UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: May 20, 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 : Review of Sheeting Fabric Specification for Cigarette Ignition Mockup Tests*

Introduction

The U.S. Consumer Product Safety Commission (CPSC) staff is developing a draft flammability standard addressing both cigarette and small open flame ignition of upholstered furniture. The test protocol for cigarette ignition is based on the requirements of the Upholstered Furniture Action Council (UFAC) Voluntary Program for testing and evaluating the cigarette ignition resistance of fabric, filling, and barrier materials (1). The test uses the UFAC mockup configuration, but adds the measurement of foam weight loss (2).

The cigarette ignition mockup test uses a 5x5 inch square of sheeting fabric to cover the cigarette during the test (Figure 1). Table 1 lists the sheeting material specified in various standards. The specifications for the sheeting material vary from 100% cotton to cotton/polyester blend, from laundered sheet to unlaundered sheet, and with a broad range of thread count from 120 to 210 threads per square inch. Unlaundered 100% cotton sheeting fabric was used in the LS test program according to the UFAC specification (1,2). The CPSC Staff 2005 Draft Standard for Flammability of Upholstered Furniture (3) requires the sheeting fabric to be laundered once before use for testing. This memorandum reports on an evaluation of the effects of using unlaundered and laundered sheeting fabrics on the draft proposed CPSC staff cigarette ignition mockup tests.

* 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.

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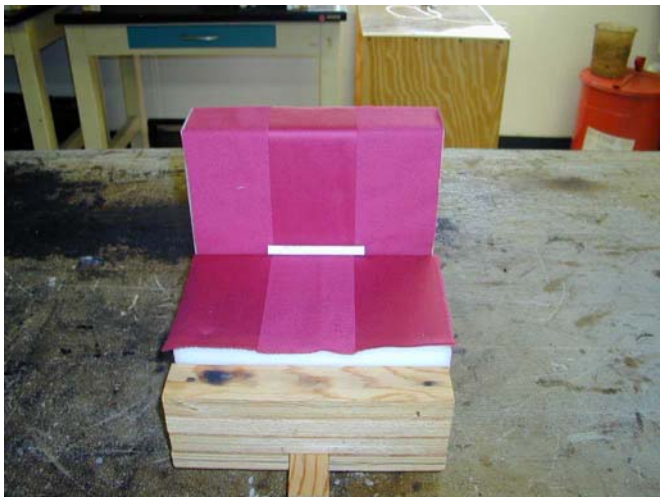

(a)

(b)

Figure 1. Mockup for Cigarette Ignition Test

Table 1. SMOLDERING CIGARETTE IGNITION TESTS FOR UPHOLSTERED FURNITURE & MATTRESSES
SHEETING MATERIAL SPECIFICATIONS

TEST METHOD	FIBER CONTENT	THREAD COUNT	WEIGHT g/m^2 (oz/yd^2)	COLOR	LAUNDER	CHEMICAL TREATMENTS
ASTM (4)	100% Cotton or 50 Cotton/50 Poly Blend.	N/A	125±28 (3.7 ± 0.8)	N/A	Yes	N/A
UFAC (1)	100% Cotton	N/A	125±28 (3.7 ± 0.8)	White	No	None should be present
CA TB 117: Current Version (5)	100% Cotton or Cotton/Poly. Blend	N/A	125±28 (3.7 ± 0.8)	White	Yes	None should be present
2002 Draft (6)	100% Cotton	120-210		White	Yes	None should be present
CA TB 116 (7)	100% Cotton or Cotton/Poly. Blend	N/A	125±28 (3.7 ± 0.8)	White	Yes	None should be present
CPSC 1632 (8) (Mattress Std)	100% Cotton	120-210	125±28 (3.7 ± 0.8)	White	Yes	None should be present
CPSC Staff 1981 Draft Proposed Std. for Cig. Ignition Resistance of Upholstered Furniture (9)	100% Cotton or Cotton/Poly. Blend	N/A	125±28 (3.7 ± 0.8)	White	Yes	None should be present
CPSC Staff 2005 Draft Proposed Standard for Flammability of Upholstered Furniture (3)	100% Cotton	120-210	125±28 (3.7 ± 0.8)	White	Yes	None should be present

Goal

The main goal of this evaluation was to determine the effects of unlaundered vs. laundered sheeting fabric on smoldering ignition test results.

Test Methods

Materials:

Fabrics:

Two upholstery fabrics from the recent LS test program (2) were used, fabric 23 (100% cotton twill) and fabric 24 (TB117+ standard upholstery test fabric, 100% cotton velvet). They were selected because earlier testing showed that they were both prone to smoldering but at different levels (2). Fabric 24 is the proposed standard cover fabric specified in the CPSC staff draft standard (3).

