STATUS REPORT:

CPSC Staff Research Update on Upholstered Furniture Flammability

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November 2006

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Initial RR Date 11/3/06

EXECUTIVE SUMMARY

The U.S. Consumer Product Safety Commission (CPSC) is considering regulatory options to address the risk of residential fire associated with smoldering cigarette and small open flame ignitions of upholstered furniture. Pursuant to the Commission's October 2003 advance notice of proposed rulemaking (ANPR), the staff developed a draft standard and several possible alternatives. The staff has been conducting additional research on "standard" test materials used in the staff's draft standard, and analyzing recent public comments. This status report describes the staff's progress to date on these issues.

The CPSC staff's additional testing and analysis of standard test materials, along with input from stakeholders, has led the staff to consider some modifications to the specification of these standard materials in the draft standard, in order to improve the consistency of the materials' flammability performance. The staff's evaluation of a draft-limiting enclosure used in smoldering tests has also led the staff to consider whether modifications to the smoldering test method may be appropriate. Further work is ongoing; the staff plans to conduct an interlaboratory study on standard materials, along with large scale tests of less ignition prone upholstery materials and research on the impact of lower-ignition-propensity cigarettes on the smoldering fire risk.

The staff's analysis of recent comments and recommendations on statistical and economic issues concluded that no significant changes are warranted to either the staff's fire loss estimation methodology or the staff's estimates of potential benefits and costs associated with a possible standard. The staff's preliminary regulatory (economic) analysis, along with other key technical staff reports, underwent peer review in 2006, in accordance with an Office of Management and Budget bulletin; the staff will forward the results of these peer reviews to the Commission and post them on the agency's web site for public review.

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: NOV - 3 2006

TO : The Commission
Todd Stevenson, Secretary

THROUGH: Page C. Faulk, General Counsel
Patricia M. Semple, Executive Director
Lowell F. Martin, Deputy Executive Director

FROM : Jacqueline Elder, Assistant Executive Director for Hazard Identification & Reduction
Dale R. Ray, Project Manager, Directorate for Economic Analysis
301-504-7704

SUBJECT : Status Report : CPSC Staff Research Update on Upholstered Furniture Flammability

The U.S. Consumer Product Safety Commission (CPSC) is considering regulatory options to address the risk of residential fire associated with smoldering cigarette and small open flame ignition of residential upholstered furniture. The Commission published an advance notice of proposed rulemaking (ANPR) for public comment in October 2003. The CPSC staff forwarded a briefing package describing regulatory options, including a staff draft performance standard and several possible alternatives, to the Commission in January 2006*.

This status report presents the results of recent staff activities to address technical concerns identified in the staff's ongoing research and raised in stakeholder comments and recommendations. These activities include:

- further research on "standard" test materials consistency and qualifying test methods; and
- analyses of statistical and economic issues related to estimating potential benefits and costs of a possible standard and alternatives.

A brief summary of the staff's research and analysis appears below. The staff reports on these subjects are attached to this summary memo.

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*U.S. Consumer Product Safety Commission, "Briefing Package – Status Update on Regulatory Options for Upholstered Furniture Flammability," January 2006.

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Standard Test Materials / Test Method Issues

The Directorate for Laboratory Sciences (LS) has conducted additional testing and technical analysis on issues related to "standard" test materials specified in the staff's draft standard and the use of a draft-limiting enclosure in the standard's smoldering ignition tests. LS memoranda on these two issues appear at **Tab A**.

Evaluation of Standard Test Materials

The CPSC staff's 2005 draft standard identified two standard polyurethane foam substrates and one standard cover fabric for use in establishing compliance for other materials subject to the draft standard:

- The *standard polyurethane foam* (SPUF) substrate is used to evaluate the open flame performance of barrier materials. SPUF is defined in terms of physical characteristics; it contains no FR treatments; its contribution to smoldering ignition is low, but it does not inhibit flaming combustion.
- The *standard flame retardant polyurethane foam* (SFRPUF) substrate is used in most smoldering tests and one open flame test. It is defined by an allowable range of flammability performance as well as physical characteristics; it can contribute more to smoldering and less to flaming combustion than the non-FR SPUF (FR content below a certain level can detract from foam smolder resistance).
- The *standard cover fabric* is used in smoldering and open flame tests for all other materials. It is defined by an allowable range of performance when tested over SPUF and SFRPUF; it is a smolder-prone fabric that also provides a moderate flaming combustion insult to interior materials.

The staff's initial 2005 testing indicated reasonably consistent performance from candidate standard foams and a 100% cotton velvet candidate standard cover fabric. In subsequent tests by the CPSC Laboratory and by industry, inconsistencies were observed, principally in open flame test results. These were largely attributed to variability in the standard cover fabric. Commenters stated that the consistency of open flame test results was confounded by:

- fabric / foam interdependency; and
- the inherent variability in the standard fabric.

The staff observed that these problems had an unacceptable adverse impact on the repeatability of performance test results, particularly for open flame tests. The CPSC Laboratory worked extensively with the manufacturers of the FR foams and the standard cotton velvet fabric, and conducted approximately 200 additional tests to refine and evaluate different versions of these materials. As noted in the January 2006 briefing package, the staff recognized that these standard materials needed to be carefully controlled and specified to ensure that the standard materials are within a reasonable range of performance before they are used to qualify other materials for use in complying articles of furniture.

Based on this additional research, the staff developed possible revisions to the standard materials qualification requirements of the draft standard. These revisions:

- define SPUF by physical characteristics and performance criteria when smoldering and open flame tests are conducted on bare foam, as before;
- define standard cover fabric in terms of performance criteria when smoldering and open flame tests are conducted over SPUF only;
- define SFRPUF by physical characteristics and performance criteria when open flame tests are conducted on bare foam and smoldering tests are conducted over standard fabric.

These revisions eliminate the open flame "chicken and egg" interdependency between the fabric and FR foam specifications by qualifying them independently. Working with suppliers on chemical compositions and physical constructions of foams and fabrics, the staff identified standard materials that perform with acceptable consistency under these revised requirements. The use of these standard materials is desirable for the tests to represent the synergistic effects of combinations of upholstery materials on fire behavior, and to evaluate the performance of component materials.

Evaluation of the Draft-Limiting Enclosure in Smoldering Tests

The staff's 2005 draft standard contains smoldering test protocols to establish materials' compliance with the performance standard, as well as to qualify standard (fabric and foam) test materials. The tests use the fundamental geometry of the Upholstered Furniture Action Council (UFAC) voluntary program for evaluating upholstery materials. The UFAC test protocol specifies an enclosure (which is essentially a wooden box around the seating mockups) to reduce potential effects of test room air drafts. Commenters stated that:

- Smoldering combustion may be artificially limited due to reduced oxygen inside the enclosure;
- It is difficult to load and unload mockups due to tight spacing when the maximum allowable three seating mockups are loaded into the enclosure; and
- Test personnel may be exposed to heavy smoke or flare-up when the enclosure is opened at the end of the test.

The CPSC Laboratory conducted smoldering tests, with and without the draft enclosure, to assess these issues. The staff performed 228 tests on a matrix of seating mockups constructed with five predominantly cellulosic fabrics and nine foams (including "standard" fabric and foam) representing a wide range of smoldering performance. The CPSC Laboratory's test room airflow was maintained at a very low rate, under 0.1 meters per second.

For the most smolder-prone composites, average mass loss increased significantly -- from about 7 - 8% to about 12 -16% -- without the enclosure, although none of the tested fabrics went from passing to failing the draft standard's 10% average mass loss criterion when tested with the standard test foam. Other, less smolder prone combinations were affected relatively less by the presence or absence of the enclosure. The staff's testing suggests that the draft enclosure could allow some fabrics to perform better than they would under open air conditions.

The staff also agreed that working with the mockups is more difficult when using the draft enclosure and that short-term exposure to the high levels of carbon monoxide (CO) inside the enclosure can occur at the end of the test when the enclosure is opened. The staff has not observed "flare-up" of mockups upon opening the enclosure. The staff will consider whether to revise its draft standard to eliminate the draft enclosure, specify performance requirements for tests with and without the enclosure, or make other appropriate changes.

Statistical / Economic Issues

The Directorates for Epidemiology (EP) and Economic Analysis (EC) reviewed a March 2006 industry-sponsored report prepared by CRA International (CRA). The CRA report presented comments on the CPSC staff's preliminary regulatory analysis of the staff's draft standard and alternatives. The preliminary regulatory analysis was posted on the CPSC web site in October 2005; a slightly revised version was included in the January 2006 briefing package. CRA criticized the statistical methodology used to develop national fire loss estimates, and recommended alternative methods to estimate potential benefits of a flammability standard for upholstered furniture. CRA also discussed several issues related to the estimation of potential economic benefits and costs of a possible standard. EP and EC memoranda addressing CRA's comments appear at **Tab B**.

Fire Loss Estimates Methodology

The CRA report used two alternate methods to estimate fire losses:

- one that is similar to the staff's national estimates approach, combining data from the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS) and national scaling ratios from the probability sample-based estimates of deaths and injuries from the National Fire Protection Association's (NFPA) annual survey of fires; and
- one that is different in that it produces fire loss estimates indirectly, i.e., it relies on NFPA estimates for fires only, and does not use the NFPA death and injury estimates.

CRA suggested that the CPSC staff consider these two alternate methods to estimate residential fire losses (including but not limited to upholstered furniture fire losses). Based on the alternate methods, CRA stated that the staff overestimated furniture fire losses because:

- the staff used an algorithm known as "raking" to allocate death and injury data with unknown fire cause information, despite the unreliability of the method when case counts are small; and
- the raking method incorrectly inflated the estimated number of deaths per upholstered furniture fire.

The staff identified some concerns about CRA's methodologies:

- the upholstered furniture counts in the staff's analysis were not small, as CRA claimed; therefore the use of the raking procedure was appropriate and reliable; and
- the second, indirect CRA alternative method incorrectly used the NFIRS death and injury counts rather than the unbiased NFPA survey death and injury estimates, yielding an underestimate of fire losses; the other CRA method underestimates fire deaths to a lesser extent but still counted some in-scope deaths as out-of-scope.

The EP staff memorandum provides greater detail on these points. The staff concluded that its existing approach to producing national fire loss estimates is superior to either of CRA's alternate methods because the staff's approach correctly allocates unknowns with respect to both deaths and injuries, and more fully accounts for the coding of fatal fires. The staff has not changed its estimation methodology in response to CRA's comments.

Potential Benefits and Costs

CRA provided extensive comments on the CPSC staff's estimates of benefits and costs associated with a possible standard. CRA stated that the staff overestimated likely benefits because:

- effectiveness rates were too high compared to rates reported for existing United Kingdom (UK) regulations;
- the staff's analysis did not fully account for projected declines in smoking prevalence, increases in the use of "fire-safe" (i.e., low ignition propensity, or "low-IP) cigarettes and increases in market penetration of UFAC-conforming upholstered furniture;
- consumers who own the most smoldering ignition prone furniture are at low risk because they tend not to be smokers; and
- discount rates were too low and value-of-life estimates were too high.

CRA further stated that the CPSC staff underestimated potential costs associated with a standard, and that the staff's sensitivity analysis should have considered all combinations of factors that affected benefits and costs unless they were mutually exclusive.

The staff's evaluation identified some misinterpretations and inconsistencies in the CRA report. In response to CRA's assertions, the staff noted the following:

- the CPSC staff's sensitivity analysis accounts for uncertainty in effectiveness estimates; there is no basis for applying CRA's estimates of effectiveness for the UK regulations to the CPSC staff's draft standard;
- the staff's analysis did account for future downward trends in fatal cigarette-ignited fires, although there was no specific adjustment due to a potential, unknown increase in the use of lower ignition propensity (low-IP) cigarettes;
- although CRA asserted that consumers who use the most highly smolder-prone cellulosic fabrics tend to be non-smokers, CRA acknowledged that the data were not adequate to quantify the effect; however, even if the assertion were true, the aggregate impact on benefits would be small since the benefits (derived from a fixed estimate of deaths and injuries per year that could be avoided) associated with that category of fabrics would have to be redistributed to other categories of upholstered furniture in smoking households and involved in cigarette ignitions (in order for the overall estimated number of deaths to remain the same);
- the 3 and 7 percent discount rates incorporated in the staff's analysis are consistent with Office of Management and Budget (OMB) guidance on regulatory analyses and with the current economic literature; the $5 million value of statistical life in the staff's analysis, and the $3-7 million range in the sensitivity analysis, are also consistent with the range considered appropriate in current studies, and are commonly used for federal regulatory purposes;
- CRA's cost estimates were generally reported directly as provided by the industry sectors affected; CRA did not critically analyze costs in each sector, and chose not to consider various factors that would result in lower cost estimates; and
- in a sensitivity analysis, varying more than one factor at a time is generally appropriate when those factors are highly correlated, rather than whenever they are not mutually exclusive, as CRA contended.

The EC staff memorandum provides greater detail on these points. The staff has not changed the overall conclusions of its analysis in response to CRA's comments.

Ongoing / Planned Staff Activity

The staff is continuing to refine and improve the quality of data available to support Commission decision-making on regulatory options related to upholstered furniture. The staff submitted some study reports for peer review, and initiated further laboratory testing and engineering analyses. This activity, planned for Fiscal Year 2007, will yield additional information for Commission consideration.

Peer Review

In accordance with a 2004 OMB bulletin (Memorandum M-05-03), three key technical staff reports underwent peer review in 2006. These are:

- a preliminary regulatory (economic) analysis;
- a preliminary health risk assessment of flame retardant (FR) chemicals in filling materials; and
- a technical rationale report.

The staff is incorporating comments from peer reviewers on these documents, as well as public comments received in response to the 2003 ANPR. The staff plans to post the revised economic and health risk assessment reports and the reviewers' comments on the CPSC web site early in Fiscal Year 2007; the staff plans further testing and analysis, as described below, to address peer reviewers' comments on the engineering technical rationale report.

Further Testing and Technical Analysis

Subject to approval in CPSC's FY 2007 Operating Plan, the staff intends to undertake three areas of study that relate to upholstered furniture:

- To validate the specifications for standard test materials (cover fabric and foam substrate), the staff will conduct an interlaboratory study (ILS) of the repeatability (within labs) and reproducibility (among labs) of the qualification tests in those specifications.
- To examine the potential effectiveness of safer upholstery materials, and depending on the outcome of the ILS, the staff plans to conduct, in cooperation with the National Institute of Standards and Technology (NIST), large scale tests of "complying" versus "non-complying" materials; this work would begin upon completion of the ILS on standard test materials.
- To assess the potential impact of projected increases in the use of low-IP cigarettes, the staff plans a separate project to obtain and test a representative sample of low-IP versus non-low-IP cigarettes to assess the fire behavior of consumer products exposed to these cigarettes.

In addition to these technical research activities, the staff also plans to continue to communicate with stakeholders in government, industry and the fire community, and to solicit comments on the attachments to this memorandum. These efforts will allow the staff to share its data and to learn from the experience and recommendations of other groups interested in reducing fire risks associated with upholstered furniture.

Attachments

Tab A: Directorate for Laboratory Sciences memorandum, "Upholstered Furniture Standard – Revised Requirements for Standard Materials," L. Fansler, October 23, 2006

Directorate for Laboratory Sciences memorandum, "Upholstered Furniture – Modifications to the Cotton Velvet Cover Fabric to Address Combustion Properties for Use as a Standard Material," L. Scott, October 23, 2006

Directorate for Laboratory Sciences memorandum, "Upholstered Furniture – Evaluation of Draft-Limiting Enclosure Specified in the Smoldering Ignition Test Method," W. Tao, October 23, 2006

Tab B: Directorate for Epidemiology memorandum, "CPSC Staff Response To CRA Comments on Upholstered Furniture," D. Miller & M. Greene, September 18, 2006

Directorate for Economic Analysis memorandum, "Responses to Comments on Economic Issues Contained in 'An Evaluation of the CPSC Staff Preliminary Regulatory Analysis of the Draft Upholstered Furniture Flammability Standard,' by Mark Berkman, Ph.D., CRA International," C. Smith, September 29, 2006

Tab A

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Memorandum

Date: October 23, 2006

TO	:	Dale Ray, Project Manager, Upholstered Furniture Directorate for Economic Analysis
THROUGH:		Andrew G. Stadnik, P.E., Associate Executive Director for Laboratory Sciences Edward W. Krawiec, P.E., Director, Division of Engineering
FROM	:	Linda Fansler, Division of Engineering LF
SUBJECT	:	Upholstered Furniture Standard – Revised Requirements for Standard Materials*

Introduction

This memorandum presents the results of recent research (1, 2) performed by the U.S. Consumer Product Safety Commission's (CPSC) Directorate for Laboratory Sciences (LS) staff regarding the standard material requirements of the staff's draft upholstered furniture standard. Following work reported on in May 2005 (3) and in December 2005 (4), approximately 250 additional tests were completed to evaluate the staff's draft standard's requirements for standard materials to be used for flammability testing and to provide data to address several industry comments. Based on this additional research, LS staff has developed possible revisions to refine the requirements for standard test materials.

Discussion

Standard Foam

The CPSC staff's 2005 draft furniture standard (5) identifies and defines two standard foams. The first, Standard Polyurethane Foam (SPUF) is defined as having no flame retardant chemical treatment. The second, Standard Flame-Retardant Polyurethane Foam (SFRPUF) must be formulated so that specific open flame and smoldering performance criteria are met. The first open flame performance requirement is a time to ignition test and the second specifies acceptable mass loss when tested with the standard cover fabric. Table 1 summarizes the physical properties these foams must have.

* 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.

Table 1. Physical Properties of SPUF and SFRPUF Foam

Foam ID	SPUF	SFRPUF
Density (lb/ft^3)	1.8	1.4
Indentation Load Deflection	25 to 30	25 to 30
Air Permeability (ft^3/min)	> 4	> 4

The density of the SPUF foam is a nominal density for untreated foam found in current upholstered furniture. The density of the SFRPUF foam was taken from the density of the foam specified in Technical Bulletin 117 (6).

In the staff's 2005 draft furniture standard, SPUF foam is used to evaluate furniture components used in Type I (interior barrier) and Type II (cover barrier) upholstered furniture constructions with respect to open-flame ignition resistance. As a standard test material, SPUF generally does not contribute to smoldering but does not inhibit flaming combustion.

SFRPUF foam is used in smoldering and open flame ignition tests specified in the staff's 2005 draft furniture standard. SFRPUF is used to evaluate furniture components used in Type I, II, and III (specified component materials) upholstered furniture constructions with respect to smoldering ignition resistance and furniture components used in Type III upholstered furniture with respect to open flame ignition resistance. As a standard test material, SFRPUF appears to contribute somewhat more to smoldering and less to flaming then SPUF.[1] It is intended to have 'borderline' open flame performance and provide a reasonable challenge to other components. As such, it would generally not fully meet the performance requirements of the staff's 2005 draft standard for foam used in actual upholstery.[2]

Two shipments of FR treated foam were evaluated as part of the 2005 test program (4,7) to determine if they met the requirements for SFRPUF foam. The first shipment met the flammability and physical requirements for SFRPUF foam. The second shipment of foam was also analyzed by LS staff and found to contain higher amounts of the FR chemicals than the first shipment; this foam yielded inconsistent performance. Extensive flammability and chemical analysis of this foam in addition to discussions with the manufacturer led to a revised manufacturing target for FR chemical additives.

In April/May 2006, a third shipment of FR treated foam was tested and chemically analyzed by LS staff. Results indicate that the revised manufacturing target for FR chemical additions was achieved. The foam was certified by the manufacturer to meet the physical properties specified in the staff's 2005 draft standard for SRFPUF foam. This foam also met the requirements of the SFRPUF small open flame and smoldering bare foam tests. The six smoldering bare foam tests had an average of 0.40 percent mass loss of foam. The staff's 2005 draft standard requires a

[1] Smoldering combustion of chemically treated foam can depend on the type and amount of FR chemicals present in the foam.

[2] Unlike the test foam specified in California TB117 which may qualify and then be used as foam in finished furniture, the CPSC staff draft standard's SFRPUF is a minimally FR-treated foam and may not meet the performance requirements for resilient fillings specified in the CPSC staff's 2005 draft upholstered furniture standard. Any FR-treated foam used in actual furniture needs to be more than a minimally compliant foam, i.e., any mockup mass loss must consistently be 20 percent or less for small open flame evaluations and the foam mass loss must consistently be 10 percent or less for smoldering evaluations.

mass loss of less than 1 percent. The small open flame requirements in the staff's 2005 draft standard include a 20-second ignition exposure where the foam must not sustain combustion and have a mass loss of 1 percent or less. The foam is then subjected to a 30-second ignition exposure. The acceptance criteria require that once ignited the mass loss be greater than 5 percent, 120 seconds after removal of the small flame ignition source. The results of the small open flame bare foam tests with a 30-second exposure are shown in Figure 1. In all trials, the foam ignited and had mass losses greater than 5 percent, 120 seconds after removal of the ignition source.

