UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: May 9, 2005

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

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

FROM : Weiying Tao, Ph.D. WT
Textile Technologist, Division of Electrical and Flammability Engineering

SUBJECT : Assessment of Fabric Open Flame Test Methodology*

Introduction

This report provides an assessment of a fabric classification test method proposed by the American Furniture Manufacturers Association (AFMA) in May, 2004 to be used to classify upholstered furniture cover fabrics for their resistance to small open flame ignition. This report also provides the U S Consumer Product Safety Commission's (CPSC) Laboratory Sciences (LS) staff suggestions for an alternative small open flame fabric test for possible incorporation in proposed revisions to the CPSC staff 2001 draft standard for upholstered furniture (1).

Background

On May 13, 2004, the American Furniture Manufacturers Association (AFMA) submitted a proposal to the CPSC recommending various test methods for possible inclusion in an upholstered furniture standard. One recommendation was to use a modified version of the fabric classification test method in the ASTM International D-1230, Standard Test Method for Flammability of Apparel Textiles (2). The modification is to use a 5 second flame exposure time instead of 1 second as specified in ASTM International D-1230. In order to explore the validity of the modified ASTM International D-1230 test method, AFMA sponsored a round robin study using ten upholstery fabrics. CPSC laboratory staff participated in the study and made the data available to AFMA for analysis.

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Fabric Test Methodology Overview

An effective test to evaluate the performance of upholstery cover fabrics when exposed to a small open flame requires careful consideration of many parameters including sample geometry, type and duration of ignition source, and appropriate performance criteria. Repeatability and reproducibility considerations are also important. There are several proposed methodologies under consideration. The three principal methods under consideration and assessed in this report are:

1) The AFMA proposed fabric classification test method following a modified ASTM D-1230 protocol;
2) The 20 second small open flame mockup test method, detailed in the CPSC's staff 's 2001 proposed draft standard (1); and
3) Open flame test methods using mockup assembly weight loss vs. time as a performance criterion being explored by the CPSC staff (3).

In order to evaluate these test methodologies, CPSC LS staff conducted tests using over 35 fabrics that represent a spectrum of fiber and material compositions. The test program included the AFMA proposed method (45 degree, 5 second fabric test), small open flame mockup method (20 second exposure), and a modified mockup method with flame exposure times of 5, 10, and 15 seconds using weight loss vs. time data as the basis for assessing performance.

Test Program Description

This section describes the fabric materials used in this test program and provides details of the AFMA proposed fabric test method. The detailed description of the CPSC test methods are found in the CPSC staff's 2001 proposed draft standard (1) and a report on open flame testing currently being explored by the CPSC staff (3).

Materials:

The upholstery fabrics are listed below. Not all fabrics were evaluated in all of the methodologies under consideration, as discussed further below.

1. 60% acetate/40% cotton, 3.5 oz/yd^2
2. 100% Cotton print, 6.0 oz/yd^2
3. 57% acrylic/31% polyester/12% olefin, 8.0 oz/yd^2
4. 100% cotton corduroy, 9.0 oz/yd^2
5. 56% rayon/34% polyester/10% cotton, 10.0 oz/yd^2
6. 100% cotton twill, 11.5 oz/yd^2
7. 92% cotton/8% rayon chenille, 20.0 oz/yd^2
8. 90% cotton/10% rayon chenille, FR backcoated, 24.0 oz/yd^2
9. 100% cotton twill, FR backcoated, 14.0 oz/yd^2
10. 50% cotton/50% polyester, ½ FR backcoated, 9.0 oz/yd^2
11. 100% cotton, FR (Pyrovatex), 7.5 oz/yd^2
12. 57% cotton/36% polyester/7% rayon, FR backcoated, 12.0 oz/yd^2

