



UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: October 25, 2004

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

THROUGH: Andrew G. Stadnik, P.E., AED, Laboratory Sciences *Andrew G. Stadnik*
Edward W. Krawiec, P.E., Division Director, Electrical and Flammability
Engineering *Edward W. Krawiec*

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

SUBJECT : Exploratory Tests of Barrier Materials*

INTRODUCTION

This memorandum contains a summary of testing done by the U.S. Consumer Product Safety Commission's (CPSC) laboratory staff to support the development of an alternate barrier test procedure to the small open flame seating area test in the staff's 1997 draft upholstered furniture standard.¹ The alternate test procedure in the staff's 2001 draft standard² uses a small wooden crib as the ignition source and is based on a similar test in a British Standard.³ Barrier fabrics and materials were evaluated with small open flame and cigarette ignition sources. Twelve barrier fabrics/materials were evaluated during the test program. This testing was conducted in the fall of 2001.

BACKGROUND

The 1997 draft *Standard for Upholstered Furniture*¹ evaluates the ability of upholstery fabric and materials to resist ignition when subjected to a small open flame source. The performance requirement calls for the cessation of combustion and limited flame progression on the test specimen following a 20-second flame exposure.

In the 2001 revision to the draft *Standard for Upholstered Furniture*,² CPSC staff included an alternate test method that allows for limited fire growth when a fire-resistant barrier fabric or material is used in furniture assemblies. The test method, called the Alternate Barrier Test, would be conducted in lieu of the small open flame test. The proposed Alternate Barrier Test is based on a similar test found in the British Standard BS 5852, *Methods of Test For Assessment of Upholstered Seating by Smouldering and Flaming Ignition Sources*.³ A wooden crib is used as

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

¹ Draft Standard For Upholstered Furniture, R. Khanna, Engineering Sciences, October 1997, CPSC.

² Draft Standard For Upholstered Furniture, R. Khanna, Engineering Sciences, revised February 19, 2001.

³ BS 5852:1990, Methods of Test for Assessment of the Ignitability of Upholstered Seating by Smouldering and Flaming Ignition Sources, British Standards Institution, London.



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the ignition source and although the test specimen is allowed to ignite, any flaming present must cease within 10 minutes. At one hour into the test, smoke and glowing embers must not be present.

The purpose of a fire-resistant barrier is to prevent filling materials from becoming involved in an ignition. The barrier, also known as an interliner, is placed between the upholstery fabric and filling materials and is either a separate layer or laminated directly onto the back of the upholstery fabric. In most cases, a barrier does not prevent the upholstery fabric from becoming involved in the ignition.

Although CPSC staff has conducted flammability tests⁴ on full-scale furniture and mockups with fire-resistant barriers, this was very limited testing and the barriers were only subjected to the small open flame test and criteria in the published 1997 draft *Standard for Upholstered Furniture*.¹ This memorandum outlines CPSC staff expansion of this limited testing to support the inclusion of an Alternate Barrier Test in the draft furniture standard.

EXPLORATORY TESTS

A limited number of exploratory tests were first conducted to gain a better understanding of the fire behavior of the wooden crib ignition source. These exploratory tests were conducted with combinations of two barrier fabrics and six upholstery fabrics.

The two barriers used in the exploratory tests were a woven cotton fabric treated with flame-retardant chemicals to resist ignition and an aramid nonwoven fabric that is inherently resistant to ignition. These two barrier fabrics were combined with untreated polyurethane foam and one of up to six cover fabrics, including three flame-resistant (FR) fabrics and three non-FR fabrics. Two ignition sources were used, the small open flame and a wooden crib.⁵

The small butane flame ignition source as specified in the 1997 and 2001 versions^{1,2} of the draft standard was used to establish a baseline for the cover and barrier fabric combinations. Some of the small flame tests were stopped at two minutes (the flaming condition criteria found in the 1997 draft furniture standard), while other exploratory small flame tests continued beyond two minutes until either the mockup self-extinguished or the mockup became fully involved in the combustion process. This extended observation time allowed CPSC laboratory staff to gain insight into the severity of flaming, smoke production and total combustion time produced by a fully involved burning mockup.

The exploratory tests using the crib as the ignition source established the wood crib as a more severe ignition source when compared to the small butane flame. In addition, CPSC laboratory staff thought the wood crib showed promise as a simulation for the additional flaming and smoldering present when the cover fabric was involved in the ignition.

⁴Test results documented in the 1997 Upholstered Furniture Briefing Package and Technical Report: Summary of Flammability Tests Upholstered Furniture Project (1998-2000), L. Fansler, October 2000, CPSC.

⁵These wooden cribs were constructed of bass wood and hobby glue by CPSC laboratory staff following the dimensional specifications in BS 5852.

As a result of the exploratory tests with a variety of cover fabrics, the staff decided to evaluate barriers with the wooden crib ignition source using a standard FR polyester cover fabric as specified in the British Regulations.⁶ The FR polyester fabric was chosen to investigate the role provided by a standardized cover fabric in the ignition process.

TEST PROGRAM

Building on the exploratory testing, CPSC laboratory staff developed a plan to evaluate barrier fabrics and materials to support the inclusion of an Alternate Barrier Test in the draft *Standard for Upholstered Furniture*. The plan identified three ignition sources to use in developing the alternate test: the number 5 wooden crib specified in BS 5852, the small butane flame specified in the CPSC staff 2001 draft *Upholstered Furniture Standard*, and the Pall Mall® cigarette specified in the Mattress Standard.⁷ The CPSC Standard Untreated foam, as specified in the 1997 draft standard was used to evaluate the barrier fabrics and materials. Figures 1, 2, and 3 below show test mockups with the three ignition sources. In Figure 2, the mockup shown is a larger frame required to accommodate the dimensionally larger ignition source.



