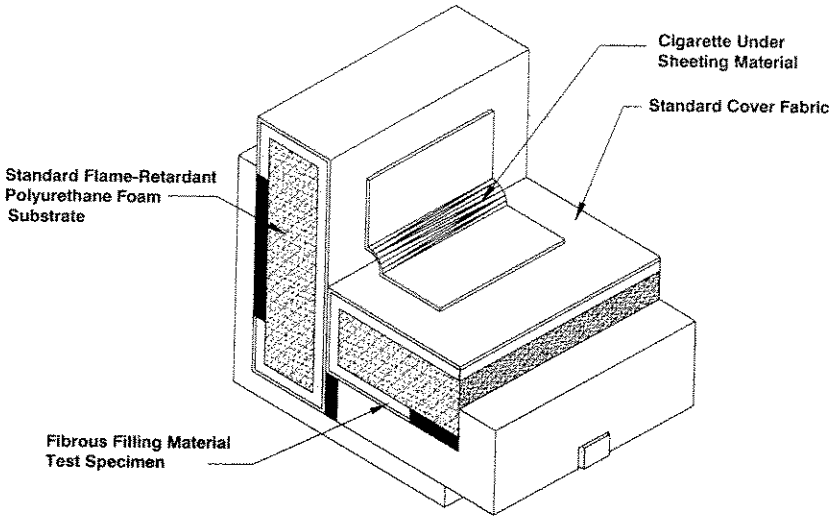


Figure 8 - Mockup Assembly for Fibrous Filling Material Smoldering Ignition Resistance Test.

Significance and Use

This test method is designed to measure the response of fibrous filling material to a smoldering ignition source when placed between a standard cover fabric and specified flame-retardant foam substrate. The smolder propensity and ability to prevent smolder transfer by fibrous filling materials to underlying materials is evaluated in this test.

5.3 Loose Filling Materials

Scope

This test method is intended to measure the cigarette ignition resistance of loose filling materials used in upholstered furniture. This test applies to all loose filling materials including, but not limited to shredded polyurethane and cellular foams, feathers and down, loose synthetic/natural/synthetic-natural blends of fiber, polystyrene beads, and other loose filling used in upholstered furniture construction.

In addition to complying with this test, loose filling materials must also comply with open flame requirements specified in the draft standard to be acceptable for use in Type III furniture. Loose filling materials that do not meet the requirements of this test can only be used when

encased in interlining fabrics complying with smoldering and open flame test requirements specified in the draft standard (Type III-B), or approved fire-barriers.

Smoldering requirements for loose filling materials are included in the draft standard to reduce the use of loose filling materials that can contribute to the smoldering ignition hazard of furniture. There is a wide variety of loose filling material used in upholstered furniture. Smoldering requirements are necessary to ensure that loose filling materials maintain good smolder resistance, as they can present a significant fuel load in furniture.

Summary of Test Method

Vertical and horizontal panels of loose filling materials to be tested are placed under a standard cover fabric **(See Figure 9)**. The panels are assembled on three specimen holders and a lighted cigarette is placed in the crevice formed by the intersection of the vertical and horizontal panels in each test assembly. Each cigarette is covered with a piece of sheeting fabric. The cigarettes are allowed to burn their full length. Test measurements and observations are recorded after the 30-minute test duration. The sample must not exceed the mass loss limit, or transition to open flaming. Three test specimens are required for the loose filling sample.

This test geometry is based on the fibrous and particulate filling materials tests contained in the UFAC and ASTM voluntary standards. The significant differences in the draft standard from the UFAC and ASTM test methods include a test duration of 30 minutes and the use of mass loss of the substrate as a performance measure as opposed to vertical char length. In addition, loose filling material test specimens are assembled in both vertical and horizontal panels of the mockup, to account for the use of loose filling in both seat and back locations of furniture. The loose filling specimens are contained in vertical and horizontal inserts that can account for tests of a range of loose filling densities.

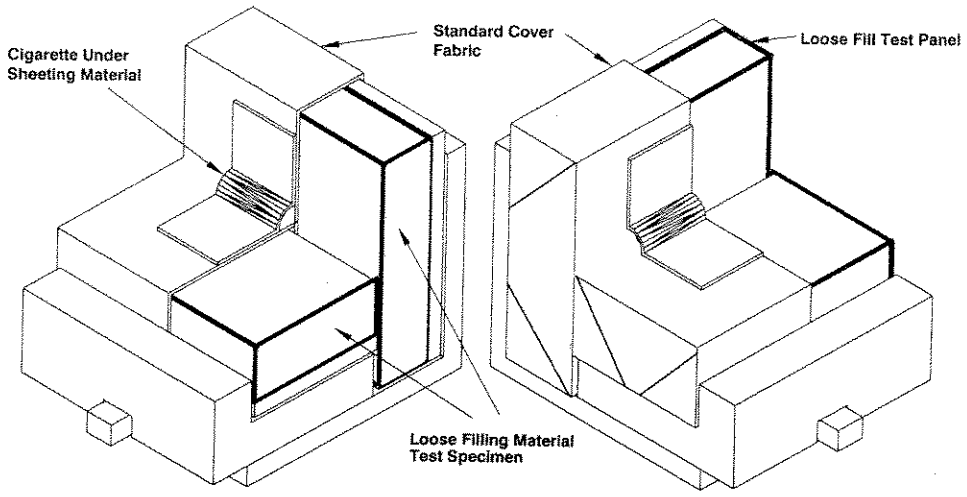


Figure 9 - Mockup Assembly of Loose Filling Material Smoldering Ignition Resistance Test.

Significance and Use

This test method is designed to measure the response of loose filling materials to a smoldering ignition source when placed under a standard cover fabric. The smolder propensity, propagation of smoldering, and the likelihood of transition to flaming combustion of loose filling are evaluated in this test.

5.4 Loose Filling Interliner Fabrics

Scope

This test method is intended to measure the cigarette ignition resistance of interliner fabrics used to encase loose filling materials. Such materials are commonly used as protective lining for loose filling found in loose or semi-attached backs, arms, or throw pillows. This test applies to protective interliners including, but not limited to fire-resistant ticking or non-woven fabrics.

In addition to complying with this test, loose filling interliner fabrics must also comply with open flame test requirements specified in the draft standard for use in Type III-B furniture. Loose filling interliner fabrics that do not meet the requirements of this test can only be used in furniture with complying loose filling material (Type III) or fire-barrier materials. Smoldering

requirements for loose filling interliner fabrics are included in the draft standard to allow the use of fire-resistant interliner fabrics, if needed to encase loose filling materials that do not comply with smoldering and open flame test requirements. Fabrics that comply with these test requirements act as a localized fire-barrier to protect loose filling from smoldering ignition.

Summary of Test Method

Vertical and horizontal panels of loose filling interliner fabrics to be tested are filled with standard polyester fiber fill substrate and placed under a standard cover fabric **(See Figure 10)**. The panels are assembled on three specimen holders and a lighted cigarette is placed in the crevice formed by the intersection of the vertical and horizontal panels in each test assembly. Each cigarette is covered with a piece of sheeting fabric. The cigarettes are allowed to burn their full length. Test measurements and observations are recorded after the 30-minute test duration. The substrate must not exceed the mass loss limit, or transition to open flaming. Three test specimens are required for each loose filling interliner fabric sample.

This test geometry is based on the general approach contained in the barrier material test and fibrous and particulate filling materials tests contained in UFAC and ASTM voluntary standards. The significant differences in the draft standard from the UFAC and ASTM test methods include the use of a standard polyester fiber fill substrate, test duration of 30 minutes, and the use of mass loss as the performance measure as opposed to vertical char length. The construction of the mockup involves the use of metal inserts to contain the polyester fiber fill substrate.

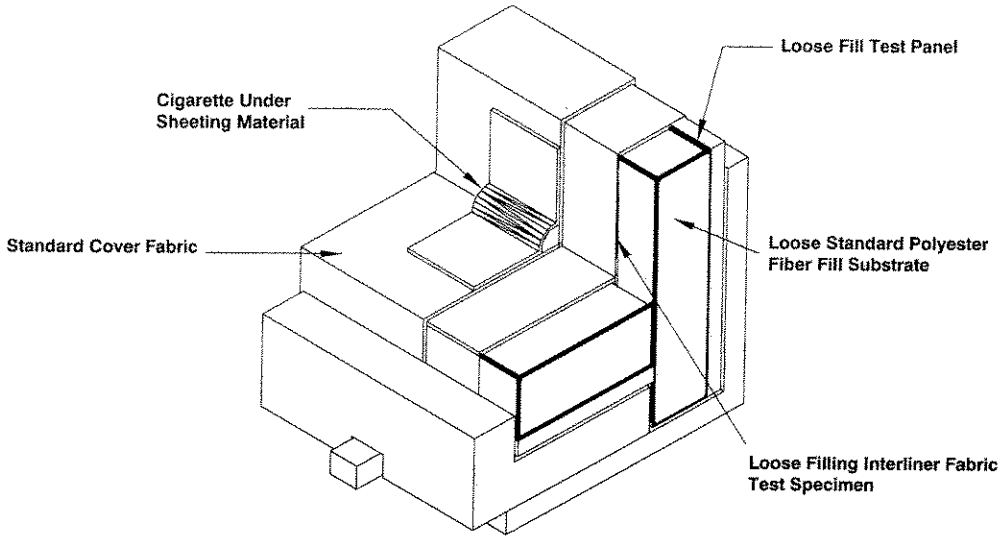


Figure 10 - Mockup Assembly of Loose Filling Interliner Fabric Smoldering Ignition Resistance Test.

Significance and Use

This test method is designed to measure the response of protective interliner fabrics to a smoldering ignition source when placed between a standard cover fabric and a specified loose filling substrate. Interliner fabrics that comply with both smoldering and open flame test requirements may be used with non-complying loose filling.

5.5 Resilient Filling Material

Scope

This test method is intended to measure the cigarette ignition resistance of resilient filling materials used in upholstered furniture. This test applies to all resilient filling materials including, but not limited to polyurethane, synthetic latex, rubber, and any other types of resilient cellular polymer and copolymer materials used to provide resiliency. This test does not apply to rigid plastics used as structural material.

In addition to complying with this test, resilient filling materials must also comply with open flame test requirements specified in the draft standard to be qualified as Type III furniture. Resilient filling

materials that do not meet the requirements of this test can only be used in furniture with complying fire-barriers.

Smoldering requirements for resilient filling materials are included in the draft standard to reduce the use of resilient filling materials that can contribute to the smoldering ignition hazard of furniture. Most resilient filling materials consist of polyurethane foams. Polyurethane foams typically have good smolder-resistance properties, however formulations to improve the open flame ignition resistance of foam may increase smolder propensity. To ensure good smolder resistance of resilient filling materials, requirements for smoldering performance are necessary.

Summary of Test Method

Vertical and horizontal pieces of the resilient filling material sample to be tested are placed under a standard cover fabric **(See Figure 11)**. The panels are placed in three specimen holders and a lighted cigarette is placed in each crevice formed by the intersection of the vertical and horizontal panels in each test assembly. Each cigarette is covered with a piece of sheeting fabric. The cigarettes are allowed to burn their entire length. Test measurements and observations are recorded after the 30-minute test duration. The sample must not exceed the mass loss limit, or transition to open flaming. Three test specimens are required for the resilient filling sample.

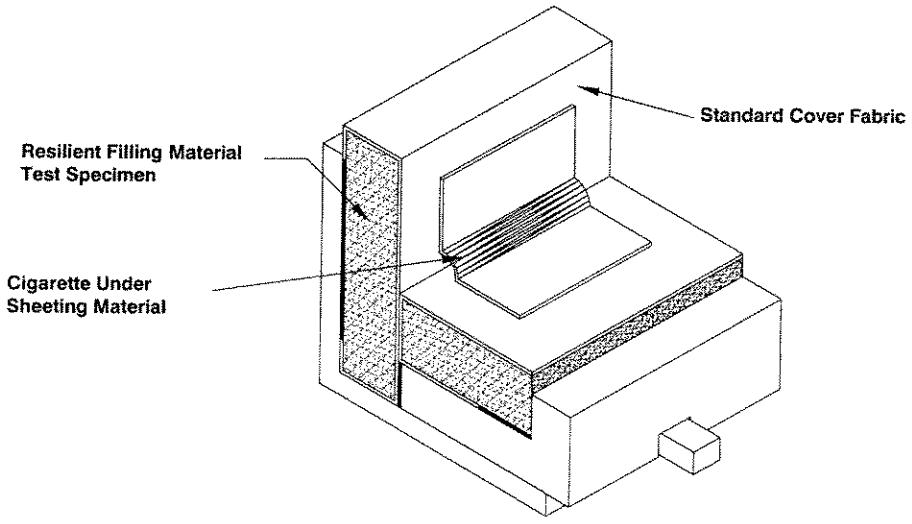


Figure 11 - Mockup Assembly of Resilient Filling Material Smoldering Ignition Resistance Test.

This test geometry is based on the filling/padding tests contained in UFAC and ASTM voluntary standards. The significant differences in the draft standard from the UFAC and ASTM test methods include a 30 minute test duration and the use of mass loss as the performance measure as opposed to vertical char length.

Significance and Use

This test method is designed to measure the response of resilient filling material to a smoldering ignition source when placed under a standard cover fabric. The smolder propensity, propagation of smoldering, and the likelihood of transition to flaming combustion of resilient filling materials is evaluated in this test.

5.6 Interior Fire-Barrier Materials

Scope

This test method is intended to measure the cigarette ignition resistance of interior fire-barrier materials used in upholstered furniture. This test method applies to fire-resistant materials including, but not limited to all interior fabrics or high loft battings to be qualified as approved fire-barriers.

