UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: May 31, 2005

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

THROUGH: Andrew G. Stadnik, P.E., Associate Executive Director,
Directorate for Laboratory Sciences
Edward W. Krawiec, P.E., Director, Division of Electrical and Flammability Engineering

FROM : Lisa L. Scott, Division of Electrical and Flammability Engineering

SUBJECT : Smoldering and Small Open Flame Ignition Performance of Upholstered Furniture Loose Fill Materials*

Introduction

The U. S. Consumer Product Safety Commission (CPSC) Directorate for Laboratory Sciences (LS) conducted tests of ten different loose fill materials to support development of the staff draft upholstered furniture standard. Smoldering ignition resistance and small open flame ignition resistance tests were conducted. The rationale for and results of these tests are discussed in this memorandum.

Test methods and standard materials for both smoldering and small open flame protocols have been identified and presented in separate LS staff memos.[1,2,3] Those memos discuss constructions employing resilient filling materials (e.g., foam slabs). Constructions with loose filling materials are covered in this report. For consistency throughout the suite of tests in the staff's draft upholstered furniture standard, the test procedures for loose filling closely mirror those for resilient filling materials. The procedures deviate only to accommodate issues specific to loose filling materials.

This memo discusses how test methods were developed for evaluating loose fill materials under both smoldering and small open flame ignition scenarios using methods presented in the open

* This document was prepared by the CPSC staff, and has not been reviewed or approved by, and may not reflect the views of, the Commission.

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

2 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.

3 Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from L. Fansler and L. Scott, "Assessment of Classification Schemes, Performance Criteria, and Standard Materials for the CPSC Staff Draft Upholstered Furniture Standard," May 2005.

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flame[1] and smoldering[2] methodology reports as a basis. It also discusses the American Furniture Manufacturers Association (AFMA) proposed tests[4] for loose filling materials.

Background

On October 23, 2003, the Commission published an Advance Notice of Proposed Rulemaking (ANPR) expanding the scope of the agency's upholstered furniture proceeding to cover both cigarette and small open flame ignition. In May 2004, in response to the ANPR, AFMA submitted a proposal[4] containing approaches to address the risks associated with the ignition of upholstered furniture. Commission staff assessed the proposal and began work toward developing revisions to the staff's February 2001 draft standard[5] for upholstered furniture.

For both smoldering and small open flame ignition resistance tests for loose filling materials, AFMA proposed using the procedure in the California Bureau of Home Furnishings Technical Bulletin 117 Draft Standard of February 2002 (TB117+).[6] The small open flame test described in TB117+ calls for a small pillow to be constructed approximating the packing density of the finished furniture product. The pillow is then supported horizontally over a test apparatus and subjected to a nominal 35 mm butane flame for 20 seconds from below the pillow. The primary test criterion is percent mass loss, which may not exceed 5 percent of the initial mass of the pillow after self-extinguishing. The smoldering procedure is a sandwich test in which a smoldering cigarette is completely surrounded by the loose filling material inside a draft enclosure. At the conclusion of the test, determined as absence of smoke or at a time limit, char length from the cigarette is measured. The char length may not exceed 1 inch from the edge of the cigarette ashes. AFMA proposed that these tests only be applied to loose filling materials intended for use in horizontal configurations in finished furniture. Loose filling materials intended for use in vertical configurations would be exempt under AFMA's proposal.[7]

Test Program

Test Materials

Table 1 identifies the loose filling materials and loose fill containment materials tested by LS staff. All tests were conducted using the cotton velvet cover fabric (Fabric 24, 10 oz./yd^2) identified in other LS reports.[1,2] A small selection of tests were conducted with either Interliner D (nonwoven, sheet barrier) or Interliner R (100% down proof cotton). They were chosen to demonstrate the principle that using interliners can be an effective means of protecting the underlying loose filling material. Specifically, Interliner D was selected because of its performance when tested over foam.[1,2] These tests were not intended to be exhaustive. LS staff believe other interliners tested over resilient filling materials may also serve this purpose. LS staff also note that specific combinations of loose fill containment materials and loose filling materials may perform adequately when tested together, even though the individual materials may not exhibit good fire performance when tested independently. LS staff propose that

[4] Letter to Chairman Hal Stratton from the American Furniture Manufacturers Association, dated May 13, 2004.
[5] Draft Standard for Upholstered Furniture, R. Khanna, Engineering Sciences, revised February 19, 2001.
[6] California Bureau of Home Furnishings and Thermal Insulation Technical Bulletin 117, *Requirements, Test Procedure and Apparatus for Testing the Flame and Smolder Resistance of Upholstered Furniture*, DRAFT February 2002.
[7] Conversation between D. Ray, CPSC and R. Batson, AFMA, March 2004.

composite testing of pairs of materials (a loose fill and a containment material) can result in a qualified pairing that has comparable fire performance to other components tested.