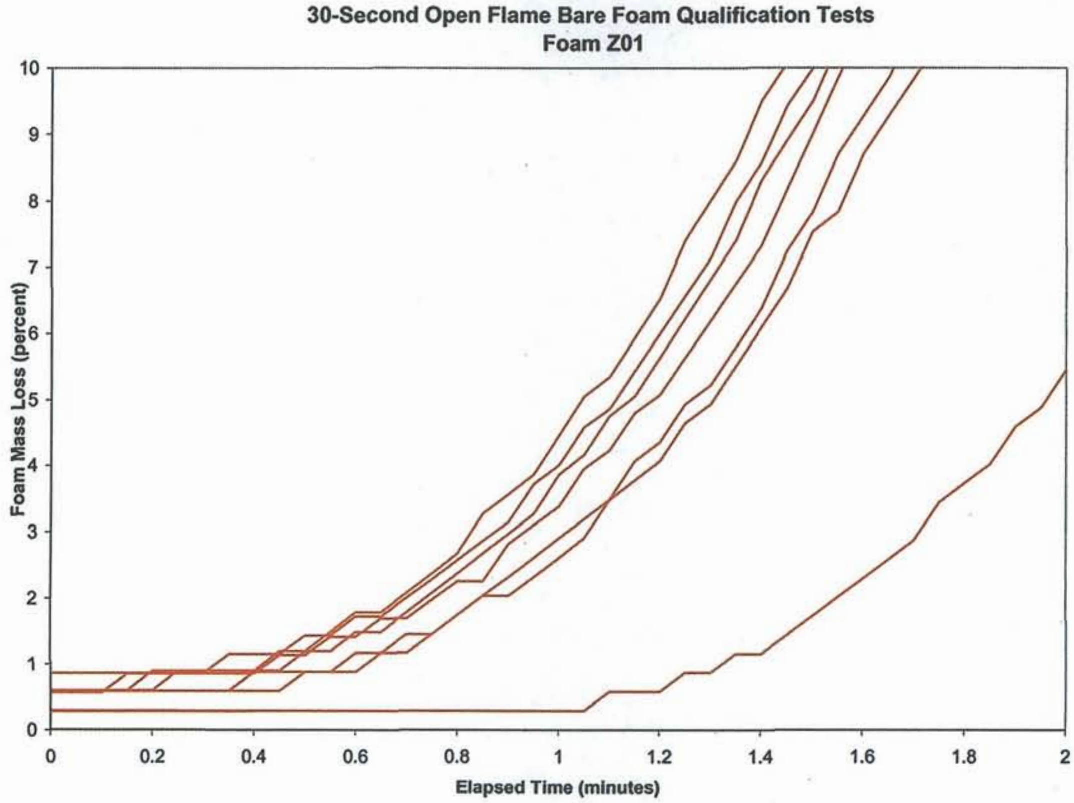

Figure 1. Open Flame Qualification Tests: Assembly mass loss versus elapsed time for FR treated foam (Z01).

The final verifications to determine whether an FR treated foam meets the specifications for the SFRPUF foam in the staff's 2005 draft standard are small open flame and smoldering tests with the standard cover fabric. Because recent shipments of cotton velvet fabric identified as a candidate for the standard cover fabric did not meet the requirements for standard cover fabric specified in the staff's 2005 draft standard, those tests would not be meaningful, and were not done on this most recent batch of foam. This issue is discussed below in further detail.

Standard Cover Fabric

In the staff's 2005 draft standard, a standard cover fabric is used in mockup tests to evaluate the performance of Type I and III furniture. The specifications for Standard Cover Fabric Performance are also contained in the staff's 2005 draft furniture standard. In that draft standard, the smoldering and open flame flammability performance of the standard cover fabric is evaluated by testing the fabric on SPUF and SFRPUF foams. LS staff identified a cotton velvet fabric that met the draft performance requirements. Initial tests with this fabric provided consistent results. Tests on later shipments of this fabric confirmed the observation made by industry representatives (8) of variable test results. This variability resulted in the inability to properly qualify either the standard fabric and/or standard foam as specified in the staff's 2005 draft standard.

LS staff and the manufacturer of the cotton velvet established a cooperative effort in August 2005 to evaluate modifications to the manufacturing process intended to produce a fabric with more consistent flammability performance. In the fall of 2005, CPSC staff visited the manufacturer's plant to gain an understanding of the manufacturing process. Plant staff visited the CPSC Laboratory in December 2005, to gain a better understanding of the combustion properties observed in the bench scale test program. Production of cotton velvet with some of the proposed modifications began in January 2006.

Beginning in February 2006, LS staff evaluated a series of cotton velvet fabrics provided by the manufacturer. Some were modified with chemical finishing components including the addition of a small quantity of an FR chemical, and some with an addition of a smolder promoting salt. LS staff conducted extensive flammability testing and chemical analysis of those versions of the cotton velvet fabric. As the data were collected, teleconference discussions were held with the manufacturer to determine an appropriate direction for the evolving study.

Although the cotton velvet provides a moderate open flame insult while maintaining good smoldering performance, the recent data (1) confirmed that the cotton velvet fabric is a borderline fabric that may not meet the cover fabric small open flame performance requirements in the staff's 2005 draft standard. When the cotton velvet is combined with a potential SFRPUF foam, about 50 percent of the time the small open flame flammability performance is such that the fabric falls into the standard cover fabric flammability performance band specified in the CPSC staff's 2005 draft upholstered furniture standard and about 50 percent of the time it does not. For those trials where ignition occurred in 3 to 5 minutes after removal of the ignition source, the mockups burned aggressively as shown in Figure 2. While this represents a challenge to the underlying materials, it is not reasonable to establish this split behavior as a performance criterion for defining a standard material. See Figure 2 below.

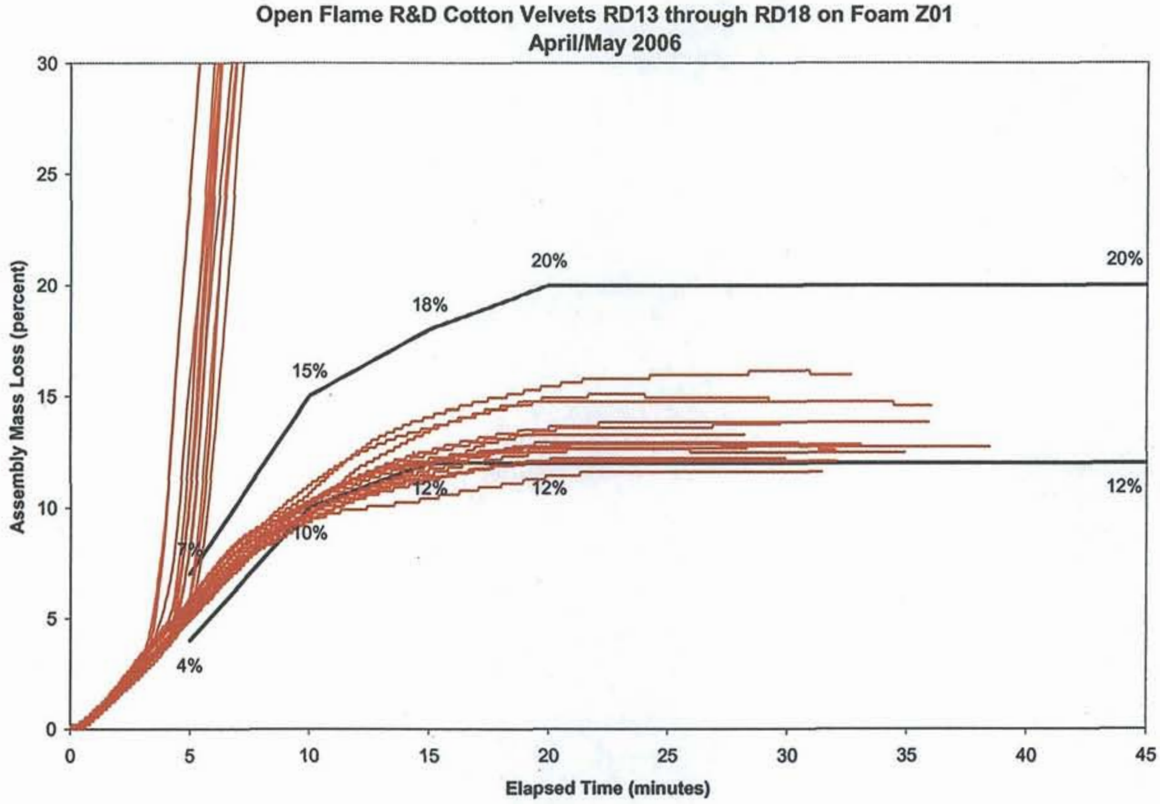

Figure 2. Open Flame Tests: Assembly mass loss versus time for cotton velvet fabrics on FR treated foam (Foam Z01).

The use of a cover fabric to evaluate interior furniture materials is desirable in order to capture the post-ignition fire behavior of fabric/filling furniture components. CPSC staff had considered evaluating resilient filling materials without a cover fabric but recognized that the interaction of the fabric/foam interface along the combustion front had a significant impact on performance. The burning cover fabric/foam interaction realistically characterizes the post-ignition fire behavior. Identification of a 'standard' cover fabric is necessary in order to define an acceptable level of performance and to minimize variations during tests to evaluate other components.

CPSC staff originally identified the cotton velvet fabric as a potential standard cover fabric since it provided a reasonable challenge to any materials below in both open flame and smoldering ignition tests. Other fabrics considered for use as a standard fabric performed consistently but either burned too aggressively or did not burn at all. CPSC staff considered alternate approaches to identify and qualify the standard cover fabric in light of the recent test results and comments provided by the industry. A potential revised approach to qualify the standard cover fabric is discussed below.

Industry Comments and Recommended Revised Approach

Among the several comments the CPSC staff has received from industry groups concerning the staff's 2005 draft standard, some issues raised (9) related to potential effects of:

- fabric/foam interdependency on their respective qualification requirements; and
- the allowable mass loss range on the qualification of standard foams.

In the current version (December 2005) of the CPSC staff's draft furniture standard, the standard cover fabric is qualified using SPUF and SFRPUF foam and the SFRPUF foam is qualified using the standard cover fabric. A suggestion was made to have an independent measure to qualify standard foams.

LS staff agrees with this recommendation. To eliminate the dependence of the SFRPUF foam and the standard cover fabric on each other for qualification purposes, LS staff has developed a revised approach to qualifying standard materials. This approach:

- defines SPUF flammability performance;
- defines the standard cover fabric in terms of open flame and smoldering performance on only SPUF;
- defines SFRPUF open flame performance based on only tests on the bare foam; and
- defines SFRPUF smoldering performance when tested with the standard cover fabric.

Standard Polyurethane Foam

SPUF is readily defined using physical and flammability properties. The physical specifications for SPUF foam remain the same as specified in the staff's 2005 draft furniture standard.

- Polyether polyurethane foam.
- Not treated with any flame retardant chemicals (should be confirmed[3] by chemical analysis).
- Density: 1.8 ± 0.1 lb/ft^3.
- Indentation Load Deflection (ILD): 25 to 30.
- Air Permeability: Greater than 4 ft^3/min.

SPUF flammability performance has not changed from that specified in the staff's 2005 draft furniture standard for both smoldering and small open flame ignition sources:

- Smoldering: With the cigarette placed directly in the mockup crevice on the bare foam, the allowable SPUF foam mass loss for each of three consecutive trials must be less than 1 percent.

[3] One shipment of non-FR foam received by CPSC contained a small amount of FR chemical, on the order of approximately 1 percent by weight.

- Small Open Flame: Using a 5-second flame impingement of the 35 mm butane flame on bare foam in the small open flame mockup, in three consecutive trials, the SPUF foam must have a mass loss that is greater than 20 percent in less than 120 seconds after removal of the ignition source.

This flammability performance is typical of resilient polyurethane foams that are currently used in upholstered furniture, i.e., as an individual component, untreated foam generally resists smoldering and is highly susceptible to small open flames.

Standard Cover Fabric

Under the staff's draft protocol, the ideal standard cover fabric is a smoldering enhancing fabric that provides a challenge to the materials below in both open flame and smoldering ignition tests. The standard cover fabric is defined by physical and flammability properties.

- The physical property of fabric weight of the standard cover fabric remains the same as stated in the staff's 2005 draft furniture standard, i.e., weight per linear yard: 14.5 oz, (nominally 10.0 oz/yd^2).

The flammability performance properties of the standard cover fabric are now proposed to be defined only by testing with qualified SPUF foam.

- Smoldering: The average SPUF foam mass loss of six consecutive smoldering tests must be 8 ± 2 percent (2) when tested with the standard cover fabric in accordance with the staff's 2005 draft furniture standard.

- Small Open Flame: When the SPUF foam is tested with the standard cover fabric using a 20-second flame impingement of the 35 mm butane flame, five of six trials must fall within the bounds of the performance band as shown in Figure 3. This requirement is the same as specified in the staff's 2005 draft furniture standard.

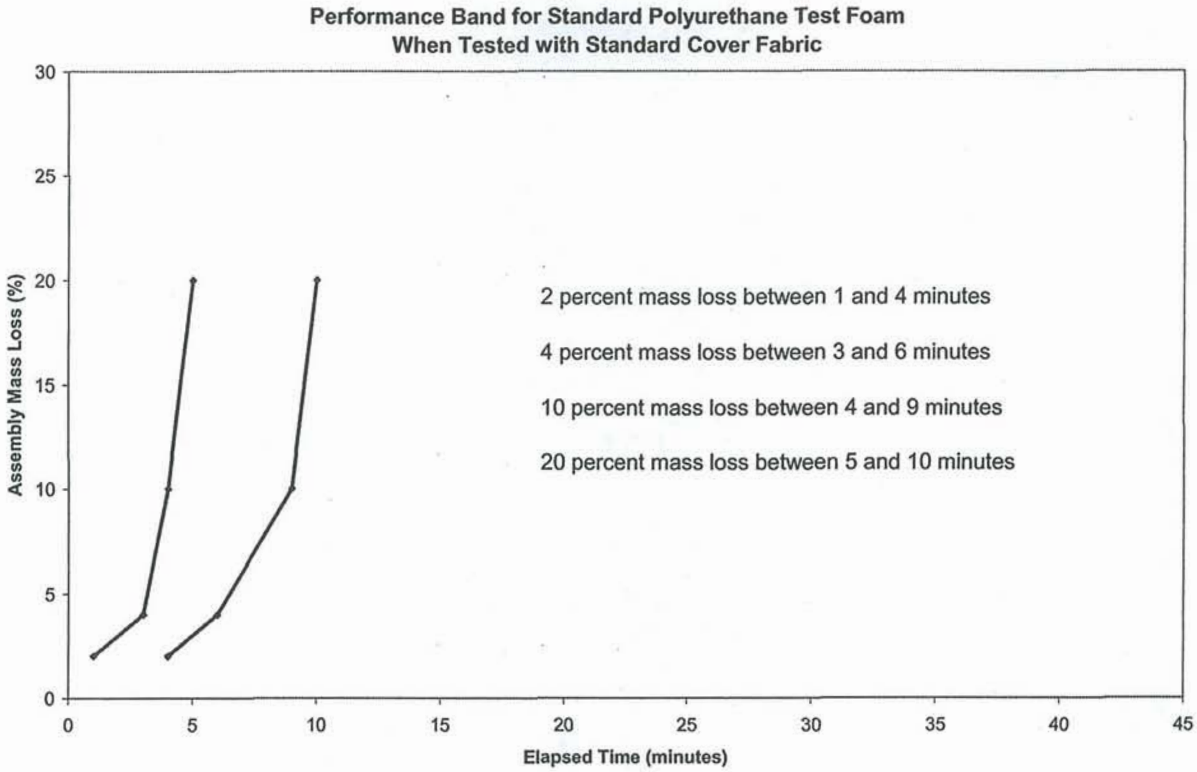

Figure 3. Small open flame performance band for SPUF foam tested with standard cover fabric.

Standard Flame-Retardant Polyurethane Foam

SFRPUF foam is defined using physical and flammability properties. The physical properties remain the same as specified in the staff's 2005 draft furniture standard.

- Polyether polyurethane foam.
- Treated with flame retardant chemicals to impart resistance to ignition.
- Density: 1.4 ± 0.1 lb/ft^3.
- Indentation Load Deflection (ILD): 25 to 30.
- Air Permeability: Greater than 4 ft^3/min.

The flammability of SFRPUF foam is defined by both smoldering and small open flame ignition performance. SFRPUF is first defined by itself with a small open flame ignition bare foam test. This test is specified in the staff's 2005 draft furniture standard. The second performance requirement that defines the flammability of SFRPUF foam is a smoldering test using the standard cover fabric. To eliminate the interdependency of the standard cover fabric and the SFRPUF foam, no small open flame testing with the standard cover fabric is required. The smoldering and small open flame flammability requirements are outlined below.

- Small Open Flame: The bare foam is exposed to a 35 mm butane flame for 20 seconds. In three consecutive trials, the mass loss of the SFRPUF foam must not exceed 1 percent as measured 120 seconds after removal of the butane flame. Then the bare foam is exposed to the ignition source for 30 seconds. In three consecutive trials, the SFRPUF foam must have a mass loss greater than 5 percent 120 seconds after removal of the ignition source. Each trial is conducted on a new sample from the same production lot except that up to three trials may be conducted on one sample if each trial shows full compliance and the ignition sites are equally spaced across the sample in order to avoid overlaps or interactions.

- Smoldering: The average mass loss of the SFRPUF foam is 5 ± 2 percent (2) for six consecutive smoldering tests each on a new sample from the same production lot, when tested with the standard cover fabric in accordance with the staff's 2005 draft furniture standard.

A commenter (9) questioned the overlap of the performance ranges of foam mass losses specified in the staff's 2005 draft standard. In the staff's 2005 draft standard for foam smoldering tests, the allowable range of mass loss of the SPUF foam is between 3 and 12 percent. The allowable mass loss of the SFRPUF foam is between 4 and 18 percent. Conceivably, one foam could meet the requirements for both ranges. However, since the different purposes of SPUF and SFRPUF require that their specified physical properties be different, a single foam could not qualify as both SPUF and SFRPUF. The revised standard materials qualification approach outlined above also addresses this comment.

Summary

The use of a standard cover fabric and standard foams continues to be a feasible way to evaluate individual furniture components. Revised physical properties and flammability performance requirements for qualifying the standard cover fabric and the standard foams have been identified. The standard cover fabric will provide a reasonable challenge to underlying components. The untreated SPUF foam continues to be a reasonable choice to evaluate barrier open flame products. The chemically treated SFRPUF foam discriminates among other furniture components for acceptable flammability performance. LS staff have identified revised performance requirements for these standard materials to ensure the consistency of upholstery materials performance tests. This would allow potential standard foams and fabrics to be independently qualified as standard materials.

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1. Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from L. Scott, "Upholstered Furniture – Modifications to the Cotton Velvet Cover Fabric to Address Combustion Properties for Use as a Standard Test Material," October 2006.
2. Memorandum to D. Ray, Project Manager, Upholstered Furniture Project, from W. Tao, "Upholstered Furniture – Evaluation of the Draft-Limiting Enclosure Specified in the Smoldering Ignition Test Method," October 2006.
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8. Letter to Commissioner Nancy Nord, from Mr. Robert Luedeka and Mr. James McIntyre, of the Polyurethane Foam Association (PFA), July 11, 2005.
9. Commission staff met with representatives from Western Nonwovens, Inc., May 17, 2006.