Figure 1. Mockup with Small Open Flame Ignition Source

⁶The Furniture and Furnishings (Fire) (Safety) Regulations 1988, Department of Trade and Industry, United Kingdom.

⁷CFR Part 1632 Standard For The Flammability of Mattresses and Mattress Pads.

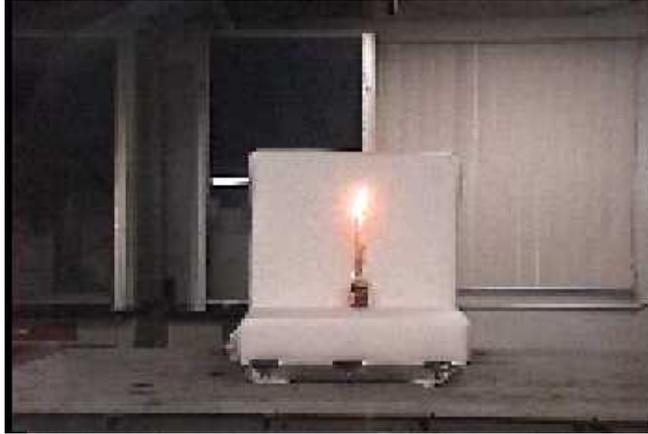


Figure 2. Mockup with Wooden Crib Ignition Source



Figure 3. Mockup with Smoldering Cigarette Ignition Source

In addition to the standard FR polyester cover fabric, seven upholstery fabrics were included in the small open flame and cigarette ignition source portions of the test program. The cover fabrics used are listed below. They include the six fabrics used in the exploratory portion of the testing, and two additional fabrics. The CPSC fabric number designation used in the FY04-FY05 regulatory development testing has been retrospectively added in parentheses.

1. 100% inherently FR polyester, plain weave, 6.5 oz/yd² (British Regulation standard FR cover fabric) (Fabric 16),
2. 56% rayon, 34% polyester, 10% cotton, jacquard weave, 10 oz/yd² (Fabric 5),
3. 100% cotton, twill weave, 11.5 oz/yd² (Fabric 6),
4. 60% acetate, 40% cotton, plain weave taffeta, 3.5 oz/yd² (Fabric 1),
5. 100% cotton, plain weave, 6.5 oz/yd² (Fabric 2),
6. 100% silk, plain weave, 3.7 oz/yd² (Fabric 15),
7. 100% cotton pile weave corduroy, 9.0 oz/yd² (Fabric 4), and
8. 57% acrylic, 31% polyester, 12% olefin, plain weave, chenille yarns, 8.0 oz/yd² (Fabric 3).

A variety of fire-resistant barrier fabrics and materials were also included in the testing. Three of the barrier fabrics, all 100% cotton, were purchased from sources in the United Kingdom (UK), where barrier fabrics are commonly used in residential furniture. The other nine barriers were obtained through sources in the United States. The barrier fabrics and materials used in this study were:

- A. 100% cotton, woven, 6.5 oz/yd²
- B. 100% cotton, woven, 6.0 oz/yd²
- C. 100% cotton, woven, 7.0 oz/yd²
- D. 100% aramid, 1.5 oz/yd²
- E. 100% aramid, 3.0 oz/yd²
- F. melamine/aramid blend, 1.5 oz/yd²
- G. melamine/aramid blend, 3.0 oz/yd²
- H. 100% novoloid, 2.4 oz/yd²
- I. 100% novoloid, 3.7 oz/yd²
- J. 100% novoloid, 5.6 oz/yd²
- K. melamine/modacrylic/polyester blend, 4.0 oz/yd²
- L. melamine/modacrylic/polyester blend, 14.0 oz/yd²

The selection of cover fabrics and barriers was randomized during these tests. In addition, the run sequences among the various cover fabric/barrier combinations were also randomized.

The cotton barrier fabrics from the UK were reported to contain a chemical treatment to make them resistant to fire. A limited number of soaking experiments using Barriers A, B and C were also done to determine the extent to which the chemical treatments were bound to the fabrics when the fabrics were exposed to either a 30-minute or a 24-hour water soak. The soaking procedure is outlined in the CPSC staff's 2001 draft *Standard for Upholstered Furniture*.³ For these tests the soaked specimens of Barriers A, B and C were only tested without the standard FR cover fabric.

SUMMARY AND DISCUSSION OF RESULTS

A. Wooden Crib Tests

Barrier A

Barrier A is a 100% cotton plain weave fabric weighing 6.5 oz/yd². This barrier fabric was obtained through a source in the UK and was reported to be chemically treated to resist flaming ignition. At the time of purchase, CPSC staff was informed that this cotton barrier fabric met the criteria of the schedule 3, crib number 5 test as specified in the British Regulations.⁶ A schedule 3, crib number 5 barrier fabric should provide protection to the filling material beneath. As Table 1 shows, this did not happen in nine trials. All of the mockups covered with Barrier A, including one soaked specimen of Barrier A, ignited. Approximately two minutes into the test, the barrier split, exposing the foam to the flames. The mockups were manually extinguished using pressurized carbon dioxide. The mockups constructed with the standard FR polyester cover fabric performed the same as those mockups without the cover fabric. Only one soaked specimen of Barrier A was tested, as the results of the nonsoaked specimens did not warrant further testing of soaked specimens.