Foams:

Four foams were tested. All these foams were treated with flame retardant chemicals.

1) Foam T, 8.2% TDCP*, 2.2% Melamine
2) Foam Z, 2.8% Melamine, 6.0% FM 550**
3) Foam R, 3.3% FM 550, 3.0% PBDE***
4) Foam S, 7.8% TDCP

*TDCP = tris-(1,3-dichloro-2-propyl) phosphate

**FM (FireMaster) 550 is a flame retardant chemical containing a mixture of halogenated aryl esters and aromatic phosphates

***PBDE = polybrominated diphenyl ethers

The flame retardant chemical content listed for these four foams is based on the chemical analysis conducted by the CPSC Laboratory Sciences Chemistry Division (LSC).

Sheeting Fabrics:

The CPSC staff draft standard specifies that the sheeting fabric used for smoldering ignition tests is white, 100% cotton sheets or sheeting material, not treated with a chemical finish which imparts a characteristic such as permanent press or flame resistance, 19 - 33 threads per square centimeter (120–210 threads per square inch), fabric weight – 125 ± 28 g/m^2 (3.7 ± 0.8 oz/yd^2). The sheeting fabric should be laundered once before use.

Table 2 lists the four sheeting fabrics, sheet1, sheet2, sheet3, and sheet4, used for this testing as well as their physical properties. Actually it is only two different sheeting fabrics each in the unlaundered and laundered condition. All these sheeting fabrics meet the CPSC staff draft standard sheeting fabric specification before laundering. Sheet2 and sheet4 were laundered according to the American Association of Textile Chemists and Colorists (AATCC) Test Method 124-1996 (10), Appearance of Fabrics after Repeated Home Laundering. Washing was performed using the wash temperature (60±3°C), and the water level, agitator speed, washing

time, spin speed and final spin cycle specified for "Normal/Cotton Sturdy" in Table III in the AATCC Test Method 124-1996. The sheets were dried according to section 8.3.1 (A) Tumble Dry of that test method using the exhaust temperature (66±5°C) and cool down time of 10 minutes. The air permeability of the sheeting fabrics was measured using ASTM International D737 (11), Standard Test Method for Air Permeability of Textile Fabrics. The sheet used for mattress compliance testing (sheet3) is heavier and has a higher thread count compared to the pre-cut sheet (sheet1) used in LS cigarette ignition test program. Therefore, it has much lower air permeability as shown in Table 2. Table 2 also shows that the air permeability of both sheets decreased slightly after laundering as expected due to the shrinkage of the sheets.

TABLE 2. SHEETING FABRICS AND THEIR PHYSICAL PROPERTIES

Sheeting Fabrics	Weight (g/m^2)	Thread Count (per square inch)	Air Permeability ($ft^3/min/ft^2$)
Sheet1 Pre-cut, UFAC sheet, unlaundered	103	154	112.580
Sheet2 Pre-cut, UFAC sheet, laundered	119	160	92.840
Sheet3 Lab-cut, used for 16 CFR 1632 (7) mattress compliance testing, unlaundered	128	205	16.800
Sheet4 Lab-cut, used for 16 CFR 1632 (7) mattress compliance testing, laundered	130	212	16.038

The sheeting fabric is used in the mockup smoldering tests to minimize air current effects on the cigarettes and reduce variability. The staff draft standard sheeting fabric specification permits a wide range in the specified fabric weight, from 97 to 153 g/m^2, and also a wide range in the specified thread count, from 120 to 210 threads per square inch. The weight of the sheet used in LS test program is near the minimum specified weight. The weight of the sheeting used for mattress compliance test is in the middle of the range and the thread count of the sheet is near the maximum specified thread count.

The original idea behind laundering the sheeting fabric before use is to remove any finishes on the fabric that may influence test results. Fabric shrinkage occurs after laundering which causes the weight, thread count, and air permeability of the sheeting fabric to change, but the change is very small, as shown in Table 2.

Test Method:

The same test method as described in a previous report (2) was used for this study. Foam weight loss but not char length was measured in this study.