In addition to complying with this test, interior fire-barrier materials must also comply with open flame test requirements specified in the draft standard for use in Type I furniture.

Smoldering requirements for interior-fire barrier materials are included in the draft standard to allow for the use of fire-resistant materials as an alternate means of achieving ignition resistance. Materials that comply with the smoldering requirements limit the transfer of smoldering to underlying materials, therefore reducing the need to modify upholstery cover fabrics or filling materials.

Summary of Test Method

Vertical and horizontal panels of the interior fire-barrier material to be tested are placed between a standard foam substrate and a standard cover fabric **(See Figure 12)**.

The panels are placed in three specimen holders and a lighted cigarette is placed in the crevice formed by the intersection of the vertical and horizontal panels in each test assembly. Each cigarette is covered with a piece of sheeting fabric. The cigarettes are allowed to burn their full length. Test measurements and observations are recorded after the 30-minute test duration. The substrate must not exceed the mass loss limit or transition to open flaming. Three test specimens are required for the interior fire-barrier material sample.

This test geometry is based on the barrier material test contained in the UFAC and ASTM voluntary standards. The significant differences in the draft standard and the UFAC and ASTM test methods are the use of a standard fire retardant polyurethane foam substrate, test duration of 30 minutes, and the use of mass loss as the performance measure as opposed to vertical char length.

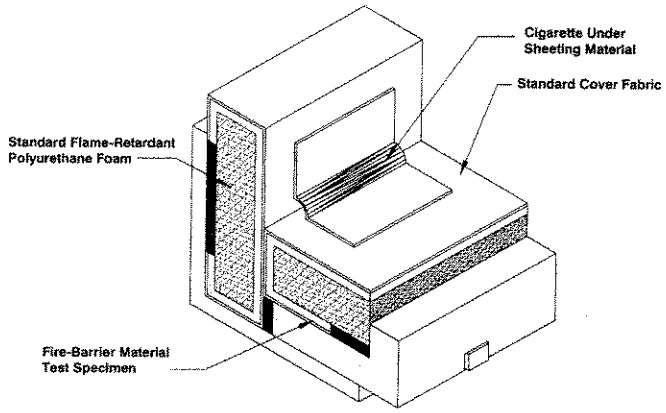


Figure 12 - Mockup Assembly of Interior Fire Barrier Material Smoldering Ignition Resistance Test.

Significance and Use

This test method is designed to measure the response of fire-barrier material to a smoldering ignition source when placed between a standard cover fabric and a standard foam substrate. Test data [11,16] show commercially available materials exist that can be placed between upholstery cover fabrics and filling materials to prevent the transfer of smoldering to underlying materials, therefore reducing the need for complying upholstery cover fabrics and filling materials.

5.7 End Product Materials

Scope

This test method is intended to measure the cigarette ignition resistance of actual combinations of materials used in the construction of a finished furniture item. This test applies to the cover fabric, interliner/fire barrier (if present), and any filling materials in the end product for use into Type IV furniture.

Summary of Test Method

Vertical and horizontal panels of cover fabric, interliner/fire barrier (if present), and any filling materials intended to be used in the finished product are constructed. The panels are placed in the specimen holders and a lighted cigarette is placed in the crevice formed by the intersection of the vertical and horizontal panels in each test assembly. Each cigarette is covered with a piece of sheeting fabric and is allowed to burn its full length. Test measurements and observations are recorded after the 30-minute test duration. The assembly without the cover fabric must not exceed the mass loss limit or transition to open flaming. Three test specimens are required for the end-product material combination.

Significance and Use

This test method is designed to measure the response of combined assemblies of cover fabric, interliner/fire barrier (if present), and any filling materials intended for use in the finished product to a smoldering ignition source. This testing approach may be advantageous for certain furniture combinations where the use of actual materials provides better flammability performance than indicated when individual materials are tested with standard materials as in Type III tests.

6.0 Open Flame Ignition Resistance Tests

Overview of Test Requirements

The open flame test requirements in the draft standard apply to filling materials as they represent the primary fuel load in furniture. There is no compulsory open flame test requirement for upholstery cover fabrics. Because

filling materials constitute the primary fuel load, the open flame ignition contribution of cover fabrics can be mitigated with the use of improved filling or fire barrier materials. In the open flame tests, the effects of upholstery fabrics are accounted for by the use of a standard cover fabric during evaluation of filling materials and fire-barriers.

The draft standard contains an optional open flame upholstery fabric fire barrier test (Type II furniture) that manufacturers may choose to conduct in order to demonstrate compliance. In cases where the upholstery cover fabric has relatively high resistance to open flame ignition, it can serve as a fire barrier to protect interior materials. Fabrics with these characteristics typically include leather, wool, or FR back-coated fabrics. If the upholstery fabric passes this test, there are no additional open flame test requirements for the other upholstery materials.

When establishing acceptance as Type III furniture, all resilient, loose, and fibrous filling materials used in furniture subject to the standard must meet the requirements of their respective open flame tests, or be used with complying fire-barriers.

As in smoldering tests, the open flame test methods use the bench-scale mockup approach. The test mockup assembly frame is based on the British Standards Institute 5852 standard (BS 5852), which is referenced in UK Furniture Flammability regulations. The mockups are constructed with the sample of material to be evaluated in conjunction with a standard test material to represent the seating area configuration of furniture. A standard open flame ignition source is placed in the crevice location formed by the intersection of the seat/back surfaces of the mockup for a specified time. Test observations and measurements are recorded during the 45-minute test duration. The pass requirement for all open flame tests is a maximum of 20% mass loss at 45 minutes.

Open Flame Acceptance Criteria Discussion

The development of the acceptance criteria for open flame ignition performance was established by data derived from a bench-scale test program [12,14,17, and 18]. In this program, a wide range of upholstery materials was tested in

accordance with open flame test procedures specified in existing standards including BS 5852, CBHFTI TB-117/Draft TB-117 (2002) (TB-117+), and modifications of existing test procedures recommended by interested stakeholders. Since there were many recommendations provided to staff on specific material test procedures, a discussion and staff position is provided in the applicable sections in this report.

20% Mass Loss Limit

Important factors that determine the potential small open flame fire hazard presented by furniture materials are the ease of ignition, intensity and rate of burning. The 20% maximum mass loss limit at 45 minutes is based on open flame ignition tests [17,18] conducted on numerous combinations of upholstery cover fabrics, fillings, and fire-barrier materials. Mockup assemblies that exhibited less than 20% mass loss within the 45 minute test duration either did not ignite or burned relatively slowly after exposure to the test flame when compared to other combinations. The ignition and intensity of burning of the substrate (i.e. filling) layer of the mockup was the primary determinant as to whether or not the test assembly would exceed the 20% threshold within 45 minutes. In most experiments, test assemblies with less then 20% mass loss typically did not result in ignition of the filling materials.

Figure 13 shows a graph of various fabric and foam combinations evaluated in the bench-scale testing program. Fabric and foam combinations that burned intensely and exhibited a relatively high mass loss appear in sector "C". These fabric and foam combinations include many common upholstery fabrics such as cotton, rayon, and thermoplastics over Type III complying foams. Based on **Figure 13,** the addition of a compulsory open flame fabric test would increase the effectiveness of Type III furniture in reducing the open flame hazard. The test combinations that burned with less intensity and exhibited moderate mass loss appear in sector "B". Combinations in the "A" sector burned with much less intensity and exhibited slow mass loss. The sector "A" material combinations typically consisted of fabrics with high open flame ignition resistance (i.e. FR back-coated fabrics, wool, and leather) and FR foams.

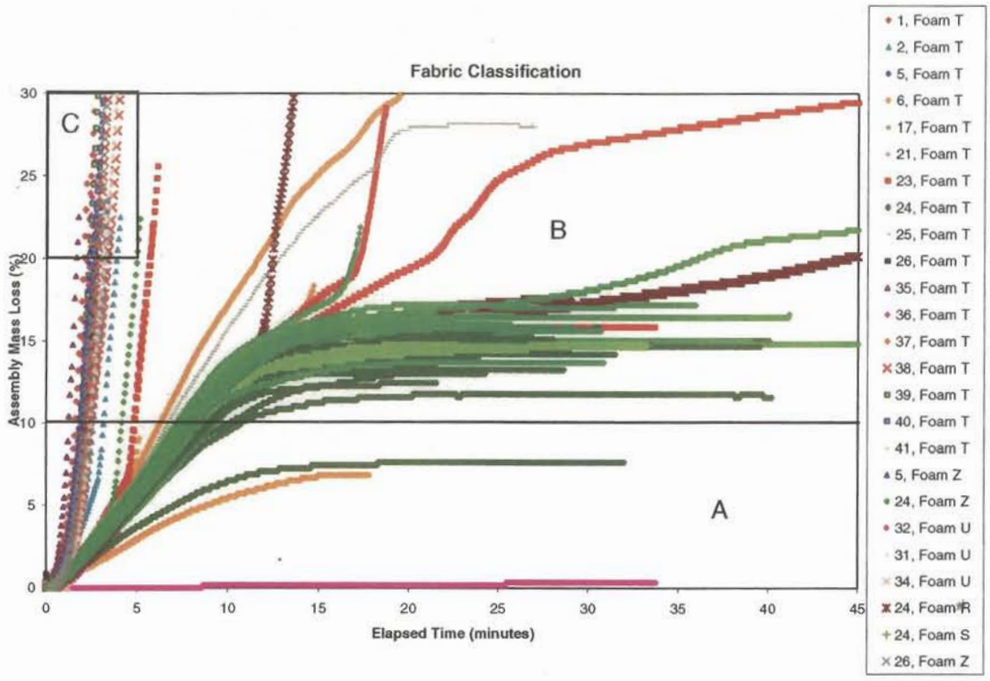


Figure 13 - Assembly mass loss versus elapsed time for all cover fabrics evaluated with various foams.

It is important to note that combinations which exhibited poor small open flame bench-scale performance (i.e. high mass loss), a substantial reduction in mass loss rate could be observed in those same combinations with the use of a currently available fire barrier and/or some FR foams. Combinations such as these may be functional for Type IV furniture.

Apparatus and Materials

Test Room

The room size needed to conduct tests is one with a volume greater than 20 m^3 in order to contain sufficient oxygen for testing. If tests are conducted in a smaller area, the room must have a ventilation system permitting the necessary flow of air. During the pretest and testing period, airflow rates are maintained below 0.1 m/s, measured in the locality of the mockup assembly to provide adequate air movement without disturbing the burning behavior. Room ventilation rates before and during tests are maintained at about 200 cfm. Airflow rates in this range have been shown to provide adequate oxygen without

physically disturbing the burning behavior of the ignition source or the mockup assembly. In addition, the ventilation system of the test facility must be capable of extracting smoke and toxic combustion products generated during testing for health and safety reasons.

Butane Gas Ignition Sources

35 mm Butane Flame

In the open flame tests for filling materials, interliner fabrics, and upholstery fabric fire-barriers, a nominal 35 mm butane flame is the standard test flame. The 35 mm butane diffusion flame is intended to simulate the heat output of potential residential ignition sources such as matches, cigarette lighters, or candles. Laboratory experiments [19] have shown that this ignition source closely approximates the heat output of typical small open flame ignition sources associated with residential upholstered furniture fires. The 35 mm flame is applied for 20 seconds in the crevice location of mockups. The 35 mm/20 second flame application is the standard Source 1 ignition source specified in BS 5852. The 20 second flame exposure time is based on experimental work [20] conducted in the U.K. to characterize burn time of matches. In this U.K. study, several types of matches were tested in several orientations. The study concluded that 20 seconds was within the upper 85% of match burn times.

CPSC staff conducted laboratory experiments [21] to characterize the burn times of common small open flame ignition sources including matches, cigarette lighters, and candles. The results of these experiments showed there was a wide range of match burn times that depended on factors including type of match, orientation, and moisture content. Cigarette lighters and candles had burn times of much longer duration. Based on the results of CPSC staff evaluation of open flame ignition sources, the flame exposure time in the draft standard cannot be based on experimental data of flame duration alone, due to the variability in results. Upholstered furniture fire incident data suggest the most frequent probable cause of open flame fires is fire play[1] by young children. Fire play is defined as a playful activity with no significant motivation toward fire setting behavior[22]. There are some motor and cognitive challenges for a young child to maintain a flame at a specific position unintentionally for

more than 20 seconds. Therefore, a child who engages in this focused behavior for more than 20 seconds is persistent beyond that which is typical of mere fire play. The behavior expected in child fire play and other inadvertent or accidental scenarios suggest that the 20 second flame application time is reasonable.

Discussion of Comments on 35 mm Flame Source

Most of the public comments supported the use of this ignition source exposure for small open flame tests. The 35 mm flame is specified in BS 5852 and the draft TB-117 (2002) standard (TB-117+).

240 mm Butane Flame

For the interior fire-barrier test in the draft standard, a nominal 240 mm standard test flame is applied for 70 seconds in the crevice location. This ignition source is specified in BS 5852, as Source 3. The larger flame size and duration is needed to evaluate the interior fire-barrier's ability to prevent the spread of fire to underlying materials. Since interior fire barriers would be located between flammable cover fabrics and filling materials, it is critical that interior fire-barriers be capable of withstanding the heat exposure presented by an ignited cover fabric.

Discussion of Comments on 240 mm Flame Source

In the 2001 draft standard, CPSC staff included a wood crib (ignition Source #5) specified in BS 5852. Public comments received stated that Source #5 was unreasonably severe and lacked repeatability in burning characteristics. CPSC staff conducted tests [23] using other suitable ignition sources for evaluation of interior fire-barrier performance. The use of alternate burners and ignition sources was examined for feasibility and consistency. Based on testing [12, 17] of available materials, the use of a gas flame ignition source was determined to provide a more consistent flame exposure than the wood crib. Of the gas flame ignition sources examined, Source 3 in conjunction the standard cover fabric provided a reasonable flame exposure for the evaluation of fire-barrier materials.