Table 1. Loose filling materials and loose fill containment materials tested by LS staff.

CPSC Staff Loose Fill ID	Material Description	Small Open Flame		Smoldering	
		Alone	With Interliner	Alone	With Interliner
A	100% polyester fibers	✓		✓	
B	100% polyester fibers	✓	Interliners D, R	✓	Interliners D, R
C	100% polyester fibers, slickened	✓		✓	
D	30%/70% down/feather blend	✓	Interliner R		Interliner R
E	crumbled polystyrene	✓		✓	
F	shredded foam	✓		✓	
H	polystyrene beads	✓	Interliner D	✓	
V	100% polyester fibers, slickened	✓		✓	
W	buckwheat Hulls	✓		✓	
&	FR* rayon/modacrylic fibers	✓		✓	

*FR = flame resistant

Small Open Flame

LS staff felt that for consistency, loose filling materials should be tested in a configuration similar to that for testing foam and reflective of actual furniture construction geometries. A test was developed that allowed for a bench top seating mockup geometry similar to that used for foam. Metal insert frames were designed and constructed to facilitate testing loose filling materials with the same frames used for small open flame testing of other materials in the program. These insert frames are constructed of steel angle iron, flat stock, and rods welded together with the same exterior dimensions as the foam specimens tested according to the CPSC staff protocol: 18 inches by 12 inches by 3 inches for the vertical element and 18 inches by 3.25 inches by 3 inches for the horizontal or seating element. This allows for the cover fabric to be cut using the same template as for all other small open flame tests suggested by CPSC staff. The intent of the insert frames is to create a skeleton for the standard cover fabric to contain the loose fill specimen in a reasonably uniform way. The frame does not interfere with the crevice of the seating configuration. In the case of especially small particles (e.g., some polystyrene beads), it may be helpful to use a screen to help contain the material in the test inserts. See Photograph 1.

Photograph 1. The loose fill test inserts for small open flame testing. The photo on the right also includes screening material to help contain loose filling materials with small particles that may otherwise fall out of the small open flame mockup.

The test procedure calls for conditioning all the test materials for a period of 24 hours prior to testing. Assembly involves taring out the non-combustible elements of the mockup assembly – the mockup frame, the loose fill insert frames and the metal clips – so that the mass of the combustible load of the assembly can be easily determined. Masses of the individual components were recorded prior to testing.

For the loose filling material, the amount of material used is dependent on the density. Materials with a density and loft similar to polyester fiber fill are tested with 300 g of material in the vertical portion and 85 g in the horizontal (seat) portion of the mockup. The appropriate filling levels (300 g for the vertical portion and 85 g for the horizontal portion) were determined to approximate the mass of the standard foam blocks in the resilient fill tests and resemble the fill level in finished furniture products. Other fill levels were also tested, both above and below these values. The lower level resulted in too many air gaps for consistent testing. The higher fill level gave an overstuffed appearance inconsistent with typical residential furniture and, when tested, the cotton velvet broke open and allowed flaming filling material to fall forward. This would cause inconsistencies in performance affecting the repeatability and reproducibility of the test protocol.

Materials with significantly different density (typically particulate filling materials such as polystyrene beads or buckwheat hulls) are filled to be level with the top of the frame, shaken to settle the material, and then filled until the material is once again level with the top of the frame.

Prescribing the loose filling levels in this manner (on a mass basis for most fills and on a volumetric basis for the remaining fills) avoids the subjective level of fill as presented in TB117+ that states that the small test pillow should be filled to a level representative of the finished product. For component tests, a loose fill manufacturer may not know the final fill level for the finished products. This approach eliminates the need to know the final fill level.

The ignition source is a nominal 35 mm butane flame applied for 20 seconds. Open flame test mass measurements were taken at 3-second intervals throughout the test interval and recorded in an electronic data file. Calculations of percent assembly mass loss were made as the data were recorded. From these data series, plots of percent assembly loss versus elapsed time were generated.

A limited number of tests of loose fill containment materials were conducted. For these tests, the procedure was the same, except that a standard polyester fiber fill material was used as the loose filling material, and the containment material was placed between the frames and the cotton velvet cover fabric (Fabric 24).