13. 88% cotton/12% nylon sateen, FR treated (Proban), 10.0 oz/yd^2
14. 100% wool, 11.0 oz/yd^2
15. 100% silk, 3.7 oz/yd^2
16. 100% standard FR polyester, 6.5 oz/yd^2
17. 100% nylon, 12.3 oz/yd^2, FR backcoated
18. 50% rayon/50% nylon, 14.5 oz/yd^2, FR backcoated
19. 100% cotton, 10.0 oz/yd^2
20. 54% acrylic/24% polyester/22% olefin, 8.2 oz/yd^2
21. 100% olefin, 18.7 oz/yd^2
22. 100% olefin, 5.7 oz/yd^2
23. 100% cotton twill, 9.5 oz/yd^2
24. 100% cotton velvet, TB117+ test fabric, 10.0 oz/yd^2
25. 100% cotton, UFAC type I, 9.0 oz/yd^2
26. 100% rayon, UFAC type II, 8.0 oz/yd^2
27. 100% cotton, 7.5 oz/yd^2
28. 56% rayon/34% polyester/10% cotton, 9.7 oz/yd^2
29. 41% olefin/33% acrylic/26% polyester, 7.9 oz/yd^2
30. 52% rayon/48% polyester, 9.4 oz/yd^2
31. 100% wool, 12.5 oz/yd^2
32. leather 1, 7.3 oz/yd^2
33. leather 2, 12.0 oz/yd^2
34. vinyl, 21.5 oz/yd^2
35. 100% olefin, 10.0 oz/yd^2
36. 100% olefin, 10.0 oz/yd^2
37. 100% polypropylene, 11.5 oz/yd^2
38. 56% cotton/44% polyester, 10.0 oz/yd^2
39. 58% polyester/42% cotton, 8.3 oz/yd^2
40. 67% cotton/33% polyester, 11.0 oz/yd^2
41. 60% rayon/40% polyester, 13.8 oz/yd^2

Fabrics 17-22, 27-30 are the ten fabrics from the round robin study.

AFMA Proposed Fabric Test Method Description:

This section summarizes the May, 2004, AFMA proposed fabric classification test methodology. The upholstery fabrics were tested according to a modified ASTM D-1230 test method (45-degree test) with a 5-second flame exposure time as described below:

1. Test 10 specimens per sample (five warp direction, five filling direction).
2. Condition specimens for 30 minutes in a 105° C oven.
3. Place conditioned specimens in a desiccator until cool, but for not less than 15 minutes
4. Adjust flame height to 5/8 inch.
5. Mount conditioned specimen in the specimen holder, brush the specimen and place it in the test chamber (All specimens were brushed before testing).
6. Expose the specimen to the flame for 5 seconds.
7. Record the data.

CPSC staff augmented the test methodology by observations intended to provide an evaluation of burning intensity of the fabrics. In order to compare the intensity of burning fabrics, the fabric tests were recorded on videotape. Grid paper was put in the back of the test chamber to allow visual estimates of the flame heights produced by each fabric.

Data Collection:

Following the AFMA methodology/procedure, data were collected as follows:

1. If the fabric burns (BB), record the time for the flame to break the thread.
2. If the fabric does not ignite (DNI), no time is recorded.
3. If the fabric begins to burn, but self-extinguishes (IBE/SE), record how many inches of the fabric burned and the time to self-extinguish.

Fabric Classification:

The AFMA proposed fabric classification scheme is summarized as follows:

1. If eight or more of the ten specimens either DNI or IBE/SE, the fabric is considered Class I fabric.
2. If two or more of the ten specimens burn (BB), the average burn time of the BB's is calculated. If the average burn time is 30.0 seconds or greater, the fabric is considered a Class I fabric. If it is less than 30.0 seconds, then the fabric is considered a Class II fabric.

CPSC staff also assessed a variant to the fabric only geometry. Fabrics from the round robin study that burned when tested using the 5 second 45 degree test were also tested with the standard Upholstered Furniture Action Council (UFAC) polyester fiber batting underneath. This allowed exploring the effect of an underlying material such as polyester batting on the test result. Five specimens in the fast burning direction (warp or filling) were tested for each fabric sample.