Metal Test Frame

Mockups are assembled in a metal test frame that is based on characteristics of the test rig specified in the BS 5852 standard (**see Figure 14**). The metal test frame consists of two rectangular steel frames locked at right angles to each other. The frames are made of nominal 25 mm x 25 mm (1 x 1 inch) steel angle 3 mm (1/8 inch) thick, and securely hold platforms of steel mesh set 6 ± 1 mm (0.25 ± 0.05 inch) below the front face of each test frame. An optional standard edging section around the steel mesh will provide protection and greater rigidity. A rod is continuous across the back of the apparatus. This test frame, or equivalent, is adequate for securing test specimens and standard materials for assembling mockups.

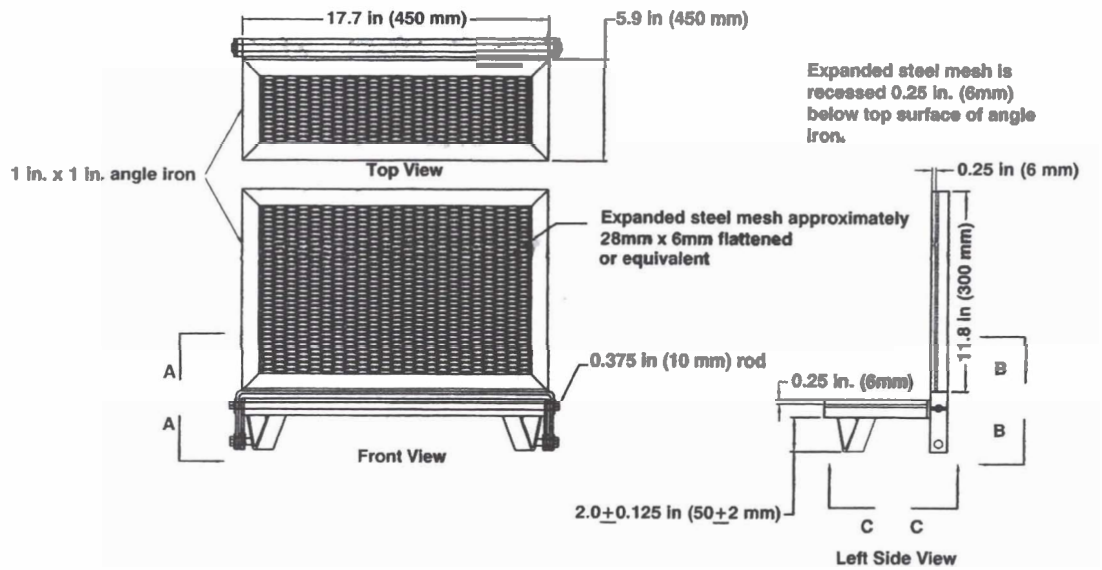


Figure 14 - Metal Test Frame.

Standard Cover Fabric

The standard cover fabric represents the outermost layer of upholstered furniture. In tests for filling materials, interliner fabrics, and interior fire-barriers, a standard cover fabric is required for assembly of the mockup. CPSC staff tested several fabrics for potential use as a standard cover fabric. The criteria for a suitable standard cover fabric were open flame ignition propensity, fabric construction consistency, and commercial availability. The standard cover fabric selected for incorporation into the draft standard is the same fabric specified in smoldering ignition tests. Although the

fabric presents a higher smoldering challenge, its use for open flame tests was determined to be suitable to account for the lesser contribution of upholstery fabrics to the open flame risk of furniture. The specifications for the standard cover fabric are the same as for the standard cover fabric used in smoldering ignition resistance tests.

Standard Polyurethane Foam (SPUF) Substrate

The Standard Polyurethane Foam (SPUF) substrate represents foam cushioning used in furniture. SPUF substrate is used in open flame tests in Sections 1634.16 (Type II furniture) and 1634.15 (Type I furniture) for assembly of the mockup for evaluation of fire barriers and to qualify standard cover fabric.

The specifications of the SPUF substrate are as follows:

(1) The flammability performance bands detailed in the draft standard
(2) Density: 1.8 ± 0.1 lb/ft^3
(3) Indentation Load Deflection (ILD) (25%): 25 to 30
(4) Air Permeability: greater than 4.0 ft^3/min
(5) No flame-retardant chemical treatment as determined by post production chemical analyses

To ensure repeatability of the SPUF substrate's combustion behavior, there are additional smoldering and open flame test performance requirements specified in the draft standard for this standard foam to meet.

Standard Polyester Fiber Fill

The Standard Polyester Fiber Fill is used in open flame tests in the assembly of the mockup for evaluation of loose filling interliner fabrics. The same polyester fiber fill specified in the smoldering tests was selected for open flame tests. This substrate was selected due to its prevalent use as loose filling in upholstered furniture.

6.1 Fibrous Filling Materials

Scope

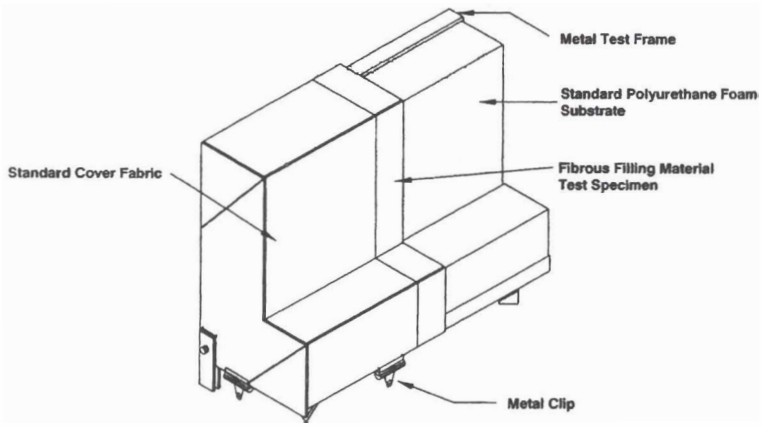
This test method is intended to measure the open flame ignition resistance of fibrous filling materials used in upholstered furniture. This test applies to all fibrous filling materials including, but not limited to synthetic and natural textile filling materials that can be carded,

garneted, air-layered or otherwise formed into a continuous fiber web for battings, pads, etc.

In addition to complying with this test, fibrous filling materials must also comply with the smoldering requirements of the draft standard for use in Type III furniture. Fibrous filling materials that do not meet the requirements of this test can only be used in furniture with complying fire-barrier materials.

Summary of Test Method

The fibrous filling material to be tested is placed between a standard foam substrate and standard cover fabric and assembled on a metal test frame (**see Figure 15**). A small open flame is applied to the crevice formed by the intersection of the seat/back surfaces of the mockup. Test measurements and observations are recorded during the 45-minute test duration. The mockup assembly must not exceed mass loss limits. Three tests are performed in succession.



NOTES:
1. Details of folds and creases not shown.
2. The number of metal clips may vary depending on material thickness, not all are shown.

Figure 15 - Mockup Assembly for Fibrous Filling Material Open Flame Ignition Resistance Test.

Significance and Use

This test method is designed to measure the response of fibrous filling material, when placed between a standard cover fabric and standard foam substrate, to a small open-flame ignition source, representing a match, candle or

cigarette lighter. The open flame ignition resistance and ability to prevent flaming combustion transfer is evaluated in this test.

Discussion of Comments on Fibrous Filling Materials Test

Open flame requirements for fibrous filling materials are included in the draft standard to reduce the use of fibrous filling material that can contribute to the open flame hazard of furniture. Commenters suggested limiting the scope of open flame test requirements to "non-foam wrapping/ topper material" found in seat cushions. Staff has interpreted this comment to apply to fibrous filling (e.g. polyester fiber fill) located in the seat cushions and excluding fibrous filling in back cushions. The commenters' suggestion to limit the application of test requirements to fibrous materials located only in the horizontal seating cushion is not appropriate. All upholstered materials that potentially contribute to fire risk should also contribute to the level of protection. Flammable fibrous filling materials located in back or side cushions (i.e. vertical cushions) present a hazard in upholstered furniture. Excluding the materials used in the vertical location from performance requirements would largely negate the protection provided by materials in the horizontal location. Fibrous filling material can provide a fire risk if these materials readily ignite when exposed to an open flame ignition source and transfer flames to underlying materials. Staff believes that materials used in the vertical location of furniture constructions should be included in the scope of the standard.

Commenters suggested two different test requirements for fibrous filling materials. The first was the TB-117+ test method, which consists of the application of a small open flame to the midpoint of a cotton sheet placed under the fibrous filling specimen. The specimen is placed over a hole in a wire mesh supported by a metal rack, and the flame is applied from underneath. The cotton sheet simulates a cellulosic material adjacent to or near fibrous filling. Observations of burning behavior and burn-though are used to measure performance of the specimen. The geometry of this horizontal test does not account for performance of fibrous filling material often used in vertical portions of the seating area.

Alternatively, other commenters suggested using the BS 5852 Source 2 Test for Non-Foam Filling Materials, for non-foam seat cushion wrapping or topper materials. This test utilizes a bench-scale mockup approach to simulate the seating area of upholstered furniture. The mockup is constructed with fibrous filling material covered with a standard fire-retardant polyester fabric. The crevice of the mockup is exposed to a 140 mm/40 second gas flame. Commenters also suggested that test requirements should be limited to materials in the horizontal seating cushion.

The draft standard incorporates elements of the BS 5852 standard with respect to the apparatus, test specimen configurations, and ignition source specifications. These elements provide a good evaluation of the performance of fibrous filling materials with respect to open flame ignition. The test method and requirements for fibrous filling materials are consistent with the requirements for other materials subject to the draft standard.

6.2 Loose Filling Materials

Scope

This test method is intended to measure the open flame ignition resistance of loose filling materials used in upholstered furniture. This test applies to all loose filling materials including, but not limited to shredded polyurethane and other cellular foams, feathers and down, loose synthetic/natural/synthetic-natural blends of fiber, polystyrene beads, and other loose filling.

In addition to complying with this test, loose filling materials must also comply with the smoldering test requirements of the draft standard to be qualified as Type III furniture. Loose filling materials that do not meet the requirements of this test can only be used in furniture when encased with complying fire-resistant interlining fabrics (Type III-B) or with complying fire-barrier materials.

Summary of Test Method

The loose filling material to be tested is assembled in a metal test frame using metal inserts and covered by a standard cover fabric (**see Figure 16**). A small open flame is applied to the crevice formed by the intersection of the

seat/back surfaces of the mockup. Test measurements and observations are recorded during the 45-minute test duration. The mockup assembly must not exceed mass loss limits. Three tests are performed in succession.

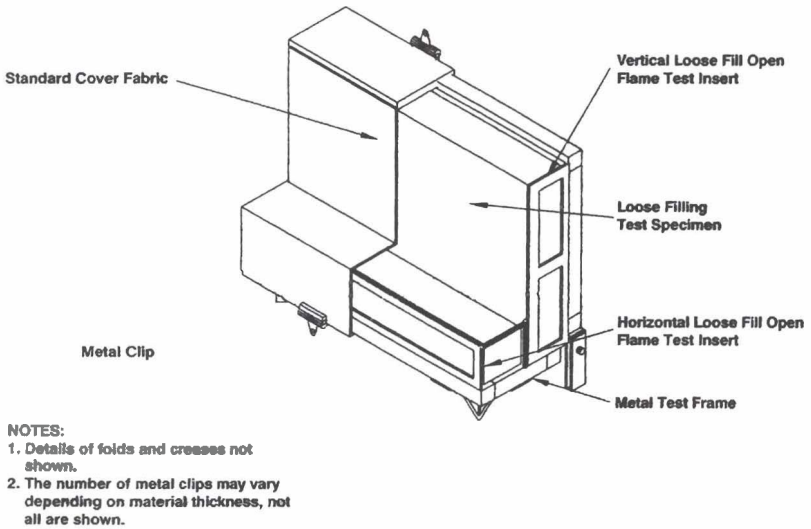


Figure 16 - Mockup Assembly for Loose Filling Material Open Flame Test.

Significance and Use

This test method is designed to measure the response of loose filling material, when placed under a standard cover fabric, to a small open-flame ignition source, representing a match, candle or cigarette lighter. The open flame ignition resistance and ability to prevent flaming combustion transfer is evaluated in this test.

Discussion of Comments on Loose Filling Materials Test

Open flame requirements for loose filling materials are included in the draft standard to reduce the use of loose filling material that can contribute to the open flame hazard of furniture. Commenters suggested limiting the scope of open flame test requirements to "non-foam cushion core materials". Staff interpreted this comment to apply to non-foam loose filling located in seat cushions and excluding loose filling materials found in back cushions. Excluding the materials used in the vertical location from performance requirements would significantly reduce the protection provided by materials in the horizontal location. Due to the presence of significant

mixtures of air with loose filling, they can readily ignite and rapidly propagate fire if the upholstery cover fabric is ignited.

The test requirements suggested by commenters for loose filling materials are those contained in the TB-117+ standard. The TB-117+ test method consists of encasing samples of loose filling material in a cushion made of flame-resistant ticking/fabric. If the manufacturer does not intend to encase the loose filling materials in a flame-resistant cushion in the article of furniture, the test cushion must be constructed using the actual upholstery fabric instead of a flame resistant fabric. The cushion is placed in a horizontal specimen holder and subjected to a 35 mm/20 second gas flame imposed from underneath the specimen. Observations of cushion integrity and mass loss are recorded. Commenters suggested that these test requirements be applicable only to loose filling materials located in a horizontal cushion.