Smoldering

More than 30 smoldering ignition resistance tests were conducted including several tests of loose fill containment material (i.e., down proof cotton fabric) over a standard polyester fiber fill material. All tests used Fabric 24 as the cover fabric.

LS staff felt that loose filling materials should be evaluated for smoldering ignition resistance in a configuration closely resembling that for resilient filling materials. Drawing on the concept of the inserted frames and on the procedure for testing loose fill described in the Upholstered Furniture Action Council (UFAC) standard, metal and wood frame inserts were designed and constructed for cigarette ignition testing of loose fill materials. As with the small open flame ignition resistance test method, the frames were constructed to be accessories to the standard test frame and to not interfere with combustion at the crevice. See Photograph 2.

Photograph 2. The photograph on the left shows the empty loose fill test frame inserts. The photograph on the right shows a fully constructed mockup assembly. Note that both images show a 2-inch configuration. A 3-inch configuration is specified in the CPSC staff draft upholstered furniture standard.

The procedure specifies that all test materials are to be conditioned for a period of 24 hours prior to testing. To assemble a mockup for testing, the cover fabric is stapled to the loose fill insert frame on three sides, leaving an opening through which the frame can be filled. The unfilled frame can be tared out on a scale so that the resultant mass of the filled frame is the mass of the loose filling material being tested.

Where the loose fill material has a density and loft similar to polyester fiber fill, vertical panels were filled with 40 g of specimen material. Horizontal panels were filled with 25 g. These tests were all completed with 2 inch deep mockup assemblies. As noted in the smoldering methodology report,[2] the staff's current draft standard specifies a specimen thickness for resilient filling tests of 3 inches. To maintain the parallelism between tests, loose filling material tests would also be conducted with 3 inch thicknesses of materials. The filling levels for these proposed 3 inch thick assemblies would be 60 g and 40 g for the vertical and horizontal panels respectively to approximate the masses of the standard foam blocks in the resilient filling material tests.

As with the open flame loose fill approach, if a loose filling material is substantially different in density and loft from polyester fiber fill, the frame would be filled until the material was level with the opening of the frame, shaken to settle and then once again filled until level before sealing the frame shut by stapling the cover fabric in place on the fourth side. This is typically the case for particulate filling materials like polystyrene beads or buckwheat hulls.

The ignition source is the standard cigarette as specified in the 16 CFR 1632 – Standard for the Flammability of Mattresses and Mattress Pads. It is placed beneath a sheeting square and allowed to burn its full length. The LS tests reported here used a test duration of 45 minutes. However, subsequent testing using foam substrates suggested a change to a 30-minute test duration is warranted.[2] The loose filling material tests were not repeated since they all performed well for the 45-minute tests. It can be inferred that they would have had equivalent or lower mass loss measurements if the test duration had been shortened.

At the conclusion of the tests, the loose filling materials were often re-conditioned for a full 24 hours. Although this step is not necessarily required if all combustion has stopped, it was often necessary since the number of samples under test precluded being able to take measurements within 15 minutes of the end of the test. Dismantling and measuring a large number of mockups in that time frame was not practical.

In determining which portions of the loose filling material were consumed and which were just discolored at the conclusion of the test, benefit of the doubt was given to the product. Only clearly consumed portions were removed after testing. Portions of loose fill that were only discolored were included with other unburned material in the post-test mass measurements. It is estimated that products would still have performed well under the smoldering procedure if a more stringent level of discrimination had been used to separate burned from unburned portions of the filling materials.

Results and Discussion

Small Open Flame Ignition Tests

Tests were conducted using the cotton velvet cover fabric (Fabric 24). Two classes of loose fill were evaluated: fibrous loose fill (e.g., polyester fiber fill) and particulate loose fill (e.g., polystyrene beads). Because of the material properties of these two different types of material, the filling procedures were somewhat different for each. Material having a density similar to polyester fiber fill was filled in the test frames to a level comparable to the mass of a similarly sized specimen of the standard flame retardant polyurethane foam (SFRPUF). This fill level was determined to result in a comparable appearance and fullness as the resilient filling material tests. Materials having a density somewhat different than that of polyester fiber fill (typically particulate filling materials) cannot be filled into the test frame on a mass basis. These materials could be either significantly more or significantly less dense than polyester fiber fill. If more dense, the same mass of materials may only partially fill the test frame. If less dense, the prescribed mass of materials may not fit inside the test frame. In either of these cases, the material is to be filled so that it is level with the top of the test frame, shaken to settle the contents, and then additional fill added until once again level with the top of the test frame. The cover fabric is then raised over the top of the enclosure and secured. A similar process is repeated for the horizontal seat portion of the mockup, filling from the front while the mockup is resting on its back.