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Memorandum

Date: October 23, 2006

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 Engineering

FROM : Lisa L. Scott, Division of Engineering

SUBJECT : Upholstered Furniture—Modifications to the Cotton Velvet Cover Fabric to Address Combustion Properties for Use as a Standard Test Material*

Introduction

The 2005 U. S. Consumer Product Safety Commission (CPSC) staff draft standard for Upholstered Furniture specifies physical properties and performance tests for a standard cover fabric (1). The CPSC staff developed those performance requirements for the standard cover fabric using data from tests conducted in 2004-2005 on a number of fabrics including the cotton velvet fabric specified in California Bureau of Home Furnishings and Thermal Insulation's Technical Bulletin 117 (TB117) (2). The cotton velvet was evaluated as a candidate cover fabric for smoldering ignition resistance tests and provided a consistent challenge to underlying materials (3). Small open flame tests with the cotton velvet fabric indicated that it had a predictable flame performance: moderate flame growth after ignition that steadily worked its way to the edges of the mockup (4). In most tests on flame retardant (FR) materials, the initial flame front progressed to all the exposed surfaces of the mockup before giving way to a subsequent smoldering front. Over untreated materials, the core materials ignited readily. These results showed promise for differentiating the materials under test.

Discussion

After releasing the 2005 CPSC staff draft standard, CPSC staff began receiving comments from industry representatives that they were getting inconsistent results with the cotton velvet test fabric (5). CPSC Laboratory Sciences (LS) staff ordered more material and conducted more tests. The inconsistencies began appearing at LS in this series of tests. Many of these tests were conducted on different types of foam substrates than had been used in the previous series of tests (6). LS staff believed that the effect was related to variability in the cotton velvet fabric, and was not just an artifact of the different substrates used for the testing.

CPSC staff began a dialog with the manufacturer of the cotton velvet fabric in August 2005. The manufacturer's representatives said at that time that they had also had discussions with

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representatives from the furniture industry. The goal of the dialog was to determine the source of the variability in combustion properties observed in tests on recent shipments of the cotton velvet cover fabric. Earlier shipments received by LS staff that had not shown that variability had been purchased through an intermediary. Consequently, the age and production parameters of the initial fabric samples could not be verified.

As a first step, in October 2005, the manufacturer agreed to provide several versions of their cotton velvet fabric from various steps in the manufacturing process. They supplied the CPSC staff with the following fabric test samples:

1. Bleached (raw fabric)
2. Dyed, with no finishing chemistry
3. Dyed, with full finishing chemistry (i.e., final product)
4. Dyed, with a partial finishing chemistry

LS staff tested these four fabric "steps" with the goal of determining at which point the combustion properties became variable. The small open flame test results are shown in Figure 1. The data show that the first two steps, both without any finishing chemistry, ignited readily and consistently. The steps with either full or partial finishing both had mixed results: some samples ignited readily, while others barely sustained a flame at all. From these data, LS staff and the manufacturer determined that the finishing chemistry plays a significant role in the fire performance of the cotton velvet cover fabric.

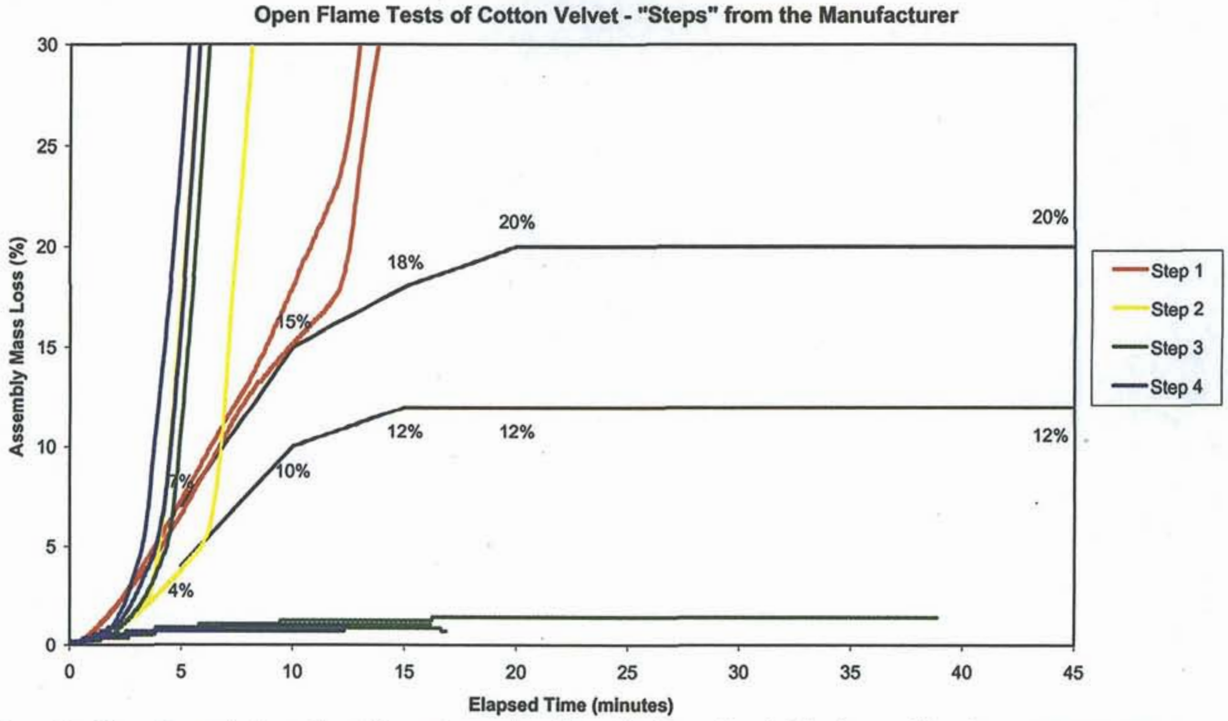

Figure 1. Open flame test results of the cotton velvet "steps". Steps 1 and 2 ignite readily. Steps 3 and 4 show divergent results. The upper and lower black boundary lines that begin at the five-minute mark designate the small open flame performance requirement for a standard fabric identified in the 2005 CPSC staff draft standard.

In November 2005, several CPSC staff members visited the manufacturer's plant to gain a better understanding of the manufacturing process. In December 2005, representatives from the company visited the CPSC Laboratory to witness first hand the variability in combustion properties observed by LS staff. The manufacturer's representatives indicated they had some solutions to control the manufacturing process better so that their product would more consistently meet the specifications in the 2005 CPSC staff draft standard.

Also in December 2005, LS Chemistry (LSC) staff determined that melamine, a chemical that can act as a flame retardant (FR), is present in the cotton velvet fabric. Subsequently, the manufacturer confirmed that melamine is present in the resin catalyst used to cure the fabric. It was not added for its FR properties, but residual levels are left on the fabric as a result of the curing process and could have an effect on its combustion performance (6).

In February 2006, LS staff received a shipment of several modified versions of the cotton velvet fabric. The quantities were limited so that only two small open flame test replicates could be completed with each version. The results are shown in Figure 2 for tests conducted with these fabrics over one of the polyurethane foam substrates being evaluated (Foam Z"). LS staff noted at the time that Foam Z" was slightly more FR-treated than the target standard foam. LS staff expected that on Standard Flame Retardant Polyurethane Foam (SFRPUF), the mass losses would be 1-3% higher than when tested with Foam Z". The results showed promise and suggested that the variability in combustion properties could be minimized.

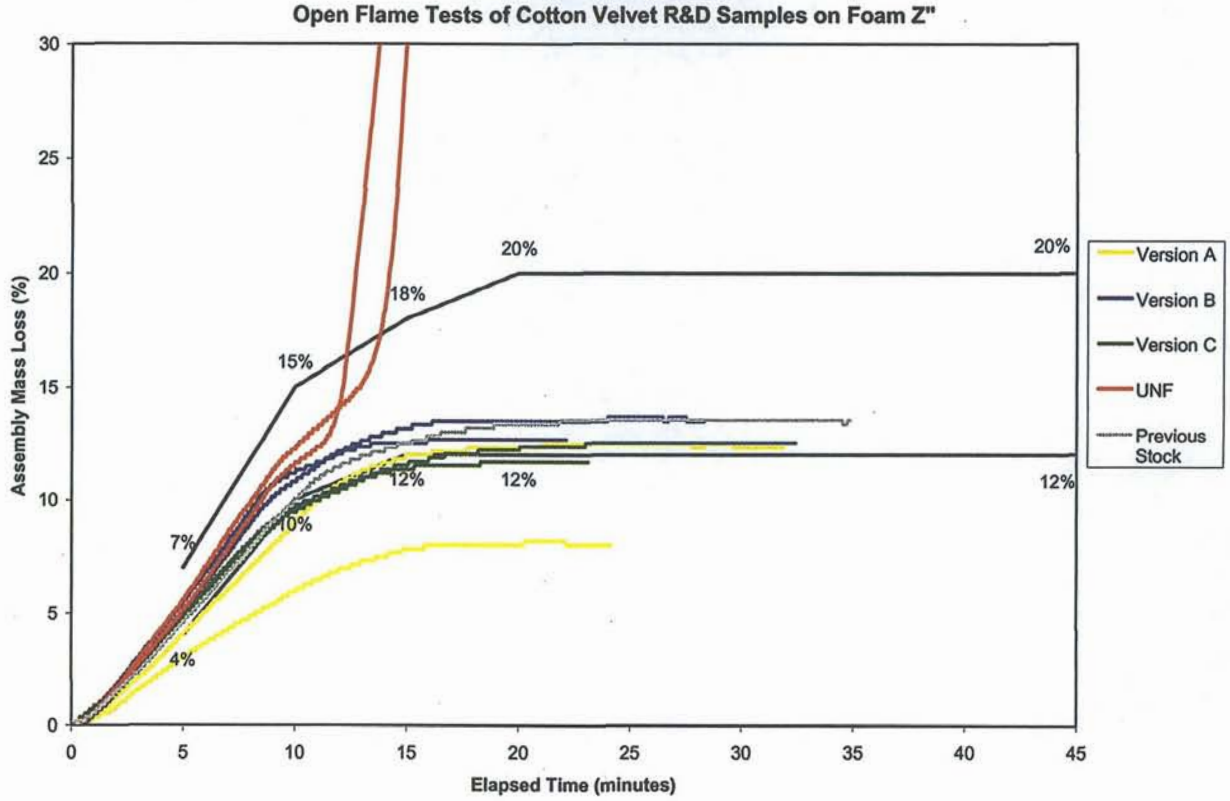

Figure 2. Open flame tests of cotton velvet R&D samples from the manufacturer tested on Foam Z". Versions B and C showed the most promise. Version B was selected for further testing. "UNF" is presumably not treated with the modified finishing chemistry. The "Previous Stock" data used a piece of cotton velvet from an early shipment that was reserved and tested on Foam Z" for comparison purposes.

LS staff concluded that version B showed the most promise and obtained larger quantities of that fabric for further testing. The company shipped 12 rolls of fabric to the CPSC Lab in March 2006. These rolls included three days' production of the requested version and a control version of the fabric, each with and without an additional treatment added to enhance the smoldering performance of the fabric. These fabrics were designated as RD1 through RD12 and were tested following both the smoldering and small open flame procedures outlined in the 2005 staff draft standard. The results of 50 smoldering tests and 24 open flame tests are shown in Figures 3 and 4.

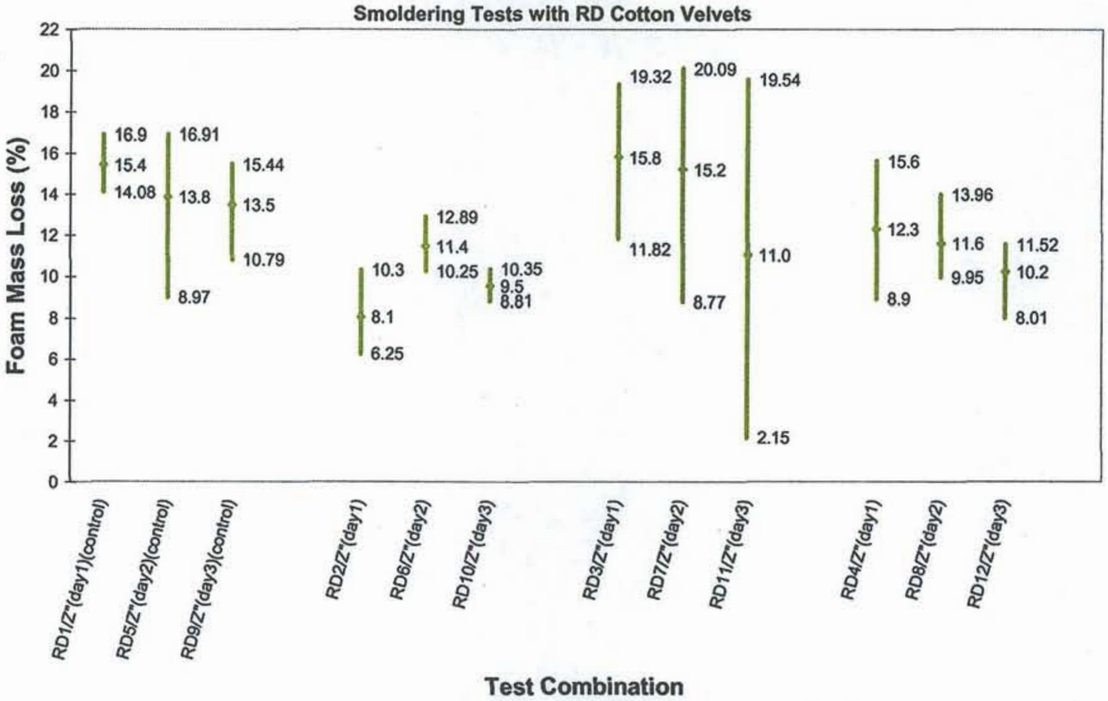

Figure 3. Smoldering tests of cotton velvets RD1 through RD12 tested on Foam Z". Nominally identical formulations from three different days' production are listed together. The data are represented with High-Low-Average bars for each combination shown.

The smoldering performance results for all four versions of the cotton velvet fabric were similar to one another and to previous test results. A baseline of three replicate tests for each combination was conducted. Once the decision was made to pursue a specific formulation, additional testing was conducted on RD3, RD7, and RD11. RD3 was tested six times, RD7 nine times, and RD11 eight times.

The small open flame performance of the different versions of fabric was consistent regardless of the day the roll was produced. For example, the control fabrics RD1, RD5, and RD9 all have the same chemistry but were produced on three different days at the plant. They all ignited readily when ignited with a small open flame. The three other chemistries also showed no apparent "day effect" and performed similarly to one another in small open flame tests.

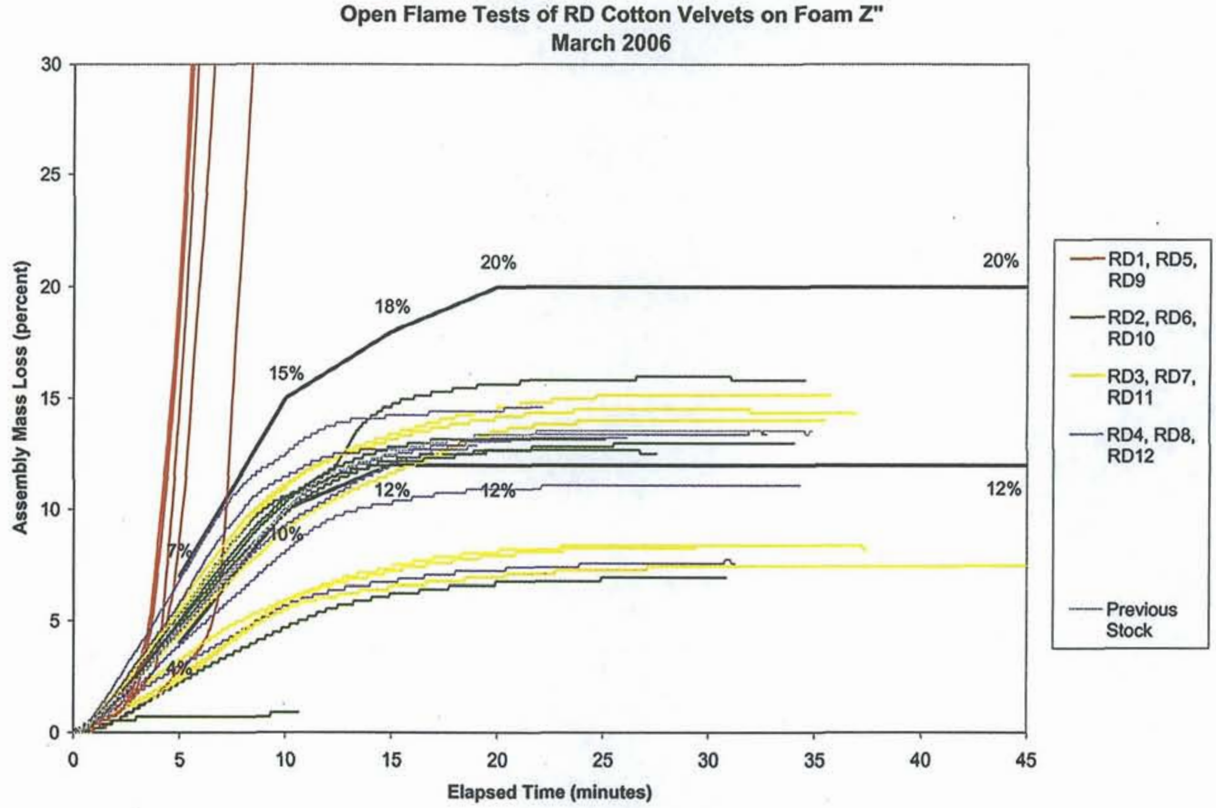

Figure 4. Open flame tests of cotton velvets RD1 through RD12 tested on Foam Z". Nominally identical formulations from three different days' production are listed together. RD1, RD5, and RD9 are the control fabrics.

With one of the four formulations, there was a tendency to burn asymmetrically from the point of open flame impingement that was observed in about 50 percent of the tests. LS staff conducted additional tests on this fabric to try to discover why it burned asymmetrically. Chemical analysis did not reveal a difference between this formulation and others that burned symmetrically. In addition, analysis of 14 evenly spaced samples from across the width of an asymmetrically burned piece of fabric did not reveal significant variation of trace metal ions with respect to location (7). Variations in the small open flame test procedure, such as tests with the fabric mounted upside down (e.g., with the pile lying from bottom to top) and with all other laboratory conditions and test procedures carefully controlled also tended to burn asymmetrically. The reason for this phenomenon remains unclear.

The formulations for RD4, RD8 and RD12 were reported to match the formulation requested from the initial series of fabrics (version B); however, their performance in open flame tests was not as consistent or promising as other variations. The formulations RD2, RD6, and RD10 performed the most erratically in small open flame tests of all the formulations, with one replicate that was unable to sustain a flame and others that burned comparably to other formulations. Consequently, the LS and manufacturer's staffs agreed to refine the process and proceed with further testing of a formulation matching RD3, RD7, and RD11.

A new shipment of fabrics matching that formulation, designated RD13 through RD18, arrived at the CPSC Lab in April 2006. They represent three days' production of the same formulation of cotton velvet. Each roll was processed independently, effectively giving six production runs of cotton velvet to assess the repeatability of the chemical finishing process.

These fabrics were tested over another test foam candidate Foam Z01. Foam Z01 arrived in April 2006. Foam Z" is slightly more FR treated than would be necessary to meet the requirements for Standard Flame Retardant Polyurethane Foam (SFRPUF) as specified in the 2005 CPSC staff draft standard. Foam Z01 is a reformulation of Foam Z" that more closely complies with the SFRPUF specifications. However, because of the uncertainties associated with the cotton velvet cover fabric, Foam Z01 would not be regarded as an SFRPUF under the existing requirements of the 2005 CPSC staff draft standard. New proposed qualification requirements are discussed in a separate memo to mitigate the adverse effects of this interdependency of standard materials (8). Foam Z01 would likely meet those requirements.

The test results for 36 smoldering and 25 small open flame tests are shown in Figures 5 and 6. As before with the RD1-RD12 versions of the cotton velvet fabric, there does not seem to be a "day effect." The data showed, however, that not all of the small open flame test runs result in a mass loss within the band prescribed in the 2005 staff draft standard. Approximately half of the tests resulted in ignition of the underlying foam between three and five minutes after the start of the test. These results can be attributed to either variations in the fabric, the foam substrate, or more likely the interaction of the two materials. However, under new proposed qualification requirements, this material combination is not tested with a small open flame ignition.