All testing materials were conditioned at a temperature of 21±3°C and between 50% and 66% relative humidity for at least 24 hours before testing in accordance with the draft standard. The weight of each piece of foam was recorded before each test. Immediately after termination of the smoldering test, the foam was removed from the test panel and the smoldered portion of the

foam was removed. The weight of the non-burned portion of the foam was then recorded. The foam weight loss is calculated as follows:

Weight loss (%) = (pre-weight – post-weight)/pre-weight x 100%

Results and Discussion

Cigarette ignition test results are shown in Table 3 and Figures 2-11. Foams Z, R, and S were only tested on fabric 24 with sheet1 and sheet4 due to a limited supply of test fabric needed for other test work. As shown in Table 3 and Figure 3, the average fabric 23 mockup foam T weight losses using unlaundered sheet1, laundered sheet2, and laundered sheet4 are similar. The average fabric 23 mockup foam T weight loss using unlaundered sheet3 is slightly higher than the mockups using sheet1, sheet2, and sheet4.

Table 3 and Figure 5 show that the average fabric 24 mockup foam T weight losses using the high thread count/high weight sheeting fabrics, sheet3 and sheet4 are lower than those using the low thread count/low weight sheeting fabrics, sheet1 and sheet2. Mockups tested with foam T using sheet3 and sheet4 also had less variation if one data point for sheet3 testing is considered an outlier and removed. However, the foam T weight losses and their variations of the mockups tested using unlaundered sheet1 and laundered sheet2 are similar, and using unlaundered sheet3 and laundered sheet4 are also similar as shown in Table 3 and Figures 4-5. These results indicate that the effect of laundering is minimal.

Table 3 and Figures 6-7 show that when fabric 24 was tested with foam Z using low thread count/low weight unlaundered sheet1 and high thread count/high weight laundered sheet4, foam Z weight losses and their standard deviations are similar, with foam Z tested with sheet4 having slightly higher foam weight loss.

Table 3 and Figures 8-11 show that when fabric 24 was tested with foams R and S, all mockups have foam weight loss data ranges above 10%. The average foam weight losses of the mockups tested using sheet4 are higher than those of the mockups tested using sheet1.

It is also seen from Table 3 and Figures 2-11 that there are large data ranges of foam weight losses even for the mockups tested with the same sheeting fabric. For example, for fabric 24 mockups tested with foam Z using unlaundered sheet1, the foam weight losses range from 4.17% to 16.17%, and for the same fabric 24 mockups tested with foam Z using laundered sheet4, the foam weight losses range from 3.86% to 17.35%. These test results indicate that there is substantial variation in foam weight loss regardless of the different sheeting fabrics (laundered or unlaundered) used for testing. This is typical of the range of variation associated with smoldering ignition source fire testing. These results suggest that any differences in performance that might be associated with the sheeting fabric as used in this protocol are too small to be recognized within the inherent variability of this type of fire testing.

TABLE 3. FOAM WEIGHT LOSS DATA

Fabric and Foam	Sheet	Number of Replicates	Weight loss (%) (low)	Weight loss (%) (high)	Weight loss (%) (range)	Weight loss (%) (average)	Weight loss (%) (Standard deviation)
23 and foam T	1	9	6.8	19.08	12.28	11.45	4.61
	2	9	7.14	14.09	6.95	11.12	2.60
	3	9	9.78	17.62	7.84	14.68	2.69
	4	9	7.95	17.02	9.07	11.14	2.95
24 and foam T	1	9	6.59	19.95	13.36	11.66	5.21
	2	9	7.89	20.83	12.94	13.96	4.59
	3	12	3.44	18.73	15.29	7.57 (6.55*)	4.20 (2.41*)
	4	12	4.46	12.87	8.41	8.90	2.43
24 and foam Z	1	14	4.17	16.17	12.00	8.14	3.21
	4	14	3.86	17.35	13.49	10.17	3.22
24 and foam R	1	6	6.62	18.06	11.44	10.53	4.39
	4	6	9.8	20.27	10.47	13.96	3.82
24 and foam S	1	6	8.57	19.25	10.68	12.47	3.90
	4	6	10.70	22.64	11.94	17.44	4.64