Results and Discussion

Five Second 45-degree Fabric Test

The 41 fabrics tested and the test results are summarized in Table 1. Table 1 shows that only 7 fabrics (fabrics 1, 2, 22, 29, 30, 38 and 39) among the 41 fabrics tested are Class II fabrics according to the AFMA proposed classification criteria. However, when ignition occurs, fabric burn rate is only one factor that will affect the overall flammability of upholstered furniture. Other important factors are the amount of heat generated by the burning fabric and the burning intensity. Since the equipment necessary to measure heat release from the burning fabrics was not available to provide quantitative data, the relative "size" of the flames from the burning fabrics was used to provide a qualitative estimate of burning intensity. Observations were made on the size of flame generated by the ignited fabrics during the tests and the flame heights were estimated. These observations are reported in Table 1. The flame heights were estimated from approximately the top of the flame to the fabric surface by visual observation against grid paper attached to the back of the test chamber. Each grid height represents 0.25 inches.

Table 1. Fabric Test Results

Fabric	Weight (oz/yd^2)	45° test (average burn time, second)	Class	Flame height (inch)	45° test with poly batting (second)	CPSC Mockup open flame test				
						20s standard foam	20s foam T	15s foam T	10s foam T	5s foam T
1. Acetate/cotton	3.5	BB (10.6)	II	~4	NT	Ignited	Ignited	NT	Ignited	Ignited
2. Cotton print	6	BB (29.7)	II	~2.5	NT	NT	Ignited	NT	Ignited	DNI
3. Acrylic/polyester/olefin	8	BB (36.7)	I	~2.5	NT	Ignited	NT	NT	NT	NT
4. Cotton corduroy	9	BB (79.2)	I	~0.25 thick smoke	NT	Ignited	NT	NT	NT	NT
5. Rayon/polyester/cotton	10	BB (30.5)	I	~4”	NT	Ignited	Ignited	NT	Ignited	DNI
6. Cotton twill	11.5	DNI	I	NA	NT	Ignited	Ignited	NT	NT	NT
7. Cotton/rayon chenille	20	IBE/SE	I	NA	NT	mixed	NT	NT	NT	NT
8. Cotton/rayon chenille (FR backcoated)	24	IBE/SE	I	NA	NT	mixed	NT	NT	NT	NT
9. Cotton twill (FR backcoated)	14	DNI	I	NA	NT	mixed	NT	NT	NT	NT