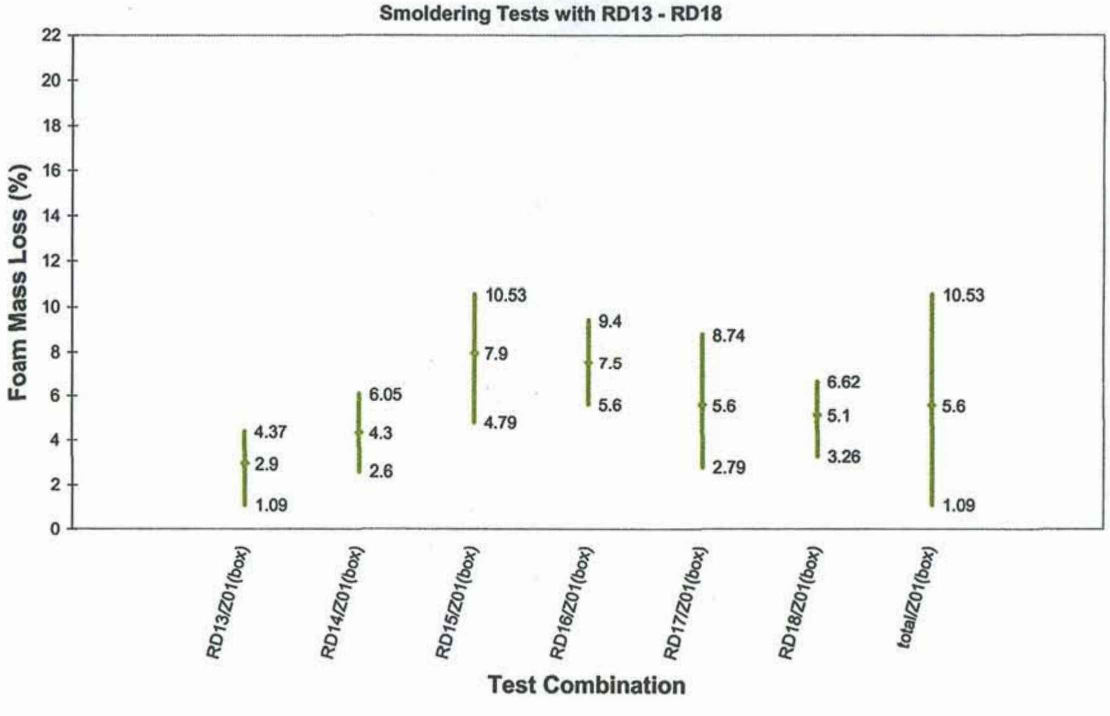

Figure 5. Smoldering test results for cotton velvets RD13 through RD18 on Foam Z01.

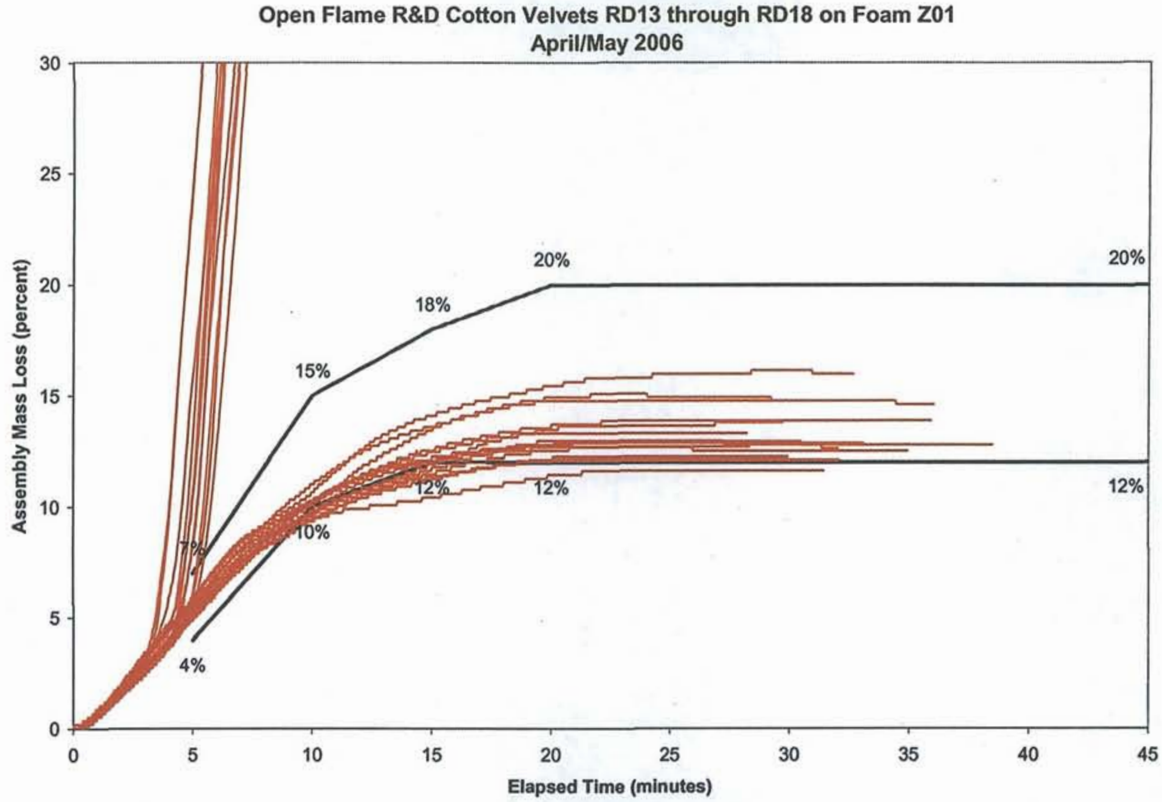

Figure 6. Small open flame test results for cotton velvets RD13 through RD18 tested on Foam Z01. All six formulations are nominally identical and no "day effect" was observed. Consequently, they are presented here grouped together.

Conclusion

Through the process of trying to understand the factors that dominate the performance of the cotton velvet cover fabric, LS staff re-evaluated the performance specifications for the standard materials requirements cited in the staff's 2005 draft standard. LS staff concludes that revisions to the standard materials qualifications requirements are needed. This is discussed in a separate memo (8). The refined cotton velvet fabric would meet those requirements. Other materials from other vendors could also meet those requirements, though CPSC staff has not received or tested any such materials to date.

The results of the limited testing performed to date suggest that the refined cotton velvet is a promising candidate standard test fabric. CPSC staff will, however, continue a dialog with the fabric manufacturer to ensure that the refinements to the finishing process for the cotton velvet fabric will provide the combustion properties necessary for upholstered furniture testing. Additional production runs will be purchased to verify the consistency of the fabric's combustion properties. A schedule of purchasing more fabric every three to four weeks over several months has been discussed and tentatively agreed upon.

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UNITED STATES
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Memorandum

Date: October 23, 2006

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 Engineering, Laboratory Sciences

FROM : Weiying Tao, Ph.D. WT
Textile Technologist, Division of Engineering, Laboratory Sciences

SUBJECT : Upholstered Furniture – Evaluation of the Draft-Limiting Enclosure Specified in the Smoldering Ignition Test Method[1]

Introduction

The U.S. Consumer Product Safety Commission (CPSC) staff is developing a draft flammability standard addressing both the smoldering and small open flame ignition performance of upholstered furniture. The most recent version of the CPSC staff draft standard was published in December 2005 (1). The smoldering ignition test protocol uses the fundamental test geometry requirements of the Upholstered Furniture Action Council (UFAC) Voluntary Program for testing and evaluating the cigarette ignition resistance of fabric, filling, and barrier materials (2).

The UFAC protocol geometry is specified in California TB 117 and other standards developed to evaluate the smoldering ignition resistance of upholstery materials (1). The CPSC staff's draft test protocol (1) uses different performance criteria than the UFAC protocol. Foam mass loss is used as the main performance criterion by CPSC instead of vertical char length as specified by UFAC. The CPSC staff's draft test protocol also requires a 30 minute test duration, and increases the foam thickness from 2 inches to 3 inches to reduce possible interactions with the mockup frame in order to improve the accuracy and repeatability of the smoldering test when using mass loss as a performance measure (3). An enclosure to reduce the effects of test room air drafts was used during the tests as specified in the UFAC test protocol. The enclosure is designed to permit simultaneous testing of up to three mockup assemblies.

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The following questions/concerns have been raised by commenters about using the draft-limiting enclosure during the smoldering test (4-6):

1. Smoldering combustion may be affected due to reduced oxygen inside the draft-limiting enclosure;
2. It is difficult to load and unload the mockups with the enclosure;
3. Spacing is tight when the maximum of 3 mockups are loaded in the enclosure; and
4. There are safety issues for test personnel who may be exposed to heavy smoke or the potential for sudden flare up of the samples when the enclosure is opened at the end of the test.

To address these comments, CPSC Laboratory Sciences (LS) staff conducted additional smoldering ignition tests with and without the draft-limiting enclosure. These tests explored the possible effect of the enclosure on smoldering performance. A range of fabrics and foam materials were used in the tests as described in the following paragraphs.

Materials and Test Methodology

Upholstery Fabrics

This study selected five upholstery fabrics from the 38 fabrics tested in previous studies (3), including smolder prone fabrics and non-smolder prone fabrics. These five fabrics are listed below:

Fabric 7: 92% cotton/8% rayon chenille, 20.0 oz/yd^2
Fabric 23: 100% cotton twill, 9.5 oz/yd^2
Fabric 24* (RD 13-18): 100% cotton velvet, 10.0 oz/yd^2
Fabric 25: 100% cotton, UFAC type I, 9.0 oz/yd^2
Fabric 26: 100% rayon, UFAC type II, 8.0 oz/yd^2

Fabric 7 is a strong smolder prone fabric. Fabric 23 is a moderate smolder prone fabric. Fabric 24* (RD 13-18) is the cotton velvet fabric with the same structure as cotton velvet fabric 24 used in previous tests but with a slightly different chemical finish (7). Fabrics 25 and 26 are UFAC standard test fabrics.

Foams

Nine different foams were used. They included untreated polyurethane foams and foams treated with different levels of flame retardant (FR) chemicals. Table 1 lists these foams and their FR chemical contents as determined by the CPSC Laboratory Sciences Directorate, Division of Chemistry (LSC).

Table 1. Chemical Contents of Foams Used for Testing

Foam	Type	Melamine %	P*%	TDCP**%	FM-550***%	Total "FR Load"
@	Polyurethane untreated	0	0	0	0	0
U01	Polyurethane untreated	0	0	0	0	0
U	Polyurethane untreated+	1.2	0	0	0	1.2
T'	Polyurethane FR treated	3.4	1.6	0	0	5
Znot	Polyurethane FR treated	0	0	0	6	6
T"	Polyurethane FR treated	2.8	0	6.2	0	9
Z01++	Polyurethane FR treated	2.9	0	0	6.7	9.6
G	Polyurethane FR treated	1.1	0	0	9.7	10.8
Y	Polyurethane FR treated	11.1	0	3.5	0	14.6

*P = phosphorus from sources including TPP
**TDCP = tris (1,3-dichloro-2-propyl) phosphate
***FM-550 is a flame retardant chemical containing a mixture of halogenated aryl esters and aromatic phosphates
+When purchased, manufacturer's specs indicated no FR chemicals
++A formulation that consistently complies with the requirements for SFRPUF in the CPSC 2005 draft standard

Test Matrix and Method:

Table 2 shows the test matrix for this evaluation of the possible effects of the draft-limiting enclosure. The matrix consists of 228 tests. The numbers in each cell are the numbers of replicates for each tested combination of materials. More tests were performed on the potential standard test fabric, foam, or smolder prone materials than non-smolder prone materials because no significant differences are expected for non-smolder prone materials when tested with or without the enclosure. The tests with the draft-limiting enclosure were performed according to the test method described in the CPSC staff 2005 draft standard (1). The tests in open air were done with the same procedures except no enclosures were used. The mockups were in the open air in the test room where the air flow rates of the CPSC test room were maintained below 0.1 m/s. Figures 1 and 2 show the physical arrangement of the smoldering test mockups with and without the draft-limiting enclosure.

Table 2. Smoldering Ignition Test Matrix (Enclosure vs. Open Air)

Fabric	Foam@		FoamU01		FoamU		FoamT'		FoamZnot		FoamT"		FoamZ01		FoamG		FoamY	
	box	air	box	air	box	air	box	air	box	air	box	air	box	air	box	air	box	air
Fabric24* (RD13-18)	18	18	6	6	6	6	3	3	3	3	3	3	36	36	3	3	0	3
Fabric 23	6	6											6	6				
Fabric 7	6	6											6	6				
Fabric 25	3	3											3	3				
Fabric 26	0	3											3	3				

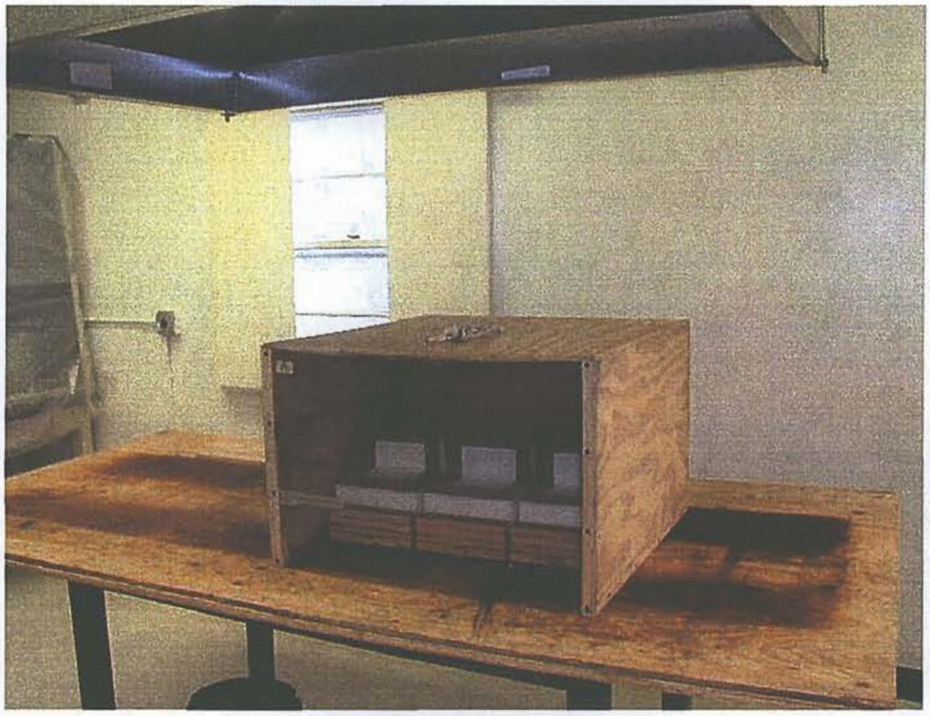

Figure 1. Smoldering Test with the Draft-Limiting Enclosure

Figure 2. Smoldering Test without the Draft-Limiting Enclosure

Results

Table 3 and Figures 3-6 show the smoldering test results. The figures are plotted in two ways: one with matching pairs of enclosure vs. no enclosure (open air) results for specific combinations of fabric and foam, and the other one with the enclosure and no enclosure data in separate groups ordered from untreated to the most highly treated foam. As expected, the test results show that foam mass losses increased for the no enclosure tests for the same fabric/foam test combination. The limited number and location of ventilating holes in the draft-limiting enclosure result in a build-up of combustion products and consequent reduction in oxygen available to support continuing smoldering combustion.

Table 3. Smoldering Ignition Test Results (Percent Foam Mass Loss)

Mockup	High	Low	Mean	Standard Deviation	Coefficient of Variation
F24*/@(box)	13.15	4.69	7.80	2.05	0.26
F24*/@(air)	18.13	8.66	13.30	3.26	0.25
F24*/U01(box)	11.32	6.55	8.76	1.77	0.20
F24*/U01(air)[1]	16.27	8.41	12.94[1]	2.88[1]	0.22[1]
F24*/U(box)	2.86	1.4	2.08	0.58	0.28
F24*/U(air)	5.18	2.66	4.06	1.03	0.25
F24*/T'(box)	3.2	1.94	2.42	0.68	0.28
F24*/T'(air)	6.53	1.55	4.27	2.52	0.59
F24*/Znot(box)	17.73	6.4	11.57	5.73	0.50
F24*/Znot(air)	18.79	12.59	16.28	3.27	0.20
F24*/T"(box)	4.74	0.84	2.31	2.12	0.92
F24*/T"(air)	8.07	5.45	6.48	1.39	0.21
F24*/Z01(box)	10.53	1.09	5.60	2.40	0.43
F24*/Z01(air)	12.05	2.38	6.50	2.12	0.33
F24*/G(box)	0.63	0.56	0.59	0.04	0.07
F24*/G(air)	0.64	0.53	0.63	0.18	0.29
F24*/Y(air)	0.89	0.73	0.82	0.08	0.10
F23/@(box)	5.57	1	3.05	1.56	0.51
F23/@(air)	13.45	3.63	7.46	3.73	0.50
F23/Z01(box)	1.64	0.94	1.38	0.25	0.18
F23/Z01(air)	5.4	2.86	3.65	1.01	0.28
F7/@(box)	6.94	3.12	4.95	1.59	0.32
F7/@(air)	18.83	11.18	14.04	3.10	0.22
F7/Z01(box)	7.11	4.42	5.49	1.00	0.18
F7/Z01(air)	11.81	3	7.79	2.95	0.38
F25/@(box)	1	0.53	0.69	0.27	0.39
F25/@(air)	0.84	0.52	0.65	0.17	0.26
F25/Z01(box)	0.72	0.58	0.63	0.07	0.11
F25/Z01(air)	1.01	0.85	0.91	0.09	0.10
F26/@(air)	0.99	0.78	0.86	0.11	0.13
F26/Z01(box)	0.58	0.48	0.52	0.06	0.12
F26/Z01(air)	0.71	0.52	0.59	0.11	0.19

[1] Outlier 34.16% removed. If outlier included, mean = 16.48%, Standard Deviation = 9.04, Coefficient of Variation = 0.55

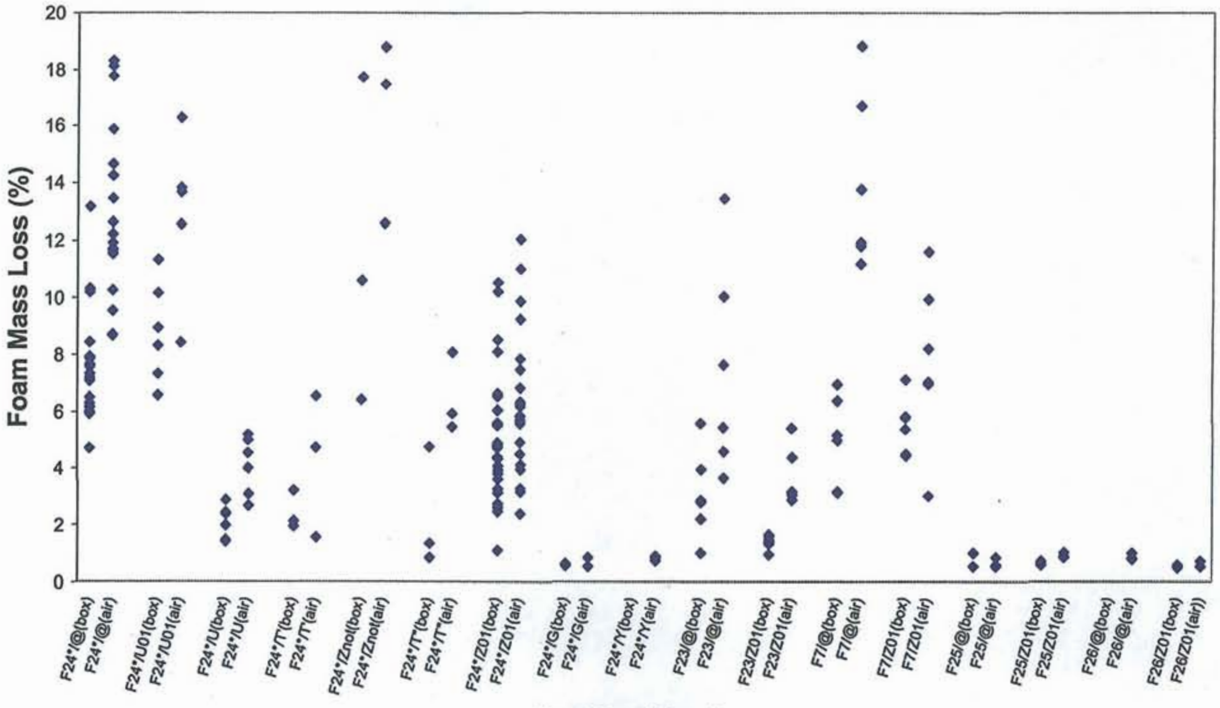

Figure 3. Foam Mass Loss Data Points (Enclosure vs. Open Air/Match Pair)