*with an outlier removed

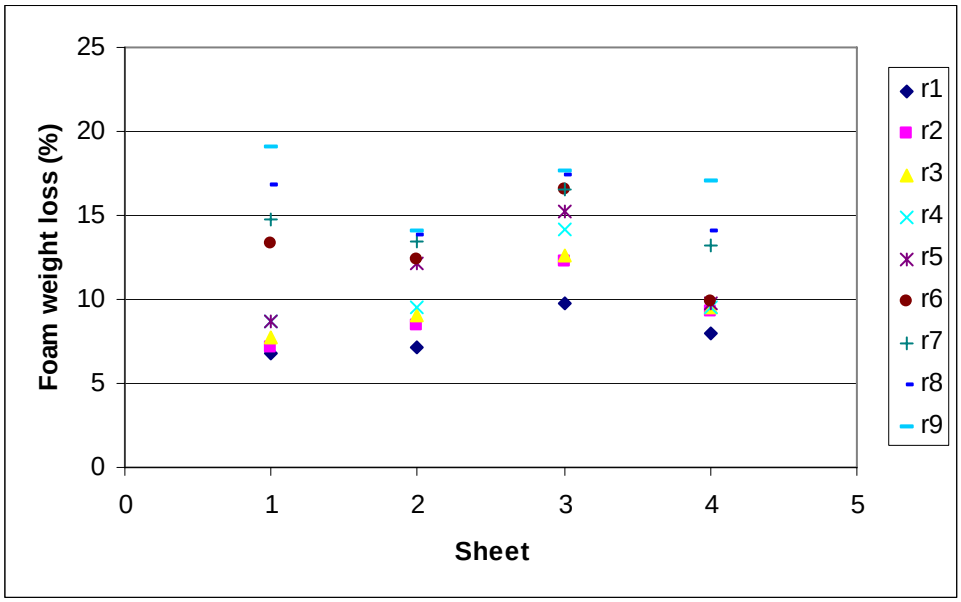

Figure 2. Fabric 23 Foam T Weight Loss (Data Range)

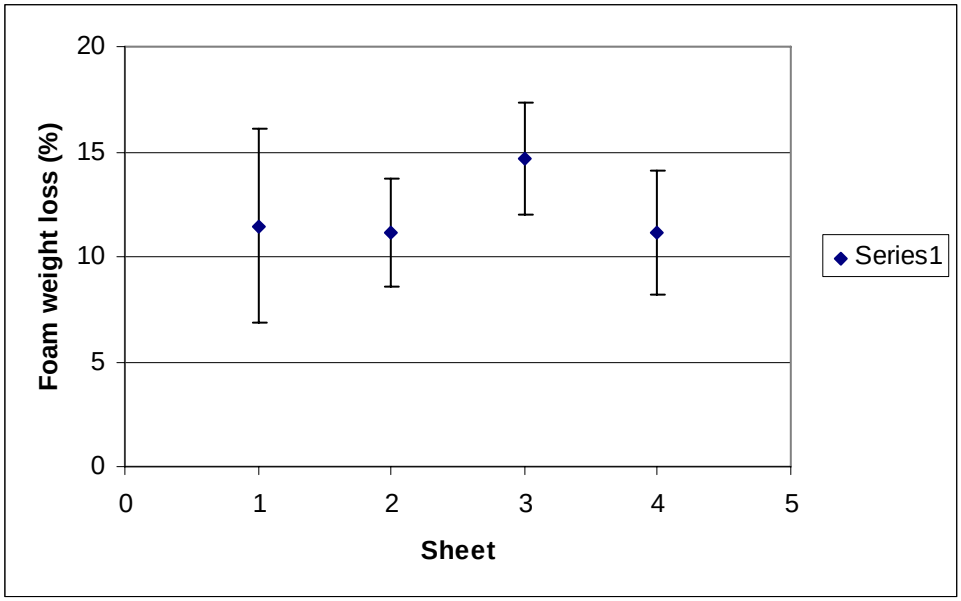

Figure 3. Fabric 23 Foam T Weight Loss (Mean and Standard Deviation)

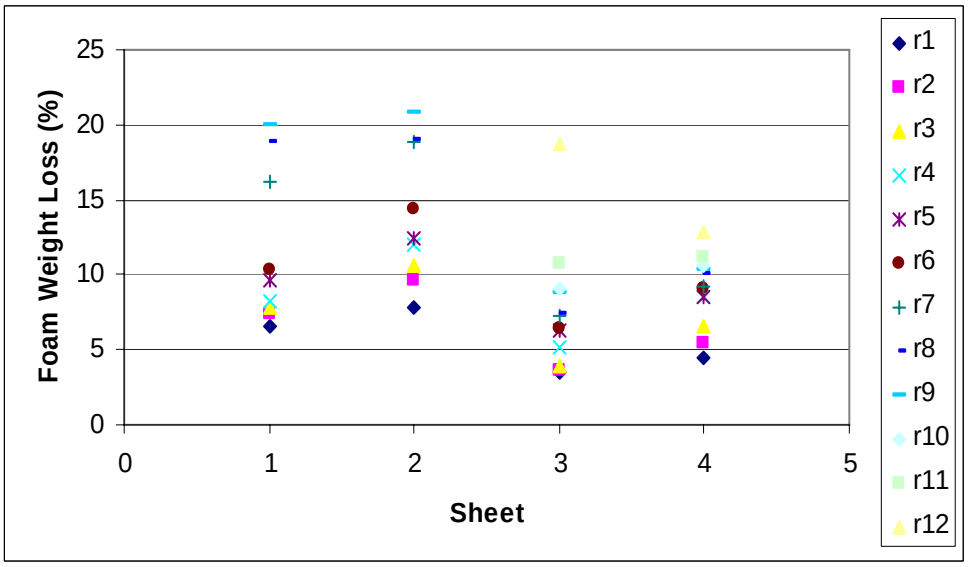

Figure 4. Fabric 24 Foam T Weight Loss (Data Range)