10. Cotton/polyester (1/2 FR backcoated)	9	Warp IBE/SE Filling DNI	I	NA	NT	IBE	NT	NT	NT	NT
11. Cotton, FR (pyrovatex)	7.5	DNI, IBE/SE	I	NA	NT	IBE	NT	NT	NT	NT
12. Rayon/polyester/cotton (FR backcoated)	12	DNI, IBE/SE	I	NA	NT	IBE	NT	NT	NT	NT
13. Cotton/nylon sateen, FR treated (proban)	10	DNI	I	NA	NT	IBE	NT	NT	NT	NT
14. 100 wool	11	DNI	I	NA	NT	IBE	NT	NT	NT	NT
15. 100 silk	3.7	DNI	I	NA	NT	IBE	NT	NT	NT	NT
16. Std. FR polyester	6.5	DNI	I	NA	NT	IBE	NT	NT	NT	NT
17. 100 nylon (FR backcoated)	12.3	DNI	I	NA	NT	NT	DNI	NT	NT	NT
18. Rayon/nylon (FR backcoated)	14.5	DNI	I	NA	NT	NT	DNI	NT	NT	NT
19. 100 cotton	10	DNI	I	NA	NT	NT	NT	NT	NT	NT
20. Acrylic/polyester/olefin	8.2	BB (41.2)	I	~2	BB(83.1)	NT	NT	NT	NT	NT
21. 100 olefin	18.7	DNI	I	NA	NT	Ignited	Ignited	NT	NT	NT
22. 100 olefin	5.7	Warp IBE/SE Filling (BB 20 seconds)	II	~0.25	DNI	NT	NT	NT	NT	NT
23. Cotton twill	9.5	BB (75.3)	I	~0.25 thick smoke	NT	Ignited	Ignited	Ignited	DNI	DNI
24. Cotton velvet (TB117)	10	BB (87.9)	I	~0.25 thick smoke	NT	Ignited	Ignited	Ignited	DNI	DNI
25. UFAC type I (cotton)	9	DNI	I	NA	NT	NT	Ignited	NT	NT	NT
26. UFAC type II (rayon)	8	BB (37.5)	I	~3.5	NT	Ignited	Ignited	NT	NT	NT
27. 100 cotton	7.5	BB (92.6)	I	~0.25 thick smoke	DNI	NT	NT	NT	NT	NT
28. Rayon/polyester/cotton	9.7	BB (37.2)	I	~4	DNI	NT	NT	NT	NT	NT
29. Olefin/acrylic/polyester	7.9	BB (24.0)	II	~4	BB(66.4)	NT	NT	NT	NT	NT
30. Rayon/polyester	9.4	BB (21.3)	II	~4	DNI	NT	NT	NT	NT	NT
31. 100 wool	12.5	DNI	I	NA	NT	DNI	NT	NT	NT	NT
32. Leather 1	7.3	DNI	I	NA	NT	smolder	NT	NT	NT	NT
33. Leather 2	12.0	DNI	I	NA	NT	NT	NT	NT	NT	NT
34. Vinyl	21.5	DNI	I	NA	NT	IBE	NT	NT	NT	NT
35. 100 olefin	10.0	BB (37.0)	I	~1	NT	NT	Ignited	NT	NT	NT
36. 100 olefin	10.0	BB (51.5)	I	~1	NT	NT	Ignited	NT	NT	NT
37. 100 polypropylene	11.5	BB (67.5)	I	~0.5	NT	NT	Ignited	NT	Ignited	DNI
38. Cotton/polyester	10.0	BB (28.9)	II	~4	NT	NT	Ignited	NT	Ignited	DNI
39. Cotton/polyester	8.3	BB (21.4)	II	~4	NT	NT	Ignited	NT	NT	NT
40. Cotton/polyester	11.0	BB (37.2)	I	~4	NT	NT	Ignited	NT	NT	NT
41. Rayon/polyester	13.8	BB (48.5)	I	~4	NT	NT	Ignited	NT	NT	NT