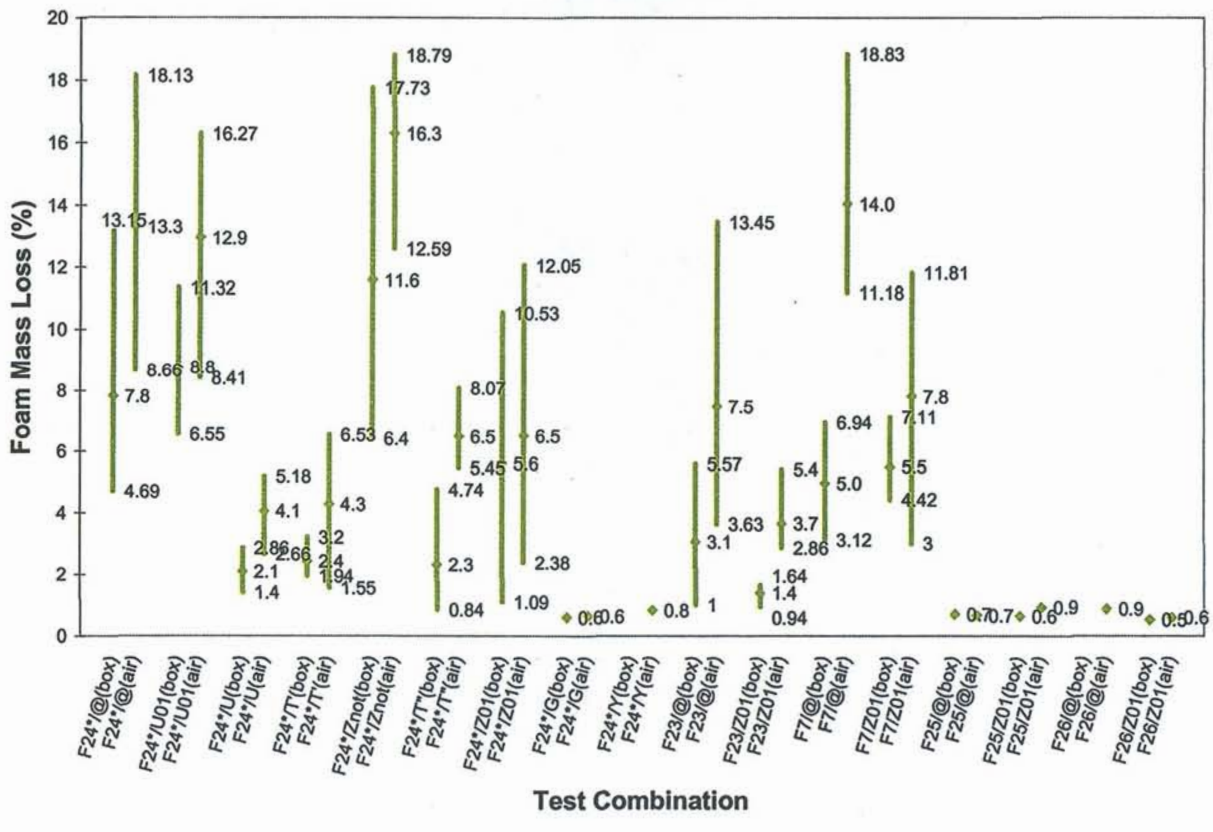

Figure 4. Average Foam Mass Losses (Enclosure vs. Open Air/Match Pair)

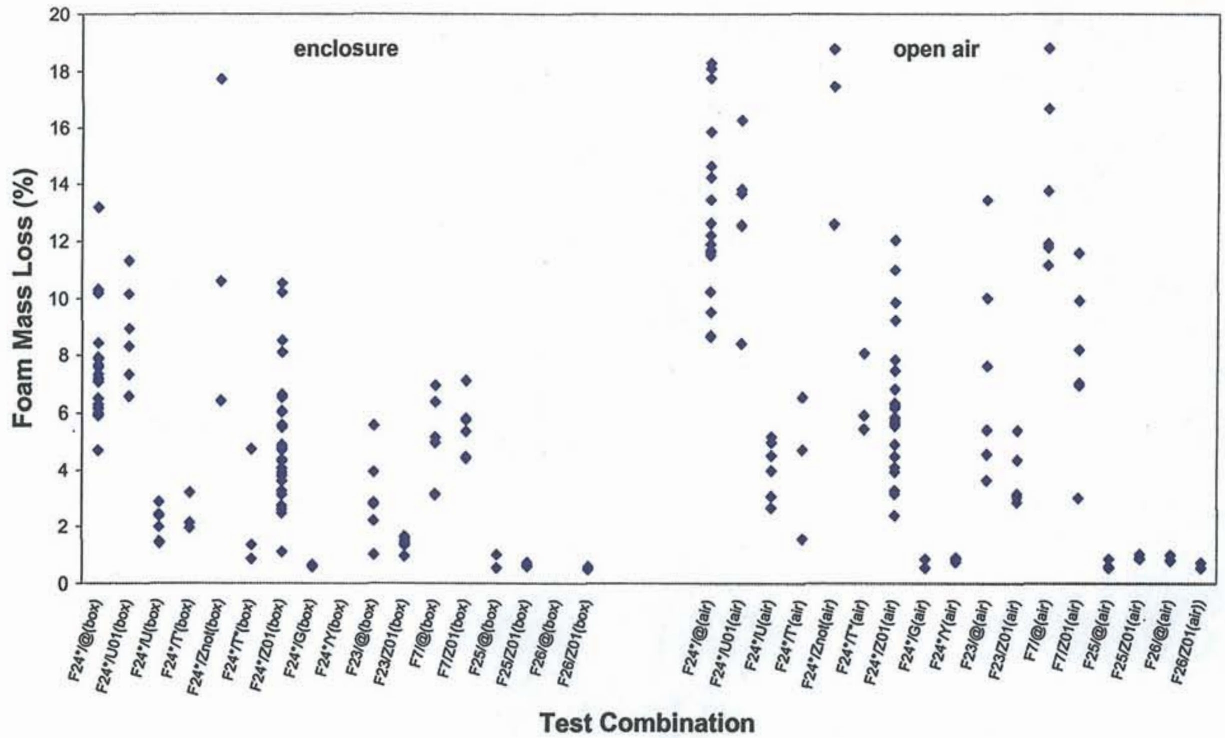

Figure 5. Foam Mass Loss Data Points (Enclosure vs. Open Air)

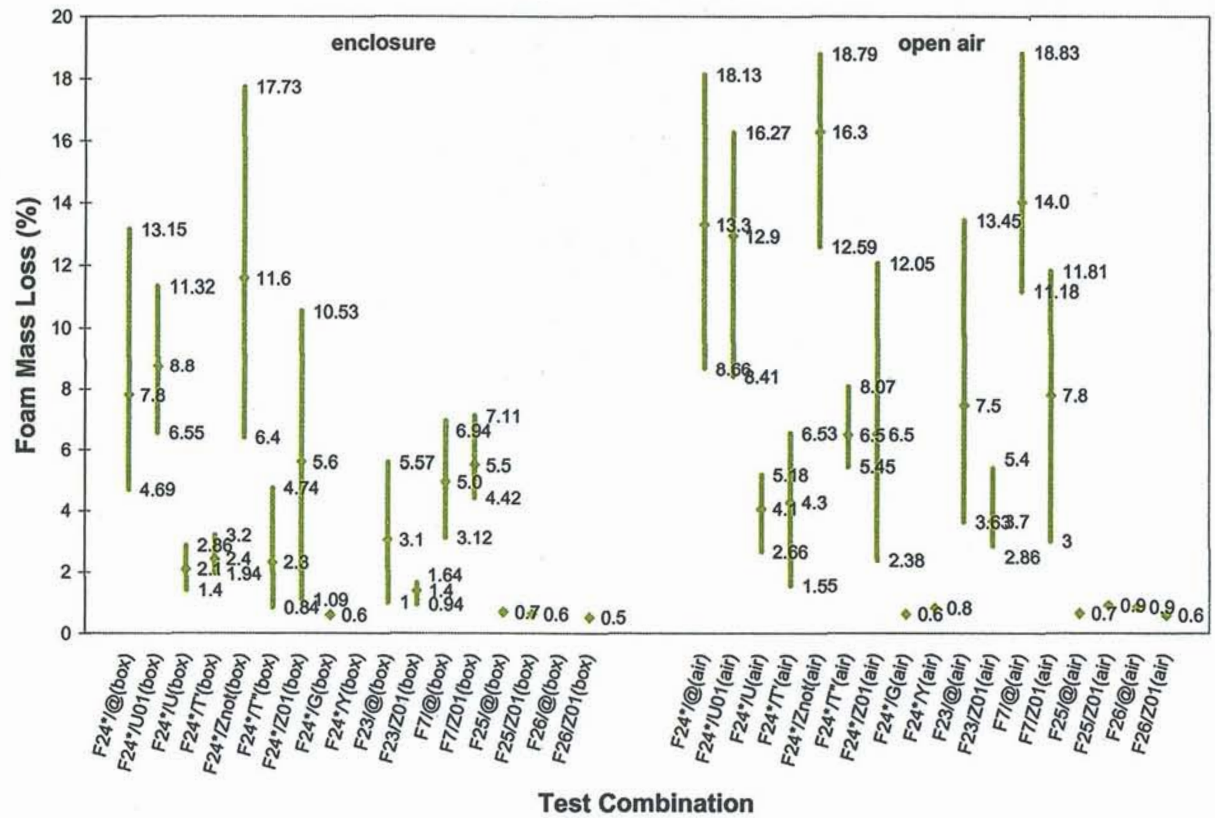

Figure 6. Average Foam Mass Losses (Enclosure vs. Open Air)

Figure 7 shows the carbon monoxide (CO) levels measured inside and outside the enclosure during the smoldering tests with the draft-limiting enclosure. This figure shows that CO levels inside the enclosure increase greatly during the 30 minute test duration, while CO levels outside the enclosure stay very low. Although the high levels of CO inside of the enclosure for combinations of smolder prone materials do not represent a workplace hazard due to its confinement within the enclosure, a short-term exposure to elevated CO levels can occur upon removing the enclosure at the end of the test and should be properly accounted for when doing smoldering testing employing the enclosure. This short-term exposure when removing the enclosure can be mitigated with engineering controls such as adequate room ventilation and/or appropriate personal protective equipment. While it is conceivable given the high levels of CO in the enclosure that the sample flare up event reported by industry could occur, CPSC staff did not experience such an event in any of these smoldering tests or previous testing.

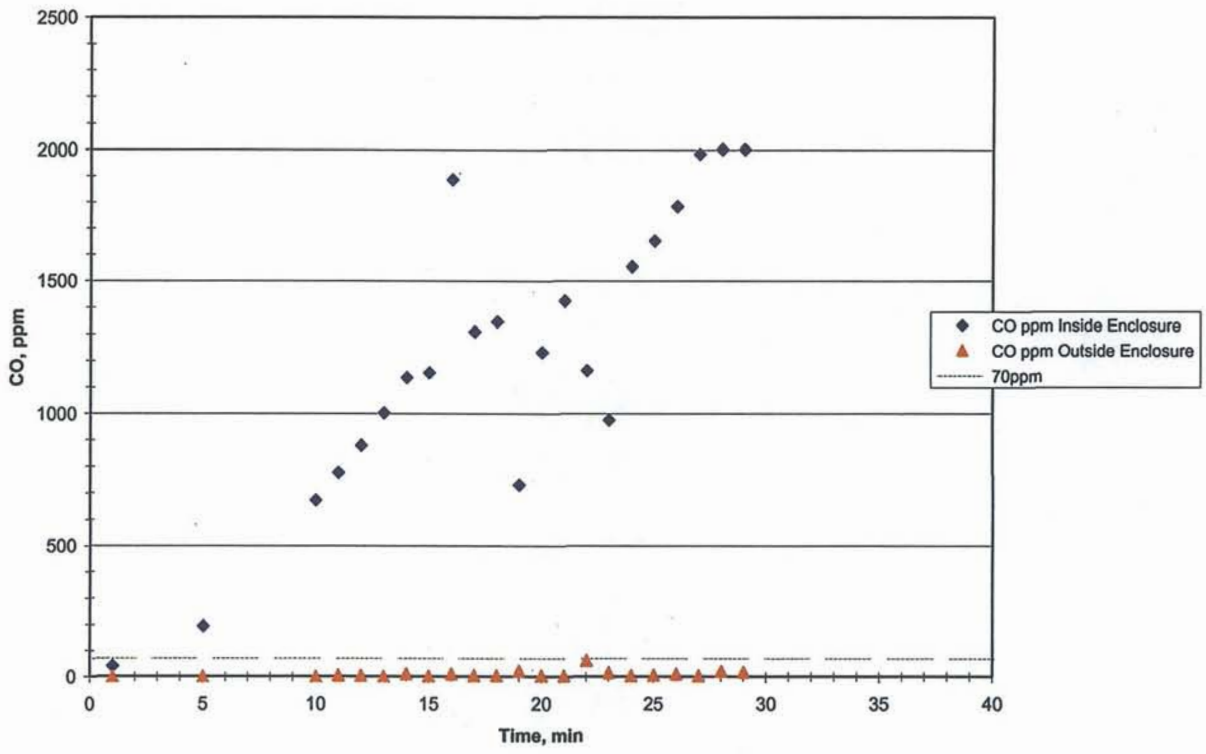

Figure 7. CO Levels During Smoldering Test

Data Analyses

The draft-limiting enclosure did not affect test results for test combinations with non-smolder prone materials because those materials do not smolder significantly with or without the enclosure. For example, fabric and foam combinations such as the flame retardant treated foams G and Y, and fabrics 25 and 26, resulted in average foam mass losses of the mockup test foams below 1% whether or not the tests were conducted in the enclosure.

When mockups made from cotton velvet fabric with untreated foam @ and cotton velvet fabric with untreated foam U01 were tested using the enclosure, their average foam mass losses were 8.04% with a standard deviation of 1.99%. When these same mockups were tested without the enclosure, their average foam mass losses increased to about 13%. One mockup made with cotton velvet fabric and foam U01 smoldered exceptionally strongly in open air; its foam mass loss reached 34%. This foam mass loss data was considered an outlier because all other foam mass loss data for the same combination were well below 20%. If the outlier were included in the data set, the average foam mass loss of U01 would be 16% when tested without the enclosure.

The test results indicate that the enclosure effects are more pronounced on mockups using untreated foams, foams @ and U01, than on the mockups made with treated foam Z01. For example, when foam @ was tested with the cotton velvet fabric, the average foam mass loss increased from 7.8% with the enclosure to 13.3% without the enclosure. When foam Z01 was tested with the same velvet fabric, the average foam mass loss increased from 5.6% with the enclosure to 6.5% without the enclosure. When foam @ was tested with the chenille fabric, the average foam mass loss increased from 5.0% with the enclosure to 14.0% without the enclosure. When foam Z01 was tested with this same chenille fabric, the foam mass loss increased from 5.5% with the enclosure to 7.8% without the enclosure.

When foams @ and Z01 were tested with a moderate smolder prone fabric 23, the average foam mass losses both increased, from 3.1% with the enclosure to 7.5% without the enclosure for foam @, and from 1.4% with the enclosure to 3.7% without the enclosure for foam Z01. These results indicate that the effect of the draft-limiting enclosure on smoldering ignition tests will also depend on the interaction between specific foam and fabric combinations.

Other mockup test combinations, such as cotton velvet fabric with foam U, cotton velvet fabric with foam T', and cotton velvet fabric with foam T", smoldered slightly with only about 2 to 3% average foam mass losses when tested with the enclosure. All their foam mass losses increased when tested in open air without the enclosure. The foam mass loss of the test combination cotton velvet fabric with foam T" increased the most, from 2.3% with the enclosure to 6.5% in open air.

The foam/fabric test combination using cotton velvet fabric with foam Znot was the most smolder prone test combination among the mockups tested, and it was the only test combination with an average foam mass loss of more than 10% (11.6%) when tested with the enclosure. Its average foam mass loss increased to 16.3% when tested in open air. Foam Znot is a lightly FR treated foam. It smoldered more than the untreated foams @ and U01 when tested with the same cotton velvet fabric. This result indicates that in some cases foams with small amounts of certain types of FR chemicals could smolder more than untreated foams, which is consistent with the findings from earlier studies (3, 8).

Assessment of the Draft Limiting Enclosure

The draft-limiting enclosure was not required by UFAC in the 1979 UFAC test program and UFAC at that time specified that the air velocity across the test assemblies should be maintained below 50 linear ft/min (0.25 m/s) (9). It recommended zero air flow at the test locations. In order to achieve test consistency, UFAC recommended open top draft enclosures in 1983 (10). The current UFAC test method requires closed top draft-preventive enclosures with ventilating holes on top of the enclosures (2). It specifies that zero air flow at the test surface is desirable which is indicated by a minimum vertical smoke plume of 6 inches observed from the mockups being tested (2). Air flow rates in the CPSC test room are maintained below 0.1 m/s to provide controlled combustion gas removal for safety purposes without affecting the smoldering behavior of the mockups. The smoke plumes observed from the mockups tested in open air in the CPSC test room are essentially vertical in excess of 6 inches above the mockups under these air flow conditions. This is consistent with UFAC testing requirements, although prior CPSC laboratory tests were conducted with the draft-limiting enclosure in place.

Table 3 compares coefficients of variation for the same fabric/foam combination tested with and without the draft-limiting enclosure. The data shows that some of the coefficients of variation are similar for the identical fabric/foam combination tested with and without the enclosure, some of the coefficients of variation tested with the enclosure are greater than those tested without the enclosure for the identical fabric/foam combination, and some are smaller. Figures 3-6 also show that some test results with and without the draft-limiting enclosure had relatively large data ranges. These smoldering test results with and without the enclosure suggest that due to the inherent variability of this type of fire testing there was no clear effect when eliminating the draft-limiting enclosure with respect to data repeatability when the air flow conditions of the test room were controlled.

The rate of consumption of the limited amount of oxygen and its displacement with combustion products within the draft-limiting enclosure is a function of the intensity with which the sample burns. Materials that do not smolder or that smolder slowly are minimally affected by the oxygen-limiting property of the enclosure within the 30 minute test duration. Materials that smolder with greater intensity may appear to perform better (less mass loss) since the time at which the combustion becomes oxygen-limited may occur within the 30 minute test duration. The test data also indicates that the poorer performing the material, the more pronounced are the effects on the smoldering tests when using the draft-limiting enclosure. The draft-limiting enclosure skews the results and may allow poor performing materials to pass.

As noted above, some commenters have expressed concerns that the build-up of gases such as CO in dangerous concentrations (>1200 ppm) and particulates from oxygen-limited combustion within the enclosure lead to the potential for an explosive combustion environment. Fresh air is introduced when an operator lifts the enclosure, and could result in a rapid combustion of those materials within the test enclosure. CPSC staff has not experienced this phenomenon, but agrees that it is theoretically possible to occur.

There is also usually heavy smoke when the enclosures are opened to remove the smoldering mockups at the end of tests. Commenters expressed concern that exposure to high concentrations of combustion products presents a potential health risk to the persons conducting the tests. CPSC staff use constant-air pressure respirators when entering the test room to conduct these tests. Because there is a tight fit for the three mockups in the enclosure, loading and unloading operations are difficult when wearing such personal protective equipment. Conducting smoldering tests without the draft-limiting enclosure can avoid most of these issues, but requires test room air circulation to be well controlled in order to achieve consistent test results and for the test results to be comparable.

Summary

The test results show that smoldering combustion can be affected by using the draft-limiting enclosure for smolder prone material combinations because available room air around the mockups is restricted. In CPSC laboratory tests, mockups smoldered more and foam mass losses increased when the mockups were tested in open air without the enclosure. Mockups made from smolder prone fabrics and standard FR foam met the CPSC staff 2005 draft standard's pass/fail criteria when tested with or without the enclosure. The draft-limiting enclosure could, however, allow poor performing material combinations that smolder with greater intensity to perform better (less mass loss) than they would without the enclosure.

The test results also indicated that eliminating the draft-limiting enclosure had no clear effect on data repeatability/variation when the test room air flow conditions were controlled. These test results suggest that smoldering tests can be conducted without using the draft-limiting enclosure; however, to ensure repeatability air flow rates and conditions for the test room should be specified and controlled. Personal protective equipment should be used when entering the test room to handle the materials at the end of the test.

