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United States
CONSUMER PRODUCT SAFETY COMMISSION
Washington, D.C. 20207

MEMORANDUM

DATE: October 9, 1997

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

Through: Andrew G. Ulsamer, Ph.D., Associate Executive Director, AGU
Directorate for Laboratory Sciences

FROM : Linda Fansler, Division of Engineering LF

SUBJECT: Summary of Upholstered Furniture Tests

Over the past year as part of the Upholstered Furniture Project, the Directorate for Laboratory Sciences has carried out a series of tests designed to better understand the smoldering (cigarette) and small open flame ignition resistance of upholstered furniture. The individual reports for each of the tests (a total of 12) are attached. There are four major categories of tests: smoldering ignition, small open flame ignition, chemical analysis and test fixture evaluations. This memorandum summarizes the major findings of each test.

SMOLDERING IGNITION

The cigarette ignition resistance of a number of upholstery fabrics was evaluated.[3,7,8,10,19,20] A wide range of upholstery fabrics were represented, including traditional non-flame resistant fabrics in a variety of fiber contents and weights,[3,8,10,19,20] fabrics laminated with aramid fire blockers[8], fabrics with flame retardant (FR) backcoatings[3,7,20], and intumescent barrier fabrics[19].

UFAC

The Fabric Classification Test Method, part of the Upholstered Furniture Action Council (UFAC) Voluntary Program[11] was used to evaluate the cigarette ignition resistance of 44 upholstery fabrics and four intumescent barrier fabrics. Thirty-seven of the 44 upholstery fabrics tested were UFAC Class I[3,7,8,10,19,20], i.e., they have vertical chars less than 1.75 inches above the mockup crevice. Two of the Class I fabrics, a 100% wool and a FR backcoated cellulosic/thermoplastic blend have the potential to cause the cigarette to self-extinguish by dissipating the heat.[3]

[3] Superscript refers to references on page 8.

The addition of the aramid fire blocker layer laminated to another Class I fabric, a 100% nylon fabric, prevented any vertical char from forming.[8] The other UFAC Class I fabrics had vertical chars ranging from 0.4 to 1.1 inches.

Five heavier weight 100% cellulosic fabrics had vertical chars ≤ 1.75 inches. In comparison three other heavier weight 100% cellulosic fabrics ignited resulting in vertical chars greater than 1.75 inches.[10,20] Under the UFAC Program these three cellulosics are UFAC Class II fabrics and would be required to have an approved barrier between the cover fabric and conventional polyurethane foam in the horizontal seating surface. Four light to medium weight cellulosic fabrics had one or more obvious ignitions and are also UFAC Class II fabrics.[19] Therefore, factors other than weight alone influence whether a fabric ignites in the cigarette ignition test.

Intumescent barrier fabrics tested in combination with a UFAC Class I upholstery fabric either had vertical chars of ≤ 0.7 or the cigarettes would not stay lit, i.e. they self-extinguished.[19]

CPSC SEAT MOCKUP

A second protocol, a modification version of the UFAC protocol was also used to evaluate the cigarette ignition resistance of some of the upholstery fabrics.[19,20] The fabrics were placed over the standard foam specified in the CPSC staff's draft standard using the seating area test mockup without the UFAC test enclosure. The lit cigarettes were placed in the crevice and the cigarette was covered with a piece of unlaundered sheeting fabric. Char measurements were recorded in both the horizontal and vertical directions.

Eight fabrics smoldered profusely during these tests and had one or more obvious cigarette ignitions.[19,20] Three of these eight fabrics were backcoated with a flame retardant coating. These three FR backcoated fabrics also did not meet the acceptance criteria in the CPSC staff's draft standard for small open flame ignition.[20] However, a non-FR backcoated fabric, a heavy weight cellulosic, that had several cigarette ignitions did meet the acceptance criteria by not igniting when the small butane flame was applied up to 30 seconds.[20] Fifteen other upholstery fabrics had vertical and horizontal chars ranging from ≤ 0.3 to 0.7 inches.[19,20]

Using the seating area test frame from the staff's draft standard, four intumescent barrier fabrics were tested in combination with a UFAC Class I upholstery fabric. These fabrics either had vertical chars of ≤ 0.7 or the cigarettes would not stay lit, i.e. they self-extinguished.[19]

SMALL OPEN FLAME IGNITION

Filling Materials

The small open flame ignition resistance of four filling materials found in upholstered furniture[5,7] was evaluated using the draft test protocol, "Bench Scale Test Method For Upholstered Furniture Ignition Resistance To Small Open Flame Sources"[12]. This draft protocol, developed by CPSC staff, specifies conditions under which a small flame may be applied to mockups representing the seating area, the skirt and the dust cover. A test fixture that automatically controls the placement of the flame and the time the flame is applied was used for these tests. The test fixture was designed and constructed by the staff at the Division of Engineering as part of the Upholstered Furniture Project.[13]

A non-FR polyurethane foam, commonly used in upholstered furniture, was tested by itself (no upholstery fabric) in the seating mockup configuration.[7] This foam ignited repeatedly with a 2 second flame application time and then self-extinguished within 5 seconds. After 3 seconds of flame application the foam ignited and continued to burn.

In another set of tests, the same foam was tested with and without a layer of polyester batting directly on top, between the upholstery fabric and the foam itself.[5] Again the polyester batting was the type commonly found in upholstered furniture and used in the seating area directly over foam. The upholstery fabric was a cellulosic/thermoplastic blend fabric. The addition of polyester batting between an upholstery fabric and conventional non-FR foam did not significantly affect ignition time for the fabric tested.

Two FR foams were also evaluated and the results compared with results obtained using non-FR foam.[5] The FR foams were taken from chairs used in the full scale open flame test program[14] and were intended to meet existing open flame standards in the State of California (Technical Bulletin 117)[15] and the United Kingdom (The Furniture and Furnishings Regulations, 1988)[16]. Analysis by Division of Chemistry determined that the foams taken from the "California" chairs contained either Fyrol FR-2 or DE-60F, two kinds of flame retardant compounds.[17] The foams from the "United Kingdom" chairs used in these tests were not analyzed for the presence of FR chemicals. However, a foam taken from a different "United Kingdom" chair was analyzed and found to contain melamine.[17] These foams were tested with two upholstery fabrics, a 100% cellulosic and a cellulosic/thermoplastic blend, two relatively easy to ignite fabrics. The times to ignition for these fabrics were not appreciably different when tested over FR and non-FR foam.

Fabrics

The draft test protocol developed by CPSC staff was also used to evaluate the small open flame ignition resistance of five dust cover fabrics[2,6,19] and 74 upholstery fabrics with the seating area mockup[2,4,6,7,10,19,20], 15 of the same upholstery fabrics in the vertical skirt orientation[2,6] and four intumescent barrier fabrics[19].

Dust Cover Fabrics

Three of the dust cover fabrics were purchased for the interlaboratory evaluation.[18] The time to ignition determinations were also used to choose the flame application time used with the dust cover fabrics in the interlaboratory evaluation. These three fabrics were a nonwoven polypropylene, a nonwoven aramid and a woven cellulosic/thermoplastic blend.[2] Another dust cover fabric, a nonwoven aramid blend, evaluated for time to ignition was supplied by a fiber manufacturer.[6] A knit dust cover fabric containing FR fibers over a glass core was also supplied by a manufacturer and was tested by itself and in combination with two traditional dust cover fabrics.[20] The dust cover fabrics were tested in a horizontal configuration. Three of the dust cover fabrics did not ignite. The non-igniting fabrics were the polypropylene which did, however, melt and two aramid fabrics. The woven blend dust cover fabric ignited in 2 seconds and burned rapidly, with the specimen being consumed in 5 seconds. The knit dust cover containing FR fibers over a glass core ignited at 20 seconds but self-extinguished. The result was the same when this dust cover fabric was tested in combination with the two traditional dust cover fabrics.[19]

Upholstery Fabrics

Skirt Tests

Four of the upholstery fabrics tested in the skirt orientation were purchased for the interlaboratory evaluation. The time to ignition determinations were also used to choose the flame application time for the skirt tests in the interlaboratory evaluation. These fabrics included a wool, cotton, cellulosic/thermoplastic blend and a cellulosic/thermoplastic blend with an FR backcoating.[2] The other 11 fabrics tested in the skirt orientation were supplied by a fiber manufacturer and consisted of a range of common upholstery fabrics with and without a laminated aramid fire blocker layer.[6] All of the fabrics were tested in the simplest skirt construction possible, a single layer, and were hemmed at the bottom edge. This construction is used in some upholstered furniture, but lacks the stiffener/backing material found in most typical skirts.