A chemical analysis⁸ was done to determine why Barrier A did not perform as expected (i.e. did not provide protection to the filling material). Based on the CPSC laboratory staff's analysis, it appears that Barrier A was not treated with flame retardant chemicals.

TABLE 1
Wooden Crib Test Results – Barrier A

Condition	Results	Results after Soaking (24 hours)
without the standard FR polyester cover fabric	ignited , foam involved, manually extinguished (5 replicates)	ignited , foam involved, manually extinguished (1 replicate)
with the standard FR polyester cover fabric	ignited , foam involved, manually extinguished (3 replicates)	not tested

Barriers B and C

Barriers B and C were both obtained from a second UK source. At the time of purchase, CPSC staff requested barrier fabrics meeting the criteria of the schedule 3, crib number 5 test as specified in the British regulations. The results (Table 2) show that Barrier B (6.0 oz/yd²) performed similarly to Barrier A. All the mockups constructed with Barrier B ignited. The foam became involved and had to be manually extinguished.

The results of wooden crib tests with Barrier C were basically the same as Barrier B with two exceptions. One mockup each with and without the standard FR polyester cover fabric ignited and self-extinguished. In addition, limited tests with both Barrier B and Barrier C soaked for either 30 minutes or 24 hours resulted in sustained ignitions.

The limited tests with the soaked specimens of Barriers B and C indicated that any FR chemicals present on these barriers were removed during the soaking process. Chemical analysis⁸ determined that these two barrier fabrics may have been chemically treated but the treatment was essentially water extractable and may not have been applied correctly to bind to the fabric.

⁸Memorandum to L. Fansler, LSE from D. Cobb, LSC, "Chemical Analysis of Barrier Fabrics," October 2001.

TABLE 2
Wooden Crib Test Results – Barriers B and C

Condition	Results		Results after Soaking*	
	Barrier B	Barrier C	Barrier B	Barrier C
without the standard FR polyester cover fabric	ignited , foam involved, manually extinguished (5 replicates)	4 reps ignited foam involved, manually extinguished 1 rep ignited , foam melted, self-exting.	ignited , foam involved, manually extinguished (both ½ & 24 hour soaks)	ignited , foam involved, manually extinguished (both ½ & 24 hour soaks)
with the standard FR polyester cover fabric	ignited , foam involved, manually extinguished (3 replicates)	2 reps ignited , foam involved, manually extinguished 1 rep ignited , foam melted, self-exting.	not tested	not tested

* Soaking = 1 rep each for 30 minutes and 1 rep each for 24 hours.

Barriers D and E

Barriers D and E are 100% aramid, nonwoven fabrics weighing approximately 1.5 and 3.0 oz/yd² respectively. Barrier D, the lighter weight aramid barrier, did not perform consistently so a decision was made to use just the 3.0-oz aramid, Barrier E, in the alternate barrier test program.

Of the six mockups covered with Barrier E, five ignited and self-extinguished within 16 minutes of testing. The sixth mockup ignited and the foam became involved so the mockup was manually extinguished with pressurized carbon dioxide. Table 3 presents the results of this testing.

TABLE 3
Wooden Crib Test Results – Barrier E

Condition	Results
without the standard FR polyester cover fabric	2 reps ignited , foam melted, self-extinguished 1 rep ignited , foam involved, manually extinguished
with the standard FR polyester cover fabric	ignited , foam melted, self-extinguished (3 replicates)

Barriers F and G

Barriers F and G from the same U.S. manufacturer are melamine and aramid blend nonwoven fabrics. Barrier F weighs approximately 1.5 oz/yd² while Barrier G weighs approximately 3.0 oz/yd². Barrier G performed consistently, igniting and self-extinguishing within 16 minutes when tested with and without the FR polyester cover fabric. Barrier F ignited and self-extinguished without the FR polyester cover fabric within 11 ½ minutes. Two mockups with the FR polyester cover fabric ignited and the mockups were manually extinguished using pressurized carbon dioxide. Table 4 presents the results of this testing.

TABLE 4
Wooden Crib Test Results – Barriers F and G

Condition	Results	
	Barrier F	Barrier G
without the standard FR polyester cover fabric	ignited , foam melted, self-extinguished (3 replicates)	ignited , foam melted, self-extinguished (3 replicates)
with the standard FR polyester cover fabric	2 replicates ignited , foam involved, manually extinguished 1 replicate ignited , foam melted, self-extinguished	ignited , foam melted, self-extinguished (3 replicates)

Barriers H, I and J

Barriers H, I and J were obtained from the same source and are novoloid nonwovens of differing weights. The three barrier fabrics weigh approximately:

- Barrier H – 2.4 oz/yd²
- Barrier I – 3.7 oz/yd²
- Barrier J – 5.6 oz/yd²

Preliminary tests on the novoloid barrier fabrics were completed. These tests included only one replicate each without the standard FR polyester cover fabric. The two lighter weight fabrics, Barriers H and I, ignited and self-extinguished. Barrier J ignited and the foam became involved. Since those initial tests in early June 2001, additional yardage of Barrier I was obtained and a complete set of tests was conducted. Barrier I performed consistently, igniting and self-extinguishing when tested with and without the FR polyester cover fabric. All mockups self-extinguished within 15 minutes. Table 5 presents the results of this testing.

TABLE 5
Wooden Crib Test Results – Barrier I

Condition	Results
without the standard FR polyester cover fabric	ignited , foam melted, self-extinguished (4 replicates)
with the standard FR polyester cover fabric	ignited , foam melted, self-extinguished (3 replicates)

Barrier K

Barrier K is a melamine/modacrylic/polyester blend batting. This barrier material performed well in the crib ignition tests. Table 6 presents the results of this testing. Although Barrier K ignited, this barrier consistently self-extinguished within 3 to 10 minutes of testing.