The tests performed by LS staff were primarily tests of loose filling materials beneath the cotton velvet cover fabric (Fabric 24). In some cases, tests were performed with an interliner material over a standard polyester fiber fill material or in combination with a specimen loose filling. The interliner material used was often interliner D, as identified in the Open Flame[1] and Smoldering[2] methodology reports. This material was designed to be a fire-blocking barrier for mattress applications, but was evaluated for its potential as a fire-blocking barrier in upholstered furniture applications. It improved the performance of the substrate under evaluation beneath it, both for resilient filling materials and for loose fill. It was deemed thin enough that it could be sewn into a containment bag for loose fill if desired. These tests were intended primarily for demonstration purposes to illustrate that a containment solution is feasible. Other fabrics or interliners may also serve the same purpose, but were not tested in that manner during this test program because of a lack of sufficient quantities of material on hand. One series of tests was also completed to evaluate down proof ticking fabric as an interliner material. These tests used standard polyester fiber fill as the loose filling substrate material.

Loose fills A, B, C, and V are all varieties of polyester fiber fill. The product literature for Fills A and B do not make any claims about their being “slickened,” while Fills C and V both do have some level of “slickening” treatment. The degree and chemical composition of that treatment was not determined by laboratory staff.

These four fills ignited readily and were largely consumed in tests that had particularly large flames. Fills B, C, and V generally ignited almost immediately upon removal of the source flame and exceeded 20 percent assembly mass loss in four to five minutes. Fill A was somewhat slower to ignite, exceeding 20 percent assembly mass loss in eight minutes.

Fill “&” was another fibrous loose filling material that was tested. It resembled polyester fiber fill, but was made of FR treated rayon and modacrylic fibers. This material performed better than the polyester materials, with a total assembly mass loss of less than nine percent before self-extinguishing in less than 25 minutes. These fibrous loose fill test data are shown in Figure 1.