All 15 fabrics tested in the skirt orientation ignited with the wool and FR backcoated fabrics self-extinguishing. The FR backcoated fabric ignited in a flame application time of 2 to 3 seconds and the wool fabric ignited in 6 seconds. The range in times to ignition for the remaining 12 fabrics was 3 to 5 seconds. The presence of an

aramid fire blocker layer did not prevent ignition or increase resistance to ignition from a small open flame source in the skirt orientation for fabrics tested in single-layer skirt constructions.

Seating Area Tests

In addition to the four upholstery fabrics purchased for the interlaboratory evaluation, 70 other upholstery fabrics were evaluated to determined their time to ignition in the seat mockup orientation.[2,4,6,7,10,19,20] These 70 fabrics represented a wide range of upholstery fabrics including traditional non-flame resistant fabrics in a variety of fiber contents and weights,[2,4,6,10,20] fabrics laminated with aramid fire blocker layers[6], fabrics reported to be "naturally flame resistant"[19], and 12 other fabrics backcoated with FR treatments[7,20]. Seventy-one of the 74 fabrics tested ignited. The ignition times for this group of 71 fabrics ranged from 3 seconds to 30 seconds[2,4,6,7,10,19,20]. The remaining three fabrics did not ignite when the butane flame was applied up to 30 seconds.[20]

Overall several fabrics performed well by either meeting the criteria in the staff's small open flame test or exceeding it. Two fabrics, a FR backcoated fabric and a heavy weight fabric did not ignite when the butane flame was applied for up to 30 seconds.[20] Two FR backcoated fabric ignited at 30 seconds and self-extinguished.[20] Two other FR backcoated fabrics and the wool fabric (both of which either do not ignite at 20 seconds or ignite and self-extinguish) had time to ignitions from 25 to 30 seconds and sometimes self-extinguished.[2,7] Four other FR backcoated fabrics ignited at 20 seconds and self-extinguished.[20] Four fabrics ignited in 19 to 20 seconds and also sometimes self-extinguished.[2,20] All the other fabrics, once ignited, continued to burn although a nylon pile fabric resisted ignition up to 21 seconds and when combined with a fire blocker resisted ignition up to 24 seconds.[6] Fifty-eight of these fabrics ignited in 3 to 20 seconds.[2,4,6,10,19,20]

Heavier weight fabrics, more than 10 oz/yd^2, had more resistance to ignition from the small butane flame than fabrics weighing less than 10 oz/yd^2, and pile fabrics regardless of weight were somewhat able to resist small flame ignition.[4,20] Fabrics with laminated fire blockers took a few seconds longer to ignite, not a substantial improvement but the fire blocker prevented ignition of filling materials below. The FR backcoating contributes to the likelihood that an upholstery fabric will resist small flame ignition and if ignited may self-extinguish. The amount and type of FR backcoating along with the fabric type and weight may play a role in the effectiveness of the FR backcoating, however, more work is needed to understand the role of each variable.

Three of the intumescent barrier fabrics tested in combination with a cellulosic/thermoplastic blend upholstery fabric that by itself ignites in 7 to 10 seconds. These three barrier fabrics met the small open flame test criteria, although they ignited in 20 seconds, self-extinguishment occurred within seconds. The other

intumescent barrier tested did not offer much improvement in small open flame resistance when combined with the easily ignitable upholstery fabric.[19]

CHEMICAL ANALYSIS

The FR backcoatings on those treated upholstery fabrics were analyzed to determine the type and amount of flame retardant present and likelihood of exposure to the flame retardant. Seven of the FR backcoated upholstery fabrics contained antimony trioxide in amounts ranging from 1.16 to 3.62% by weight.[20,21] Exposure to the antimony based FR treatments is minimal in that less than 0.02% of the antimony trioxide could be extracted using 0.1 N HCl, 0.4% NaCl, water or hexane.

One treated upholstery fabric contained 2.26% by weight of phosphorus. A substantial amount, 1.70% of the phosphorus could be extracted with 0.1 N HCl. Only relatively small amounts of the phosphorus could be extracted with water, 0.9% NaCl or hexane.

TEST FIXTURE EVALUATION

Analysis Of Flame Height/Gas Flow

The gas flow rate, outlet pressure and flame height for the butane flame used when evaluating the small open flame ignition of test materials were monitored to establish that a relatively consistent flame height can be maintained when the gas flow rate and outlet pressure are specified.[9] Results indicated that a butane flame of approximately 34 to 35 mm could be maintained whenever the gas flow rate and outlet pressure met the general specifications in the draft test protocol. This flame height is critical for correct placement of the flame during a test. Flame height is especially important for any vertical skirt and dust cover testing when using the test fixture according to the method specified in the draft test protocol. Use of a flame height gage assumes that the flame is the correct height.

In-house Evaluation Of The Draft Test Protocol And Test Fixture

A single test operator evaluation and a small in-house evaluation of the draft test protocol and test fixture was conducted in July 1996, at the Division of Engineering laboratory.[1] A total of four test operators participated in this effort. The same fabrics, protocol and test fixture as used in the interlaboratory evaluation were used. Most of the test results were consistent, although some multiple-operator variability was observed. This study emphasized the need to maintain a turbulence-free environment during the tests, to emphasize the importance of careful observation during the tests, and to provide clear instructions and guidance to participants using the draft protocol and test fixture.

CONCLUSIONS

- Nine FR backcoated upholstery fabrics met the criteria of the small open flame test.

- Three non-FR upholstery fabrics met the criteria of the small open flame test.

- Exposure to antimony based FR treatments is minimal.

- Intumescent barrier fabrics when combined with an easily ignitable upholstery fabric ignite but self-extinguish.

- A nylon pile fabric resisted ignition up to 21 seconds and when combined with a fire blocker resisted ignition up to 24 seconds. Other fabrics did not meet the criteria of the small open flame test with or without a fire blocker.

- Sixty-two upholstery fabrics did not meet the criteria of the small open flame test.

- Cigarettes placed on the wool fabric and the cellulosic/thermoplastic FR backcoated fabric have the potential to self-extinguish during UFAC tests as does an intumescent treatment.

- Four FR backcoated fabrics met both the small open flame criteria and the CPSC cigarette test.

- Most of the upholstery fabrics tested are resistant to cigarette ignition (UFAC Class I fabrics) but few of these fabrics resist open flame ignition at $\geq$ 20 seconds.

- Weight alone does not determine the resistance of cellulosic fabrics to smoldering (cigarette) and small open flame ignition, heavier weight fabrics tend to be more resistant to open flame and less resistant to cigarette ignition than lightweight cellulosics.

- Two FR foams tested did not improve the small open flame ignition resistance of two relatively easy to ignite upholstery fabrics; polyester batting did not improve ignition resistance when used over non-FR foam.

- Three dust cover fabrics tested did not ignite from a small open flame.

- The in-house evaluation emphasized the need to maintain a turbulent-free environment and the importance of careful observation during testing.

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MEMORANDUM

DATE: September 19, 1996

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

Through: Andrew G. Ulsamer, Ph.D., Associate Executive Director, AGU
Directorate for Laboratory Sciences

FROM : Linda Fansler, Division of Engineering Laboratory LF

SUBJECT: Analysis of Single Test Operator and Small In-House Evaluation Studies

The Directorate for Laboratory Sciences recently conducted a series of tests to determine the variability of a single test operator and the single laboratory variability of the draft test protocol developed to assess the small open flame ignition of upholstered furniture. Results obtained indicate some variability of the test procedures.

BACKGROUND

As part of the upholstered furniture project, staff from the Directorate for Engineering Sciences developed a draft test protocol to evaluate the resistance to small open flame ignition of three locations on upholstered furniture. The draft protocol, titled "Bench Scale Test Method For Upholstered Furniture Ignition Resistance To Small Open-Flame Sources"[1], specifies a small butane flame be applied to mockups representing the seating area, the skirt and the dust cover. A test fixture that automatically controls the placement of the flame and the time the flame is applied was used in these tests. Staff from the Directorate for Laboratory Sciences designed and constructed the test fixture at the Engineering Laboratory. A small interlaboratory evaluation of the draft test protocol and test fixture was conducted during September 1996.