The horizontal test for loose filling material in the TB-117+ standard contains elements that limit its technical feasibility for incorporation into a national standard. The geometry of upholstered furniture seating is better represented by the test apparatus contained in BS 5852, which includes both horizontal and vertical components, than the horizontal only apparatus and specimen configuration specified in TB-117+. Secondly, the TB-117+ test criteria unfairly fails loose filling materials if the interlining material or upholstery fabric breaks open during the test, regardless of mass loss of the loose filling.

The test requirements for loose filling materials in the draft standard are based on the BS 5852 mockup approach. The loose filling material to be tested is assembled in a metal test frame using metal inserts and covered by a standard cover fabric to form horizontal and vertical surfaces, as in typical upholstered furniture seating configurations. A 35 mm/20 second gas flame is placed in the crevice location. The mass loss of the mockup assembly is observed during the 45 minute test duration. The pass criterion requires no more than 20% mass loss during the 45 minute duration of the test. These test requirements for loose filling material are the same as those for resilient and fibrous filling materials.

6.3 Loose Filling Interliner Fabrics

Scope

This test method is intended to measure the open flame ignition resistance of loose filling interliner fabrics used to encase loose filling materials in upholstered furniture. Such fabrics are commonly used as protective lining for loose filling found in loose or semi-attached backs, arms, or throw pillows. The materials covered by this test method include, but are not limited to, flame-resistant ticking or non-woven fabrics used to protect loose filling.

In addition to complying with this test, loose filling interliner fabrics must also comply with the smoldering requirements of the draft standard to be qualified as Type III-B furniture. Loose filling interliner fabrics that do not meet the requirements of this test can only be used in furniture with complying loose filling material (Type III) or fire-barrier materials.

Open flame requirements for loose filling interliner fabrics are included in the draft standard to allow the use of fire-resistant interliner fabrics, if needed to encase loose filling materials that do not comply with smoldering and/or open flame test requirements. Interliner fabrics that comply with these tests act as localized fire-barriers to protect loose filling from open flame ignition. These test requirements provide manufacturers greater flexibility in production of complying furniture.

Summary of Test Method

The loose filling interliner fabric to be tested is assembled in a metal test frame using metal inserts filled with standard polyester fiber fill and covered by a standard cover fabric (**see Figure 17**). A small open flame is applied to the crevice formed by the intersection of the seat/ back surfaces of the mockup. Test measurements and observations are recorded during the 45-minute test duration. The mockup assembly must not exceed mass loss limits. Three tests are performed in succession.

The test method is based on the general approach of BS 5852, consistent throughout open flame tests in the draft standard. A standard polyester fiber fill substrate is

used to evaluate the ability of the protective interliner to prevent fire spread to filling. The construction of the mockup involves the use of metal inserts to contain the polyester fiber fill substrate.

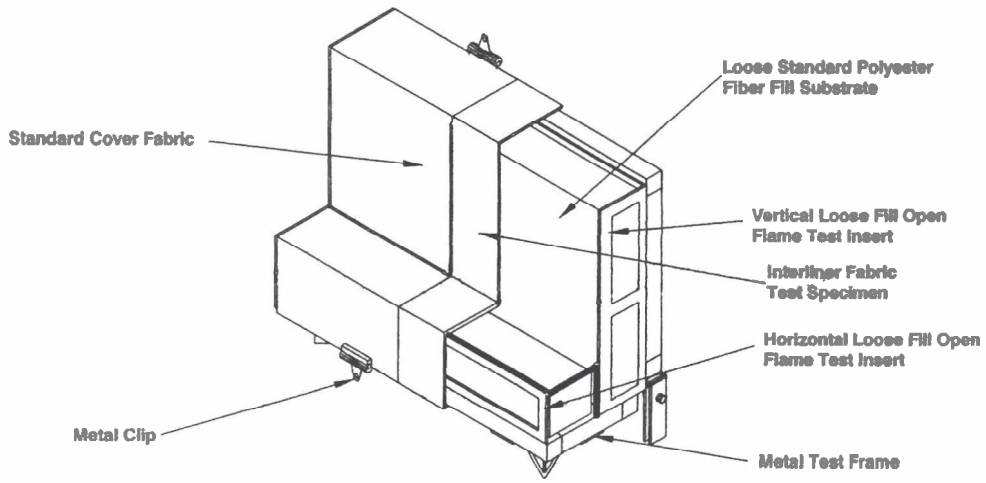


Figure 17 - Mockup Assembly for Loose Fill Interliner Fabric Open Flame Ignition Resistance Test.

Significance and Use

This test method is designed to measure the response of loose filling interliner fabrics, when filled with a standard polyester fiber fill substrate and placed under a standard cover fabric, to a small open-flame ignition source, representing a match, candle or cigarette lighter. Interliner fabrics that comply with both smoldering and open flame requirements may be used with non-complying loose filling.

6.4 Resilient Filling Materials

Scope

This test method is intended to measure the open flame ignition resistance of resilient filling materials used in upholstered furniture. The test applies to all resilient filling materials including, but not limited to polyurethane, polychloroprene (synthetic latex), polyamide,

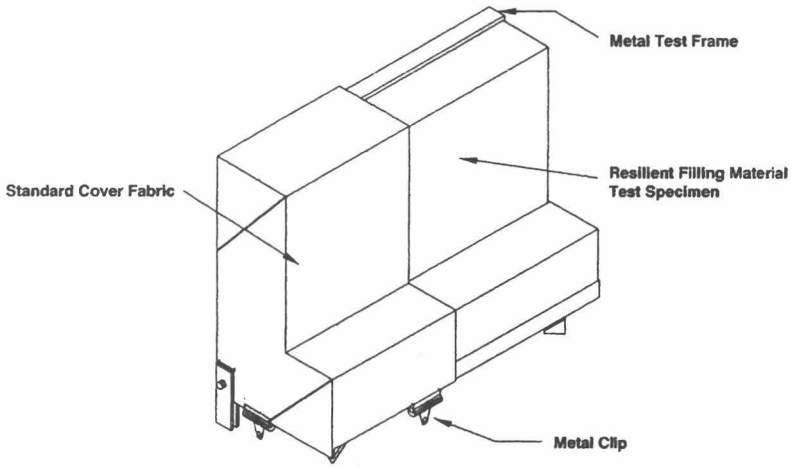
polyvinyl, latex (styrene-butadiene) rubber, etc. and other types of resilient cellular polymer and copolymer of the above or other materials. Rigid cellular plastics that provide no resiliency are considered to be structural material and thus are not subject to this test.

In addition to complying with this test, resilient filling materials must also comply with the smoldering test requirements of the draft standard for use in Type III furniture. Resilient filling materials that do not meet the requirements of this test can only be used in furniture with complying fire-barrier materials.

Open flame requirements for resilient filling materials are included in the draft standard to reduce the use of resilient filling materials that can contribute to the open flame ignition hazard of furniture. Most resilient filling materials consist of polyurethane foams. Polyurethane foams provide a significant fuel load in furniture. Conventional polyurethane foams ignite readily and can quickly spread fire. The requirements in the draft standard will result in the reduction of ignition propensity and reduce fire spread of flammable resilient filling materials.

Summary of Test Method

The resilient filling material to be tested is covered with a standard cover fabric and assembled on a metal test frame (**see Figure 18**). A small open flame is applied to the crevice formed by the intersection of the seat/back surfaces of the mockup. Test measurements and observations are recorded during the 45-minute test duration. The mockup assembly must not exceed mass loss. Three tests are performed in succession.



NOTES:
1. Details of folds and creases not shown.
2. The number of metal clips may vary depending on material thickness, not all are shown.

Figure 18 - Mockup Assembly for Resilient Filling Material Open Flame Ignition Resistance Test.

Significance and Use

This test method is designed to measure the response of a resilient filling material, when tested under a standard cover fabric, to a small open flame ignition source representing a match, candle or cigarette lighter. The ignition propensity and combustion intensity of resilient filling material are evaluated in this test.

Discussion of Comments on Resilient Filling Materials Test

The open flame test requirements for resilient filling materials suggested by commenters are those contained in TB-117+. There are two test options in the TB-117+ standard. Option A, Mock-up Tests of Cellular Foam, utilizes a bench-scale mockup approach based on the BS 5852 standard. This test method is based on the application of a 35 mm/20 second flame to the crevice of a seat/back mockup of the foam with no cover fabric. The burning behavior is observed and mass loss of the assembly is recorded. Option B, Vertical Flame Test of Cellular Foam, is intended for use in determining the resistance of resilient cellular materials to flame propagation of a thin sample. This test method is based on the application of a 35 mm/12 second flame to a thin specimen of resilient cellular material in a vertical configuration. The test

cabinet is that contained in 16 CFR 1615 and 1616 standards for the flammability of children's sleepwear. The burning of the test specimen is observed for the presence of flaming and melting drips, and the char length and after-flame times are recorded and averaged.

The CPSC staff has incorporated elements of Option A as the basis for open flame test requirements for resilient filling materials in the draft standard. The primary modifications to the commenters' suggestions, in addition to limiting the test duration to 45 minutes, are the addition of a standard cover fabric, modification of the pass/fail criteria, and elimination of Option B.

Addition of Standard Cover Fabric in Mockup Assembly

A standard cover fabric was included in the draft standard to improve the test method's evaluation of resilient filling material performance by making the mockup more representative of typical upholstered furniture configurations. Resilient filling materials are used either directly beneath or wrapped with other filling material below upholstery cover fabrics. An effective test method to evaluate resilient filling materials requires the use of cover fabric in the construction of the mockup to account for the contribution of upholstery fabrics in a fire. The inclusion of the standard fabric creates a test that better evaluates the performance of resilient filling materials and establishes better correlation to real-world furniture. The standard cover fabric specified to evaluate resilient filling materials is the same fabric used in smoldering resistance tests in the draft standard.

Pass/Fail Requirements

In the draft standard, CPSC staff modified the pass criterion suggested by commenters from a maximum of 4% at 10 minutes to allow no more than 20% mass loss during a 45 minute test duration.

The pass/fail criteria specified in the draft standard accounts for the some of the mass loss of the standard fabric used in the test. During the initial minutes of the test, 4% - 5% mass loss can result from the burning of the standard cover fabric alone without any significant ignition of the resilient filling material. CPSC test data show that the proposed test requirements will limit the use

of filling materials that ignite and burn readily from exposure to a small open flame and standard upholstery fabric in upholstered furniture construction.

Elimination of Option B

CPSC staff eliminated Option B, Vertical Flame Test of Cellular Foam, for evaluation of resilient filling material. The component aspect, sample orientation, and measurements of char length contained in this test do not relate to or adequately evaluate the performance of resilient filling material with respect to open flame performance of complex furniture items.

6.5 Upholstery Fabric Fire Barrier

Scope

This test method is intended to measure the open flame ignition resistance of upholstery fabric fire barriers used in upholstered furniture. This test allows upholstery fabrics to qualify as approved fire-barriers.

In addition to complying with this test, upholstery fabric fire barriers must also comply with smoldering test requirements of the draft standard to be qualified for use in Type II furniture.

Open flame requirements for upholstery cover fabrics are included in the draft standard to allow the use of fire-resistant cover fabrics as an alternate means of achieving ignition resistance. Upholstery cover fabrics and materials such as wool, leather, and FR back-coated fabrics that have relatively high open flame and smoldering ignition resistance characteristics reduce the need to modify filling materials. These test requirements provide manufacturers greater flexibility in production of complying upholstered furniture.

Summary of Test Method

The upholstery fabric fire barrier to be tested is placed over a standard polyurethane foam substrate and assembled on a metal test frame (**see Figure 19**). A small open flame is applied to the crevice formed by the intersection of the seat/back surfaces of the mockup. Test measurements and observations are recorded during the 45-

minute test duration. The mockup assembly must not exceed mass loss limits. Three tests are performed in succession.

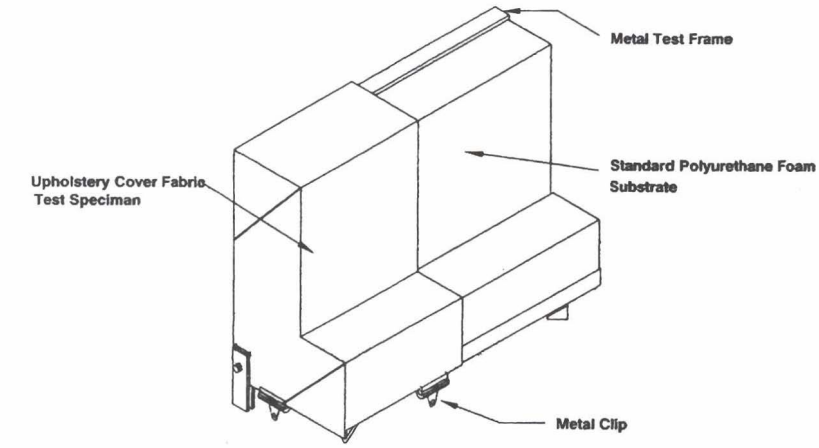


Figure 19 - Mockup Assembly for Upholstery Fabric Fire Barrier Open Flame Ignition Resistance Test.

Significance and Use

This test method is designed to measure the response of upholstery cover fabrics used as fire-barriers, when tested over standard foam substrate, to a small open-flame ignition source representing a match, candle or cigarette lighter. This test evaluates the ability of upholstery cover fabrics to resist open flame ignition and protect underlying materials from the spread of fire.

Discussion of Comments on Upholstery Fabric Test

Two different open flame test methods were suggested by commenters for upholstery cover fabrics. Some commenters suggested a test method based on the current TB-117 (CS 191-53), where a fabric sample is suspended in a test cabinet at a 45 degree angle and exposed to a approximately 5/8 inch flame for 5 seconds. The burning rate of the sample is observed. Other commenters suggested using the TB 117+ test method that applies to all upholstery fabrics used to cover filling materials and to decking fabrics below detachable cushions. This method specifies the application of a 35 mm flame for 20 seconds to the crevice of a seat/back mock-up assembly of an

upholstery fabric over a standard flame-retardant polyurethane foam substrate. The burning behavior of the specimen is observed, and the mass loss and burn time are recorded.