NA-Not Applicable NT-Not Tested

Fabric 28 is a Class I fabric per the AFMA proposed classification scheme. However, its burning intensity is very similar to the Class II fabric 30 as seen in Figures 1 and 2. The flame heights of these two fabrics were all around 4 inches. Fabric 2, a Class II fabric, generated a smaller flame than Class I fabric 28, as seen in Figure 3. The flame height of fabric 2 was only around 2.5 inches. Fabric 22 was also classified as a Class II fabric because the average fabric burn time in the filling direction is 20.0 seconds (less than 30 seconds). However, the flame generated by this fabric was very small, only about 0.25 inches. These test results and observations indicate that when ignition does occur, both fabric burn rate and the flame/heat generated from the ignited fabric deserve some consideration when classifying fabrics.

The data from tests of these fabrics using the AFMA proposal tended to fall into two broad groups: those that burned in less than 50 seconds and those that burned more than 70 seconds. The data also suggest that fabrics with average burn times of less than 50 seconds all produced considerable amounts of flame even though they had burn times ranging from 10 to 50 seconds. Fabric 22 was the exception since it burned in 20 seconds but produced a smaller flame in the filling direction and self-extinguished in the warp direction. From the 41 fabrics tested, fabrics with an average burn time greater than 70 seconds (fabrics 4, 23, 24, and 27) performed significantly better than fabrics with average burn times less than 70 seconds. These fabrics not only burned very slowly, but also generated small flames. The flame heights of these four fabrics were only about 0.25 inches. These data suggest that the concept of a fabric classification test may be useful as part of a comprehensive approach to improving the fire performance of upholstered furniture. However, such a scheme may require more than just two performance levels in order to optimize the benefits of such a test.