A single test operator evaluation and a small in-house evaluation of the draft test protocol and test fixture was conducted in July 1996, at the Engineering Laboratory. The single test operator evaluation used a test operator familiar with flammability testing and also familiar with the draft protocol and the operation of the test fixture.

[1] Superscript refers to references on page 8.

The small in-house evaluation used three test operators familiar (to different degrees) with flammability testing although not with the protocol and fixture. These test operators were trained by Engineering Laboratory staff, and allowed to practice constructing the mockups and operating the test fixture before the actual evaluation study began.

Three upholstery fabrics and three dust cover fabrics were used in both the single operator and the in-house evaluation study. These same fabrics were used in the small interlaboratory evaluation and represent a range of times to ignition and fire growth.[2] An additional upholstery fabric was included in the small interlaboratory evaluation. The additional fabric, a 100% cotton, was not received by Laboratory Sciences in time to include in the single operator and the in-house evaluation. A description of the fabrics used in the single operator and in-house evaluation and the locations found on upholstered furniture are listed in Table 1 below.

TABLE 1
FABRIC DESCRIPTION BY LOCATION

FABRIC DESCRIPTION	LOCATION ON UPHOLSTERED FURNITURE
60% rayon, 36% polyester, and 4% cotton, flame retardant backcoating	skirt and seating area
100% wool	skirt and seating area
56% rayon, 34% polyester, and 10% cotton	skirt and seating area
100% polypropylene - nonwoven	dust cover
100% aramid - nonwoven	dust cover
cellulosic/thermoplastic blend - woven	dust cover

TEST PROGRAM

There were two objectives to this test program. The first objective was to evaluate variability of a single test operator following the test procedures developed to assess the resistance to small open flame ignition of upholstered furniture. The second objective was to evaluate the single laboratory variability of the these procedures.

The fabrics were tested following the draft protocol[1] with the exception that times of flame exposure were specified. The dust cover and skirt fabrics were tested with a 5

second flame application time and the seating area fabrics were tested with a 15 second flame application time.

Flame application time, afterflame, afterglow/smoldering times and whether the specimen self-extinguished were recorded. Afterflame is the time that the fabric continues to produce a flame after the ignition source is removed. Afterglow/smoldering is the time that a fabric continues to glow or produce smoke after the removal of the ignition source. Self-extinguishment of a fabric occurs when any visible flaming, glowing or smoldering is absent at any time during the observation period, after the ignition source is removed. The test operators were asked to indicate with a small diagram the char pattern for each fabric tested.

The dust cover and skirt fabrics were tested by themselves, in single layers. The skirt fabrics were hemmed approximately 1/2 inch at the bottom edge with a double hem[3]. The seating area fabrics were tested over non-flame retardant (FR) foam having a density of 1.5 lbs/ft^3.

The conditioning requirements specified in the draft protocol were followed. All test specimens were conditioned for at least 24 hours at 25 $\pm$ 2°C and between 40 to 55% relative humidity.

In the small in-house evaluation, each of the test operators used a different model of the same test fixture in their testing. All of the test operators tested the three dust cover fabrics first, then the three skirt fabrics followed by the three seating area fabrics. Four specimens of each fabric were tested.

RESULTS

The results this series of tests are discussed below. The results of the single test operator evaluation of the test procedures are presented in Tables 2 - 4; the results of the in-house evaluation study are presented in Tables 5 - 7.

In the individual evaluation of the test procedures, the test operator reported consistent results with all four of the specimens of all three dust cover fabrics (Table 2). As expected, the thermoplastic and aramid dust covers did not ignite, while the thermoplastic/cellulosic blend dust cover fabric ignited and did not self-extinguish.

TABLE 2
DUST COVER FABRICS

FABRIC	RESULTS
100% polypropylene	0 ignitions, 0 self-extinguished
thermoplastic/cellulosic blend	4 ignitions, 0 self-extinguished
100% aramid	0 ignitions, 0 self-extinguished

The skirt test results of the individual evaluation are shown in Table 3. The test operator reported consistent results with two of the fabrics; the wool and the cellulosic/thermoplastic blend fabrics. Two specimens of the cellulosic/thermoplastic blend fabric with the FR backcoating ignited and two did not. The two specimens that did not ignite, self-extinguished as the burner flame was withdrawn. The two specimens that ignited had very short afterflame times of 1 and 5 seconds. The observed variability among the FR backcoated specimens was minor in terms of flammability performance. These results were consistent with results obtained when other CPSC laboratory staff tested these same fabrics.

TABLE 3
SKIRT FABRICS

FABRIC	RESULTS
cellulosic/thermoplastic blend, flame retardant backcoating	2 ignitions, 2 self-extinguished
wool	0 ignitions, 0 self-extinguished
cellulosic/thermoplastic blend	4 ignitions, 0 self-extinguished

The results of the seating area testing for the single test operator are shown in Table 4. The test operator reported consistent results with all three fabrics for all specimens tested. As expected, the FR backcoated and wool fabrics did not ignite while the blend fabric ignited and did not self-extinguish.

TABLE 4
SEATING AREA FABRICS

FABRIC	RESULTS
cellulosic/thermoplastic blend, flame retardant backcoating	0 ignitions, 0 self-extinguished
wool	0 ignitions, 0 self-extinguished
cellulosic/thermoplastic blend	4 ignitions, 0 self-extinguished

The results of the in-house study are presented in Tables 5 through 7. In addition, a summary of the three test operators' comments are included in Appendix A. The results of the dust cover testing for the in-house study are shown in Table 5. With one exception, all three test operators reported the same results. Test Operator B reported somewhat different results than the other two test operators when testing the polypropylene fabric. None of the polypropylene specimens ignited when tested by Tester B. Tester A and C had one specimen of the polypropylene dust cover fabric that ignited, burned slowly and self-extinguished upon reaching the edge of the metal frame holding the specimen.

TABLE 5
DUST COVER FABRICS

FABRIC	NUMBER OF IGNITIONS		
	Tester A	Tester B	Tester C
100% polypropylene	1	0	1
thermoplastic/cellulosic blend	4	4	4
100% aramid	0	0	0

The results of the skirt testing are shown in Table 6. Test Operators A and C reported the same results when testing the skirt fabrics. Test Operator B reported somewhat different results for two of the skirt fabrics, the wool and the cellulosic/thermoplastic blend. In the case of the wool fabric, one of the specimens

did not ignite and the flame was described as "slightly wobbly" when it reached that specimen. Two of the cellulosic/thermoplastic blend fabrics did not ignite when tested by Tester B. In both cases the test operator reported that the flame did not touch the lower edge of the specimen. This explains why these two specimens did not ignite as previous tests indicate that this fabric tends to ignite readily and burn rapidly. Test Operator B may not have made the necessary adjustments to the burner/flame indicator tip to position it correctly under the specimen edge. Correctly adjusted, the burner/flame indicator tip should be positioned to just touch the specimen edge. This assures that during an actual test, the burner flame moves into position and the tip of the flame touches the specimen edge.

TABLE 6
SKIRT FABRICS

FABRIC	NUMBER OF IGNITIONS		
	Tester A	Tester B	Tester C
cellulosic/thermoplastic blend, flame retardant backcoating	4	4	4
wool	4	3	4
cellulosic/thermoplastic blend	4	2	4

The results of the seating area testing are shown in Table 7. All three test operators reported the same results for two of the seating area fabrics, the wool and both of the cellulosic/thermoplastic blend fabrics. Test Operator A reported different results for the FR backcoated cellulosic/thermoplastic blend fabric. Test Operator A reported 3 ignitions and one non-ignition for this fabric. This FR backcoated fabric does not ignite easily, (30 seconds in the seat mockup was the reported time in an earlier study[2]) and self-extinguishes readily. At less than 30 seconds this fabric burns only when the flame is in contact with the fabric. The test operator may have concluded an ignition of the fabric had occurred while the burner flame was still in contact with the mockup.

TABLE 7
SEATING AREA FABRICS

FABRIC	NUMBER OF IGNITIONS		
	Tester A	Tester B	Tester C
cellulosic/thermoplastic blend, flame retardant backcoating	3	0	0
wool	0	0	0
cellulosic/thermoplastic blend	4	4	4

CONCLUSION

There was some minor variability in the test results obtained during the single test operator evaluation of the test procedures and fixture. The skirt tests with the FR backcoated fabric produced variable results. This variability may be attributed to fabric flammability itself. In addition, the FR backcoated fabric, in the skirt location may be sensitive to ignition/non-ignition or to flame instability. Additional testing can provide insight into this issue.