The 45 degree as specified test is not an appropriate test to evaluate the open flame hazard presented by upholstery cover fabrics. This test method and the performance criteria were developed to reduce deaths and injuries associated with the ignition of wearing apparel. The test method measures the ease of ignition and speed of flame spread of apparel fabrics. CPSC staff evaluation [24] of this method showed that fabrics passing the 45 degree test could produce large amounts of heat and flame generation. Furthermore, the configuration of this test and the accompanying performance criteria do not account for the effect of fabrics in combination with other materials used in upholstered furniture construction. In the absence of a smoldering test for upholstery fabrics, the 45 degree test may encourage the use of slow-burning but smolder-prone fabrics, an unacceptable result.

The primary hazard presented by upholstery cover fabrics, smoldering ignition, is accounted for by the smoldering test requirements in the draft standard. Minimizing the open flame ignition hazard from upholstery cover fabrics is accomplished in the draft standard with the use of a standard cover fabric during evaluation of filling and fire-barrier materials. The standard cover fabric provides an appropriate burning challenge to the filling and barrier materials. Requiring fillings and barriers to perform well when challenged with the flaming imposed by the standard cover fabric diminishes the need for establishing testing requirements for all upholstery fabrics. The test methodology used in the draft standard to evaluate the open flame hazard of filling and fire-barrier material is consistent with the approach specified in the TB-117+ standard.

6.6 Interior Fire Barrier

Scope

This test procedure is intended to measure the open flame ignition resistance of interior fire-barrier materials used in upholstered furniture construction. This

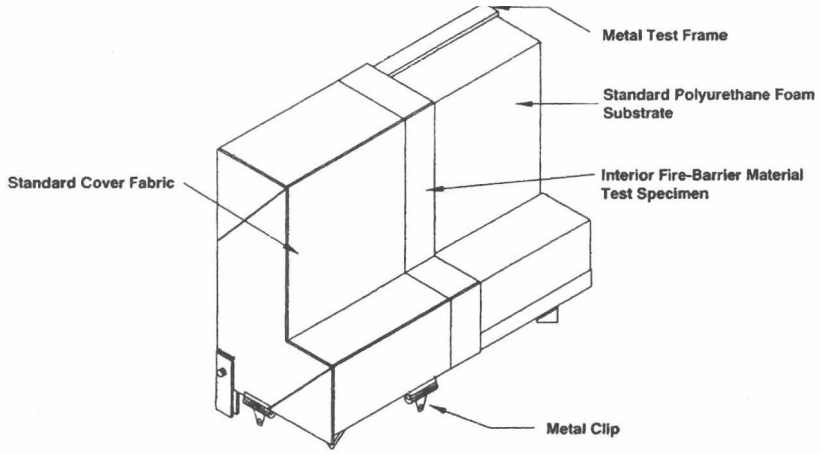
test applies to interior fabrics or high loft battings to qualify them as approved fire-barriers.

In addition to complying with this test, interior fire barriers must also comply with the smoldering test requirements of the draft standard for use in Type I furniture.

Open flame requirements for interior fire-barrier materials are included in the draft standard to allow for the use of fire-resistant materials as an alternate means of achieving ignition resistance. Materials that comply with the smoldering and open flame requirements of the standard limit the transfer of combustion to underlying materials, therefore reducing the need to modify upholstery fabrics and fillings. These test requirements provide manufacturers greater flexibility in production of complying upholstered furniture.

Summary of Test Method

The interior fire-barrier material to be tested is placed between a standard cover fabric and standard foam substrate and assembled on a metal test frame (**see Figure 20**). An open flame (240 mm) ignition source is applied to the crevice formed by the intersection of the seat/back surfaces of the mockup. Test measurements and observations are recorded during the 45-minute test duration. The mockup assembly must not exceed mass loss limits. Three tests are performed in succession.



NOTES:
1. Details of folds and creases not shown.
2. The number of metal clips may vary depending on material thickness, not all are shown.

Figure 20 - Mockup Assembly for Interior Fire Barrier Materials Open Flame Ignition Resistance Test.

Significance and Use

This test method is designed to measure the response of an interior fire-barrier material over a standard foam substrate when exposed to a burning standard cover fabric. These test requirements provide manufacturers greater flexibility in production of complying upholstered furniture.

Discussion of Comments on Interior Fire Barrier Test

Commenters stated their support of provisions for the use of fire-barriers as an alternate means of compliance to a national flammability standard. The allowance for the use of barriers would provide greater flexibility for manufacturers and choice to consumers, especially for higher-end furniture using decorative fabrics.

CPSC staff agrees that allowance should be provided in a national flammability standard for fire-barriers as an alternate means of compliance. This allows the use of fabrics that cannot be modified to improve their fire performance by protecting interior materials from significant involvement in a fire. The draft standard contains provisions for the use of fire-barriers that can

include high loft battings, interior, or upholstery cover fabrics/materials that provide resistance to smoldering and small open flame ignition.

6.7 End Product Material

Scope

This test procedure is intended to measure the open flame ignition resistance of actual combinations of materials intended for use in the construction of the finished furniture item. This test applies to the cover fabric, interliner/fire-barrier (if present) and any filling materials in the end product for use in Type IV furniture.

In addition to complying with this test, end product materials must also comply with the smoldering test requirements of the draft standard for use in Type IV furniture.

Open flame requirements for end product materials are included in the draft standard to allow for the use of fire-resistant materials as an alternate means of achieving ignition resistance. Materials that comply with the smoldering and open flame requirements of the standard limit the transfer of combustion to underlying materials, therefore reducing the need to modify upholstery fabrics and fillings. These test requirements provide manufacturers greater flexibility in production of complying upholstered furniture.

Summary of Test Method

The cover fabric, interliner/fire-barrier (if present) and any filling materials in the finished product are assembled on a metal test frame. A small open flame (240 mm) ignition source is applied to the crevice formed by the intersection of the seat/back surfaces of the mockup. Test measurements and observations are recorded during the 45-minute test duration. The mockup assembly must not exceed mass loss limits. Three tests are performed in succession.

Significance and Use

This test method is designed to measure the response of combined assemblies of cover fabrics, interliner/fire-

barrier (if present) and any filling material intended for use in the finish product to a small open flame ignition source representing a small match, candle or cigarette lighter. This testing approach may be advantageous for certain furniture combinations where the use of actual materials provides better flammability performance than indicated when individual materials are tested as in Type III tests.

7.0 Large Scale Fire Testing

The CPSC staff is currently developing a large scale fire test program. It is expected that in this study, large scale fire tests using both open flame and smoldering ignition sources will be conducted to provide information on the effectiveness of the bench-scale test requirements in the draft standard. This will be accomplished by measuring the combustion parameters and test room conditions.

An interagency agreement between the CPSC and National Institutes of Standards and Technology (NIST) was established in July 2005 to conduct a portion of large scale tests. A pilot study was completed in December of 2005. Data analysis from this pilot is in process. The results of this pilot will be used to refine the large scale test program.

8.0 Conclusions

This report serves as a technical rationale document to support the draft standard. The goal of the standard is to reduce the number of deaths, injuries, and property loss caused by upholstered furniture fires. The draft standard consists of bench-scale tests based on existing flammability standards addressing both smoldering and open flame ignition. During the development of the draft standard, numerous technical comments provided by stakeholders were taken into consideration.

The draft standard developed by staff is a technically reasonable and commercially feasible flammability standard that would significantly improve the flammability performance of upholstered furniture.

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[2] Upholstered Furniture Action Council Test Methods

[3] British Standards Institute (BS) 5852 - "Methods of test for assessment of the ignitability of upholstered seating by smouldering and flaming ignition sources" 1990.

[4] State of California Department of Consumer Affairs Bureau of Home Furnishings and Thermal Insulation (BHFTI) Technical Bulletin 117 "Requirements, Test Procedure and Apparatus for Testing the Flame Retardance of Resilient Filling Materials Used in Upholstered Furniture" March 2000.

[5] TB-117 Draft, "Requirements, Test Procedure and Apparatus for testing the Flame and Smolder Resistance of Upholstered Furniture" 2002.

[6] V. Babrauskas and J. Krasny, "Fire Behavior of Upholstered Furniture", November 1985.

[7] Memorandum to D. Ray from L. Fansler, UK Chair and Mockup Test Results", October 2000.

[8] Memorandum to L. Fansler from Craig Morris, "UK Chair Upholstery Study Flammability Test Results", March 2001.

[9] Response to 2003 ANPR Comments, "Upholstered Furniture Flammability Proceeding", L. Morris, CBHFTI, December 2003.

[10] Response to 2003 ANPR Comments, "Review and Analysis of Inter-Laboratory Study (ILS) on Upholstered Furniture Composite Mock-ups", A. Grand, Ph.D., N. Ullman. January 2004.

[11] Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from W. Tao, "Evaluation of Test Method and Performance Criteria for Cigarette Ignition

(Smoldering) Resistance of Upholstered Furniture Components", May 2005.

[12] Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from L. Fansler and L. Scott, "Performance Criteria, and Standard Materials for the CPSC Staff Draft Upholstered Furniture Standard," May 2005.

[13] NBSIR 78-1438, "Back-Up Report for the Proposed Standard for the Flammability (Cigarette Ignition Resistance) of Upholstered Furniture PPF 6-76", J. Loftus, June 1978.

[14] Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from L. Fansler, "Upholstered Furniture Project - Update on Standard Materials" December 2005.

[15] Memorandum to J. Sharman from J. Loftus, "Results of Temperature Measurements Made on Burning Cigarettes and Their Use as a Standard Ignition Source for Mattress Testing", June 1971.

[16] Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from L. Fansler, "Exploratory Tests of Barrier Materials", October 2004.

[17] Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from L. Fansler and L. Scott, "Open Flame Ignition Test Methodology Development", May 2005.

[18] Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from L. Fansler and L. Scott, "Performance Criteria, and Standard Materials for the CPSC Staff Draft Upholstered Furniture Standard", May 2005.

[19] Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from J. Murphy and L. Mulligan, "Heat Flux and Temperature Measurements of 35 mm Butane Flame, Cigarette Lighters, Candles, and Matches", June 1997.

[20] Journal of Fire Sciences, "Standard Flaming Ignition Sources for Upholstered Composites, Furniture and Bed Assembly Tests", K.T. Paul. May 1987.

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[22] Lerner, N.D., "Abilities of Young Children to Operate Butane Cigarette Lighters", Comsis Corporation, March 1998.

[23] Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from L. Fansler, "Alternate Ignition Sources for Fire Blocking Barrier Evaluations", November 2004.

[24] Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from W. Tao, "Assessment of Fabric Open Flame Test Methodology", May 2005.

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: January 25, 2006

TO : Dale Ray, Project Manager, Upholstered Furniture
Directorate for Economic Analysis

THROUGH: Andrew G. Stadnik, P.E., AED Laboratory Sciences
Edward W. Krawiec, P.E., Division Director,
Electrical and Flammability Engineering
Joel R. Recht, Ph.D., Division Director, Chemistry

FROM : Linda Fansler, Division of Electrical and Flammability Engineering LF

SUBJECT : Upholstered Furniture Project – Update on Standard Materials

INTRODUCTION

This memorandum reports on testing done by the U.S. Consumer Product Safety Commission's (CPSC) Directorate of Laboratory Sciences (LS) staff from May 2005 to the present. This testing further assesses the flammability performance of potential standard materials candidates. Following work reported on in May 2005,[1] an additional 450 tests were done to further assess the staff's recommendation to use cotton velvet as the standard cover fabric, and a minimally flame retardant treated foam as the standard foam in the CPSC staff's, May 2005, draft proposed standard.[2]

BACKGROUND

Test results reported in May, 2005, established the feasibility of using a standard cover fabric for small open flame testing of foam and interliner materials found in upholstered furniture.[1] Of the 41 upholstery cover fabrics evaluated in this program, Fabric 24, the standard test fabric specified in Technical Bulletin 117[3] provided a reasonable challenge to underlying components. Fabric 24 is a 10 oz/yd^2 cotton velvet fabric. Figure 1 shows the results of tests with Fabric 24 and a variety of foams included in the test program. A 35 mm flame applied for 20 seconds was used in these tests to evaluate the fabric and foam combinations. For the most part, Fabric 24 performed consistently when combined with both treated and non-treated foam.

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[1] Memorandum to D. Ray, Project Manager, Upholstered Furniture, from L. Fansler, "Performance Criteria, and Standard Materials for the CPSC Staff Draft Upholstered Furniture Standard.

[2] Draft Standard For The Flammability of Upholstered Furniture And Upholstered Furniture Materials, May 2005, CPSC's website: http://www.cpsc.gov.

[3] Technical Bulletin 117, Requirements, Test Procedure and Apparatus for testing the Flame and Smolder Resistance of Upholstered Furniture, State of California, Department of Consumer Affairs, Bureau of Home Furnishings and Thermal Insulation, February 2002, DRAFT.