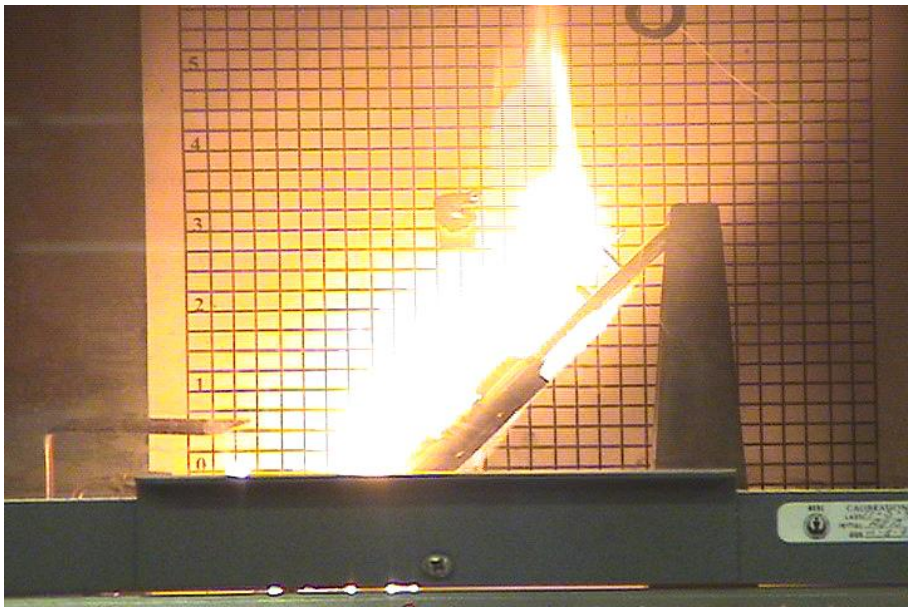

Figure 1. Class I Fabric 28 Burned with Intense Flame

Figure 2. Class II Fabric 30 Burned with Intense Flame

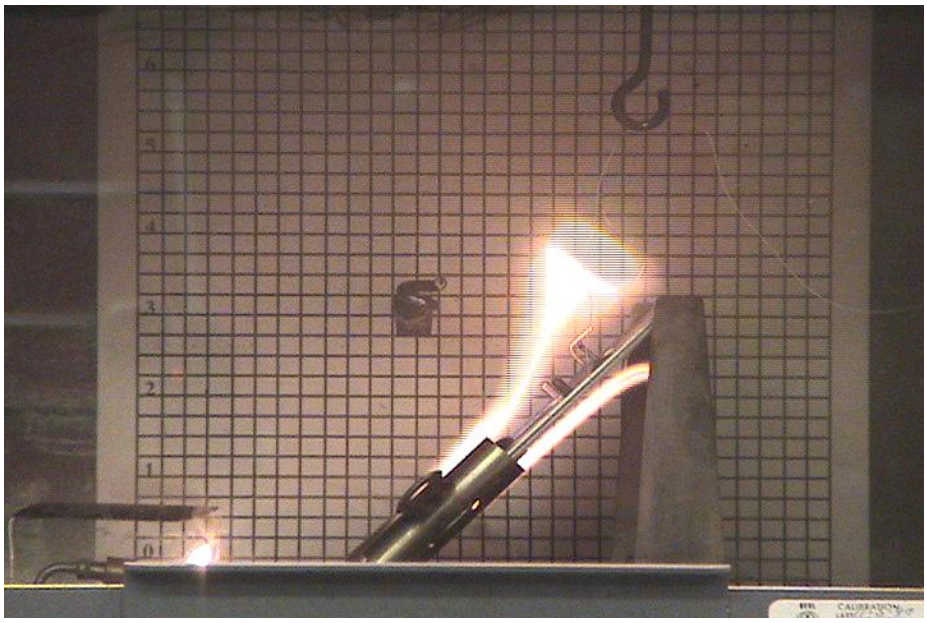

Figure 3. Class II Fabric 2 Burned with Less Intense Flame

Effect of Polyester Batting

Since the AFMA proposed 45 degree fabric screening test ignites fabrics suspended in air, a limited number of tests were conducted with the fabric over-laying a batting material as would be the case in actual use. This modification of the AFMA proposed test was also viewed as permitting a closer approximation of the performance expected from the CPSC staff proposed mockup configuration. Fabrics 20, 22, 27-30 were tested using the 45 degree test method with UFAC polyester fiber batting underneath. As shown in Table 1, all of these fabrics, even Class II fabrics 22, 29, and 30, either did not ignite or burned more slowly when tested with the batting underneath. Figure 4 compares the average burn time of the fabrics tested with and without UFAC polyester fiber batting. Fabrics 22, 27, 28, 30 did not ignite (DNI) when tested with the UFAC polyester fiber batting underneath (the 100 seconds burn time shown in Figure 4 for these fabrics represents a DNI condition).