TABLE 6
Wooden Crib Test Results – Barrier K

Condition	Results
without the standard FR polyester cover fabric	ignited , foam melted, self-extinguished (3 replicates)
with the standard FR polyester cover fabric	ignited , foam melted, self-extinguished (3 replicates)

Barrier L

Barrier L is a melamine/modacrylic/polyester blend fiber batting. All six mockup tests (Table 7) with and without the standard FR polyester cover fabric, ignited and self-extinguished within 12 minutes of testing.

TABLE 7
Wooden Crib Test Results – Barrier L

Condition	Results
without the standard FR polyester cover fabric	ignited , foam melted, self-extinguished (3 replicates)
with the standard FR polyester cover fabric	ignited , foam melted, self-extinguished (3 replicates)

Summary of all Crib Test Results

Overall, five of the nine barriers tested without the standard FR polyester cover fabric passed the tests using a wooden crib ignition source. For purposes of this testing, a pass is defined as when the foam did not become involved in the combustion process and the mockup self-extinguished. One barrier, the 3-oz aramid (Barrier E) exhibited variable performance. The foam in these mockups became involved in the combustion process and was manually extinguished in one of three trials. All three cotton barriers were unable to prevent ignition of the foam. Of the nine barriers tested with the standard FR polyester cover fabric, five passed and two consistently failed when two of the three replicates tested had sustained ignitions. Two other barriers failed when two of the three replicates tested had sustained ignitions. Table 8 has a summary of these results.

The results with and without the standard FR polyester cover fabric are consistent except for Barriers E and F. Barrier E passed in two of three trials without the standard FR polyester cover fabric and passed in all three trials with the standard cover fabric. Barrier F, the lighter weight melamine/aramid nonwoven blend, passed without the standard cover fabric, but failed in two of three mockup tests with the standard cover fabric.

TABLE 8
Summary of Crib Test Results

Barriers	Test Results	
	Without FR polyester cover fabric	With FR polyester cover fabric
A 100% cotton (FR treated?)	failed: obvious ignition	failed: obvious ignition
B 100% cotton (FR treated)	failed: obvious ignition	failed: obvious ignition
C 100% cotton (FR treated)	failed: obvious ignition (4 of 5 tests)	failed: obvious ignition (2 of 3 tests)
E 100% aramid	passed (2 of 3 tests)	passed (3 of 3 tests)
F melamine/aramid blend	passed (3 of 3 tests)	failed (2 of 3 tests)
G melamine/aramid blend	passed (3 of 3 tests)	passed (3 of 3 tests)
H 100% novoloid	passed (1 test)	not tested
I 100% novoloid	passed (4 tests)	passed (3 of 3 tests)
J 100% novoloid	passed (1 test)	not tested
K melamine/modacrylic/ polyester blend	passed (3 of 3 tests)	passed (3 of 3 tests)
L melamine/modacrylic/ polyester blend	passed (3 of 3 tests)	passed (3 of 3 tests)

B. Small Open Flame Tests

A small butane flame as described in the CPSC staff's 1997 and 2001 versions of the draft *Standard for Upholstered Furniture*,^{1,2} was used as the second ignition source in this testing. The mockups used for these tests were constructed with:

1. the barrier fabrics and one of up to eight upholstery fabrics,
2. the barrier fabrics alone, and
3. to establish a baseline, the upholstery cover fabrics alone over the foam.

Table 9 presents the results of the cover fabric tests. Six of the eight cover fabrics ignited and the foam became involved. Two fabrics prevented ignition of the underlying foam.

TABLE 9
Small Open Flame Test Results – Eight Cover Fabrics

Cover Fabric	Test Results (3 replicates)
std. FR polyester	ignited , foam melted, self-extinguished
cellulosic/thermoplastic blend	ignited , foam involved, manually extinguished
cotton twill	ignited , foam involved, manually extinguished
cotton corduroy	ignited , foam involved, manually extinguished
silk	smoke only, self-extinguished
acrylic/olefin/nylon blend*	ignited , foam involved, manually extinguished (2 reps.)
acetate/cotton taffeta	ignited , foam involved, manually extinguished
cotton print	ignited , foam involved, manually extinguished

*Mockups constructed with the acrylic blend cover fabric had flaming drips and flaming to the edge of mockup.

Barrier A

Barrier A was tested by itself and with the eight cover fabrics. Table 10 presents the results of these tests. Barrier A prevented the foam from becoming involved in the majority of the tests, (21 of 27 tests). In the six tests where ignitions occurred, the flames on the cover fabric were intense enough to sustain the ignition until the foam ignited. The mockups were manually extinguished using pressurized carbon dioxide.

TABLE 10
Small Open Flame Test Results – Barrier A

Cover Fabric	Test Results (3 replicates)
no cover fabric	smoke only, self-extinguished
std. FR polyester	smoke only, self-extinguished
cellulosic/thermoplastic blend	2 reps ignited , foam involved, manually extinguished 1 rep ignited , foam melted, self-extinguished
cotton twill	did not ignite
cotton corduroy	ignited , foam melted, self-extinguished
silk	smoke only, self-extinguished
acrylic/olefin/nylon blend*	ignited , foam involved, manually extinguished
acetate/cotton taffeta	2 reps ignited , foam melted, self-extinguished 1 rep ignited , foam involved, manually extinguished
cotton print	ignited , foam melted, self-extinguished

*Mockups constructed with Barrier A and the acrylic blend cover fabric had flaming drips and flaming to the edges of the mockup in 1 minute.