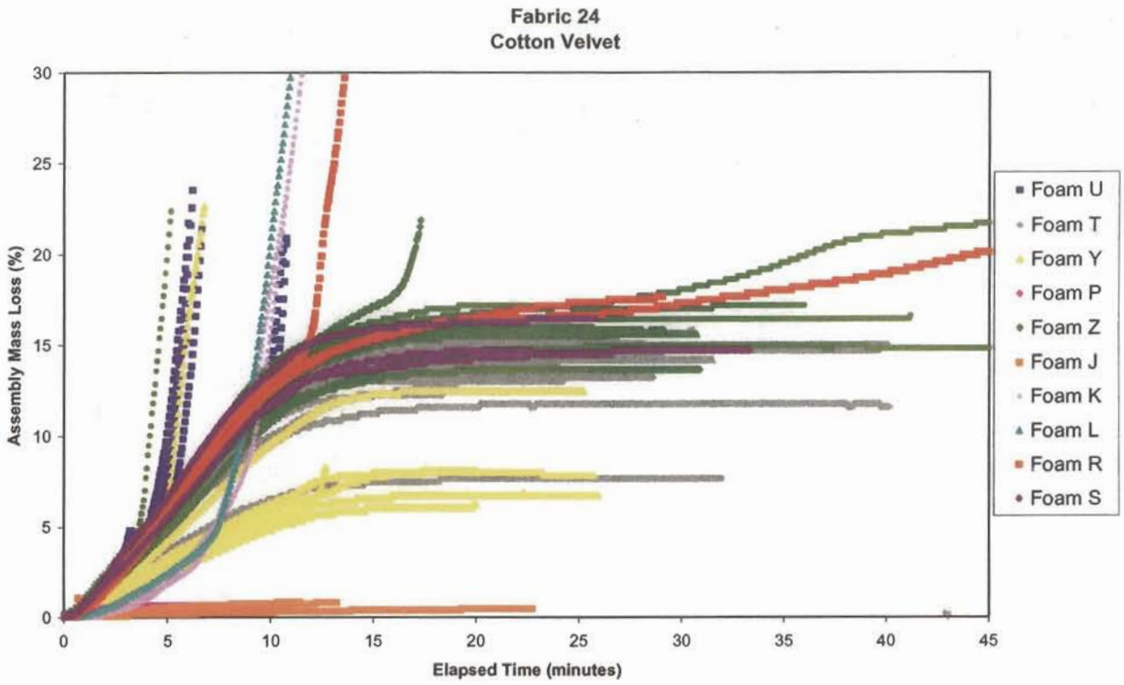


Figure 1. Small open flame test results for cotton velvet (Fabric 24) on a variety of foams.

For smoldering ignitions, the data[4] also suggest that Fabric 24 is a reasonable choice as a standard fabric because it is a smolder-enhancing fabric. Fabric 24 provides a challenge to the materials below in small open flame ignitions and in addition, is the standard fabric specified by the State of California[5] for smoldering ignition tests. Figure 2 shows that Fabric 24 when combined with chemically treated foams (Foams T, R and Z[6]) Foams R and Z provided the greater challenge. For a standard test fabric, a foam mass loss range for smoldering of between 8 and 20 percent was established along with a test duration of 30 minutes using a three-inch thick foam substrate.

[4] Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from W. Tao, "Evaluation of Test Method and Performance Criteria for Cigarette Ignition (Smoldering) Resistance of Upholstered Furniture Components," May 2005, CPSC.

[5] Fabric 24, 100% cotton velvet is specified in California Bureau of Home Furnishings and Thermal Insulation Filling Materials Used in Upholstered Furniture, March 2000 and the revised Technical Bulletin 117, Requirements, Test Procedure and Apparatus for testing the Flame and Smolder Resistance of Upholstered Furniture, DRAFT February 2002.

[6] Limited tests were done using Foam Z due to the limited amount of Foam Z available.

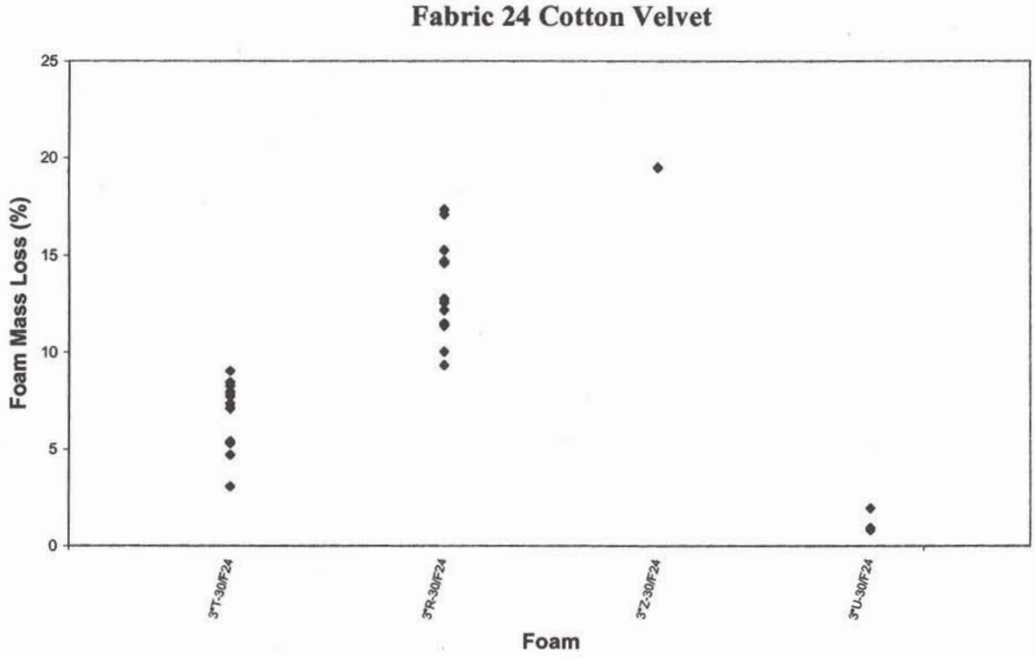


Figure 2. Smoldering ignition test results for cotton velvet (Fabric 24) on a variety of foams.

Subsequent to publishing these findings in May 2005, Commission staff became aware of industry concerns about the observed variability in the flammability performance of Fabric 24, especially when the cotton velvet fabric was used in small open flame tests.[7] To address these concerns, LS staff acquired additional rolls of Fabric 24 and initiated an ongoing dialogue with the manufacturer of Fabric 24.

Foam performance was also evaluated and reported on in the May 2005, memorandum.[1] LS staff established two criteria to measure acceptable foam performance. The first is the foam ignition protocol in Technical Bulletin 117, DRAFT 2002,[3] where chemically treated foams did not ignite when the small flame was applied for 20 seconds, but did ignite with a 30-second ignition source flame. In addition, a small open flame performance band was established using Fabric 24 test data. The performance band is narrow in the early stages of the test but at 20 minutes widens to an allowable range of assembly mass loss of 12 to 20 percent. Figure 3 shows the assembly mass loss versus elapsed time performance band established for the standard flame retardant chemically treated foams when tested with Fabric 24. Chemically treated foams, Foam R and Foam Z, met these two small open flame criteria.

[7] Letter to Commissioner Nancy Nord, from Mr. Robert Luedeka and Mr. James McIntyre, of the Polyurethane Foam Association (PFA), July 11, 2005.

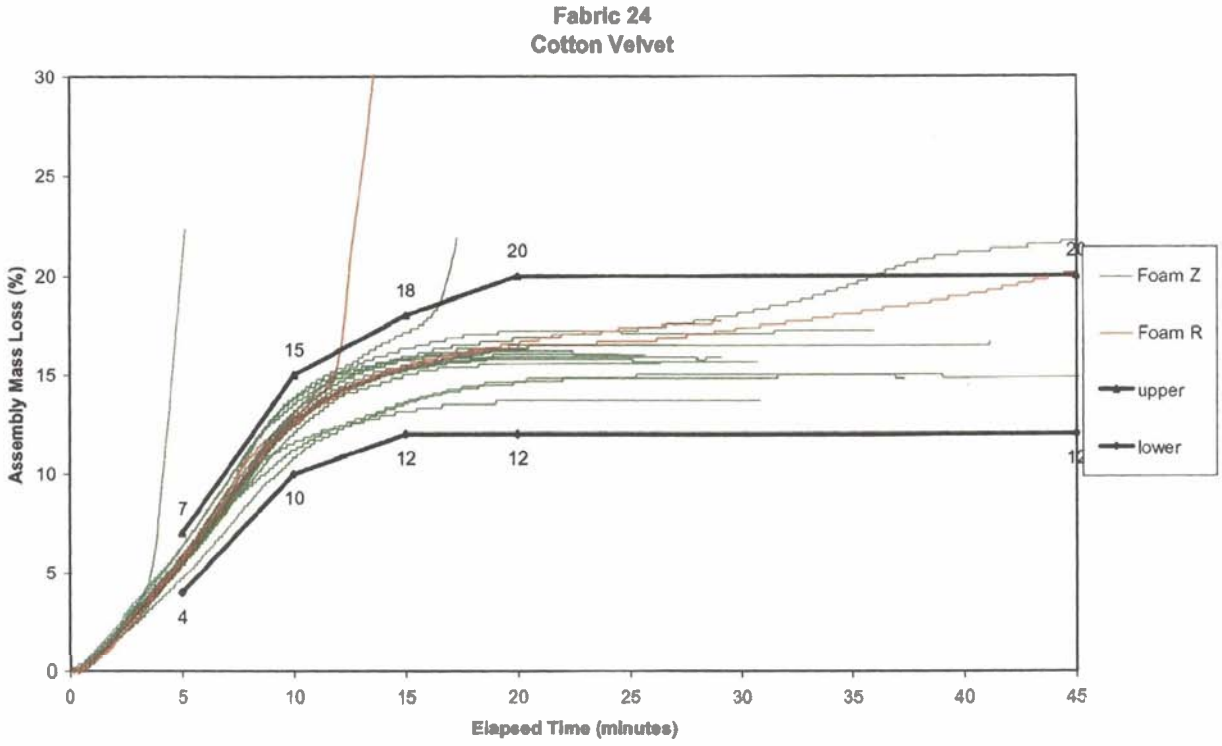


Figure 3. Small open flame performance band.

LS chemistry staff analyzed[8] these two chemically treated foams. Foam R was found to contain global averages of 3.0% of Polybrominated Diphenal Ether (PBDE) and 3.3% of FM-550™,[9] and is no longer available from the manufacturer. Foam Z was found to contain global averages of 2.8% of melamine and 6.0% of FM-550™. CPSC contacted the manufacturer of Foam Z to obtain an additional quantity of this foam. The new batch of Foam Z was analyzed by LS staff and found to contain a global average of 3.1% melamine and 7.0% FM-550™ . Both of these percentages of flame retardant chemicals and chemical compositions are greater than found in the original batch of Foam Z. The new batch of foam was labeled as Foam Z". Because Foam Z" contained more flame retardant chemicals it did not meet the bare foam ignition test; about 50% of the time this foam did not ignite with a 30 second flame application. LS staff contacted the manufacturer to determine why Foam Z" was different than the original Foam Z.

This memorandum reports on the recent work at LS involving flammability testing and chemical analysis with cotton velvet fabric and Foam Z" purchased in the spring and summer of 2005.

[8] Memorandum to D. Ray from D. Cobb and S. Chen, LSC, "Analysis of FR Chemicals Added to Foams, Fabric, Batting, Loose Fill and Barriers," May 2005, CPSC.
[9] The material safety data sheet for FM-550™ indicates it contains a mixture of halogenated aryl esters and aromatic phosphates such as triphenyl phosphate.

RESULTS AND DISCUSSION

Cotton Velvet Fabric (Fabric 24)

LS staff ordered a total of 400 additional yards of Fabric 24 from a textile supplier. Two orders of two hundred yards each were placed with the first order consisting of five rolls of Fabric 24 varying in length from approximately 16 yards to 50 yards. The rolls were randomly numbered 1 through 5. The second order consisted of four 50-yard rolls. The rolls of fabric were randomly numbered 6 through 9. Table 1 contains the fabric weights for each roll of fabric. The fabric weights were similar to the weight of Fabric 24 used in the original set of tests, (10 oz/yd^2).

Table 1. Fabric Weight – Fabric 24

Fabric 24 Roll Identification	Fabric Weight (oz/yd^2)
1	10.2
2	10.0
3	10.0
4	10.0
5	10.5
6	10.5
7	10.2
8	10.0
9	10.3

20-Second Small Flame Tests

The fabrics were evaluated using the 20-second small flame test protocol outlined in the CPSC staff's draft standard.[2] Fabric Rolls 1 through 5 arrived at LS while staff was waiting for the new batch of foam, Foam Z". Foam T a more heavily chemically treated foam, (global averages of 2.2% melamine and 8.2% tris (1, 3-dichloro-2-propyl) phosphate), was used to initially evaluate these rolls of fabric.

Overall Rolls 4 and 8 performed consistently and were most like the original rolls of cotton velvet fabric. Six tests were done with Roll 4 because its flammability performance was similar to the original rolls of cotton velvet. All six tests were consistent and fell into the small open flame performance band.

Five of the six tests with Roll 8 performed consistently and fell into the small open flame performance band. In the sixth test, the foam ignited at the upper corner at approximately 12 minutes and burned rapidly with an 80 percent assembly mass loss. Figure 4a shows the results of these tests.

Three tests were done with Roll 1 and Foam Z". Although the foam did not ignite in the first test, it did ignite in the second and third test. Once ignited, the foam burned quickly resulting in greater than an 80 percent assembly mass loss.

When tested with Foam Z", Roll 2 broke open in two tests allowing ignition of the foam below resulting in rapid combustion of the mockup. A third test with Roll 2 can be characterized as performing more similarly to the original rolls of cotton velvet.

Three tests with Roll 3 were also inconsistent. In two tests the mockups ignited and burned rapidly and in the other test, the flames went out early in the test and the mockup smoldered for the remainder of the test.

Three tests were done with Roll 5 and Z". The foam did not ignite in the first two tests resulting in very little assembly mass loss, between 7 and 8.5 percent. In the third test the foam ignited and burned rapidly reaching an assembly mass loss of 78.7 percent.