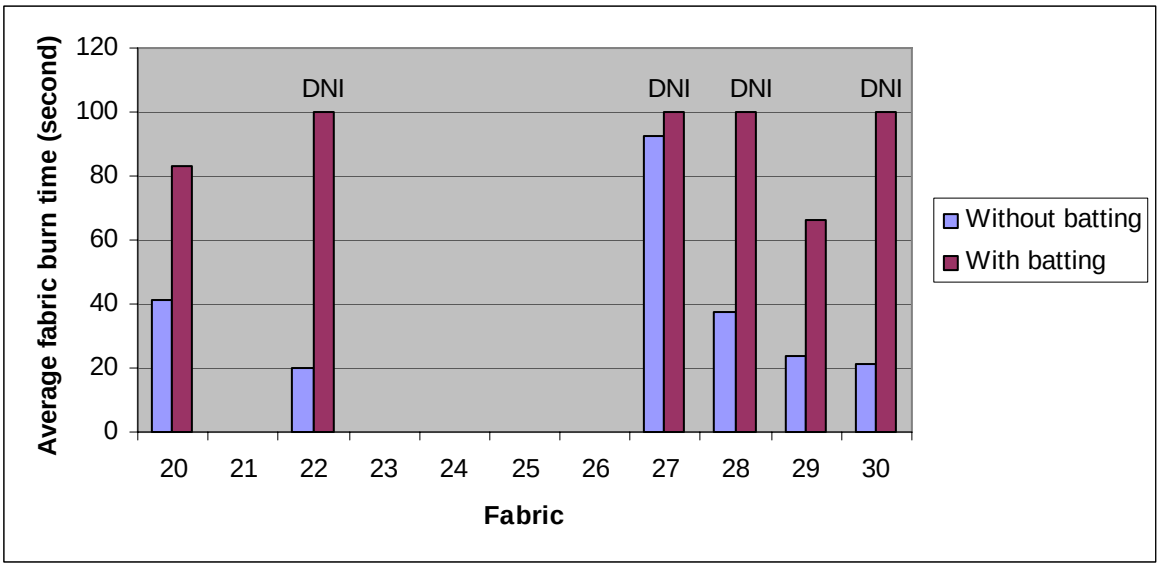

Figure 4. Comparison of Fabric Burn Time with and without Batting

Five Second 45 Degree Fabric Test vs. CPSC Staff Mockup Open Flame Test

In order to compare the proposed 45 degree fabric test with the CPSC staff small open flame mockup test methods, results from the CPSC staff mockup open flame testing (3) are also listed in Table 1. In the mockup open flame test, the fabric flammability was tested using the protocol in the CPSC staff's 2001 draft standard for upholstered furniture (1). A mockup was assembled on a test frame with the fabric covering foam underneath as specified in the draft standard (1). A small butane flame was applied by hand to the crevice of the seating area test mockup for the specified time (3). Tests were performed using both an untreated foam – foam U, and a FR treated foam – foam T. The detailed description of foams U and T can be found in the open flame test methodology development report (3). The data in Table 1 show that eight fabrics (fabrics 3, 4, 5, 6, 21, 23, 24, 26), considered to be Class I fabrics based on the AFMA proposed 45 degree fabric test, ignited when tested to the CPSC staff's 20 second small open flame test

using untreated foam U. Fabrics 5, 6, 23, and 24 burned especially vigorously in the 20 second mock-up configuration and are examples of potential standard cover fabrics for underlying materials. Nine 45 degree test Class I fabrics (fabrics 10-16, 31, and 34) either ignited but self-extinguished (IBE) or did not ignite (DNI) when tested with the CPSC staff's 20 second small open flame mockup test using the untreated foam. These fabrics self-extinguished or did not ignite because they are either flame retardant treated or backcoated with a flame retardant treatment or inherently resistant to ignition when exposed to the small open flame source.

Figure 5 shows mockup assembly mass losses over time for fabrics 1, 2, 5, 23, 24, 37, and 38 tested with foam T using 5, 10, 15, and 20 second flame exposure times respectively. Figure 5 shows that mockups made with the 45 degree test Class I fabrics 23 and 24 with foam T lost about 10% of their original mass in about 10 minutes with either a 15 or 20 second flame exposure time and only an additional 10% of the assembly mass loss at 45 minutes. The mockups made with the 45 degree test Class I fabrics 5 and 37 with foam T lost over 20% of their original mass in less than 5 minutes with only a 10 second flame exposure time. These results indicate that the 45 degree fabric test does not provide consistent classification results when compared to the fabric mockup open flame test method. The CPSC staff's small open flame mockup test with at least a 10 second flame exposure time provides better discrimination between the burning characteristics of fabrics than does the 45 degree fabric test method.

Conclusions

The AFMA proposed method is intended to measure fabric burn rate to classify fabrics. Fabric burn rate is only one factor that will affect the overall flammability of upholstered furniture. Fabric burn rate, the flame/heat generated from the ignited fabric, geometry, and other upholstery materials are important factors that affect upholstered furniture flammability. Structures of upholstered furniture are complex in their construction and flammability performance. CPSC staff believes that the AFMA proposed fabric flammability test would not represent an adequate screening test and may not really represent the flammability behavior of the upholstery materials when used in the upholstered furniture. The CPSC staff's small open flame mockup configuration provides a closer approximation to upholstered furniture structures, and the mockup open flame test would likely provide better discrimination between the burning characteristics using weight loss versus time as a performance parameter of fabrics than the AFMA proposed fabric classification test method.