Barriers B and C

The results (Table 11) of the small open flame tests with Barriers B and C were similar to the results with Barrier A. The majority of the mockups covered with Barriers B and C did not have sustained ignitions. Both barrier fabrics had 23 of the 27 mockups that did not ignite. All six of the mockups constructed with the acrylic blend cover fabric and either Barrier B or Barrier C ignited and continued to burn intensely. In addition, a mockup constructed with Barrier B and the cotton print cover fabric and another mockup constructed with Barrier C and the cellulosic/thermoplastic blend upholstery fabric both had sustained ignitions.

TABLE 11
Small Open Flame Test Results – Barriers B and C

Cover Fabric	Test Results (3 replicates)	
	Barrier B	Barrier C
no cover fabric	smoke only, self-extinguished	smoke only, self-extinguished
std. FR polyester	smoke only, self-extinguished	smoke only, self-extinguished
cellulosic/thermoplastic blend	ignited , foam melted, self-extinguished	2 reps ignited , foam melted, self-extinguished 1 rep ignited , foam melted, manually extinguished
cotton twill	did not ignite	did not ignite
cotton corduroy	ignited , foam melted, self-extinguished	ignited , foam melted, self-extinguished
silk	smoke only, self-extinguished	smoke only, self-extinguished
acrylic/olefin/nylon blend*	ignited , foam involved, manually extinguished	ignited , foam involved, manually extinguished
acetate/cotton taffeta	ignited , foam melted, self-extinguished	ignited , foam melted, self-extinguished
cotton print	2 reps ignited , foam melted, self-extinguished 1 rep ignited , foam involved, manually extinguished	ignited , foam melted, self-extinguished

*Mockups with either Barrier B or C and the acrylic blend cover fabric had flaming drips and flaming to the edges of the mockup at 1 minute.

Barrier E

Only five cover fabrics were tested with Barrier E due to the limited amount of Barrier E fabric available. However, as shown in Table 12, this barrier consistently provided protection to the foam when tested by itself or combined with a cover fabric.

TABLE 12
Small Open Flame Test Results – Barrier E

Cover Fabric	Test Results (3 replicates)
no cover fabric	smoke only, self-extinguished
std. FR polyester	smoke only, self-extinguished
cellulosic/thermoplastic blend	not tested
cotton twill	not tested
cotton corduroy	ignited , foam melted, self-extinguished
silk	smoke only, self-extinguished
acrylic/olefin/nylon blend*	ignited , foam melted, self-extinguished (2 replicates)
acetate/cotton taffeta	not tested
cotton print	not tested

*Mockups with Barrier E and the acrylic blend cover fabric had flaming drips and flaming to the edges of the mockup at 1 minute.

Barriers F and G

Six mockups covered with Barriers F and G ignited and were manually extinguished. One of these ignitions occurred on a mockup covered with the acrylic blend cover fabric. The foam in the back of the mockup became involved from a flaming, dripping piece of cover fabric. The other ignitions occurred from the front of the mockup when the barrier split exposing the foam to the flames. The results of Barriers F and G are presented in Table 13.

TABLE 13
Small Open Flame Test Results – Barriers F and G

Cover Fabric	Test Results (3 replicates)	
	Barrier F	Barrier G
no cover fabric	ignited , smoke only, self-extinguished	ignited , smoke only, self-extinguished
std. FR polyester	ignited , smoke only, self-extinguished	ignited , smoke only, self-extinguished
cellulosic/thermoplastic blend	2 reps ignited , foam melted, self-extinguished 1 rep ignited , foam involved, manually extinguished	ignited , foam melted, self-extinguished
cotton twill	2 reps ignited , foam involved, manually extinguished 1 rep ignited , foam melted, self-extinguished	2 reps ignited , foam involved, manually extinguished 1 rep ignited , foam melted, self-extinguished
cotton corduroy	ignited , foam melted, self-extinguished	ignited , foam melted, self-extinguished
silk	not tested	not tested
acrylic/olefin/nylon blend*	2 reps ignited , foam melted, self-extinguished 1 rep ignited , foam involved, manually extinguished**	ignited , foam melted, self-extinguished
acetate/cotton taffeta	ignited , foam melted, self-extinguished	ignited , foam melted, self-extinguished
cotton print	ignited , foam melted, self-extinguished	ignited , foam melted, self-extinguished

*Mockups with either Barrier F or G and the acrylic blend cover fabric had flaming drips and flaming to the edges of the mockup at 1 minute.

**Mockup ignited when foam in the vertical panel ignited from the back of the mockup, possibly from a flaming dripping piece of upholstery fabric.

Barriers H, I and J

Due to limited quantities of Barriers H and J available to CPSC staff, only one small open flame test each using Barriers H and J were performed. Both barriers were tested without cover fabrics. The fabrics charred but did not sustain combustion when the small butane flame was applied. Additional yardage of Barrier I was obtained to complete a full set of small open flame tests.

All three of the mockups covered with the cotton twill and two of the mockups covered with the cellulosic/thermoplastic blend upholstery fabric ignited. The foam became involved in these five mockups and they were extinguished manually using pressurized carbon dioxide. The results of Barrier I testing is presented in Table 14.