There was also some variability in the test results obtained during the small in-house evaluation study of the test procedures and fixture. Some of the variability may have been due to operator error, incorrect burner/flame tip indicator positioning and a misunderstanding as to the meaning of specific flammability terms/when to record observations. Variability may also be due to failure on the operator's part to properly observe during the test, as in the case of the FR fabric in the seat mockup tests. Other variability can be attributed to localized air currents which caused burner flame instability; again, this may have contributed to the reported ignitions in the seat mockup by one of the test operators. These issues can be addressed by making changes in the instructions/guidance given to participants in the small interlaboratory evaluation with special emphasis on the importance and necessity of careful observation during the tests. In addition, making adjustments to the test fixture/test room conditions so a steady flame is delivered to the test specimen will also address burner flame instability.

Variability may also be attributed to fabric flammability itself. In the case of the polypropylene dust cover, polypropylene tends to melt and shrink away from the flame source. However if flame contact is maintained, polypropylene does burn slowly[4]. This could have occurred if the flame were not carried away from the specimen by the melting/dripping that often occurs. Continued flame contact on the polypropylene fabric after initial melting could also have been caused by air currents. This issue can only be addressed through increasing the number of tests required and by maintaining a non-turbulent environment.

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APPENDIX A

Summary Of Comments From Three In-House Test Operators

- Too many adjustments to make; adjustments too complicated.
- Rename flame in/out switch so that "in" means into the sample; "out" means out to the operator.
- Timer not always responsive to the time set.
- Clips on dust cover frame make the frame hard to position.
- Surprised that still need to make individual adjustments for each seat mockup.
- Need separate flame height gage for horizontal position.
- Terms after-glow and smoldering could use further clarification.
- Measurement of char can be problematic.
- Difficult to measure (with any accuracy) more than one thing with the stopwatch: (after flame, afterglow, 2 minute maximum test time).
- Cut notch deeper in fabric specimen for seat mockup.
- Specimen numbers should be visible from the front of the assembly.
- Need a directional marking on the small horizontal piece of foam to prevent assembly mistakes.

United States
CONSUMER PRODUCT SAFETY COMMISSION
Washington, D.C. 20207

MEMORANDUM

DATE: September 25, 1996

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

Through: Andrew G. Ulsamer, Ph.D., Associate Executive Director, AGU
Directorate for Laboratory Sciences

FROM : Linda Fansler, Division of Engineering Laboratory LF

SUBJECT: Ignition Time Tests For Interlaboratory Evaluation Fabrics

The Directorate for Laboratory Sciences has conducted tests to determine the ignition times (with a small butane flame) of four upholstery fabrics and three dust cover fabrics. These fabrics were chosen for use in the small interlaboratory evaluation conducted in September 1996 because they represent a range of resistance to small open flame ignition.

BACKGROUND

As part of the upholstered furniture project, CPSC staff developed a draft test protocol to evaluate the small open flame ignition resistance of three locations on upholstered furniture. The protocol, entitled "Bench Scale Test Method For Upholstered Furniture Ignition Resistance To Small Open-Flame Sources"[1], specifies that a small butane flame be applied to mockups representing the seating area, the skirt and the dust cover. A test fixture that automatically controls the placement of the flame and the time that the flame is applied was used for all tests. This fixture was designed and constructed by staff at the Engineering Laboratory.

Four upholstery fabrics and three dust cover fabrics were purchased for the interlaboratory evaluation. These fabrics were chosen to represent a range of resistance to ignition from a small flame source. A description of the fabrics and their locations on upholstered furniture are listed in Table 1 below.

[1] Superscript refers to references on page 6.

TABLE 1
UPHOLSTERY FABRICS AND LOCATIONS

FABRIC DESCRIPTION	LOCATION ON UPHOLSTERED FURNITURE
60% rayon, 36% polyester, and 4% cotton, flame retardant backcoating	skirt and seating area
100% wool	skirt and seating area
100% cotton	skirt and seating area
56% rayon, 34% polyester, and 10% cotton	skirt and seating area
100% polypropylene - nonwoven	dust cover
100% aramid - nonwoven	dust cover
cellulosic/thermoplastic blend - woven	dust cover

The wool and flame retardant (FR) treated fabric were chosen because they are resistant to small open flame.[2] The cellulosic fabric was included in this interlaboratory evaluation because heavy weight cellulosic fabric offers an intermediate degree of resistance to small open flame by forming a char that protects the filling material underneath until the char splits.[2] The thermoplastic fabrics provide no resistance because they tend to melt and shrink away from a flame exposing any filling material present; the thermoplastics can also burn.[2] The 100% aramid fabric was chosen as it is inherently flame resistant.[3]

TEST PROGRAM

The objective of the test program was to determine the time to ignition of a small selection of upholstery and dust cover fabrics. The fabrics were tested following the draft bench scale protocol[1] prepared by the Directorate for Engineering Sciences. The fabrics were exposed to the butane flame until ignition occurred. The established ignition times for these fabrics will be used to determine the appropriate flame application times for the interlaboratory evaluation.

In addition to the various flame application times, other observations were recorded, including afterflame, afterglow/smoldering times and whether the specimen self-extinguished. Afterflame is the time that the fabric continues to produce a flame after the ignition source is removed. Afterglow/smoldering is the time that a fabric continues to glow or produce smoke after the removal of the ignition source.

Self-extinguishment of a fabric occurs when any visible flaming, glowing or smoldering disappeared at any time during the observation period after the ignition source is removed.

The dust cover and skirt fabrics were tested by themselves. The skirt fabrics were hemmed approximately 1/2 inch at the bottom edge. The seating area fabrics were tested over non-FR foam having a density of 1.5 lbs/ft^3.

The conditioning requirements specified in the draft protocol were followed. All test specimens were conditioned for at least 24 hours at 25 $\pm$ 2°C and between 40 to 55% relative humidity.

RESULTS

The results of the time to ignition evaluation are presented in Tables 2 through 4. The results of the dust cover evaluation are shown in Table 2. Two of the dust cover fabrics did not ignite. The nonwoven polypropylene melted away from the flame creating a hole in the fabric about 1 inch in diameter. The nonwoven aramid fabric discolored but did not allow the flame to break through when the flame was applied up to 2 minutes. The woven blend fabric ignited in 2 seconds, burned rapidly with the specimen being consumed in 5 seconds.

TABLE 2
TIME TO IGNITION OF DUST COVER FABRICS

FABRIC	TIME TO IGNITION
100% polypropylene	did not ignite - flame applied up to 15 seconds, melted away from the flame
thermoplastic/cellulosic blend	2 seconds - specimen consumed
100% aramid	did not ignite - flame applied up to 120 seconds

The results of the skirt fabric evaluation are shown in Table 3. All four of the skirt fabrics ignited with two of them self-extinguishing. The FR backcoated fabric ignited in a flame application range of between 2 to 3 seconds with 6 to 9 seconds of afterflame and then self-extinguished. The wool fabric ignited in 6 seconds with 5 to 8 seconds afterflame then self-extinguished. The cotton and blend fabrics ignited within 5 seconds and did not self-extinguish. The cotton fabric burned more slowly than the blend fabric but was consumed in 65 to 70 seconds. The blend fabric burned more rapidly and was consumed in 20 seconds.

TABLE 3
TIME TO IGNITION OF SKIRT FABRICS

FABRIC	TIME TO IGNITION
cellulosic/thermoplastic blend, flame retardant backcoating	2 to 3 seconds with 6 to 9 seconds of afterflame then self-extinguished
wool	6 seconds with 5 to 8 seconds of afterflame then self-extinguished
cotton	4 seconds - specimens consumed in 65 to 70 seconds
cellulosic/thermoplastic blend	3 to 5 seconds - specimens consumed in 20 seconds

The results of the seating area fabric evaluation are shown in Table 4. All four of the seating area fabrics ignited but two of them self-extinguished. The FR backcoated fabric ignited when the flame was applied for 30 seconds but self-extinguished after 12 seconds of afterglow. The wool seating area fabric ignited in 25 to 30 seconds but afterflame times ranged from 1 second with self-extinguishment to greater than 120 seconds, while burning slowly. The cotton seating area fabric ignited in 16 to 18 seconds of flame application with afterflame times of greater than 120 seconds while burning slowly. The blend fabric ignited in 7 to 10 seconds with afterflame times also greater than 120 seconds, however this fabric burned rapidly.