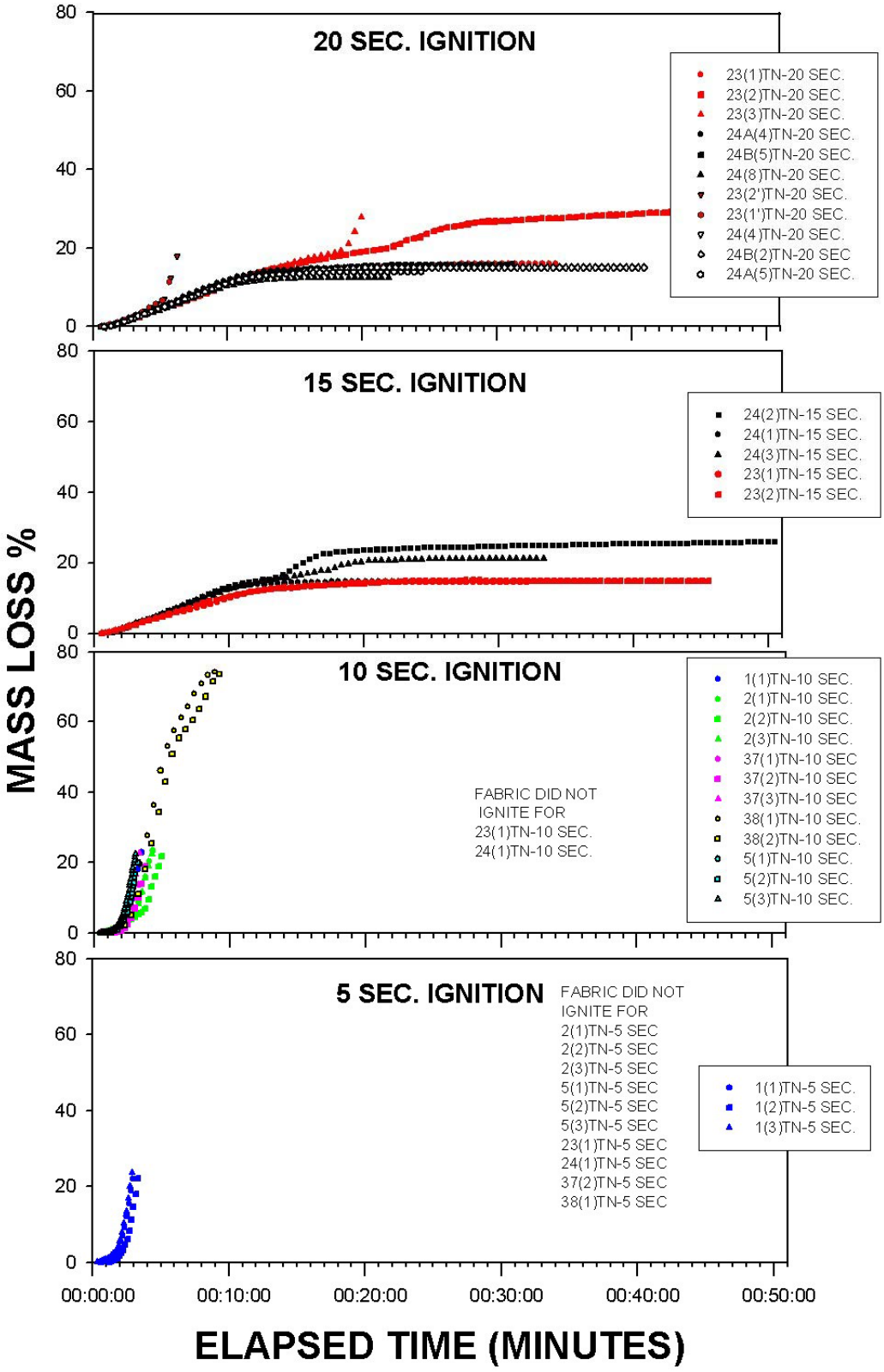

Figure 5. Mockup Open Flame Test Assembly Mass Loss over Time

Acknowledgement

Frank Dunmore for the open flame mockup test data figure.

References

1. Draft Standard for Upholstered Furniture, R. Khanna, Engineering Sciences, revised, February 19, 2001.
2. ASTM International D-1230-94, Standard Test Method for Flammability of Apparel Textiles, Annual Book of ASTM International Standards, Volume 07.01, 1997.
3. Memorandum to Dale Ray from Linda Fansler and Lisa Scott, LS, Open Flame Ignition Test Methodology Development, Consumer Product Safety Commission, May 2005.