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8. California Bureau of Home Furnishings and Thermal Insulation, Technical Bulletin 117, Draft, February 2002.
9. UFAC Test Methods, Upholstered Furniture Action Council, 1979.
10. UFAC Test Methods, Upholstered Furniture Action Council, 1983.

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Tab B

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: October 23, 2006

TO:	Dale Ray Directorate for Economic Analysis
THROUGH:	Russell Roegner, Ph.D. Associate Executive Director Directorate for Epidemiology
	Kathleen Stralka, Director Division of Hazard Analysis
FROM:	David Miller Division of Hazard Analysis
	Michael Greene, Ph.D. Division of Hazard Analysis
SUBJECT:	CPSC Staff Response to CRA Comment on Upholstered Furniture Fire Loss Estimates

The purpose of this memo is to discuss the estimates for addressable fire deaths and injuries made by CRA International in their submission on the U.S. Consumer Product Safety Commission (CPSC) staff's draft Upholstered Furniture Flammability Standard.[1] CRA used two different methods in making their estimates, one similar to the CPSC Staff Method and the second considerably different. This document presents estimates from both CRA methods. The discussion focuses on the second method because it resulted in an estimate of 30 percent fewer addressable fire deaths than the Staff Method.[2] This difference in estimated deaths has a potential impact on the staff's preliminary regulatory analysis of a possible standard.

The following section presents a background description of two issues inherent in the data sources used by CPSC staff and CRA and the processes to adjust for these issues when estimating fire losses in the United States. Building on the background, the method used by CPSC staff and the two CRA methods and the resulting estimates are characterized. Finally, CPSC staff address the statistical soundness of CRA's methods and their resulting estimates.

CPSC staff believe that their method will tend to produce more accurate estimates than the CRA methods, particularly CRA's second method. This second CRA method will underestimate fire deaths.

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[1] CRA International, "An Evaluation of the CPSC Staff Preliminary Regulatory Analysis of the Draft Upholstered Furniture Flammability Standard", CRA Project No. D08452-00, March 2, 2006. The analysis was prepared for the American Home Furnishing Alliance, National Home Furnishings Association, and the Upholstered Furniture Action Council.

[2] CPSC staff estimated 360 addressable fire deaths, while CRA estimated 250. Using the method that was similar to the CPSC Staff Method, CRA estimated 340 fire deaths (6% lower than that the CPSC staff estimate).

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

Background

Fire loss analysis is complicated by two basic issues.

First, the detailed fire incident records that are necessary to determine the role of consumer products in fires, deaths, and injuries, come from a voluntary sample of U. S. fire departments and are compiled into a database annually by the U. S. Fire Administration (USFA). This database, the National Fire Incident Reporting System (NFIRS), does not contain records on all U. S. incidents because some departments and some entire states do not submit reports. The amount of reporting changes from year to year. Thus, by itself NFIRS cannot be used to estimate the number of consumer product-related fire losses.

Second, although each NFIRS record describes a fire incident, in many cases the records are not complete. The cause of ignition (which analysts use to separate out-of-scope, intentionally caused incidents from in-scope, unintentional incidents) may be unknown.[3] The source of the heat that started the fire may be unknown, or the item that was ignited first by that source of heat may be unknown. This means that occasionally the data do not indicate if the source of heat was smoking materials, small open flame or another source, if the item first ignited was upholstered furniture or another item, or if the incident was intentionally or unintentionally caused. While any statistical dataset is likely to have some unknown data, between one-quarter and one-half of the data on an important variable may be unknown in NFIRS. In particular, fatal fire incidents are more likely to have unknown data than non-fatal incidents.[4]

Since the 1980's, analysts at the USFA, CPSC, and the National Fire Protection Association (NFPA) have been using a procedure that has come to be called the National Estimates Approach to address the dual problems of voluntary reporting and missing data.[5] The National Estimates Approach addresses the problem of voluntary reporting by using a separate survey, a probability sample of U. S. fire departments conducted annually by the NFPA. This survey asks each sampled fire department about the number of fires, fire deaths, injuries and property loss experienced that year. From this survey, estimates can be made about annual national totals of fires, deaths, injuries and property loss. The NFPA survey is then used to create scaling factors for fires, deaths, fire injuries, and fire-related property loss to weight NFIRS counts to national totals. For example, there were 977 civilian deaths from residential structure fires reported in NFIRS in 1999. The national estimate of residential structure fire civilian deaths from the NFPA survey for 1999 is 2,920. So the fire death scaling ratio for 1999 is 2,920/977, which is 2.989.

To address the second issue of missing data, the National Estimates Approach deals with missing data by allocating it proportionally to the known data. CPSC staff uses a different allocation method than the USFA and the NFPA, but with both methods the following is true: at the end of the application of the allocation process, all important variables have been allocated,

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[3] Sometimes NFIRS variables are left blank. Other times they are coded as 'Undetermined'. Either way the information for that variable in those cases is unknown, or missing. These instances are treated the same, whether the variable was left blank or coded as 'Undetermined'. For the purposes of the analysis, the information is 'unknown'.
[4] R. Chowdhury, M. Greene, D. Miller, L. Smith, "1999 Revised – 2002 Residential Fire Loss Estimates", p. 28 – 29, CPSC, November 2005.
[5] J. Hall, B. Harwood, "The National Estimates Approach to U.S. Fire Statistics", *Fire Technology*, May 1989.

and there are no missing data.[6] The staff method is called "raking." It was developed in the 1950's and is a widely used method in the statistical community for allocating unknown data.

Estimates

Table 1 presents three sets of upholstered furniture fire loss estimates of interest here. These sets of estimates are the CPSC staff estimates, to which CRA took exception, and two different sets of CRA estimates. Appendix A summarizes the three methods used to generate these different sets of estimates.

The first set of CRA estimates is that produced using what CRA calls the "CPSC Extrapolation Method". For the purpose of this discussion, the method is referred to as the CRA Direct Method because it directly produces national estimates of deaths and injuries using the National Estimates Approach. That is, the CRA Direct Method uses death and injury estimates generated from NFIRS data and adjusts them using the NFPA probability based scaling ratios to produce national estimates of upholstered furniture fire deaths and injuries. The CRA Direct Method is very similar to the CPSC Staff Method with the exception of some differences in conventions that are documented in Appendices A and B. National estimates of fire deaths using the CPSC Staff Method and the CRA Direct Method differ by 6 percent.

A much larger departure from the CPSC Staff Method, in that it departs from the spirit and intent of the National Estimates Approach, is what CRA calls the "CRA Extrapolation Method". This method will be referred to as the CRA Indirect Method because it estimates deaths and injuries indirectly by only allocating and using NFPA survey estimates for fires. The probability based NFPA estimates for deaths and injuries are not used. After obtaining fire estimates using the National Estimates Approach, CRA multiplies them by death-per-fire and injury-per-fire estimates to arrive at estimates for deaths and injuries. These casualty-per-fire estimates are obtained from NFIRS without the use of the NFPA estimates. Also, CRA uses only the NFIRS casualties where Heat Source and Item First Ignited are known to produce the casualty-per-fire estimates. Casualties where Heat Source or Item First Ignited are unknown are ignored. The fundamental differences between the CPSC Staff Method and the CRA Indirect Method result in death estimates that differ by 30 percent.

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[6] CPSC staff used the same method in the 1999 Annual Fire Loss Estimates report, which was the first year that separated intentionally caused from unintentional incidents. This increased the number of variables in the analysis. Further discussion of the procedure, raking, is found in M. Greene, L. Smith, M. Levenson, S. Hiser, J. Mah, "Raking Fire Data", *Proceedings of the Federal Conference on Statistical Methodology*, 2001.

Table 1: Comparisons of Estimates of Addressable Upholstered Furniture Fire Losses: Annual Averages 1999-2002

Heat Source	CPSC Staff Estimates	CRA Direct Estimates	CRA Indirect Estimates
Total In-scope Fires	4,800	5,600	5,600
Smoking Materials[7]	3,600	3,700	3,700
Small Open Flame	1,300	1,900	1,900
Total In-scope Fire Injuries	740	770	860
Smoking Materials	480	460	510
Small Open Flame	260	310	340
Total In-scope Fire Deaths	**360**	**340**	**250**
Smoking Materials	300	270	200
Small Open Flame	60	70	50

Source: U.S. Consumer Product Safety Commission from data obtained from the U.S. Fire Administration and the National Fire Protection Association.
Notes: Estimates include residential structure losses only and exclude losses involving arson. Firefighter casualties are also excluded. Estimated fires rounded to the nearest 100. Estimated injuries and deaths rounded to the nearest 10. Detail does not always add to total due to rounding.

CPSC Staff Response to Comments of a Statistical Nature

CPSC staff have three main objections to the CRA Indirect Method: (1) it is motivated by a misunderstanding; (2) it departs substantially from the spirit and practice of the National Estimates Approach; and (3) it tends to return lower fire death estimates for any consumer product, not just upholstered furniture.

CRA contends that "… the methodology the CPSC staff employs to account for unknowns may substantially overstate the true losses from cigarette and small open flame-ignited furniture fires." CRA cites part of a recent CSPC annual fire loss report[8] which says that the raking algorithm "… cannot appropriately produce raked results when cell values are zero or very low." For these reasons CRA employed a different method of estimating upholstered furniture fire casualties than the National Estimates Approach: the Indirect Method. Straying from the National Estimates Approach because of the statement cited above about not being able to appropriately produce raked results, indicates CRA's misunderstanding of the allocation process.

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[7] 'Smoking Materials' in the CPSC staff estimates includes the *Heat Source* codes for 'Cigarette', 'Pipe or cigar', and 'Heat from undetermined smoking material'. For the CRA estimates, it only includes the code for 'Cigarette'.
[8] R. Chowdhury, M. Greene, D. Miller, L. Smith, "1999 Revised – 2002 Residential Fire Loss Estimates", p. 34, CPSC, November 2005.

The quote that CRA cites does appear in the 1999 – 2002 Fire Loss Report. However the quote is taken out of context. CPSC staff made the statement about raking being unsuitable when cell values are zero or very low due to a situation caused by a data coding revision that was introduced with NFIRS version 5.0 in 1999. In 1999 more than 90% of the data were still coded in the old system. Data coded in the old system goes through a conversion process to make it as much like the new system as possible. However the conversions are not always one-to-one. One of these conversion problems involves 'Installed Wiring' and 'Outlet, Receptacle, Switch'. If a case is coded in the old system with an equipment code belonging to one of these two categories, it converts to the same code in the new system. In 1999 that were 10 deaths associated with either one of these two categories – 'Installed Wiring' or 'Outlet, Receptacle, Switch'. These deaths were confounded in the conversion process so there was no way to know how many were associated with one category and how many with the other. In addition to these 10 deaths, there was one death coded in the new system that was given an equipment code in one of these two categories. It was associated with 'Installed Wiring'. If raking were to allocate these 10 deaths based on the one death, they would all be allocated to 'Installed Wiring'. This would probably lead to an overestimate of 'Installed Wiring' deaths and an underestimate of 'Outlet, Receptacle, Switch' deaths. To avoid this, CPSC staff allocated the deaths in proportion to the estimates of the number of fires associated with these two products. The estimates for fires were much larger. The assumption made by estimating the deaths in this way was that deaths-per-fire for 'Installed Wiring' would be the same as deaths-per-fire for 'Outlet, Receptacle, Switch'. This is the situation that CPSC staff was discussing in the quotation that CRA cites.

The allocation of deaths for upholstered furniture fires is a very different situation. There is no complication of converting from the old version to the new version related to upholstered furniture. The upholstered furniture conversion is one-to-one. There are many fire deaths with unknown *Item First Ignited.* Raking allocates the unknowns. The **many** deaths with unknown fire cause information are allocated based on the **many** deaths with known fire cause information. Over 1999 – 2002, there was an average of 57 in-scope upholstered furniture fire deaths reported in NFIRS with known *Cause of Ignition, Heat Source, and Item First Ignited.* These are not low counts.

Aside from it being unnecessary to stray from the National Estimates Approach for upholstered furniture fire deaths and injuries, there are significant statistical issues with the CRA Indirect Method. First is the inherent problem that the NFIRS/NFPA scaling ratios differ for fires, deaths, and injuries. Looking at the proportion of deaths per NFIRS fire is not so straightforward an estimate of national deaths per fire because the fire and death scaling ratios differ. When the National Estimates Approach was formulated, the authors warned against the idea of using fires to estimate deaths and injuries indirectly. The authors wrote, "Note that the use of separate scaling ratios for each measure of loss also means that one should not use NFIRS data alone to calculate deaths per fire (or other severity-per-fire) ratios for specific kinds of fires. Instead, the numerator and denominator should each be computed according to the national-estimates methodology before the severity per fire ratio is computed. Failure to follow this procedure can mean that a deaths per fire ratio will not be consistent with the figures for deaths and fires, each calculated separately according to the national-estimates methodology, because the scaling ratios will not cancel out in a rate calculation."[9]

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[9] J. Hall, B. Harwood, "The National Estimates Approach to U.S. Fire Statistics", *Fire Technology*, May 1989, p. 103.

The National Estimates Approach ties the estimates to the totals from the NFPA annual fire loss survey (a probability-based sample). The NFPA survey national estimates of residential structure fire deaths and injuries are the best available fire death and injury estimates. Therefore, it makes sense to choose a method such that the estimates for all products would add to the totals from the NFPA survey. If the CPSC Staff Method or the CRA Direct Method were to produce estimates of deaths and injuries across all the values of *Cause of Ignition, Heat Source*, and *Item First Ignited* (not just upholstered furniture), the totals of the estimates would match the totals from the NFPA survey for deaths and injuries. The CRA Indirect Method estimates however, are not tied to the NFPA total estimates for deaths and injuries. If the CRA Indirect Method were used to estimate deaths and injuries across the values for *Cause of Ignition, Heat Source*, and *Item First Ignited*, they would not add up to national estimates of deaths and injuries. By not adding to the death and injury total estimates from the NFPA survey, this methodology appears flawed from the outset.

The Indirect Method would not produce totals matching the estimates from the NFPA survey because it uses estimates of deaths per fire and injuries per fire as taken from NFIRS counts. Taking the number of deaths per fire (and the number of injuries per fire) from NFIRS without scaling it to national totals from NFPA does not adjust for the fact that the number of deaths per fire (and injuries per fire) in NFIRS differ from the probability sample based national estimates of these ratios. If these scaling ratios were the same for fires, injuries, and deaths, this would not be an issue, however they differ.

The final feature of the CRA Indirect Method is that using the fires with **known** *Heat Source* and *Item First Ignited* to estimate the proportion of deadly fires, leaves out the more deadly fires – the ones where one or more variables is unknown. As a result the Indirect Method will underestimate the number of deaths per fire and tend to lead to an underestimate of deaths.

CRA arrives at their estimate of deaths per fire in a two-step process. They take the number of upholstered furniture NFIRS fires (cigarette-ignited and small open flame-ignited, respectively) where at least one death occurs and divide by the number of NFIRS upholstered furniture fires (cigarette-ignited and small open flame-ignited respectively). This is their estimate of deadly fires per fire. Then CRA takes the number of deaths among those deadly fires (some fires have more than one death) and divide by the number of deadly fires. This is CRA's estimate of deaths per deadly fire. Last, CRA multiplies their estimate of deadly fires per fire by their estimate of deaths per deadly fire. The result is CRA's estimate of deaths per fire.

CRA states in their evaluation, "There is no reason why raking should increase the average number of deaths per deadly fire, unless there is evidence to show that deadly fires that take many lives are more likely to have unknown characteristics than deadly fires that take fewer lives".[10] CPSC staff checked the NFIRS databases for 1999 – 2002 and the number of deaths per deadly fire is not very different for fires with known *Heat Source* and *Item First Ignited* than it is for fires with unknown *Heat Source* or *Item First Ignited*. However, the other estimated proportion in CRA's multiplication, the number of deadly fires per fire, does not hold up to this scrutiny. The ratio of deadly fires per fire in NFIRS is much higher for fires with unknown characteristics (Heat Source and Item First Ignited) than for fires with known characteristics. See Appendix C for this evidence. Since it is similar for one ratio and higher for another, the resulting product, which is the estimate of deaths per fire, is higher for unknown fires than for

[10] CRA International, "An Evaluation of the CPSC Staff Preliminary Regulatory Analysis of the Draft Upholstered Furniture Flammability Standard", p. 91-92.

known. By ignoring the unknown fire deaths, CRA uses an artificially low estimate of deaths per fire.

For this reason, CRA's method of not using the deaths with unknown *Heat Source* or *Item First Ignited* underestimates deaths. This is reflected in CRA's estimates. The only difference in the two CRA methodologies (Direct and Indirect) is this technique of estimating the casualties from the fires in the Indirect Method as opposed to weighting up by the NFPA survey totals in the Direct Method. The result is an estimate of 250 upholstered furniture fire deaths per year in the Indirect Method as opposed to 340 deaths per year in the Direct Method, 20% - 30% lower. Since the Indirect Method estimates are not tied to the NFPA survey, the sum of all the death estimates across *Item First Ignited* could be much lower than the national estimate of fire deaths from the NFPA survey.

In conclusion, the CRA Indirect Method for estimating fire deaths and injuries resulted from a misunderstanding of a CPSC staff statement about small counts. This method strays from the National Estimates approach for making fire loss estimates by estimating casualties per fire without taking into account that scaling ratios for fires, deaths, and injuries differ. Finally, this indirect method of estimating deaths and injuries from the number of estimated fires will underestimate fire deaths by not accounting for those NFIRS fire deaths for which *Heat Source* or *Item First Ignited* are unknown.

CRA's Direct Method produces better estimates than the Indirect Method because it uses the National Estimates approach. However, the CPSC Staff Method yields more sound estimates than the CRA Direct Method estimates by including *Cause of Ignition* in the raking, excluding confined fires and child play fires, collapsing cells to simplify the raking algorithm to the level of interest of the analysis, and by including 'Heat from Undetermined Smoking Material' cases as in-scope. These things are explained in more detail in Appendices A and B.

Appendix A

Summary of Three Methodologies for Estimating Upholstered Furniture Fire Losses

Method 1: CPSC Staff Method

General Methodology – NFIRS deaths estimates are produced from a database of NFIRS deaths. The NFIRS variables *Cause of Ignition, Heat Source* and *Item First Ignited* are run through a raking algorithm which allocates unknowns and produces estimates of smoking material-ignited and small open flame-ignited, non-arson upholstered furniture fire deaths. These estimates are then weighted up by NFIRS/NFPA weights for deaths. The NFIRS/NFPA weight for deaths is the NFPA survey estimate for total residential structure fire deaths in a given year divided by the total number of NFIRS residential structure fire deaths for that same year. The exact same process is used to produce estimates for injuries, using the NFIRS/NFPA weights for injuries instead of deaths.

Conventions:

Confined fires – Confined fire incidents are eliminated from the NFIRS databases before analysis begins. A confined fire is a fire that is confined to a non-combustible container causing no flame damage beyond the container. Confined fires are limited to specific *Incident Types* which do not include upholstered furniture fires.

Allocation variables – the raking algorithm includes *Cause of Ignition, Heat Source* and *Item First Ignited.*

Collapsing Cells – Values for imputation variables are reduced to level of interest of the analysis (e.g., *Item First Ignited* is either 'Upholstered Furniture', 'Not upholstered furniture', or 'Unknown').

Child Play – If a case is coded as child play, the Cause of Ignition is edited to be 'Unintentional' before raking is performed. Therefore cases coded as child play will not be excluded as arson.

Smoking Material – Heat Source codes '61 – Cigarette', '62 – Pipe or cigar', and '63 – Heat from undetermined smoking material' are included as in-scope.

Method 2: CRA Direct Method

General Methodology – The general methodology is identical to **Method 1** with the exception that *Cause of Ignition* is excluded from the raking algorithm. The consequence is that only cases coded explicitly as 'Intentional' will be excluded as arson. Unknown cases (for *Cause of Ignition*) cannot be allocated into arson and therefore are included in the estimates en masse.

Conventions:

Confined fires - Confined fire incidents are left in the NFIRS databases. None of these are upholstered furniture cases but they are mostly cases that are left blank for the variables of interest so some will be allocated into the estimates.

Allocation variables – the raking algorithm includes *Heat Source* and *Item First Ignited.*

Collapsing Cells – Values for *Heat Source* and *Item First Ignited* are left as coded. There are tens of NFIRS codes for these variables and the raking algorithm is run from a database with all of these possible values.