In three tests with Roll 6, the fabric broke open exposing the foam in less than 5 minutes resulting in rapid ignition of the mockups in two tests. The flames went out in 5 minutes in the third test with Roll 6, and the mockup smoldered for the remainder of the test. Roll 7 was evaluated in three tests with two tests performing similarly (rapid ignition of the mockup within the first 5 minutes) and the third test self-extinguishing. Roll 9 performed similarly to Roll 7; two mockups had fast ignitions and one mockup self-extinguished. Figure 4b shows the results of these tests.

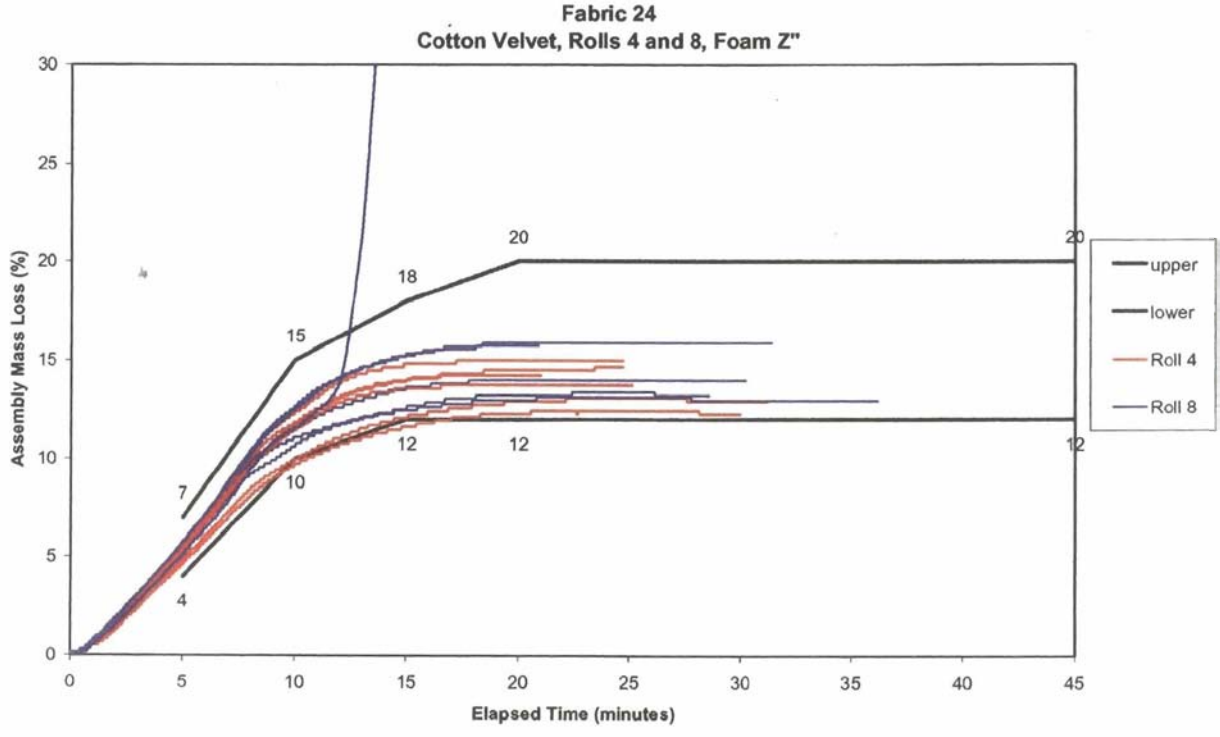
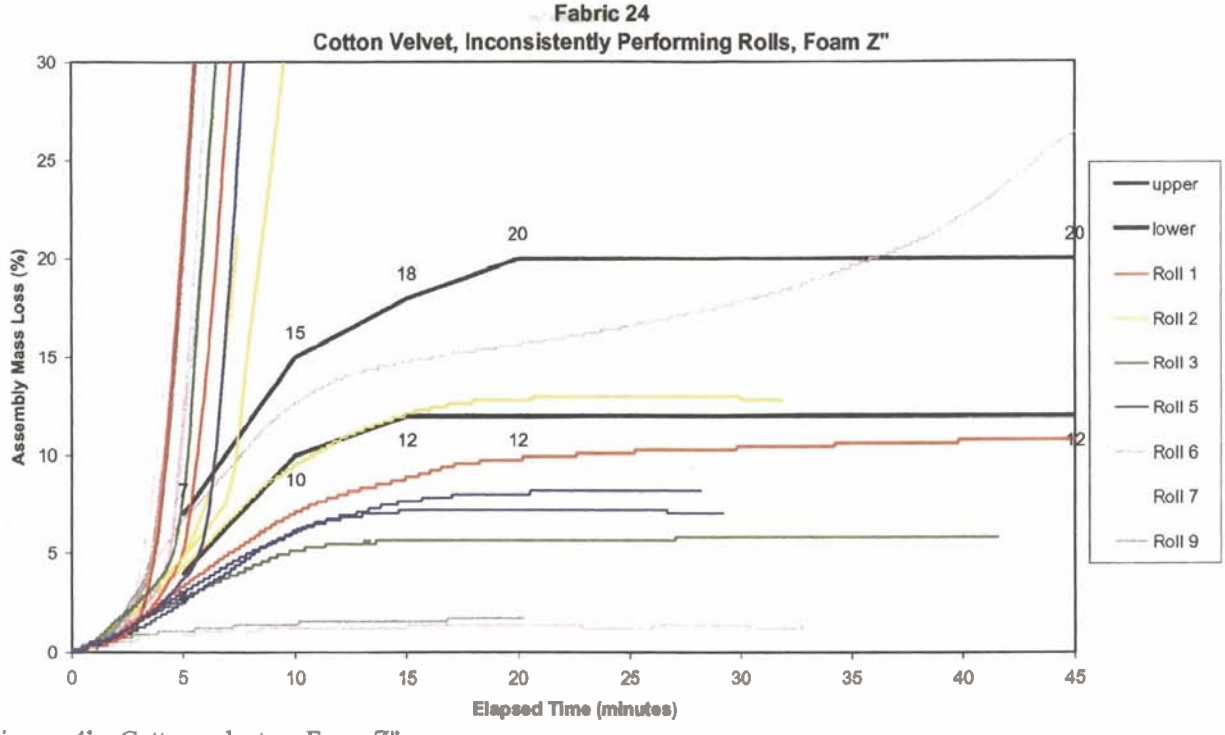


Figure 4a. Cotton velvet on Foam Z".



Figures 4b. Cotton velvet on Foam Z".

Smoldering – Cigarette Ignition Tests

The fabrics were evaluated using the cigarette ignition protocol outlined in the CPSC staff's draft standard.[2] Rolls 1 and 5 were not evaluated using the cigarette ignition protocol for the same reasons that Rolls 1 and 5 were not initially evaluated using the small open flame ignition source. The Smoldering Performance Requirement in the CPSC staff's draft standard[2] states that the foam mass loss must be between 8 and 20 percent with an average of 12 trials between 10 and 15 percent. Most of the rolls of cotton velvet fabric (Fabric 24) met this requirement when tested with Foam Z". Rolls 2 and 4 had lower foam weight losses (around 4.3 percent). Overall the foam weight loss for all rolls of fabric was between 4.3 and 17.9 percent. Three mockup tests were done with each roll of fabric. Figure 5 shows the results of these tests.

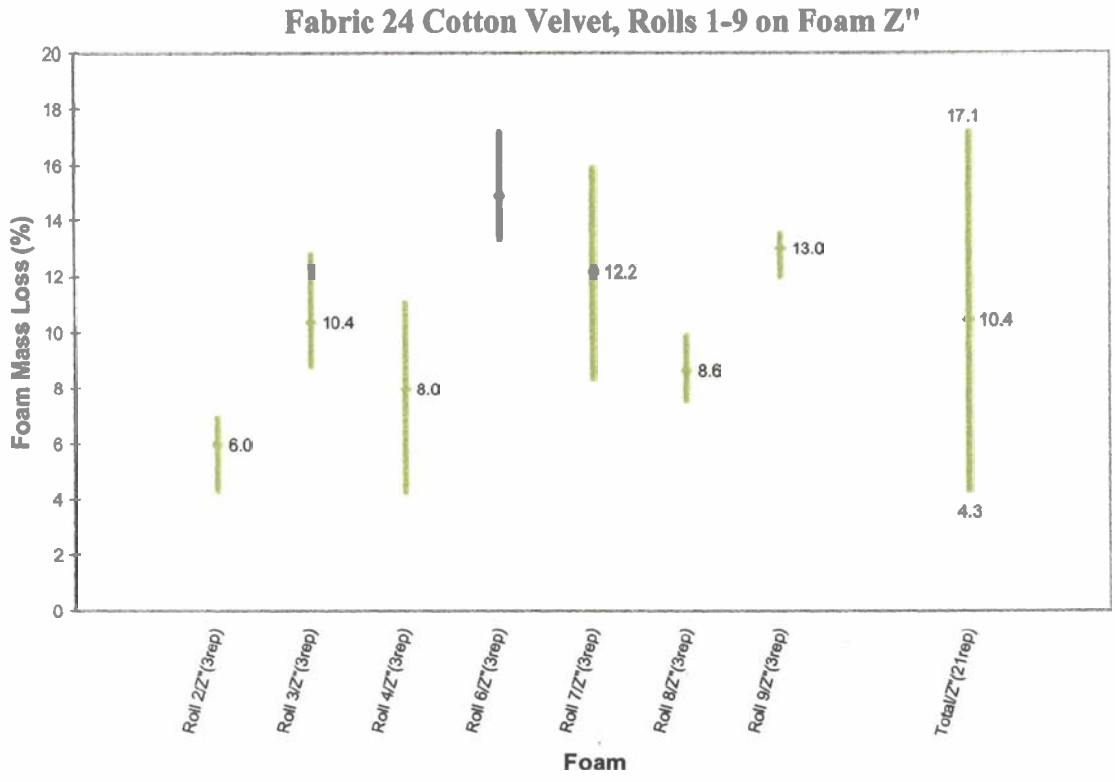


Figure 5. Cotton velvet on Foam Z"

Chemical Analysis

As part of our effort to better understand the variability seen among the different rolls of Fabric 24, LS staff chemically analyzed all of the rolls and determined that melamine was present in all cases. Discussions with the fabric manufacturer revealed that melamine was present in a resin applied to the fabric. Because the melamine was present as a resin, it was only partially extractable and could not be quantified directly. Determining the amount of nitrogen present in the fabric was chosen as a way to ascertain the amount of melamine present on the fabric. LS staff sent pieces of most of the different rolls of cotton velvet fabric along with leftover scraps of fabric from three of the original rolls of Fabric 24 to an outside laboratory for nitrogen analysis. Several pieces of Roll 6 were sent for analysis. Pieces of this fabric were taken from a specimen that showed an unusual burn pattern, igniting and burning on only half of the mockup surface. The locations where samples were taken from the mockup are indicated. Table 2 shows the results of this analysis. In addition, Table 2 shows the metal ion content of some of the rolls of Fabric 24.

Table 2. Chemical Analysis of Percent Nitrogen and Metal Ions

Roll ID	% N	Effective % Melamine Concentrations*	% Ca	% Mg	% Na	% K	% Zn	% P	% B	% Sb
X**	0.39	0.49								
A**	0.34	0.41								
B**	0.42	0.53								
1	0.34	0.41								
4	0.35	0.43								
5	0.35	0.43								
6 center left	0.58	0.77	0.01	0.12	0.53	0.05	0.01	0.002	0.003	0.001
6 center right	0.55	0.73	0.02	0.07	0.65	0.06	0	0.003	0.006	0.001
6 wide left	0.56	0.74								
6 wide right	0.54	0.71								
7			0.01	0.1	0.53	0.05	0	0.002	0.004	0
8	0.43	0.55	0.01	0.08	0.45	0.06	0.01	0.002	0.004	0
9			0.02	0.08	0.56	0.05	0.01	0.002	0.003	0

*Based on the fact that melamine contains 66.64% nitrogen, and subtracting the average nitrogen content (0.064%) found in two pieces of untreated fabric provided by the manufacturer.
**Rolls X, A and B are original rolls of Fabric 24 obtained by LS.

These results show that other than Roll 6, the new rolls' concentrations of melamine are bracketed by the concentrations in the older, original rolls of cotton velvet. This suggests that melamine concentration within these ranges is not the only reason for the variability seen in flammability test results with the new rolls.

Fabric 24 Manufacturer

Commission staff contacted the manufacturer of Fabric 24, to discuss the differences in test results obtained by LS staff in recent tests. As a result, the manufacturer of Fabric 24 sent samples of cotton velvet representing four different steps in the production process. By studying samples from discrete steps in the manufacturing process, an attempt could be made to identify the mechanical or chemical treatments that most affect the flammability characteristics of the cotton velvet. The four steps were:

1. boil off,
2. boil off, dyed, dried, brushed, and sheared,
3. boil off, dyed, dried and finished with only the resin, catalyst and foaming agents, and
4. boil off, dyed, dried, brushed, sheared, all finishing chemicals (final product).

LS staff tested the four steps with Foam Z". Results of these tests are presented in Figure 6. In small open flame tests of mockups constructed with Steps 1 and 2, the mockups ignited and burned rapidly. Mockups constructed with Steps 3 and 4 had mixed results. In three tests with Step 3, the mockup ignited and burned rapidly in one test and did not ignite in the other two tests. Tests using Step 4 had similar results with two mockups igniting and two mockups not igniting. Figure 6 shows the results of these tests.