TABLE 14
Small Open Flame Test Results – Barrier I

Cover Fabric	Test Results (3 replicates)
no cover fabric	smoke only, self-extinguished
std. FR polyester	smoke only, self-extinguished
cellulosic/thermoplastic blend	1 rep ignited , foam melted, self-extinguished 2 reps ignited , foam involved, manually extinguished
cotton twill	2 reps ignited , foam involved, manually extinguished
cotton corduroy	ignited , foam melted, self-extinguished
silk	not tested
acrylic/olefin/nylon blend*	2 reps ignited , foam melted, self-extinguished
acetate/cotton taffeta	ignited , foam melted, self-extinguished
cotton print	ignited , foam melted, self-extinguished

*Mockups with Barrier E and the acrylic blend cover fabric had flaming drips and flaming to the edges of the mockup at 1 minute.

Barrier K

Mockups constructed with Barrier K performed well when tested with Barrier K by itself or with four of the seven cover fabrics. However, seven mockups ignited, the foam became involved and these mockups were manually extinguished. Ignitions occurred on the mockups covered with the cellulosic/thermoplastic, cotton twill and cotton corduroy cover fabrics. Table 15 presents the results of the testing.

TABLE 15
Small Open Flame Test Results – Barrier K

Cover Fabric	Test Results (3 replicates)
no cover fabric	ignited , smoke only, self-extinguished
std. FR polyester	ignited , smoke only, self-extinguished
cellulosic/thermoplastic blend	1 rep ignited , foam melted, self-extinguished 2 reps ignited , foam involved, manually extinguished
cotton twill	ignited , foam involved, manually extinguished
cotton corduroy	1 rep ignited , foam melted, self-extinguished 2 reps ignited foam involved, manually extinguished
Silk	not tested
acrylic/olefin/nylon blend*	ignited , foam melted, self-extinguished
acetate/cotton taffeta	ignited , foam melted, self-extinguished
cotton print	ignited , foam melted, self-extinguished

*Mockups with Barrier E and the acrylic blend cover fabric had flaming drips and flaming to the edges of the mockup at 1 minute.

Barrier L

Mockups constructed with Barrier L performed well when tested with Barrier L by itself or with three of the seven cover fabrics. Nine mockups ignited, the foam became involved and these mockups were manually extinguished. Ignitions occurred on mockups covered with the cellulosic/thermoplastic blend, cotton twill, acrylic blend and cotton print cover fabrics. Table 16 presents the results of this testing.

TABLE 16
Small Open Flame Test Results – Barrier L

Cover Fabric	Test Results (3 replicates)
no cover fabric	ignited , smoke only, self-extinguished
std. FR polyester	ignited , smoke only, self-extinguished
cellulosic/thermoplastic blend	1 rep ignited , foam melted, self-extinguished* 2 reps ignited , foam involved, manually extinguished
cotton twill	ignited , foam involved, manually extinguished
cotton corduroy	ignited , foam melted, self-extinguished
Silk	not tested
acrylic/olefin/nylon blend	ignited , foam involved, manually extinguished
acetate/cotton taffeta	ignited , foam melted, self-extinguished
cotton print	1 rep ignited , foam melted, self-extinguished 2 reps ignited , foam involved, manually extinguished

*Although this mockup self-extinguished the foam melted resulting in a char approximately 2 7/8 inches in depth.

Summary of all Small Open Flame Tests

In general, barriers that did well in the crib test did not always provide protection to the foam in the small open flame tests. Mockups covered with either the cellulosic/thermoplastic blend fabric, or the cotton twill fabric tended to have sustained combustion. Ten mockups covered with the cellulosic/thermoplastic blend cover fabric and 12 mockups covered with the cotton twill fabric ignited and were manually extinguished after the foam became involved in the combustion process.

The small open flame test procedure is designed to test the ability of mockups to self-extinguish. In general, the barriers did not accomplish this. The fuel load of the burning cover fabric was such that the barrier could not always provide protection to the foam.

C. Cigarette Tests

The third ignition source used in this test program was a non-filtered cigarette. The mockups used for these tests were constructed with:

1. the barrier fabrics and up to eight upholstery fabrics,
2. the barrier fabrics alone over the foam, and
3. to establish a baseline, the upholstery cover fabrics alone over the foam.

Table 17 presents the results of the cover fabric tests. None of the eight cover fabrics ignited from a lit cigarette.

TABLE 17
Cigarette Ignition Test Results – Eight Cover Fabrics

Cover Fabric	Test Results (3 replicates)
std. FR polyester	not tested
cellulosic/thermoplastic blend	did not ignite
cotton twill	did not ignite
cotton corduroy	did not ignite
silk	did not ignite
acrylic/olefin/nylon blend	did not ignite
acetate/cotton taffeta	did not ignite
cotton print	did not ignite

Barrier A

Tests with lit cigarettes as the ignition source were conducted with Barrier A in combination with the variety of cover fabrics. Ignitions occurred on the mockups constructed with the heavier cotton cover fabrics, the twill and corduroy, and Barrier A. Table 18 presents the results of the cigarette tests.

TABLE 18
Cigarette Ignition Test Results – Barrier A

Cover Fabric	Test Results (3 replicates)
no cover fabric	did not ignite
std. FR polyester	did not ignite
cellulosic/thermoplastic blend	did not ignite
cotton twill	ignited , foam involved, manually extinguished
cotton corduroy	2 reps did not ignite, 1 rep ignited , foam involved, manually extinguished
silk	did not ignite
acrylic/olefin/nylon blend	did not ignite
acetate/cotton taffeta	did not ignite
cotton print	did not ignite

Barriers B and C

The results (Table 19) of the cigarette ignition tests on mockups constructed with Barriers B and C were similar to the results of Barrier A. Ignitions occurred only on the mockups constructed with the cotton corduroy and Barriers B and C.