Child play – No editing is done related to child play. If a case is coded as child play and also coded as 'Intentional' for *Cause of Ignition,* then it will be excluded as arson.

Smoking Material - Heat Source code '61 – Cigarette' is in-scope. Codes '62 – Pipe or cigar' and '63 – Heat from undetermined smoking material' are excluded as out-of-scope.

Method 3: CRA Indirect Method

General Methodology – First, CRA uses the same method as **Method 2** but to produce national estimates for fires. They use the raking algorithm with *Heat Source* and *Item First Ignited* and the NFIRS/NFPA weight for fires to produce national estimates of cigarette-ignited upholstered furniture fires and small open flame upholstered furniture fires. Fires where Cause of Ignition is 'Intentional' are excluded as arson.

To get from national estimates of fires to estimates for deaths, CRA multiplies by estimates of deaths-per-fire. They obtained estimates of deaths-per-fire for both cigarette-ignited and small open flame-ignited upholstered furniture fires from the NFIRS counts. The estimate, for instance, of deaths-per-fire for cigarette-ignited upholstered furniture fires is the number of NFIRS deaths where *Cause of Ignition* is not 'Intentional', *Heat Source* is 'Cigarette', and *Item First Ignited* is 'Upholstered Furniture' divided by the number of such fires. No allocation of unknowns is involved in these estimates of deaths-per-fire. Last, the estimates of deaths-per-fire for cigarette-ignited and small open flame-ignited upholstered furniture fires are multiplied by the national estimates of cigarette-ignited and small open flame-ignited upholstered furniture fires to arrive at estimates for upholstered furniture fire deaths. The same process is used for injuries.

<u>Conventions:</u>

Identical to the **Method 2** conventions.

Appendix B

Differences Between CPSC Staff Method and Both CRA Methods

Aside from the major differences between the CRA Indirect Method and the CPSC Staff Method and CRA Direct Method, there are several smaller ways in which the CPSC Staff Method differs from both CRA Methods. These differences appear to have a relatively small net effect on the estimates. The differences include the treatment of confined fires, the coding of child play, the inclusion of the variable *Cause of Ignition* in the imputation algorithm, collapsing cells before imputing, editing out cases that have some codes inconsistent with upholstered furniture, and what comprises in-scope smoking materials. On all of these issues, CPSC staff chose one way for their method and CRA chose another for both of their methods.

Of these differences, the one that appears to make the most discernible difference in the estimates is the difference in what comprises in-scope smoking materials. CPSC staff include the following Heat Source codes as 'Smoking Materials' for their estimates:

61 - 'Cigarette'
62 - 'Pipe or cigar'
63 - 'Heat from undetermined smoking material'

CRA uses only the code 61 - 'Cigarette' for their estimates. Table 2 presents a breakdown of CPSC's Smoking Material casualty estimates by the three *Heat Source* codes.

Table 2: CPSC Staff Estimates of 1999 – 2002 Annual Average Addressable Smoking Material Upholstered Furniture Fire Casualties by Heat Source Code

Casualties	Cigarette	Pipe or Cigar	Undetermined Smoking Material	Total
Deaths	250	10	40	300
Injuries	420	10	40	480

Source: U.S. Consumer Product Safety Commission from data obtained from the U.S. Fire Administration and the National Fire Protection Association.
Notes: Estimates include residential structure losses only and exclude losses involving arson. Firefighter casualties are also excluded. Estimated deaths and injuries rounded to the nearest 10.

While it might be reasonable to exclude 'Pipe or cigar', the data in Table 2 indicate that much of what makes up 'Heat from undetermined smoking material' is cigarettes. Excluding '62 - Pipe or cigar' and to a greater extent '63 – Heat from undetermined smoking material' has a downward effect on CRA's estimates.

Like CPSC staff, CRA has employed a general policy of allocating unknowns. If CRA counts 'cigarette' losses as in-scope and 'pipe or cigar' losses as out-of-scope, then it stands to reason that CRA would allocate the 'Heat from undetermined smoking material' losses between in-scope and out-of-scope. Instead all of these losses were incorrectly excluded as out-of-scope.

Comparing the CPSC staff estimates to the CRA Direct estimates, the CRA Direct estimates are actually higher for total fires and injuries. The CPSC staff estimate for total deaths is higher by 20 because the estimate for smoking material deaths is higher by 30 (300 vs. 270). Had CRA included the deaths from 'Heat from undetermined smoking material', their total death estimate would be higher than CPSC staff's estimate of 360.

Appendix C

Fires with Unknown Fire Cause Information Are More Deadly

Table 3: Comparison of Deadliness of Fires where Variable is Known[11] vs. When It Is Unknown for 1999 - 2002

Proportion of Fires that are Deadly	Heat Source	Item First Ignited
#**Known** Fires that are Deadly per 10,000 Fires	50	54
#**Unknown** Fires that are Deadly per 10,000 Fires	118	114
#**All** Fires that are Deadly per 10,000 Fires	67	67

The difference between the proportion of known fires that are deadly and the overall proportion of fires that are deadly (0.50% vs. 0.67% for *Heat Source* and 0.54% vs. 0.67% for *Item First Ignited*) might appear small but it is not. The CRA Indirect Method multiplies the estimated number of fires by the estimated proportion of deaths per fire to get to the death estimates. This means multiplying a large number of fires by a small ratio of deaths per fire. Comparing very small ratios to other very small ratios, the differences may seem small but may be proportionally large. By using the proportion of deadly fires from among the **known** fires only, CRA is multiplying by a proportion that is about 20% - 30% lower. Their resulting estimates for national fire deaths from the Indirect Method are lower than from their Direct Method by approximately this same percentage.

Another way of looking at it is the proportion unknown for the variables in question for fires, injuries, and deaths. Table 4 presents these proportions.

Table 4: Comparison of Proportion of Unknowns for Fires, Injuries, and Deaths for 1999 - 2002

Proportion of Incidents where Variable is Unknown	Heat Source	Item First Ignited
%Unknown - Fires	27%	23%
%Unknown - Injuries	23%	19%
% Unknown - Deaths	47%	39%

Deaths are much more likely to have unknown information for both variables than fires. So, by taking the death-per-fire estimates only from fires with known *Heat Source* and *Item First Ignited*, CRA leaves out the deadlier fires.

[11] 'Known' means that the NFIRS value for the fire is neither blank nor coded as 'Undetermined'.

United States
Consumer Product Safety Commission
Washington, DC 20207

Memorandum

Date: September 29, 2006

TO : Dale R. Ray, Project Manager for Upholstered Furniture

FROM : Charles L. Smith, Senior Economist, Directorate for Economic Analysis CLS
Gregory B. Rodgers, Ph.D., Associate Executive Director, Directorate for Economic Analysis GBR

SUBJECT: Responses to Comments on Economic Issues Contained in "An Evaluation of the CPSC Staff Preliminary Regulatory Analysis of the Draft Upholstered Furniture Flammability Standard," by Mark Berkman, Ph.D., CRA International

Introduction

In a March 2, 2006, report sponsored by the American Home Furnishings Alliance (AHFA), the National Home Furnishings Association (NHFA), and the Upholstered Furniture Action Council (UFAC), CRA International (CRA) evaluated the Consumer Product Safety Commission (CPSC) staff's preliminary regulatory analysis of the staff's draft upholstered furniture standard. The principal author of the report was CRA vice president, Mark Berkman, Ph.D. This memorandum presents the CPSC staff's response to comments on significant economic issues raised in the CRA report.

Comment 1:

"... the staff relies on the effectiveness rates that are not based on thorough or recent testing and that are inconsistent with rates recently reported in the United Kingdom where similar standards have been in place for almost two decades." (CRA, p. 11)

Response:

The preliminary regulatory analysis explicitly identified effectiveness as an issue involving uncertainty. In accordance with Office of Management and Budget (OMB) guidelines, effectiveness estimates were included as a factor in the sensitivity analysis. In that analysis, staff showed that even if effectiveness were only half that in the base analysis (which would have implied an overall effectiveness rate of about 36 percent), the expected benefits of the standard would still have exceeded the costs by about \$284 million, at a 3 percent discount (or about \$151 million, at a 7 percent discount rate).

The CRA analysis, in contrast, estimates that the staff's draft standard would only be about 22 percent effective in addressing cigarette-ignited upholstered furniture fires, based on their evaluation of the effectiveness of the United Kingdom's *Furniture and Furnishings Fire*

Regulations (UK standard) that went into effect in 1988, and a range of 48 to 50 percent effectiveness in addressing small open flame fires. Since cigarette-ignited fires account for about 78 percent of all upholstered furniture fires, the implied overall effectiveness rate in the CRA analysis is about 28 percent, somewhat lower than the lower bound estimate in the staff's sensitivity analysis. As described below, there is little basis for the CRA effectiveness estimates for addressing cigarette ignition. Nevertheless, if the CRA effectiveness assumption had been used as the lower bound in the staff's sensitivity analysis, the estimated net benefits would have been $186 million, at a 3 percent discount rate (or about $80 million at a 7 percent discount rate).

Regarding the CRA effectiveness estimates for cigarette and small open flame fires, it should be noted that the cigarette effectiveness estimates are based on a prior analysis of a University of Surrey report on the effectiveness of the United Kingdom's furniture standard (the "Surrey Report") conducted by National Economic Research Associates (NERA) in 2001.[1]

After criticizing the findings of the Surrey Report on the effectiveness of the UK standard, CRA makes the following claim (p. 59): "The NERA report estimated the true effectiveness of the U.K. standard – after declines in smoking, increased smoke detector prevalence, and other relevant factors were taken into account – to be approximately 18 percent to 22 percent."[2] This is the estimated rate of effectiveness for addressing cigarette-ignited furniture fires that CRA believes would be appropriate to apply to the CPSC staff's draft proposed standard.

One basic flaw in CRA's analysis involves the decision to base effectiveness of the CPSC draft standard on its analysis of the UK furniture standard. The effectiveness of the UK standard is not relevant to the CPSC staff's cost-benefit analysis. While the UK standard and the staff's draft standard are both flammability standards that apply to furniture, they are different standards and apply to different settings. Even if the NERA report used appropriate methodologies to estimate the effectiveness of the UK standard, a claim that is subject to debate, there is no reason to expect that effectiveness of the UK standard in the UK would be the same as a U.S. standard in the U.S.

Several other points also need to be made regarding CRA's estimated effectiveness of the CPSC staff's draft standard. These points relate to CRA's assessment of the effectiveness of the UK standard (which is then applied to the CPSC staff's draft standard) and its assessment of the effectiveness of specific provisions of the draft standard.

First, the CRA effectiveness estimates of the UK standard are based on a critical evaluation of the Surrey Report. The Surrey report was based largely on fire trends from 1988 through 1996. However, while some of the UK requirements went into effect beginning in 1988, they were phased in over about a 5-year period ending in 1993. Given the relatively lengthy

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[1] Mark Berkman, the lead researcher for the CRA report, was also the author of the NERA report. Both reports were prepared for furniture industry members: the NERA report was prepared for the UFAC; as noted above, the CRA report was prepared for UFAC, AHFA, and the NHFA.

[2] In a 2005 follow-up study by the University of Surrey researchers disputed some of the contentions in the NERA report. See, Emsley A, Lim L, and Stevens G, Williams P, "International Fire Statistics and Potential Benefits of Fire Counter-Measures," University of Surrey, Polymer Research Centre, May 2005.

product life of furniture, the Surrey report's effectiveness estimates were developed at a time when only a small proportion of the furniture in use in the UK met the requirements of the standard.

Second, the CRA effectiveness estimates (*i.e.*, 18 to 22 percent), based on the NERA report, are at variance with the NERA conclusion which said: "Through the use of several methods, we found that the likely effectiveness of the U.K. standard was in the range of 20 to 50 percent. To be conservative, we will use the high end of this range as our estimate for the effectiveness of the CPSC's proposed standard." (NERA, p. 73)

Third, the CRA effectiveness estimates also conflict with some statements in the CRA report itself. For example, while discussing cigarette ignition associated with the less ignition prone cellulosic and thermoplastic cover fabrics, CRA says: "Though we disagree with the CPSC staff's estimate [of effectiveness], we again lack sufficient information to calculate our own cigarette effectiveness rate for this group of furniture, and rely on the CPSC's estimate in our analysis." (CRA, p. 58) Despite this statement, CRA used the lower UK-based estimate in its analysis.

Fourth, the CRA effectiveness estimate for small open flame fires is also internally inconsistent. After evaluating several CPSC staff laboratory studies, CRA says:

> "Taken together, our adjustments to the CPSC staff's assumptions result in a more conservative estimate of the hazard reduction rate for heavyweight cellulosic fabrics of about 62 percent (60 percent of furniture x 57 percent effectiveness + 40 percent of furniture x 68 percent effectiveness) plus-or-minus *at least* 14 percent. We consider a more realistic small open flame effectiveness rate for heavy cellulosic furniture to be approximately 48 percent, the lower bound of our estimate." (CRA, p. 54)

Thus, CRA calculates an effectiveness estimate of 62 percent, with a 95 percent confidence interval of 48 to 76 percent, and then inexplicably announces that the lower bound of the estimate is the more realistic measure of effectiveness.

Fifth, CRA cites the results of barrier testing done by the CPSC's Directorate for Laboratory Sciences (LS) as demonstrating a much lower effectiveness level than used in the preliminary regulatory analysis. According to CRA, this provided a basis for using the lower UK effectiveness assumptions, rather than the staff estimates. CRA cited results based on limited exploratory testing by LS that barriers would have no effect at all in reducing cigarette ignition hazards of furniture covered with heavy cellulosic fabrics. (CRA, p. 57) However, this conclusion was based on a misinterpretation of the results. The barrier materials subjected to the limited testing **were not** materials that complied with the open flame and cigarette ignition barrier tests. In fact, at least three of the barrier materials were found to fail the open flame barrier test of the UK standard consistently, and would not, therefore, have qualified as barriers under the staff's draft standard. Consequently, the failure of these materials has no implication for the effectiveness of the draft barrier requirements. Moreover, unlike the UK standard, the staff's draft standard would subject barrier materials to the draft standard's smoldering test for upholstery fabrics. Therefore, the results cited by CRA are irrelevant for purposes of estimating effectiveness of barriers under the draft standard.

Sixth, in the evaluation of the effectiveness of FR treated fabrics, CRA reduced the estimated effectiveness of FR fabric treatments by including chairs that were covered by fabrics that did not comply with the draft CPSC test (CRA, p. 56). Since they were not complying items, those fabrics would not be used in complying upholstered furniture, and they should not have been included in the analysis of the effectiveness of the requirements. As in the case of CRA's estimated effectiveness of barriers under the staff's draft standard, inclusion of test data from these chairs results in an understatement of potential effectiveness.

Comment 2:

"...the cost-benefit analysis fails to fully account for the expected continued downward trend in fatal cigarette-ignited furniture fires resulting from further reductions in smoking prevalence, fire-safe cigarette regulation, and further market penetration of furniture meeting UFAC voluntary fire safety standards." (CRA, p. 11)

Response:

Contrary to CRA's assertion, CPSC staff accounted for the expected downward trend in fatal cigarette-ignited fires in Section 5.1 of the regulatory analysis. The staff analysis, which evaluated general trends, attempted to account for all factors associated with the reduction in cigarette-related furniture deaths over time, including changes in smoking-related behavior, the increased use of smoke alarms, changes in furniture cover and filling materials, and changes in furniture construction that have been encouraged by the UFAC program since the late-1970s. The staff's analysis was based on an auto-regressive model of trends in cigarette-related upholstered furniture deaths since 1980. Based on this analysis, the staff reduced the present value of the expected lifetime societal costs of cigarette-related deaths by approximately 13 percent. This contrasts with the slightly higher 20 percent reduction suggested by the CRA analysis. (CRA, p. 40)

The staff did not specifically adjust for the New York State regulation requiring self-extinguishing cigarettes.[3] The regulation became effective in June 2004, and only preliminary data are available. There is not an adequate empirical basis for adjustment at this time. (CRA apparently based its analysis on information reported in a September, 2005, ABC News clip.) (CRA, p. 43) However, the staff noted that some preliminary reports from New York indicated a reduction in cigarette fire losses since the regulation went into effect, and that similar laws were expected in Vermont and California. More recently, the staff has learned that New Hampshire, Illinois, and Massachusetts have adopted similar laws to become effective in late 2007 and early 2008. The staff plans to review the New York data when they become available. Also, the staff will consider testing data that may be available on relative ignition propensities of current

[3] To conform to these requirements, a cigarette brand must exhibit full-length burns in no more than 25 percent of 40 tested cigarettes.

cigarettes and cigarettes that comply with state laws. This information may enable the staff to evaluate the potential reduction in fire losses that might result from reduced ignition propensity cigarettes.

As noted above, the staff's analysis of cigarette-related upholstered furniture deaths attempted to account for all factors associated with the downward trend, including changes in furniture construction associated with the UFAC program. Consequently, no separate analysis of future market penetration of furniture conforming to the voluntary program was needed.

Comment 3:

"..the staff does not consider whether the distribution of smokers among furniture buyers could affect benefits. For example, highly smolder-prone, heavy cellulosic fabrics – which according to CPSC staff assumptions account for a large fraction of fatal fires – may be less likely to be purchased by smokers. These fabrics tend to be expensive and smoking prevalence falls with income. This would reduce benefits because the standards would affect consumers with already very low risk of fatal fires." (CRA, p. 11)

Response:

The CRA analysis speculates that furniture covered with the smolder-prone heavy cellulosic fabrics tends to be used by non-smokers. They criticize the CPSC analysis for not explicitly taking this relationship into account and suggest that it may have important implications for benefits calculations. However, CRA also acknowledges that the information that would be needed to quantify this relationship does not exist. According to CRA: "Lacking sufficient data on the prices of different types of furniture, we are unable to make this adjustment in our calculations." (CRA, p. 49)

Lacking data on the relationship between furniture use and smoking, the staff analysis implicitly assumes a uniform distribution of furniture among smokers and non-smokers. That is, smokers are just as likely to have furniture covered with the various fabrics as non-smokers. As noted above, the CRA analysis makes the same assumption in its calculations.

Nevertheless, even if CRA is correct in its assumption that smokers are less likely to have furniture covered with the ignition-prone cellulosics, adjusting for this relationship would only have a minor impact on the results of the benefits assessment. The estimated cigarette-ignition risk for furniture covered with severely ignition-prone fabrics would be lower under their assumption. However, CRA neglects to point out that that such an adjustment would necessarily imply that the estimated risk of smoldering ignited fires in other furniture categories was higher than estimated. This is because risk is computed on the basis of a fixed number of smoldering-related injuries and deaths: the average for the 1999-2002 time period. Thus, mathematically, if risk is overestimated in one category it must be underestimated in another category. Consequently, as long as these other categories are adequately addressed by the standard, the aggregate impact on benefits would be small since the benefits would be redistributed from the "severely ignition-prone" fabrics category to other fabric categories involved in cigarette ignitions.

The effect of the CRA-recommended adjustment can be illustrated by the following example: Suppose (1) that cigarette-ignited fires occur only in homes with smokers, (2) that smokers are half as likely to own furniture covered with severely ignition-prone fabrics as other fabrics,[4] and (3) that these excess smokers (the half that are assumed not to have the severely ignition-prone fabrics) instead have thermoplastic covered furniture items. Under these assumptions, and using the same methodology that was fully described in Section 5.2 of the regulatory analysis, the estimated gross benefits would decline from $779 million (as shown in table 2) to $756 million, a decrease of $23 million, or 3 percent.

Comment 4:

"...the staff relies on a very low discount rate and a relatively high statistical value of life to value future benefits." (CRA, p. 12)

Response:

Discount Rate

The staff's regulatory analysis used a discount rate of 3 percent to discount future benefits in the base case analysis, and conducted a sensitivity analysis with a higher 7 percent discount rate. These discount rates are consistent with OMB Circular A-4, p. 34, which says that, for regulatory analysis, analysts should provide estimates of net benefits using both 3 and 7 percent.