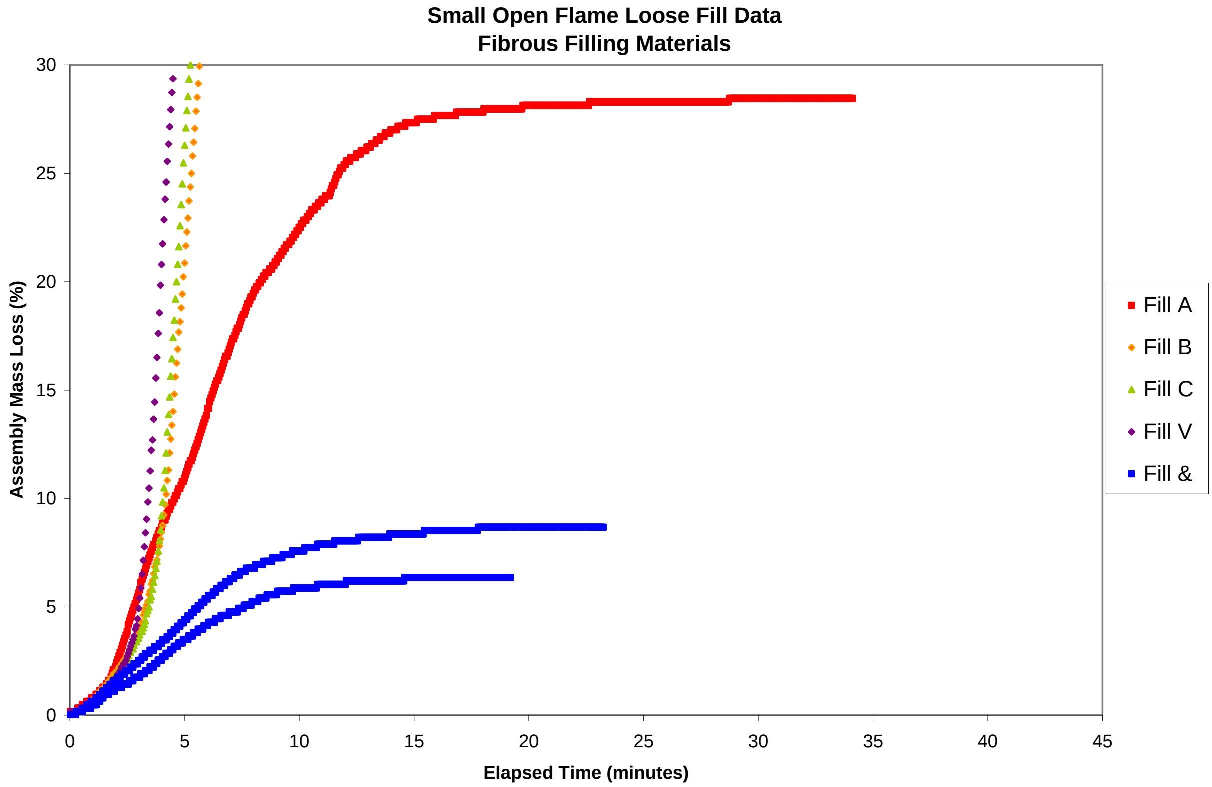

Figure 1. Assembly mass loss versus elapsed time for fibrous loose filling materials.

Several particulate filling materials were also tested. These included both crumbled polystyrene and polystyrene beads, shredded foam, buckwheat hulls, and a down and feather blend. All of these filling materials were tested beneath fabric 24 using the loose fill test frame inserts designed by LS staff. The down and feather blend was also tested as supplied by the vendor, in down proof ticking pillows sewn to size to fit the open flame mockup dimensions. In this case, the insert frames were not used. The pillows were instead placed in the mockup assembly as if they were foam blocks, and covered with fabric 24.

The fill levels for most of these particulate fills were not determined on a mass basis as was the case for the polyester fiber fill. Instead, the mockups were partially assembled so that the cotton velvet (fabric 24) cover fabric created a pocket around the test frame inserts, and the mockups were filled to the top, shaken until the contents settled, and filled again to the top. The mockup assembly was then completed. The mass of the filling material used in each mockup assembly was determined, either after the assembly was complete or as it was being added to the assembly. Again, the exception to this procedure was the down and feather combination. When the loose down and feather blend was tested directly beneath the cotton velvet cover fabric, the test insert frames were filled with 300 g and 85 g for the vertical and horizontal panels respectively. Because the pillows supplied by the vendor were already sewn and filled to a customary level, the masses of the pillows were recorded directly. The loose fill test insert frames were not used in this case because the pillows eliminated the need to use the frames for structural purposes.

The results for these particulate fill tests are shown in Figure 2. Fill F, the shredded foam, ignited easily and burned rapidly, losing 20 percent of the assembly mass in less than two minutes. The polystyrene filling materials, Fills E and H, both reached 20 percent assembly mass loss in less than four minutes. Fill W, the buckwheat hulls, performed well, losing only 0.3 percent before self-extinguishing. The down and feather blend also performed well and did not ignite. When tested loose inside the insert frames, the assembly mass loss was 10.4 percent at 42 minutes when it self-extinguished. The pre-sewn pillows lost 2.3 percent of the assembly mass before self-extinguishing.