TABLE 4
TIME TO IGNITION FOR SEATING AREA

FABRIC	TIME TO IGNITION
cellulosic/thermoplastic blend, flame retardant backcoating	30 seconds with 12 seconds of afterglow before self-extinguishing
wool	25 to 30 seconds with 1 second of afterflame before self-extinguishing or continuing to burn slowly beyond 120 seconds
cotton	16 to 18 seconds, continues to burn slowly beyond 120 seconds
cellulosic/thermoplastic blend	7 to 10 seconds, continues to burn rapidly beyond 120 seconds

CONCLUSION

Based on the results of this study, a 5 second flame application time for the dust cover and skirt fabrics and 15 and 20 second flame application times for the seating area fabrics will be used in the interlaboratory evaluation.

For dust covers a flame application time of 5 seconds discriminates between a fabric that is easily ignitable, one that does not ignite and remains intact and another that does not ignite but melts away from the flame potentially exposing anything above it to the source of ignition. (See Table 2.)

For skirts a flame application time of 5 seconds provides for two fabrics that ignite easily, one fabric melting away from the flame and burning rapidly and the other fabric burning more slowly. A third fabric will ignite but self-extinguish and the fourth fabric may exhibit borderline behavior by either not igniting or igniting and then self-extinguishing. (See Table 3.)

For the seating area fabrics two flame exposure times (15 and 20 seconds) were chosen to maximize sensitivity. The 15 second flame application time discriminates between a fabric that is easily ignitable and burns rapidly and another fabric that may exhibit borderline ignition behavior with a 15 second flame application. The two other fabrics won't ignite with a 15 second application time. The 20 second flame application time identifies two fabrics that are easily ignitable, one burning more rapidly than the other. The two remaining fabrics won't ignite with a 20 second flame application time. (See Table 4.)

REFERENCES

1. "Bench Scale Test Method For Upholstered Furniture Ignition Resistance To Small Open-Flame Sources", draft, February 1996, Consumer Product Safety Commission, Directorate For Engineering Sciences.

2. NBS Monograph 173, "Fire Behavior of Upholstered Furniture", Vytenis Babrauskas and John Krasny, November 1985.

3. DuPont Thermablock™ Kevlar® Z-11 product information available from DuPont Advanced Fibers Systems.

United States
CONSUMER PRODUCT SAFETY COMMISSION
Washington, D.C. 20207

MEMORANDUM

DATE: September 25, 1996

TO : Dale Ray, Directorate for Economic Analysis,
Project Manager Upholstered Furniture
Through: Andrew G. Ulsamer, Ph.D., Associate Executive Director, AGU
Directorate for Laboratory Sciences
FROM : Linda Fansler, Division of Engineering Laboratory LF

SUBJECT: Cigarette Ignition Resistance of Interlaboratory Evaluation Fabrics

The Directorate for Laboratory Sciences recently completed tests to determine the cigarette ignition resistance of four upholstery fabrics. These upholstery fabrics represent a range of resistance to ignition from a small open flame source and will be used in the interlaboratory evaluation planned for September. The fabrics tested were: a cellulosic/thermoplastic blend fabric with a flame retardant (FR) backcoating, a wool fabric, a cotton fabric and a cellulosic/thermoplastic blend fabric.

BACKGROUND

Some individual components of upholstered furniture may have good cigarette ignition resistance but poor small flame ignition resistance whereas other components may be resistant to a small open flame source but not to cigarette ignition. For example, increasing the amount of thermoplastic materials (fabrics and filling) increases the cigarette ignition resistance because a large portion of the heat from the cigarette is consumed in melting the thermoplastic fibers and the thermoplastics do not smolder along with the cigarette. However, thermoplastic fabrics melt or burn and shrink away from open flame exposing the filling materials below.[1]

Cellulosic materials behave quite differently. Increasing the amount of cellulosic materials (fabrics and filling) decreases cigarette ignition resistance as cigarettes induce smoldering in medium to heavy weight cellulosic fabrics. Medium or heavy weight cellulosic fabrics, however, burn and form a char in response to open flame. Until the char breaks the filling below is protected.[1]

[1] Superscript refers to references on page 5.

The cigarette ignition resistance of cellulosic/thermoplastic blends falls somewhere between 100% cellulosic and thermoplastic fabrics depending upon the percentage of thermoplastic fibers present in the blend. Again, the greater percent of thermoplastic fibers present, the more likely the fabric will shrink and curl away from the open flame.[1]

TEST PROGRAM

The objective of the test program was to evaluate the cigarette ignition resistance of four upholstery fabrics. These fabrics were purchased for the limited interlaboratory evaluation planned for September 1996. The fabrics were selected for the interlaboratory study because they represent a range of ignition resistance to small open flame and also a range of post ignition behaviors or fire growth.[2]

The Fabric Classification Test Method[3], part of the Upholstered Furniture Action Council (UFAC) Voluntary Program was used to evaluate the cigarette ignition resistance of the four upholstery fabrics. In order for a UFAC member to use the UFAC hang tag, the firm must use upholstery fabrics that have been classified as Class I or Class II by the UFAC Fabric Classification Test Method.

The UFAC Fabric Classification Test Method is intended as the means of establishing the performance level of upholstery cover fabrics in contact with polyurethane foam with respect to cigarette ignition resistance.[3] A small scale mockup is used (figure 1). The mock-up consists of two square pieces of wood, each nominally 8 inches by 8 inches by 0.75 inch thick and are joined at one edge. Vertical and horizontal panels containing the upholstery fabric over a standard foam substrate are placed in the mockup. Unfiltered Pall Mall cigarettes are used as the ignition source and are placed in the crevice formed at the intersection of the two panels. The cigarette is covered with a 5 inch by 5 inch piece of unlaundered cotton sheeting fabric during the test. A minimum of three test specimens are required for each upholstery fabric to be classified. Fabrics with a vertical char of less than 1.75 inches above the mockup crevice are Class I. All other fabrics are Class II and require (by the UFAC Voluntary Program) an approved barrier between the cover fabric and conventional polyurethane foam in the horizontal seating surface.