TABLE 19
Cigarette Ignition Test Results – Barriers B and C

Cover Fabric	Test Results (3 replicates)	
	Barrier B	Barrier C
no cover fabric	did not ignite	did not ignite
std. FR polyester	did not ignite	did not ignite
cellulosic/thermoplastic blend	did not ignite	did not ignite
cotton twill	did not ignite	did not ignite
cotton corduroy	ignited , foam involved, manually extinguished	2 reps ignited , foam involved, manually extinguished 1 rep did not ignite
silk	did not ignite	did not ignite
acrylic/olefin/nylon blend	did not ignite	did not ignite
acetate/cotton taffeta	did not ignite	did not ignite
cotton print	did not ignite	did not ignite

Barrier E

Due to limited quantities of Barrier E available to CPSC staff, only a few cigarette ignition tests could be completed using Barrier E. Mockups constructed with Barrier E did not ignite when tested with lit cigarettes. These results are presented in Table 20. One of the mockups constructed with Barrier E and the cotton corduroy ignited when the lit cigarette was used as the ignition source.

TABLE 20
Cigarette Test Results – Barrier E

Cover Fabric	Test Results (3 replicates)
no cover fabric	did not ignite
std. FR polyester	did not ignite
cellulosic/thermoplastic blend	not tested
cotton twill	not tested
cotton corduroy	1 rep ignited , 1 rep did not ignite (only 2 replicates tested)
silk	did not ignite
acrylic/olefin/nylon blend	not tested
acetate/cotton taffeta	not tested
cotton print	not tested

Barriers F and G

Of the eight cover fabrics tested over Barriers F and G, cigarette ignitions occurred only on the mockups constructed with the cotton corduroy. Table 21 presents the results of these tests.

TABLE 21
Cigarette Test Results – Barriers F and G

Cover Fabric	Test Results (3 replicates)	
	Barrier F	Barrier G
no cover fabric	did not ignite	did not ignite
std. FR polyester	did not ignite	did not ignite
cellulosic/thermoplastic blend	did not ignite	did not ignite
cotton twill	did not ignite	did not ignite
cotton corduroy	ignited , foam involved, manually extinguished	ignited , foam involved, manually extinguished
silk	not tested	not tested
acrylic/olefin/nylon blend	did not ignite	did not ignite
acetate/cotton taffeta	did not ignite	did not ignite
cotton print	did not ignite	did not ignite

Barriers H, I and J

No cigarette tests were done with Barriers H and J because of insufficient fabric available to CPSC staff. Barrier I was tested with lit cigarettes. Table 22 presents the results of this testing. Cigarette ignitions occurred on the mockups constructed with the cotton twill, cotton corduroy, acetate/cotton blend, and cotton print cover fabrics. A total of seven mockups had cigarette ignitions, while ten mockups did not ignite.

TABLE 22
Cigarette Test Results – Barrier I

Cover Fabric	Test Results (3 replicates)
no cover fabric	did not ignite
std. FR polyester	did not ignite
cellulosic/thermoplastic blend	did not ignite
cotton twill	2 reps ignited (only 2 replicates tested)
cotton corduroy	2 reps ignited (only 2 replicates tested)
silk	not tested
acrylic/olefin/nylon blend	did not ignite
acetate/cotton taffeta	2 reps ignited (only 2 replicates tested)
cotton print	1 rep ignited , 2 reps did not ignite

Barrier K

Five mockups covered with Barrier K ignited from the lit cigarette ignition source. The cover fabrics for these five mockups were the cotton twill and the cotton corduroy. Table 23 presents the results of this testing.

TABLE 23
Cigarette Test Results – Barrier K

Cover Fabric	Test Results (3 replicates)
no cover fabric	did not ignite (only 2 replicates tested)
std. FR polyester	did not ignite (only 2 replicates tested)
cellulosic/thermoplastic blend	did not ignite
cotton twill	ignited , foam involved, manually extinguished
cotton corduroy	ignited , foam involved, manually extinguished
silk	not tested
acrylic/olefin/nylon blend	did not ignite
acetate/cotton taffeta	did not ignite
cotton print	2 reps did not ignite, 1 rep ignited , foam involved, manually extinguished

Barrier L

Table 24 presents the results of testing Barrier L with lit cigarettes. Only two of the three mockups covered with cotton twill fabric ignited. The foam became involved and these mockups were manually extinguished.

TABLE 24
Cigarette Test Results – Barrier L

Cover Fabric	Test Results (3 replicates)
no cover fabric	did not ignite
std. FR polyester	did not ignite
cellulosic/thermoplastic blend	did not ignite
cotton twill	2 reps ignited , foam involved, manually extinguished 1 rep did not ignite
cotton corduroy	did not ignite
silk	not tested
acrylic/olefin/nylon blend	did not ignite
acetate/cotton taffeta	did not ignite
cotton print	did not ignite

Summary of all Cigarette Ignition Tests

None of the cover fabrics ignited from a lit cigarette when tested by themselves. Most of the cover fabrics also did not ignite when tested with the barriers. An exception to this was the cotton corduroy and the cotton twill fabrics. At least one replicate constructed with seven of the eight barriers ignited when covered with the cotton corduroy fabric. Barrier L was the exception to this. However, mockups constructed with Barrier L ignited when covered with the cotton twill fabric. Mockups constructed with Barrier K also ignited when covered with the cotton twill fabric and in one case the cotton print fabric.

SUMMARY

Table 25 presents a summary of the data for this test program. Barriers G, I, K, and L did not ignite during the tests with the wooden crib ignition source either with or without the standard FR cover fabric. Although these four barriers had no crib ignitions, some ignitions did occur when these barriers were tested with upholstery cover fabrics in the small open flame and smoldering cigarette ignition tests.