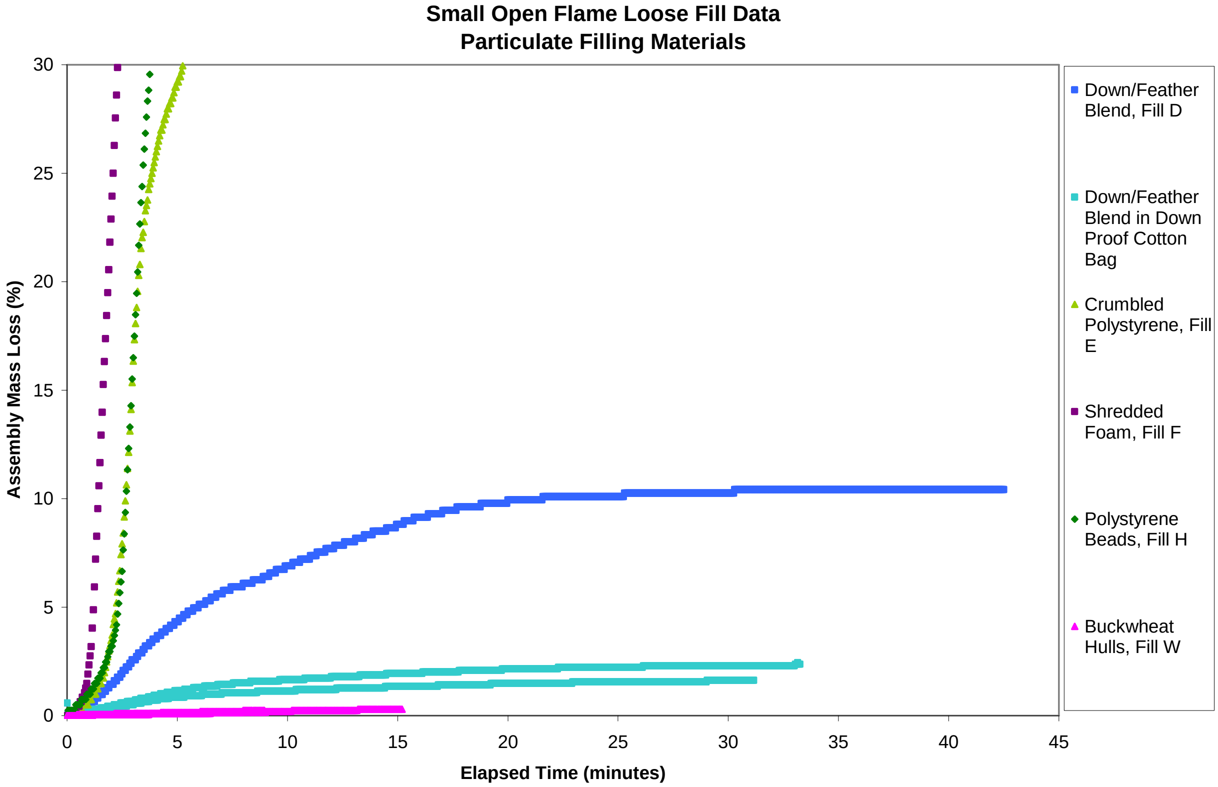

Figure 2. Assembly mass loss versus elapsed time for particulate loose filling materials.

The down proof ticking (Interliner R) was also tested independently with mixed results. When tested over the standard polyester fiber fill substrate, it ignited in two replicates, losing 20 percent assembly mass in less than seven minutes. In another replicate, it protected the substrate without losing more than seven percent assembly mass during the 45-minute test interval.

Interliner D, a fire-blocking barrier designed for mattress applications, was also evaluated as a loose fill containment material. In a test over a polyester fiber fill (Fill B), it allowed a 13.6 percent assembly mass loss over the 45-minute test interval. It was also tested over polystyrene beads, Fill H, and allowed 17.3 percent assembly mass loss in approximately 35 minutes. These data are shown in Figure 3.