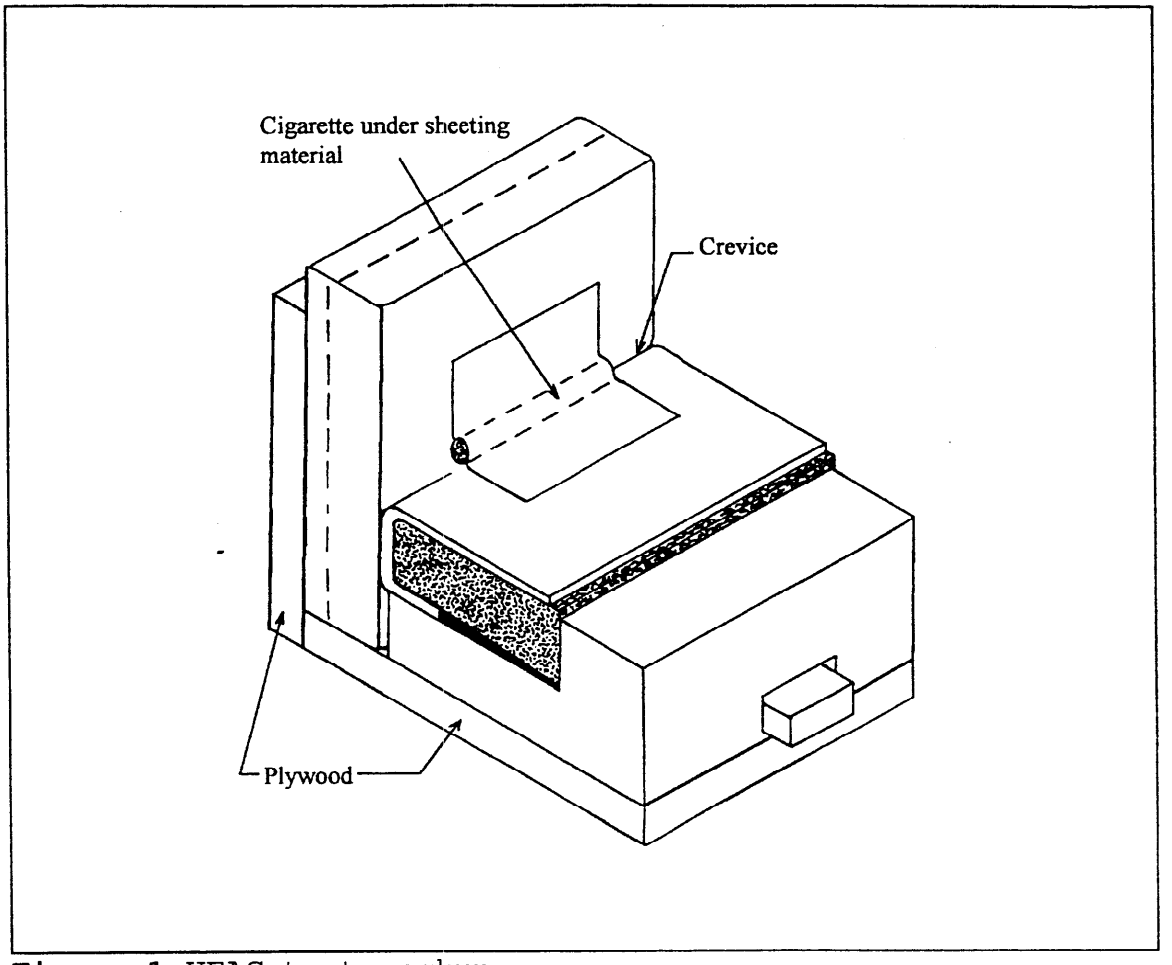

Figure 1 UFAC test mockup

The conditioning requirements as specified in the UFAC Fabric Classification Test Method were followed. These requirements specify that standard materials and test specimens be conditioned for at least 4 continuous hours prior to testing at a temperature of 21± 3°C (70± 5°F) and 50 to 60% relative humidity.

RESULTS

All four of the upholstery fabrics were determined to be UFAC Class I. The cigarettes placed on the 100% cotton and cellulosic/thermoplastic blend fabric burned their entire length. The vertical char lengths for these two fabrics were 1/2 inch or less.

The cigarettes placed on the wool and FR backcoated fabric self-extinguished. The vertical char lengths for these fabrics were less than 1/2 inch.

The fiber content of each fabric and their resistance to smoldering (cigarette) and small open flame ignition are presented in Table 1.

TABLE 1
SMALL FLAME AND SMOLDERING IGNITION RESISTANCE

FABRIC	RESISTANCE TO SMALL OPEN FLAME[2]	RESISTANCE TO SMOLDERING (CIGARETTE) IGNITION
60% rayon, 36% polyester, and 4% cotton, flame retardant backcoating	ignites at 30 seconds, self-extinguishes in 12 seconds	cigarettes self extinguished, char <½
100% wool	ignites at 25 to 30 seconds, self-extinguishes in 1 second or continues to burn slowly beyond 120 seconds	cigarettes self extinguished, char <½
100% cotton	ignites at 16 to 18 seconds, continues to burn slowly beyond 120 seconds	cigarettes burned their entire length, char ≤ ½
56% rayon, 34% polyester, and 10% cotton	ignites at 7 to 10 seconds, continues to burn rapidly beyond 120 seconds	cigarettes burned their entire length, char ≤ ½

CONCLUSION

All four fabrics tested for smoldering cigarette ignition were found to be UFAC Class I fabrics. In addition, cigarettes placed on both the 100% wool and FR backcoated blend fabrics self-extinguished. Both of these fabrics ignited when a small open flame was held to them for 30 and 25 to 30 seconds respectively and then self-extinguished although, the wool fabric sometimes continued burning beyond 120 seconds. The 100% cotton and non-FR blend fabrics ignited and burned when a small open flame was applied for 16 to 18 and 7 to 10 seconds respectively.

REFERENCES

1. NBS Monograph 173, "Fire Behavior of Upholstered Furniture", Vytenis Babrauskas and John Krasny, November 1985.

2. Memorandum To Dale Ray From Linda Fansler, LSEL, Ignition Time Tests For Interlaboratory Evaluation Fabrics, September 25, 1996, Consumer Product Safety Commission.

3. UFAC Test Methods, Upholstered Furniture Action Council, 1990.

United States
CONSUMER PRODUCT SAFETY COMMISSION
Washington, D.C. 20207

MEMORANDUM

DATE: October 3, 1996

TO : Dale Ray, Directorate for Economic Analysis,
Project Manager Upholstered Furniture
Through: Andrew G. Ulsamer, Ph. D., Associate Executive Director, AGU
Directorate for Laboratory Sciences
FROM : Linda Fansler, Division of Engineering Laboratory LF

SUBJECT: Ignition Time Tests For A Range of Upholstery Fabrics

The Directorate for Laboratory Sciences recently conducted tests to determine the ignition times (with a small butane flame) of a range of 22 upholstery fabrics that may be used in seating areas of upholstered furniture. These fabrics represent 14 different fibers or fiber blends, a variety of fabric weights from medium to heavy weight and one flame retardant (FR) backcoated fabric. The majority of the fabrics were taken from the remaining chairs purchased for the cigarette phase of the upholstered furniture project; four of the fabrics are from the interlaboratory evaluation study[1].

The established ignition times for these fabrics along with ignition times for those fabrics included in the interlaboratory evaluation held in September 1996 will aid in CPSC staff's better understanding of upholstered furniture flammability. This information will be considered by CPSC staff when determining the appropriate flame application time for a proposed upholstered furniture standard.

BACKGROUND

As part of the upholstered furniture project, staff from the Directorate for Engineering Sciences developed a draft test protocol to evaluate small open flame ignition resistance of three locations on upholstered furniture. The protocol, entitled "Bench Scale Test Method For Upholstered Furniture Ignition Resistance To Small Open-Flame Sources"[2], specifies that a small butane flame be applied to mockups representing the seating area, the skirt and the dust cover. A test fixture that automatically controls the placement of the flame and the time the flame is applied was used for these tests. The test fixture was designed and constructed by staff at the Engineering Laboratory.

[1] Superscript refers to references on page 5.

TEST PROGRAM

The objective of the test program was to determine the times to ignition of a variety of upholstery fabrics when tested over conventional upholstery foam in a typical seating area configuration. The majority of the fabrics included in this study were taken from upholstered chairs originally purchased for the cigarette ignition phase of the upholstered furniture project.[3] Four of the fabrics are those fabrics used in the interlaboratory evaluation.

The 22 fabrics included in this study represent 14 different fibers or fiber blends, a variety of fabric weights from medium to heavy weight and one FR backcoated fabric. Although this collection of fabrics was not a random selection, these fabrics, with the exception of the FR backcoated fabric, represent common fabrics used on upholstered furniture.

The fabrics were tested following the draft protocol[1] using the seating mockup procedure. The fabric covered seating mockups were exposed to the butane flame until ignition occurred.

In addition to the various flame application times, other observations were recorded, including afterflame, afterglow/smoldering times and whether the specimen self-extinguished. Afterflame is the time that the fabric continues to produce a flame after the ignition source is removed. Afterglow/smoldering is the time that a fabric continues to glow or produce smoke after the removal of the ignition source. Self-extinguishment of a fabric occurs when any visible flaming, glowing or smoldering disappeared at any time during the observation period after the ignition source is removed.

These fabrics were tested in the seating mockup configuration over non-FR foam having a density of 1.5 lbs/ft^3 . All fabric and foam specimens were conditioned for at least 24 hours to the conditions specified in the draft protocol, 25 $\pm$ 2°C and between 40 to 55% relative humidity.

RESULTS

The results of the time to ignition evaluation are presented in Table 1. The time to ignition of the four upholstery fabrics used in the interlaboratory evaluation are included, in addition to the results of the 18 fabrics collected from the cigarette ignition phase chairs. The numbers assigned to the fabrics in Table 1 are the same as those used to identify the chairs tested in the cigarette ignition phase of the upholstered furniture project.