All of the wooden crib tests with Barriers A and B ignited. When these barriers were tested to the small open flame and cigarette ignition protocols, ignitions did not occur in 77% of the small open flame ignition tests and in 89% of the cigarette ignition tests.

Eighty-three percent of the mockups covered with Barrier E did not ignite when exposed to the wooden crib ignition source. None of the Barrier E mockups exposed to the small open flame ignition source ignited. However, this barrier was not tested with all cover fabrics because the supply of Barrier E had been exhausted. Since Barrier E was not tested with the full range of cover fabrics used to evaluate the other barrier materials, it is not appropriate to conclude that it was necessarily a good performing barrier.

Overall, mockups covered with Barrier G did not ignite in the majority of the tests regardless of the ignition source. This barrier was tested with all cover fabrics but the silk cover fabric. Tests with the silk fabric were discontinued early in the test program because the silk fabric did not ignite when exposed to the small open flame. Of the 54 mockups constructed with Barrier G, 49 did not ignite.

**TABLE 25
SUMMARY OF ALL BARRIER DATA***

	Non-Ignitions/Number of Mockups Tested									
	Barrier Identification									
Ignition Source/ Cover Fabrics	A	B	C	E	F	G	I	K	L	Non-Ignitions/Type of Cover Fabric
Wooden Crib										
No cover fabric	0/5	0/5	1/5	2/3	3/3	3/3	4/4	3/3	3/3	19/34 (56%)
Std. FR poly cover fabric	0/3	0/3	1/3	3/3	1/3	3/3	3/3	3/3	3/3	17/27 (63%)
% NOT IGNITING	0%	0%	25%	83%	66%	100%	100%	100%	100%	
Small Open Flame										
no cover fabric	3/3	3/3	3/3	3/3	3/3	3/3	3/3	3/3	3/3	27/27 (100%)
standard FR polyester	3/3	3/3	3/3	3/3	3/3	3/3	3/3	3/3	3/3	27/27 (100%)
cellulosic/thermo. blend	1/3	3/3	2/3	NT	2/3	3/3	1/3	1/3	1/3	14/24 (58%)
cotton twill	3/3	3/3	3/3	NT	1/3	1/3	0/2	0/3	0/3	11/23 (48%)
cotton corduroy	3/3	3/3	3/3	3/3	3/3	3/3	3/3	1/3	3/3	25/27 (93%)
Silk	3/3	3/3	3/3	3/3	NT	NT	NT	NT	NT	12/12 (100%)
acrylic/olefin/nylon blend	0/3	0/3	0/3	2/2	2/3	3/3	2/2	3/3	0/3	12/25 (48%)
acetate/cotton blend	2/3	3/3	3/3	NT	3/3	3/3	3/3	3/3	3/3	23/24 (96%)
cotton print	3/3	2/3	3/3	NT	3/3	3/3	3/3	3/3	1/3	23/24 (86%)
% NOT IGNITING	77%	85%	85%	100%	83%	92%	82%	71%	58%	
Cigarette										
no cover fabric	3/3	3/3	3/3	3/3	3/3	3/3	3/3	2/2	3/3	26/26 (100%)
standard FR polyester	3/3	3/3	3/3	3/3	3/3	3/3	3/3	2/2	3/3	26/26 (100%)
cellulosic/thermo. blend	3/3	3/3	3/3	NT	3/3	3/3	3/3	3/3	3/3	24/24 (100%)
cotton twill	0/3	3/3	3/3	NT	3/3	3/3	0/2	0/3	1/3	13/23 (57%)
cotton corduroy	2/3	0/3	1/3	1/2	0/3	0/3	0/2	0/3	3/3	7/25 (28%)
Silk	3/3	3/3	3/3	3/3	NT	NT	NT	NT	NT	12/12 (100%)
acrylic/olefin/nylon blend	3/3	3/3	3/3	NT	3/3	3/3	3/3	3/3	3/3	24/24 (100%)
acetate/cotton blend	3/3	3/3	3/3	NT	3/3	3/3	0/2	3/3	3/3	21/23 (91%)
cotton print	3/3	3/3	3/3	NT	3/3	3/3	2/3	2/3	3/3	22/24 (92%)
% NOT IGNITING	85%	89%	93%	91%	88%	88%	67%	68%	92%	

*Note: Only limited tests were conducted with Barriers D, H and J. See text for details.

NT = not tested.

CONCLUSIONS

- Fire-resistant barriers are currently available that provided protection to the foam padding in CPSC laboratory mockup tests using a wooden crib as an ignition source. Four barriers consistently passed the crib ignition tests when tested with or without the FR polyester cover fabric. However, some fire-resistant barrier fabrics (including those that passed the crib ignition tests) did not prevent the filling materials from becoming involved in the fire when combined with certain cover fabrics in small open flame tests. Although this testing is limited, these results indicate that the wooden crib test protocol as drafted may not be as severe an ignition source to evaluate barrier fabrics as first appeared based on the earlier exploratory tests. Barriers may need to be evaluated with the cover fabric(s) with which they will be used on actual furniture.
- For two of the barriers, the standard FR polyester fabric may have affected the wood crib test results. This testing is very limited and the significance of any such effect is undetermined.
- Some barriers appear to be effective in protecting the foam from a flaming ignition source but do not always provide the same protection from a smoldering ignition source. None of the cover fabrics ignited from a smoldering cigarette when tested by themselves, yet ignitions occurred when the barriers were combined with certain cover fabrics.