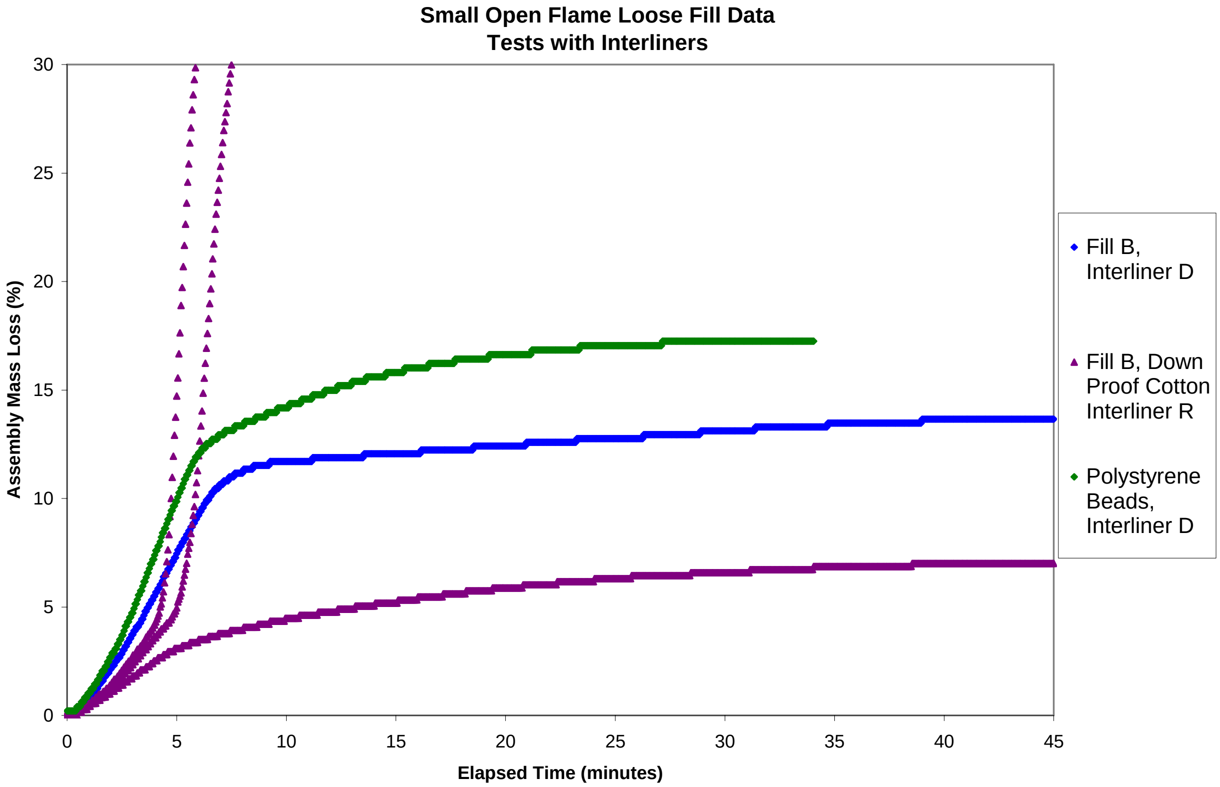

Figure 3. Assembly mass loss versus elapsed time for loose fill tests with interliners.

Smoldering Ignition Tests

All of the loose filling materials tested by LS were tested for 45 minutes with a 2-inch depth of materials. As noted in the smoldering methodology report,[2] LS staff recommends an approach that tests 3-inch thick panels for 30 minutes. The tests reported here were conducted before that recommended change was finalized. Due to limited time and limited quantities of some of the loose filling materials tested, the tests were not repeated following the updated procedure.

The smoldering test results are shown in Table 2 and Figure 4. All the test combinations performed well. The polyester fiber filling materials (Fills A, B, C, and V) lost between 0.1 and 5.5 percent of the substrate mass. Of all particulate filling materials, the maximum mass loss was 4.5 percent of the substrate mass for one replicate of polystyrene beads. The two test combinations with an interliner material over the standard polyester fiber fill (Fill B) resulted in mass losses of 2.7 to 4.8 percent of the substrate. None of these test combinations resulted in char progressing through the 2 inch depth of material. Thicker depths of material and a shorter duration should result in theoretical mass losses at least one third lower than these reported here, due to the increased proportion of unburned material in the greater initial mass of the substrate.

Interliner D has been shown to be smolder prone under other test conditions[2] (i.e., over foam blocks). The combined total energy imparted to the loose fill substrate from the combinations of velvet and interliner D could result in the more pronounced damage seen for the tests with this interliner. Likewise, the down proof cotton fabric, because it is cotton, is likely to be smolder prone, though it wasn't tested over foam to confirm this tendency. The combination of the cotton velvet (10 oz./yd.^{2}) and down proof cotton fabric (Interliner R, 4 oz./yd.^{2}) could also reasonably be expected to impart more energy to the loose fill substrate, resulting in the increased damage observed.

Table 2. Individual substrate mass loss results and average values for various smoldering loose fill test combinations.

	Fill A	Fill B	Fill C	Fill V	Fill &	Down/Feather Blend, Sewn in Down Proof Cotton	Crumbled Polystyrene, Fill E	Shredded Foam, Fill F	Polystyrene Beads, Fill H	Buckwheat Hulls, Fill W	Fill B, Interliner D	Fill B, Down Proof Cotton
Test #1	1.7	0.2	2.3	2.0	2.0	3.1	1.2	0.5	4.5	0.6	4.8	3.7
Test #2	1.5	0.1	2.7	1.6	1.6	0.4	1.8	0.0	1.0	0.7	3.4	2.7
Test #3		1.4	1.5	5.5	0.6	0.5	2.7	0.2	1.5	1.0		2.7
Average	1.6	0.6	2.1	3.0	1.4	1.3	1.9	0.2	2.4	0.8	4.1	3.0