Moreover, any action on upholstered furniture will primarily affect private consumption by households. For such regulatory scenarios, circular A-4 provides the following guidance at p. 33:

> "When regulation primarily and directly affects private consumption (*e.g.,* through higher consumer prices for goods and services), a lower discount rate is appropriate. The alternative most often used is sometimes called the "social rate of time preference." This simply means the rate at which "society" discounts future consumption flows to the present value. If we take the rate the average saver uses to discount future consumption as our measure of the social rate of time preference, then the real rate of return on long-term government

[4] That is, if x smokers would have been assumed to own severely ignition-prone fabrics under the uniform distribution, only x/2 (or half) would be assumed to own them under the conditions of the example. Under the example, if 23 percent of all homes have smokers, only 11.5 percent (or half) of homes with severely ignition-prone fabrics would be assumed to have smokers.

debt may provide a fair approximation. Over the last thirty years, this rate has averaged around 3 percent in real terms on a pre-tax basis."

Therefore, the choice of a 3 percent discount rate for the base analysis is both appropriate and supported by OMB guidelines.

A discount rate of 3 percent for evaluating regulations that affect health and safety is also consistent with guidance in the current economic literature. As noted in *Prevention Effectiveness*,[5] and following the lead of the U.S. Panel on Cost-Effectiveness in Health and Medicine,[6] most texts on the use of economic evaluation in health and safety currently recommend 3 percent as the most appropriate discount rate.

In addition to using the 3 percent discount rate, the current version of the *Preliminary Regulatory Analysis* also presents estimates based on a 7 percent discount rate in the base-case analysis.

Value of Statistical Life

CPSC staff used a $5 million value of statistical life in the base analysis, and conducted a sensitivity analysis using the values of $3 million and $7 million. The $5 million point estimate is fully consistent with estimates of the value of statistical life in the current economic literature and commonly used for federal regulatory purposes. A recent article summarizing the literature, in fact, suggests that the staff's point estimate may be too low: it found that most studies place the value of statistical life in the $4 million to $9 million range (in 2000 dollars), with a midpoint of about $6.5 million.[7] This point was also made in one of the peer reviews for the regulatory analysis, which suggested that the staff should use a higher value of statistical life since "most federal agencies undertaking analysis of the benefits of preventing premature death use values ranging from $7.0 to $7.5 million per life."

Comment 5:

"The CPSC staff understates costs according to industry data provided to us and discussions with manufacturers. There are several causes for this understatement. First, the staff assumes that foam cost increases will be modest, but industry testing indicates that more costly reformulation is required to reliably pass the draft standard. Second, the staff cost estimates do not fully account for the additional labor or efficiency losses associated with adding barriers. Third, the staff appears to underestimate the costs associated with FR treatment of cover fabrics.

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[5] Haddix, AC, Teutsch, SM, and Corso, PS. *Prevention Effectiveness: A Guide to Decision Analysis and Economic Evaluation*, second edition. New York: Oxford University Press, 2003.
[6] Gold, MR, Siegel, JE, Russell, LB, Weinstein, MC, eds. *Cost-Effectiveness Analysis in Health and Medicine.* New York: Oxford University Press, 1996.
[7] Viscusi, WK, Aldy, JE. The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World. *Journal of Risk and Uncertainty*, 27(1), pp. 5-76, 2003.

(CRA, p.12) Finally, the staff may have underestimated the costs associated with the use of FR fibrous filling materials." (CRA, p. 70)

Response:

The staff's cost estimates were based largely on information provided by industry for existing or experimental materials in recent years. While these cost estimates cannot always be precise, especially when they concern requirements that would become effective in the future, the staff has made every effort to provide reasonable and objective projections, given the information available. When estimates have varied the staff has indicated uncertainty and provided cost ranges. Additionally, as described below, the staff conducted a sensitivity analysis to determine the sensitivity of the results to changes in the cost estimates.

The above comment suggests several causes of understatement of costs in the staff's analysis. Each is discussed in turn. The CRA analysis is characterized by an absence of transparency and insufficient details in many instances, which hampers our ability to understand and to respond to some of their cost estimates. In several instances, however, CRA's cost estimates seem to be contradicted by the available information.

Urethane Foam Costs

CRA reportedly estimated cost increases for complying urethane foam based on bulk price data it received from the Polyurethane Foam Association (PFA). Following the CPSC staff's assumption that foam that would pass the 2002 draft revision of California's furniture flammability standard Technical Bulletin 117 (commonly referred to as "TB117+") would also pass the CPSC staff's draft standard, CRA estimates that per-unit costs of FR foam would be $7.99 per unit (compared to the midpoint of the range of estimated costs in the preliminary CPSC staff estimate of $2.81 per unit). (CRA, p. 69) However, as discussed below, the bulk pricing information provided to the CPSC staff by PFA and information on foam costs at the furniture manufacturer level provided by a major foam supplier are not consistent with the higher CRA estimate.

Based on information provided by a major supplier of foam to the furniture industry, the CPSC staff estimated that about 65 percent of the foam used in seat cushions of upholstered furniture was 1.8 pounds per cubic foot (pcf) and above, 30 percent was about 1.4 pcf, and about 5 percent was lower density (assumed to be 1.0 pcf for cost estimation purposes). This distribution of foam was consistent with an INTOUCH publication provided by the PFA. This publication included a chart (entitled "Typical Density Ranges for Different Foam Applications") showing that the typical density of foam used in furniture seat cushions ranged from about 1.4 pcf to 3.4 pcf.[8]

Urethane foam use in furniture locations other than seat cushions (*e.g.*, in arms, sides, and backs) was estimated by subtracting estimated foam use in seat cushions from industry estimates of total annual consumption of urethane foam by furniture manufacturing. Based on overall estimated distribution of foam production by density, CPSC staff estimated that 62 percent of the

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[8] PFA, *INTOUCH*, Volume I, Number 2, May 1991.

foam used in these other applications is about 1.0 pcf foam; almost 21 percent is approximately 1.4 pcf foam; and 17 percent is about 1.8 pcf and denser foam.[9]

CPSC staff's cost estimates were based, in part, on the results of research done by major foam suppliers, which indicates that foam that is 1.4 pcf and greater which meets the current version of TB117 would also pass the revised draft California furniture standard (commonly referred to as TB117+). We assumed that such foams would pass the draft CPSC standard, based on foams tested by the CPSC's Directorate for Laboratory Sciences. CPSC's Directorate for Engineering Sciences and Directorate for Laboratory Sciences judged that the CPSC draft open flame test for foam may be somewhat more stringent than TB117+. To reflect this, we assumed that furniture manufacturers would incur cost increases associated with switching from lower density foams to foams with at least 1.4 pcf. Bulk price information provided by PFA in 2005 was then used to estimate costs of the draft standard related to urethane foam. Based on the comments of a leading foam manufacturer, estimated bulk price increases were increased by 50 percent to reflect the foam cost increases faced by furniture manufacturers.

The pricing information provided to the CPSC staff in August 2005 by PFA contradicts the estimated increases presented by CRA on page 69 of its analysis. For example, CRA states that, according to PFA data, the bulk price for 1.8 pcf foam would increase by $0.083 per board foot to comply with TB117+. Bulk price data provided to the CPSC by PFA showed the price for 2.0 pcf TB117+ foam was $0.013 greater than 1.8 pcf foam without FR. The estimated cost increase to furniture manufacturers would therefore be about $.02 per board foot (with a 50 percent increase over bulk foam prices), rather than $0.083 per board foot. As noted above, major foam suppliers advised CPSC staff that they believe that 1.8 pcf foam that complies with the current TB117 would also comply with TB117+, without the additional cost of increasing foam density to 2.0 pcf. This would further reduce the increase in foam price to about $0.01 per board foot at the furniture manufacturer level for 1.8 pcf foam.

The judgment of major suppliers of foam regarding the impact of TB117+, in combination with results of CPSC staff laboratory tests showing that treated foams with densities in the range of 1.4-1.5 pcf would be compliant with the CPSC staff's draft standard, lead us to conclude that significant increases in foam densities above those commonly used in seat cushions would not be required under the draft standard.

Assertions that the open flame test drafted by CPSC staff is substantially more burdensome than the draft TB117+ appear to be based on tests in which the test fabrics used in mockup tests varied in ignition characteristics. The staff is working to address this fabric variability issue so that foams would not require significantly greater levels of FR treatment than under TB117+ in order to comply with the CPSC staff's draft standard.

Costs for Using Barrier Materials

CRA reports that "data provided by a mid-range furniture manufacturer on several styles of upholstered chairs and sofas indicate that the raw materials cost increase incurred by the use of FR barriers may be closer to $26.82 per unit [versus an estimated range of $9.65 to $12.05 by

[9] Based on overall distribution of foam production by densities reported for major foam supplier, Hickory Springs.

CPSC staff]." (CRA, p. 68) Information provided by this manufacturer "further suggest that increased labor costs of adding barriers are closer to $17.86 per unit, compared to $6.25 to $10.00 per unit as estimated by the CPSC staff." Based on this information, CRA estimates per unit barrier costs to be $44.68, compared to the CPSC staff's estimated range of $15.90 to $22.05. (CRA, p. 69)

CRA's analysis is not transparent regarding the type of barrier material, cost per unit of weight or area, quantity needed per unit of furniture, and labor time or hourly labor costs, making it difficult to evaluate its higher cost estimate. The report does note that their estimate "… takes into account the reduction in costs due to the replacement of non-FR batting materials by the FR barrier." (CRA, p. 68) This indicates that CRA's estimate is based on costs for a fibrous filling barrier material that would be substituted for non-FR batting. If so, it is unclear how labor cost increases of $17.86 per unit of furniture could be assigned for an operation that involves installation of an FR batting rather than a non-FR batting. Any incremental labor costs should be minimal if such barrier materials were to be used.

Fire-blocking barriers have not been used extensively on residential furniture produced in the U.S. Consequently, unlike CRA, which questioned U.S. firms, the staff's estimates are based on costs of barrier materials in the extensive experience of the UK industry in complying with the barrier tests of the UK standard. Under the UK standard, complying barrier materials have been FR fabrics; however, the 2005 standard drafted by the CPSC staff would allow the use of barriers made with other types of materials, such as battings, if they can pass the barrier tests.

It is likely that the upholstered furniture made with barriers under the staff's current draft standard would be the more expensive furniture items made with interior fabrics covering or encasing the filling materials. The staff (in *Preliminary Regulatory Analysis*) assumes that barrier materials would largely be replacing the interior fabrics now used in those items. The staff's analysis also included estimated costs of barrier materials that would have to be used in areas of chairs that might not currently use interior fabrics. In estimating additional labor costs, staff assumed that hourly wage rates would be up to 50 percent higher than average reported wage rates for upholsterers. The estimates of additional labor time and labor costs were in line with those estimated by a manufacturer of high-end furniture. Thus, the *Preliminary Regulatory Analysis* has already considered the cost elements identified by CRA; no increase in projected costs is warranted.

Fabric Treatment Costs

The CRA analysis estimated fabric treatment costs under the 2005 CPSC staff's draft standard based on estimates that were obtained from U.S. firms for the treatment of cellulosic fabrics to comply with the 2001 CPSC staff's draft open flame standard. These costs ranged from $1.80 to $3.15 per linear yard. Using other CPSC staff assumptions, CRA estimated FR fabric treatment costs per unit of furniture ranging from $18.60 to $32.62 per unit, compared to a range of $6.61 to $11.28 per unit estimated by the CPSC staff. (CRA, p. 68)

As with costs of barriers under the draft standard, CPSC staff estimates of upholstery fabric FR treatment costs were based on the extensive experience of the major fabric treatment firm in the UK, and confirmed in conversations with a U.S. backcoating firm. These costs are based on the treatments necessary to pass the open flame fabric test of the UK furniture standard. While there is no experience in treating fabrics to pass the draft cigarette ignition test of the staff's draft standard, costs could be lower than under the UK standard since somewhat less FR loading might be required for passing results.

Additionally, as noted in the *Preliminary Regulatory Analysis*, aggregate costs for fabric treatments under the staff's draft standard could be overestimated because less costly alternatives would be available to the industry. The estimated costs are based on the assumption that fabrics that do not comply with the fabric smoldering test would still be used by the furniture industry through the use of either FR treatments or barriers. Some furniture manufacturers could choose to reduce their costs by dropping fabrics that require FR treatments or barriers from their product lines. Also, some producers of fabrics could reformulate fabrics that do not comply (such as by adding thermoplastic fibers or changing other fabric characteristics) to allow them to pass the fabric smoldering test by means other than using FR treatments.

Fibrous Filling Costs

CRA used CPSC staff's estimated cost increases per pound of loose fiber. However, anecdotal information obtained by CRA from one high-end furniture manufacturer led them to assume that greater pounds per unit of material would be affected by the CPSC staff's draft standard. Therefore, CRA estimated average per-unit costs for treated fibrous filling materials to be $3.72, compared to $2.44 per unit estimated by the staff. In cases where fibrous filling materials would be encased by FR interliners, an option provided in the draft standard, CRA cites anecdotal information on costs discussed above for the use of fire barriers as suggesting that the optional method of compliance "would be substantially more costly than the use of treated polyester fiberfill." (CRA, p. 70)

A wide range of costs was obtained for loose filling products that potentially could be used under the draft standard. The staff's analysis assumed that about three pounds of loose fill are used in typical back cushions. Fibrous batting materials were addressed separately by the staff, given information indicating that complying batting could be developed at minimal or no additional cost. Assumptions regarding the use of loose fiberfill and fiberfill batting materials are not clear in the CRA analysis. Regarding the option of using complying FR interliners, many firms (especially those specializing in high-end furniture) currently encase loose fill in backs with interliners, and use interliner materials in other areas of furniture items. Therefore, any additional labor costs of encasing fibrous filling materials could be negligible.

Summary of Issues Related to Cost Estimates

In summary, the staff concludes that its analysis incorporates reasonable cost estimates based on the information made available from industry sources. The staff will continue to seek cost information to refine these estimates. The staff also recognizes that some cost estimates are for processes that have not yet been implemented; therefore, they are necessarily approximate. Consequently, the staff conducted a sensitivity analysis to gauge the effect of alternative cost estimates. As described in the *Preliminary Regulatory Analysis*, even if the costs were twice as high as the staff estimated, the benefits of the 2005 draft standard would still be greater than the costs.

Comment 6:

"The CPSC staff does conduct a sensitivity analysis as required by Office of Management and Budget (OMB), but it is incomplete. The staff reports results varying one important factor at a time, including the discount rate, compliance cost, effectiveness, and the statistical value of life. There is no reason to consider these factors separately unless they are mutually exclusive. They are not. Consequently, the sensitivity analysis should have reviewed all of the combinations of these factors. In addition, the sensitivity analysis should have addressed the potential for further declines in furniture fire fatalities in the absence of a standard." (CRA, p. 12)

Response:

The most common approach to conducting sensitivity analysis is to estimate the change in net benefits while varying a single parameter, leaving the other parameters at their base value. Using this approach, Section 7.2 of the *Preliminary Regulatory Analysis* showed that substantial variations in the key parameters did not alter the results: in all cases, net benefits were positive. Varying more than one parameter at one time can sometimes provide additional insights. In the case of the upholstered furniture *Preliminary Regulatory Analysis*, varying two parameters simultaneously confirmed the robustness of the analysis. Using a 3 percent discount rate, for example, net benefits were positive for all possible scenarios in which two parameters were varied. Using a 7 percent discount rate, net benefits were marginally negative under only one extreme scenario: when it was assumed that the costs were twice the staff's best estimate while at the same time assuming that the effectiveness at preventing deaths and injuries was only half the staff's best estimate.

However, it should be noted that the usual basis for varying *more* than one parameter at a time in a deterministic cost-benefit framework is that the key parameters are highly correlated (not that they are *not* mutually exclusive, as asserted by CRA). Since the factors evaluated in the upholstered furniture sensitivity analysis were generally independent (*i.e.*, the values of one factor are not systematically related to the values of another factor), the method employed by the staff was appropriate.

As just noted, a reason for varying more than one factor at a time would be that the factors are highly correlated. For example, if the height and weight of individuals were factors in an analysis, it would probably be reasonable to vary both at the same time in a sensitivity analysis, since these two variables are usually highly correlated and tend to move together. On the other hand, if two factors are generally independent (for example, there is no reason to expect that estimates of the value of statistical life used in the preliminary regulatory analysis would in any way be related to costs of complying with the upholstered furniture requirements) it is unlikely that the extreme values of one would be associated with the extreme values of the other in any systematic way. Consequently, if the factors are generally independent, the results of a sensitivity analysis that assumes extreme values for more than one variable at a time are not very meaningful.

As an example, suppose there are three independent factors evaluated in a sensitivity analysis, and for each factor there is a best estimate, a low estimate, and a high estimate. Further assume that the probability of each of the low estimates occurring is 10% or less and that the probability of each of the high estimates occurring is 10% or less. Consequently, if the sensitivity analysis evaluated two of the factors at the low (or high) levels at the same time, the actual probability of that situation occurring in the real world would be 1% or less (i.e., 0.10 X 0.10). Furthermore, if all three variables were assumed to be at the low (or high) levels at the same time, the probability of this second situation occurring would be 0.1% or less (i.e., 0.10 X 0.10 X 0.10). These unlikely eventualities could be considered in a sensitivity analysis, but, given their low probability of occurring simultaneously, they fail to reflect real world eventualities.

The CRA comment that all factors should be considered in a sensitivity analysis unless they are mutually exclusive leads to the following CRA assertion: "Sensitivity analysis showed that in 29 out of 36 scenarios we considered, costs exceeded benefits." (CRA, p. 72) Statements like this have little meaning unless they are supplemented with some indication of the likelihood of the scenarios occurring. CRA's presentation is highly misleading because it implicitly assigns all scenarios equal weight.

In addition, the sensitivity analysis conducted by CRA was incomplete in that it tends to be a *one-sided* analysis. Consider, for example, the CRA cost estimates, which were 2 to 2.5 times those in the CPSC staff analysis. These estimates were apparently based on industry estimates (some of which were included in the earlier NERA report) that were uncritically accepted by CRA and applied in their analysis. Whereas CPSC staff considered the possibility that its cost estimates were underestimated (and doubled them for its own sensitivity analysis), CRA does not consider the possibility that their cost estimates were overestimated. In fact, their cost estimates that are twice the CPSC staff estimates are described in the CRA sensitivity analysis as the "Lower CRA Cost Estimates" and the estimates that are 2.5 times the level of the CPSC staff estimates are termed the "Higher CRA Cost Estimates." Hence, the sensitivity analysis gives the appearance of objectivity (*i.e.*, the descriptive terms "lower" and "higher" suggest balance) when CRA has not critically evaluated one of the most important components of their analysis.

The inputs used for discount rate alternatives in the CRA sensitivity analysis (3, 7, and 10 percent), and the alternatives used for the value of statistical life (VSL) estimates in the CRA sensitivity analysis ($2.9 and $5 million), are also problematic. First, in the context of health and safety regulation (such as the draft standard under discussion) there is no basis for using the 10 percent discount rate in a sensitivity analysis. As already noted, OMB suggests using 3 and 7 percent.[10] Second, the CRA range of estimates for the VSL is lower than what the peer-reviewed economic literature reports. As noted earlier, the most recent meta-analysis conducted by W.K.

[10] The 2001 NERA report did not suggest the use of a 10 percent discount rate; rather, it recommended a sensitivity analysis with 5 and 7 percent.

Viscusi suggests a VSL range of $4 to $9 million, in 2000. In fact, the range of VSL estimates used in the CPSC staff analysis can be criticized as too low (as was noted in the peer review analysis of the *Preliminary Regulatory Analysis*).

Re-evaluating the conclusions of the CRA sensitivity analysis in light of more balanced assumptions shows how easily the CRA conclusions can be altered. If the CRA sensitivity analysis shown in Table 10 (CRA, p. 74) is performed using three cost estimates (*i.e.,* the CPSC staff cost estimates as the low figures, in addition to the two higher CRA estimates of costs), two discount rates (3 and 7 percent), and three VSL estimates ($2.9, $5, and $7 million), but holding all other CRA assumptions constant, the results are very different. In this case, benefits exceed costs in 59 percent of the possible scenarios (32 out of the possible 54).[11] This contrasts with the CRA sensitivity analysis, which concluded that costs exceeded benefits in 81 percent of the possible scenarios (*i.e.*, 29 out of the possible 36).

In summary, the CPSC staff's sensitivity analysis was appropriate and consistent with common practice. Varying more than one factor at a time at extreme values can be problematic and misleading without a good justification. There is little basis for evaluating all possible scenarios that are not mutually exclusive, as recommended by CRA. In fact, doing so can confound the decision process by focusing attention on unlikely scenarios.

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[11] Of course, if we allowed the range of VSL to rise to higher levels, as recommended in the peer review, and used CPSC staff estimates of fire losses, the proportion of scenarios in which benefits would have exceed costs would been substantially higher.