TABLE 1
TIME TO IGNITION FOR UPHOLSTERY FABRICS

FABRIC NO.	FABRIC CONSTRUCTION	FIBER CONTENT/ FABRIC WT. (oz/yd^2)	TIME TO IGNITION (seconds)
72	plain	olefin/6.0	4 to 5
37	plain	acrylic/polyester/6.6	4
56	plain	acrylic/6.8	4 to 5
54	plain	polyester/rayon/6.9	7
53	plain	cotton/polyester/7.0	5 to 6
77	plain	cotton/7.1	7 to 8
48	plain	rayon/cotton/polyester/8.2	6 to 8
75	plain	cotton/polyester/olefin/8.8	6
interlab. eval. fabric	plain	rayon/polyester/cotton/10.3	7 to 10
interlab. eval. fabric	plain	rayon/polyester/cotton/11.9	30*
81	plain	acrylic/olefin/cotton/15.2	11 to 12
82	plain	nylon/14.2	12
73	print	cotton/6.2	7 to 8
74	jacquard	polyester/rayon/8.5	7 to 8
64	jacquard	cotton/polyester/11.8	9 to 10
interlab. eval. fabric	jacquard	wool/10.7	25 to 30**
interlab eval. fabric	twill	cotton/12	16 to 18
30	pile - velvet	nylon/cotton/polyester/7.9	19 to 20
28	pile-velvet	polyester/olefin/10.1	7 to 8
83	pile - suede	polyester/11.0	12 to 13
62	pile - velvet	acrylic/cotton/poly/11.2	11 to 12
34	pile - corduroy	acrylic/polyester/12.6	8

* Flame retardant backcoating - fabric self-extinguished.
** Fabric may self-extinguish.

The ignition times for this group of fabrics ranged from 4 seconds to 30 seconds. In general, it appears that resistance to small flame ignition depends more on fabric weight than fiber content for non-FR treated fabrics. The heavier weight fabrics, around 10.0 oz/yd^2 and above resisted the small butane flame longer than fabrics weighing less than 10.0 oz/yd^2, (4 to 8 seconds as compared to 7 to 30 seconds). Fabric number 30, a 7.9 oz/yd^2 fabric, is an exception with a time to ignition range of 19 to 20 seconds.

This exception may be due to fabric construction. Fabric number 30 was a velvet, a pile surface fabric. Other pile surface fabrics, numbers 28, 34, 62 and 83 also had longer times to ignition, between 7 to 30 seconds. However these pile fabrics were all in a heavier weight range (10.1 to 12.6 oz/yd^2) than fabric number 30.

The ignition time for the FR treated fabric, 30 seconds with the fabric self-extinguishing, was due more to the FR backcoating than the fabric weight. An interlaboratory fabric with the same fiber content but not backcoated with an FR treatment, was also a heavier weight fabric but had an ignition range of 7 to 10 seconds.

Two of the interlaboratory evaluation fabrics ignited but self-extinguished. The wool fabric ignited in 25 to 30 seconds, but afterflame times ranged from 1 second with self-extinguishment to greater than 120 seconds, while burning slowly. The FR backcoated fabric ignited when the flame was applied for 30 seconds but self-extinguished after 12 seconds of afterglow.

CONCLUSION

A range of ignition times from 4 seconds to 30 seconds was established for these 22 upholstery fabrics. Fabric weight is an important factor in the ignition of upholstery fabrics when tested over conventional upholstery foam with a small butane flame. Heavier weight fabrics, more than 10 oz/yd^2, although they did ignite, had better small flame ignition resistance than upholstery fabrics weighing less than 10 oz/yd^2. Fabric construction, as in the case of pile fabrics, may also contribute to small open flame ignition resistance, however, more testing to confirm this is needed.

Among those fabrics tested, wool fabric and fabric treated with an FR backcoating resisted ignition the longest. In addition, once ignited they both may self-extinguish.

REFERENCES

1. Memorandum To Dale Ray From Linda Fansler, LSEL, Ignition Time Tests For Interlaboratory Evaluation Fabrics, September 25, 1996, Consumer Product Safety Commission.

2. "Bench Scale Test Methods For Upholstered Furniture Ignition Resistance To Small Open-Flame Sources", draft, February 1996, Consumer Product Safety Commission, Directorate For Engineering Sciences.

3. "Upholstered Furniture Flammability Testing: Cigarette Ignition Data Analysis", July 17, 1996, Gail Stafford and Linda Fansler, Consumer Product Safety Commission.

United States
CONSUMER PRODUCT SAFETY COMMISSION
Washington, D.C. 20207

MEMORANDUM

DATE: October 3 , 1996

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

Through: Andrew G. Ulsamer, Ph.D.,Associate Executive Director, AGU
Directorate for Laboratory Sciences

FROM : Linda Fansler, Division of Engineering Laboratory LF

SUBJECT: Ignition Time Tests With Flame Retardant Foams And
Polyester Batting

The Directorate for Laboratory Sciences recently conducted limited small open flame testing to determine the effects on fabric ignition in seating area mockup tests of: 1) flame retardant (FR) treated foam as the filling material and 2) combining polyester batting with non-FR foam. Ignition time tests were conducted using two of the upholstery fabrics included in the interlaboratory evaluation, a cellulosic and cellulosic/thermoplastic blend. The results of these tests are compared with those previously obtained using conventional non-FR foam as the filling material.

BACKGROUND

As part of the upholstered furniture project, staff from the Directorate for Engineering Sciences developed a draft test protocol to evaluate small open flame ignition resistance of three locations on upholstered furniture. The protocol, entitled "Bench Scale Test Method For Upholstered Furniture Ignition Resistance To Small Open-Flame Sources"[1], specifies that a small butane flame be applied to mockups representing the seating area, the skirt and the dust cover. A test fixture that automatically controls the placement of the flame and the time the flame is applied was used for these tests. The test fixture was designed and constructed by staff at the Engineering Laboratory.

The two upholstery fabrics used in these tests were initially tested as part of the ignition time test study[2] of the fabrics used in the interlaboratory evaluation. In that study, a total of four upholstery fabrics were tested over a conventional non-FR foam

[1] Superscript refers to references on page 4.

in a seating mockup. Times to ignition were reported as being between 7 and 18 seconds for the cellulosic and cellulosic/thermoplastic blend fabrics.[2] Many other types of filling material are used in upholstered furniture in addition to non-FR foam. One type, polyester batting, is commonly found in upholstered furniture between the upholstery fabric and the foam in the back, seat and side areas.

FR treated foam is also used in some instances in upholstered furniture. An example of this is residential furniture made to meet the regulations in the State of California[3] or the United Kingdom[4]. Although resistance to a small open flame depends more on the fabric than the filling material, self-extinguishment after small flame ignition of upholstery fabrics is more likely with an FR treated foam than a non-FR foam.[5]

TEST PROGRAM

The objective of this test program was to determine the time to ignite of upholstery fabrics when filling materials other than conventional non-FR foam were used in the seating mockup.

In the first set of tests, garnetted polyester fiber batting weighing approximately 2 oz/ft^2 was placed between a cellulosic/thermoplastic blend upholstery fabric and the foam on a seating area mockup. The foam was a non-FR treated foam with a density of 1.5 lbs/ft^3.

In the second set of tests, two types of FR foams were used with a cellulosic and cellulosic/thermoplastic upholstery fabrics. These foams were taken from chairs intended to meet existing open flame standards in the State of California (Technical Bulletin 117) and the United Kingdom (The Furniture and Furnishings Regulations 1988). These chairs/foams were left over from the full scale open flame test program and are described fully in the report titled "Upholstered Furniture Flammability: Full Scale Open Flame Data Analysis"[6].

The draft test protocol prepared by the Directorate for Engineering Sciences was followed. Different flame application times were tried until a time to ignition or range of times to ignition was established.

In addition to the various flame application times, other observations were recorded, including afterflame, afterglow/smoldering times and whether the specimen self-extinguished. Afterflame is the time that the fabric continues to produce a flame after the ignition source is removed. Afterglow/smoldering is the time that a fabric continues to glow or produce smoke after the removal of the ignition source. Self-extinguishment of a fabric occurs when any visible flaming, glowing or smoldering is absent at any time during the observation period after the ignition source is removed.

The conditioning requirements specified in the draft protocol were followed. All test specimens were conditioned for at least 24 hours at 25 ± 2°C and between 40 to 55% relative humidity.

RESULTS

The results are presented in Tables 1 and 2. Table 1 shows the ignition times for the cellulosic/thermoplastic blend fabric with and without the addition of the polyester batting. When the polyester batting was present, the cellulosic/thermoplastic blend fabric appeared to ignite slightly faster with the "fabric splitting apart quickly" as reported by the test operator. During the tests the polyester batting melted through to the foam underneath.