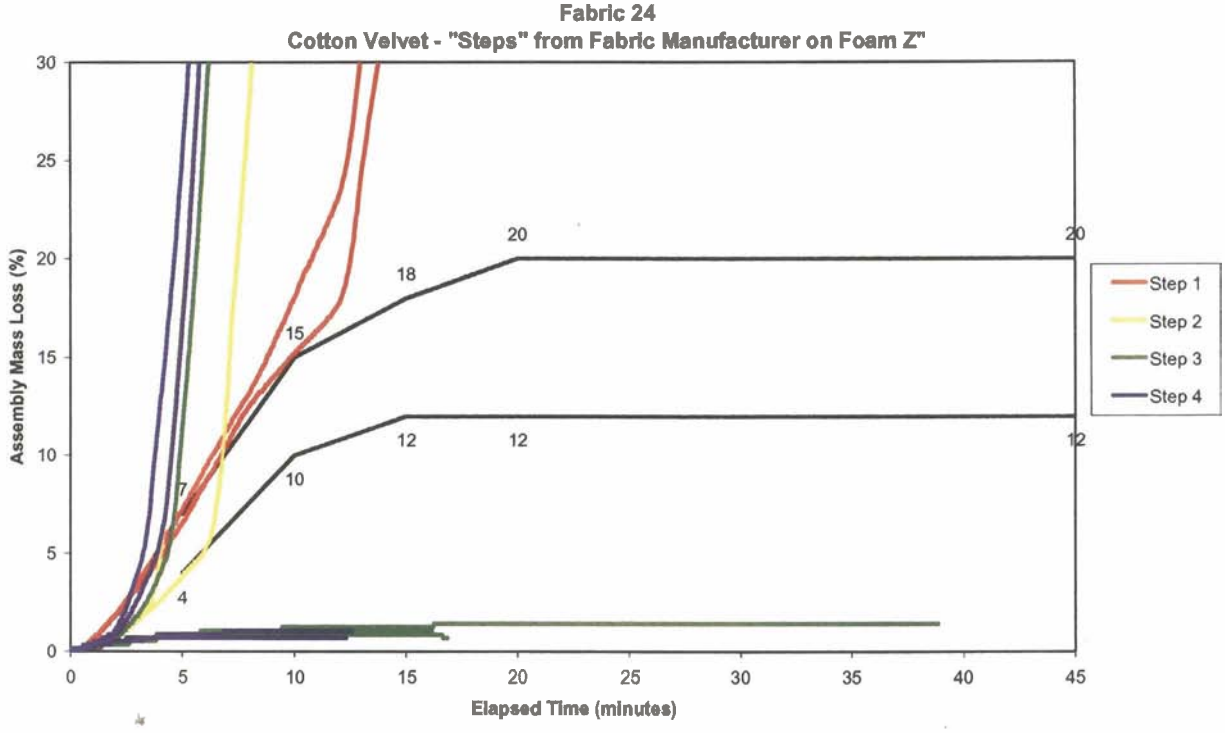


Figure 6. Cotton velvet "Steps" on Foam Z".

Smoldering tests of each of the steps produced results similar to those for the open flame tests. Mockups with Step 1 barely smoldered; on average, the foam mass loss was 1.1 percent. Mockups with Step 2 had an average foam mass loss of 3.7 percent. Steps 3 and 4 had greater foam mass loss although the foam mass loss range was greater for Step 3. Three mockup tests were done with each roll of the "step" fabrics. Figure 7 shows the results of these tests.

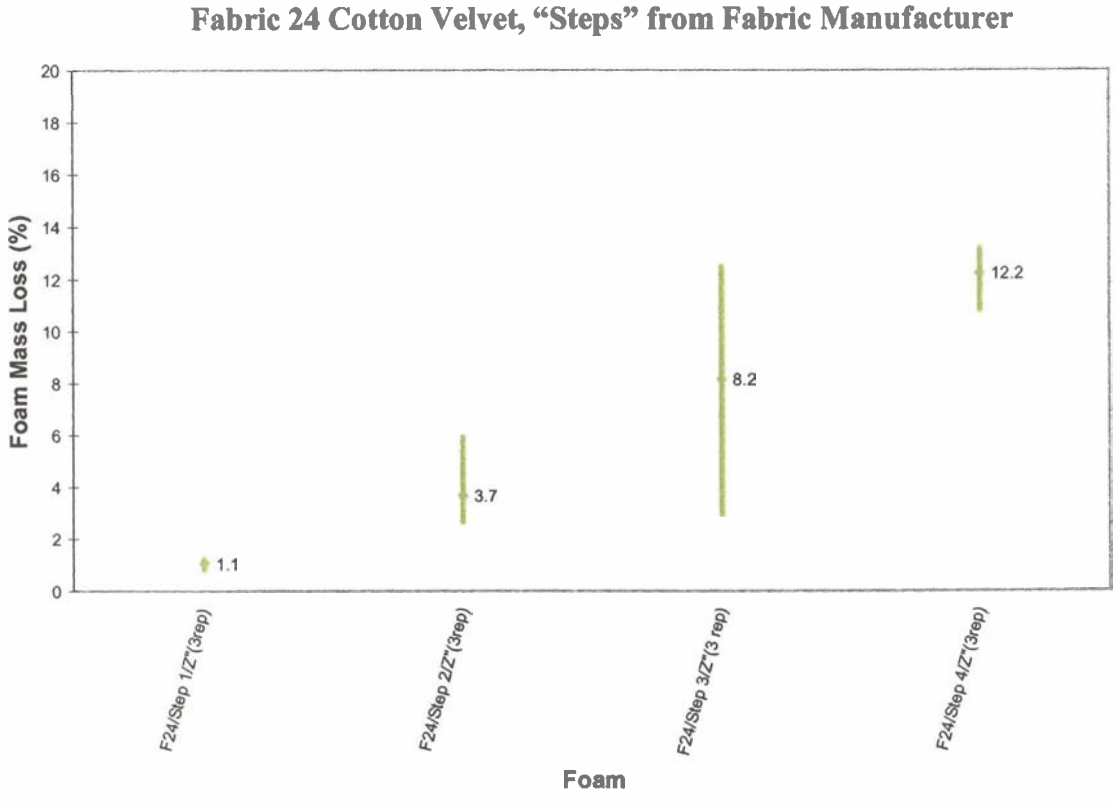


Figure 7. Cotton velvet "Steps" on Foam Z".

LS staff also chemically analyzed the four steps. Results show little nitrogen in Steps 1 and 2. The finishing process used on the cotton velvet was not applied to these two steps. Thus, the nitrogen present in these fabrics was considered to be a background amount from a source other than melamine and was subtracted from all other results to calculate the effective melamine concentration in Steps 3 and 4.

Step 3 had a lower amount of nitrogen than Step 4. The nitrogen concentration and therefore the effective melamine concentration for Step 4 were similar to the results obtained for the rolls of fabric reported in Table 2. Table 3 presents the results of the nitrogen analysis on each of the four steps of cotton velvet. From discussions with the manufacturer, it was not believed that nitrogen-containing chemicals were added in Step 4 relative to Step 3.

Table 3. Chemical Analysis of Percent Nitrogen

Roll Identification	% Nitrogen	Effective % Melamine Concentrations*
Step 1	0.063	0.00
Step 2	0.065	0.00
Step 3	0.25	0.28
Step 4	0.39	0.49

*Based on the fact that melamine contains 66.64%, nitrogen and subtracting the average nitrogen content (0.064%) found in Steps 1 and 2.

In November 2005, Commission staff visited the manufacturing plant to observe the manufacturing process of velvet fabrics. In December 2005, representatives from the manufacturer of cotton velvet met with Commission staff to further discuss the recent variability in test results. As a result of this meeting, the fabric manufacturer will continue to work with Commission staff, including examining ways to reduce the variability in the flammability performance of Fabric 24.

Alternative Standard Fabrics

Due to the variability observed in recently procured rolls of the cotton velvet fabric, LS staff also looked at other fabrics as potential choices for a standard fabric in the current staff draft standard. A standard fabric is a surrogate for any cover fabric and once ignited ultimately becomes the ignition source for underlying materials being evaluated. Therefore, a standard fabric should provide a realistic challenge to any materials underneath whether used for an open flame or smoldering test. A standard fabric should also provide consistent results.

LS staff looked at several cotton fabrics including a 9.0 oz/yd^2 cotton duck and an 8.5 oz/yd^2 cotton twill and a 14.5 oz/yd^2 rayon/polyester blend. None of these three fabrics showed promise. Foam Z" ignited before 4 minutes into the test with the cotton fabrics resulting in the mockups burning rapidly until the end of the test. Foam Z" ignited even faster when tested with the blend fabric. This fabric broke through immediately when the ignition flame was applied with the foam igniting 45 seconds into the test. While these fabrics are aggressive in challenging the underlying materials, they do not provide a smoldering threat.

LS staff also re-examined Fabric 25, a 100% cotton twill fabric specified as a standard cover fabric in smoldering ignition tests in the Upholstered Furniture Action Council (UFAC) voluntary program. Initial tests with Fabric 25 led LS staff to conclude that Fabric 25 did not challenge the foam (Foam T). The mockups self-extinguished and the foam did not ignite. Two tests were also done with Foam Y a more heavily flame retardant treated foam than Foam T. Additional tests with Fabric 25 both before and after laundering[10] were done. Mockups were constructed using Foam Z". Figure 8 shows the results of all of the tests using Fabric 25.

[10] The UFAC procedure requires this fabric to be laundered and tumbled dried once before using. UFAC Filling/Padding Component Test Method – 1990.

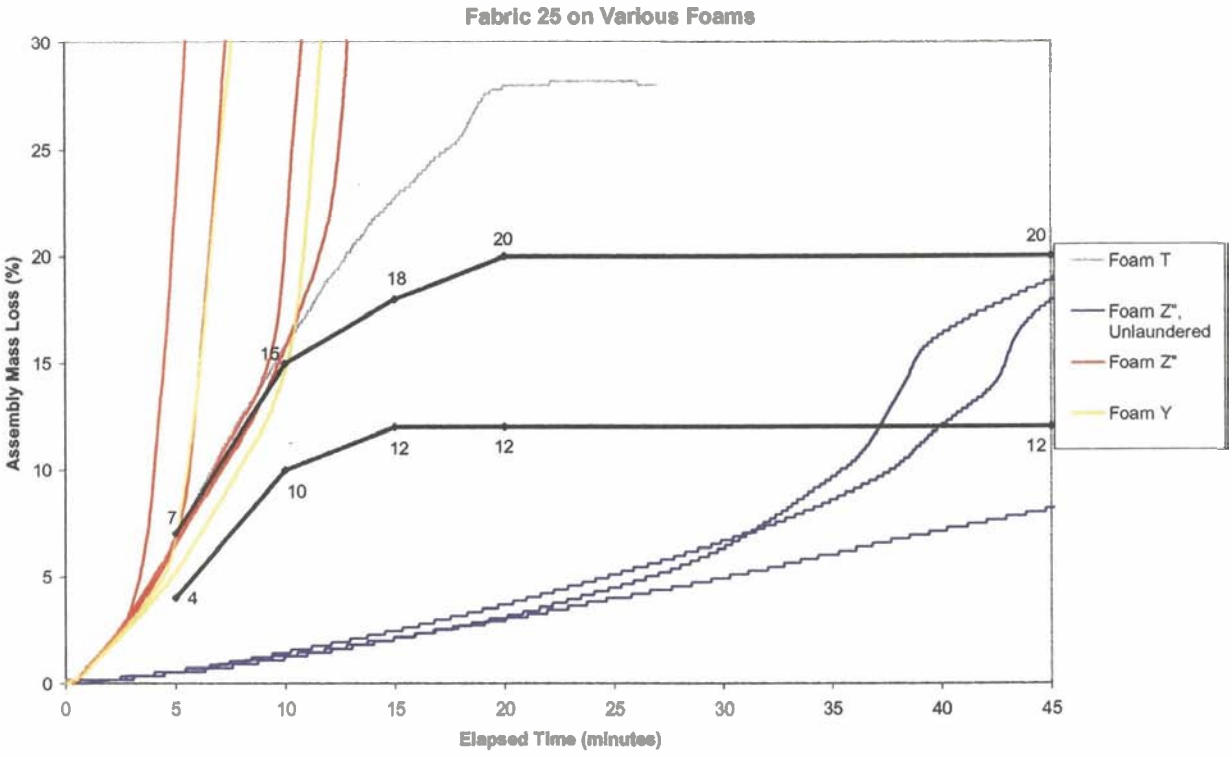


Figure 8. Fabric 25 small open flame results on several foams.

Figure 8 shows the original test with Fabric 25 (laundered) on Foam T. The flames were out in 21 minutes, the assembly mass loss was 27.96 percent at 26 minutes, the end of the test. Foam ignition occurred in both tests with Foam Y and Fabric 25 (laundered). In all three tests with Fabric 25 (unlaundered) with Foam Z", the foam did not ignite and the mockups self-extinguished. In the four tests where Fabric 25 was laundered before testing, Foam Z" ignited in almost 3 minutes to 12 minutes and burned rapidly. The mockups reached an assembly mass loss of 20 percent in almost 5 to 11.5 minutes.

Continuing Activity

LS staff is currently working with the manufacturer of Foam Z" to identify manufacturing controls to tighten the levels of flame retardant chemicals added to the foam mix during the manufacturing process to produce a consistent standard flame retardant treated test foam. In addition, based on LS staff's chemical analysis, LS staff has consulted the manufacturer for target levels of the two flame retardant chemicals necessary to achieve acceptable flammability performance. Another order of foam will be placed with the foam manufacturer in the near future.

LS staff will continue to study Fabric 24 to understand the test result differences and plans to work closely with the manufacturer of cotton velvet. LS staff is also pursuing a potential screening tool for Fabric 24 to identify whether the cotton velvet's flammability performance will meet the specifications in the CPSC staff's draft upholstery standard. In addition, LS will continue to seek an alternative standard fabric.

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