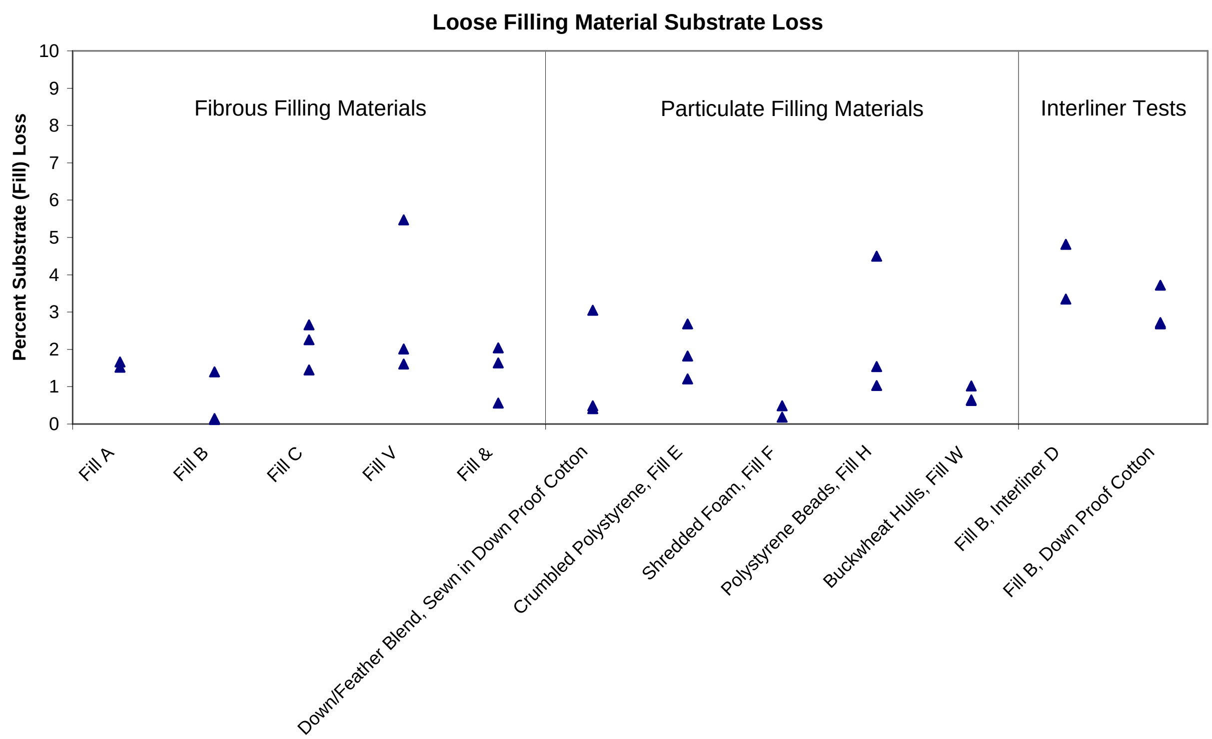

Figure 4. Percent of substrate loss for various smoldering loose fill test conditions.

As evidenced by the results, the loose filling materials tested in this program resisted smoldering very well. Increasing the depth of material from 2 inches to 3 inches (the smolder front interacting with the mockup frame) would not adversely affect the results for the loose fills tested.

Prior smoldering tests with untreated and a range of fire retardant (FR) treated foam substrates demonstrated that moderately FR treated materials may be more prone to smoldering than either untreated or heavily treated materials.[2] It is possible that, in the future, loose fill materials may be chemically treated and may then experience the same phenomenon as moderately FR treated resilient filling materials. If that is the case, the depth of material tested may impact the results by allowing the smoldering front to interact with the wooden test apparatus. Consequently, the

LS staff suggests that it is advisable to evaluate loose filling materials with the same 3-inch depth required of resilient filling materials.

Summary and Conclusions

The LS staff developed proposed test procedures that allowed for evaluating loose filling materials in similar configurations to those used for resilient filling material (foam block) tests as identified in the current CPSC staff draft standard. This was accomplished by designing and constructing test inserts for the standard mockup frames used for each protocol. With parallel procedures for both resilient and loose filling materials, parallel acceptance criteria can be used: no more than 20 percent assembly mass loss in 45 minutes for open flame tests and no more than 10 percent mass loss of the filling material in 30 minutes for smoldering tests.

All of the loose fill materials tested would comply with the smoldering test requirements. Several would also comply with the proposed open flame requirements. Using these criteria, some of the loose filling materials tested would be complying materials. Fibrous loose fill "&" complies, as do buckwheat hulls and the down and feather blend tested by LS staff, both alone and when contained in a down proof cotton bag material.

Other conventional loose filling materials were shown to be highly flammable in open flame testing, igniting readily and being fully consumed in less than 10 minutes. These include the four polyester fiber fills as well as both polystyrene products.

Sample tests of two interliner materials showed that the down proof cotton material would not independently comply with the loose fill containment material test requirements. However, when tested in combination with the intended filling material – the down and feather blend - the performance improved. Interliner D does show promise as a containment material. It dramatically improved the performance of two filling materials that, when tested independently, were two of the worst performers. Tests of both the polyester fiber fill and the polystyrene product tested beneath Interliner D yielded complying results. LS staff believes that other interliner materials tested in other portions of this program may also show promise in this role.

Acknowledgements

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