TABLE 1
TIME TO IGNITE WITH AND WITHOUT POLYESTER BATTING

FABRIC	IGNITION TIMES	
	POLY BATTING AND NON-FR FOAM	NON-FR FOAM[2]
cellulosic/thermoplastic	6 to 8 seconds	7 to 10 seconds

Table 2 shows that the ignition times of the cellulosic and cellulosic/thermoplastic blend fabrics were not appreciably different when tested over FR and non-FR foams. The presence of an FR foam did not cause these fabrics to self-extinguish once ignited. In addition, while the two FR foams did not ignite themselves, the heat transferred from the fabric melted away the foam behind the burning fabric. A visual examination of the two FR foams after testing, revealed that similar amounts of foam had melted away during tested. This was also the case with the non-FR foam.

TABLE 2
TIME TO IGNITE WITH FR FOAM AND NON-FR FOAM

FABRIC	FR FOAM		NON-FR FOAM[2]
	CALIFORNIA	UNITED KINGDOM	
cotton	16 to 17 seconds	17 to 18 seconds	16 to 18 seconds
cellulosic/thermoplastic blend	8 to 9 seconds	7 seconds	7 to 10 seconds

CONCLUSION

This limited testing suggests that the addition of polyester batting between an upholstery fabric and conventional non-FR foam, did not improve the ignition resistance for the fabric tested. The two FR foams tested also did not improve the ignition resistance of two relatively easy to ignite upholstery fabrics. In addition, once ignited, the upholstery fabrics continued to burn. Results were similar to those obtained when these two fabrics were tested over non-FR foam.

REFERENCES

1. "Bench Scale Test Methods For Upholstered Furniture Ignition Resistance To Small Open-Flame Sources", draft, February 1996, Consumer Product Safety Commission, Directorate for Engineering Sciences.

2. Memorandum To Dale Ray From Linda Fansler, LSEL, Ignition Time Tests For Interlaboratory Evaluation Fabrics, September 25, 1996, Consumer Product Safety Commission.

3. Technical Bulletin 117, State of California, Department of Consumer Affairs, Bureau of Home Furnishings And Thermal Insulation, January 1980.

4. The Furniture And Furnishings (Fire) (Safety) Regulations 1988, United Kingdom, 1988 No. 1324.

5. NBS Monograph 173, "Fire Behavior of Upholstered Furniture", Vytenis Babrauskas and John Krasny, November 1985.

6. "Upholstered Furniture Flammability Testing: Full Scale Open Flame Data Analysis", February 26, 1996, Consumer Product Safety Commission, Directorate for Laboratory Sciences, Engineering Laboratory.

United States
CONSUMER PRODUCT SAFETY COMMISSION
Washington, D.C. 20207

MEMORANDUM

DATE: February 4, 1997

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

Through : Andrew G. Ulsamer, Ph.D., Associate Executive Director, AGU
Directorate for Laboratory Sciences

FROM : Frank A. Vitaliti, Division of Engineering Laboratory FAV

SUBJECT: Ignition Time Tests For A Range Of Upholstery Fabrics
With And Without Fire Blocker Backings

The Directorate for Laboratory Sciences recently conducted small open flame tests to determine the time-to-ignition performance of several upholstery fabrics with and without fire blocker backings, and a dust cover fabric. This work was performed as part of the upholstered furniture project, using a draft test protocol[1] previously developed by CPSC staff, to evaluate the small open flame ignition resistance of upholstered furniture. A small butane flame was delivered to the test material (upholstered fabric and dust cover fabric) using a test fixture, developed by CPSC staff, that accurately places the flame in a specific location for a preselected amount of time.[2]

TEST PROGRAM

The objective of the test was to determine the minimum flame application times to ignite a variety of upholstery fabrics, when tested in the seat and skirt mockups, and a dust cover fabric in the dustcover mockup.

The materials tested represent five different fabrics with and without an aramid fire blocker fabric, a flocked fiber on Kevlar®, and a nonwoven dust cover fabric blend. The fabric weights ranged from light to heavy weight, or 5.1 oz/yd^2 to 12.1 oz/yd^2. All fabrics were supplied by a manufacturer with and without the laminated fire blocker. The upholstery fabrics without the fire blocker backing are common fabrics used on upholstered furniture.

The fabrics were tested following the referenced draft protocol[1] using the seat, skirt and dust cover mockup procedures. The butane flame was applied to the fabric mockups until the fabric ignited and times-to-ignition were recorded.

The upholstery fabrics were first tested in the seat mockup over nonflame retardant foam having a density of 1.5 lbs/ft^3 and then tested in the skirt mockup. The dust cover fabric was tested in a single-layer horizontal configuration with no materials above it. All fabric and foam specimens were conditioned for at least 24 hours to the conditions specified in the draft protocol, 25 $\pm$ 2°C and between 40 and 55% relative humidity.

RESULTS

The time-to-ignition data for the test fabrics are presented in Table 1. Overall, the ignition times for this group of fabrics ranged from three seconds to 24 seconds in the seat mockup, and from one second to four seconds in the skirt mockup. The upholstery fabrics backed with fire blocker fabrics ignited in nine to 24 seconds in the seat mockup, and two to four seconds in the skirt mockup. In each instance, fabric with the fire blocker took more time to ignite (three to six seconds longer for the seat and one to two seconds longer for the skirt) than the corresponding non-backed upholstered fabrics. The microfiber velvet nylon (Fabric No. I) took the longest to ignite in the seat test while the polyester, olefin and cotton fabrics had shorter ignition times similar to each other's. Although skirt ignition times were always less than seating area ignition times for similar fabrics, this difference for the olefin (Fabric No. IV) was very slight. The differences in ignition times for the three different nylon fabrics (with or without the fire blocker) may relate to differences in fabric construction.

None of these upholstery fabrics performed as well in the seat and skirt mockups as two of the fabrics, a wool and a flame resistant backcoated fabric, included in the interlaboratory evaluation.[3] Neither of these interlaboratory fabrics ignited in under 25 seconds. Both of the previously tested fabrics have the potential to self-extinguish after the flame is removed whereas none of the fabrics tested in this study self-extinguished after ignition. The fire blocker does, however, slow down the fire penetration into the standard foam, and keeps the standard foam from melting as much as occurred in the mockups without the fire blocker.

The Nomex® and Kevlar® blend dust cover (Fabric No. VII) did not ignite even after a 120 second flame application.

TABLE 1

SMALL OPEN FLAME TIME TO IGNITION FOR SELECTED TYPICAL UPHOLSTERY FABRICS

FABRIC NO.	FIBER CONTENT	FABRIC WEIGHT (oz/yd^2)	TIME TO IGNITION FOR SEAT (seconds)	TIME TO IGNITION FOR SKIRT (seconds)	FABRIC CONSTRUC-TION
I	Nylon	7.2	21	2	microfiber velvet
Ia	Nylon w/ FB*	11.5	24	3	microfiber velvet
II	Nylon	6.9	9	2	woven jacquard
IIa	Nylon w/ FB*	11.3	12	4	woven jacquard
III	Polyester	7.4	4	1	jacquard
IIIa	Polyester w/ FB*	12.1	9	2	jacquard
IV	Olefin	5.8	3	2	woven
IVa	Olefin w/ FB*	10.1	9	3	woven
V	Cotton	5.1	6	1	printed woven
Va	Cotton w/ FB*	9.6	9	2	printed woven
VI	Nylon on Kevlar®**	5.0	11	2	nylon flocked on aramid
VII	Nomex® & Kevlar®	1.6	DUST COVER: did not ignite in 120 seconds		nonwoven blend

* FB = Fire Blocker

** Kevlar® = Fire Blocker

CONCLUSIONS

Upholstery fabrics in this study that are not backed with fire blocker fabrics ignite and burn more quickly than those that are backed with a fire blocker fabric. The observed increase in resistance to ignition for fire blocked fabrics is relatively small overall (3 to 6 seconds) and would probably not be an important factor in preventing upholstered furniture fires. The fire blocker did, however, prevent the flame from reaching the foam. The dust cover material did not ignite and would also have prevented the flame from reaching materials above it.

REFERENCES

1. "Bench Scale Test Method For Upholstered Furniture Ignition Resistance To Small Open-Flame Sources", Draft, September 1996, Consumer Product Safety Commission.

2. "Furniture Flammability Fixture, Operation Manual," September 1996, U. S. Consumer Product Safety Commission.

3. Memorandum To Dale Ray From Linda Fansler, LSEL, Ignition Time Test For Interlaboratory Evaluation Fabrics, September 25, 1996, Consumer Product Safety Commission.