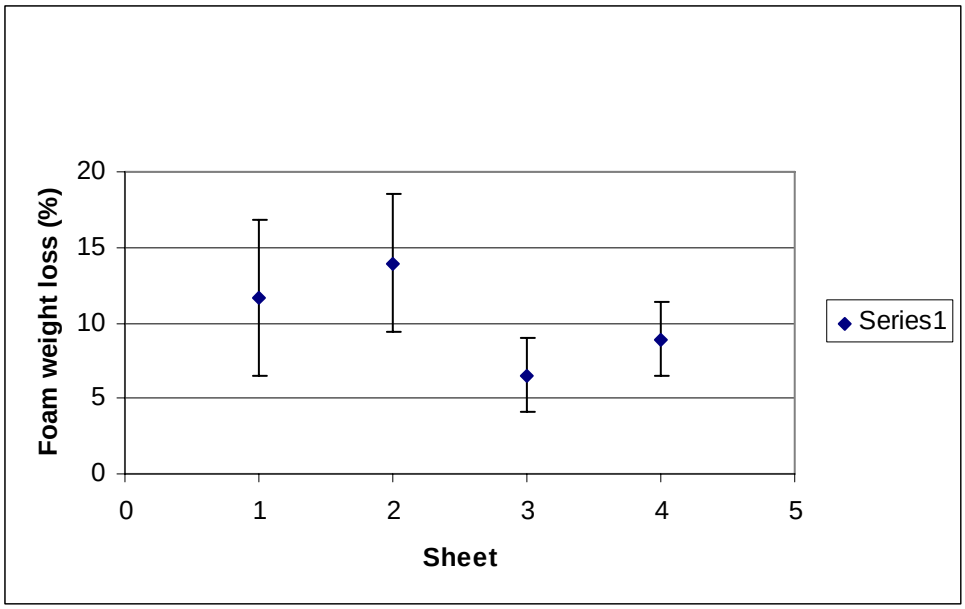

Figure 5. Fabric 24 Foam T Weight Loss
(Mean and Standard Deviation with one outlier removed)

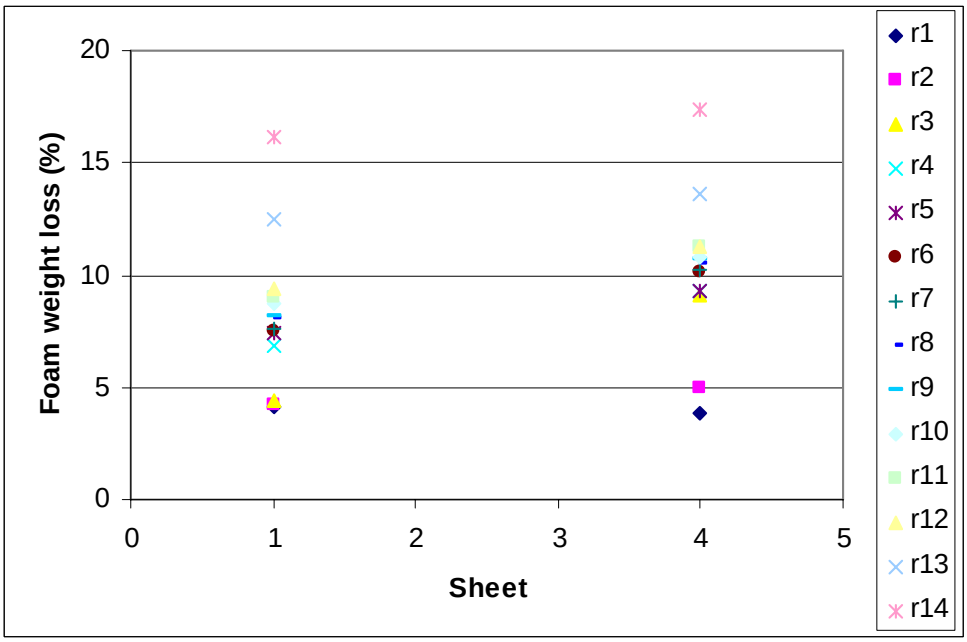

Figure 6. Fabric 24 Foam Z Weight Loss (Data Range)

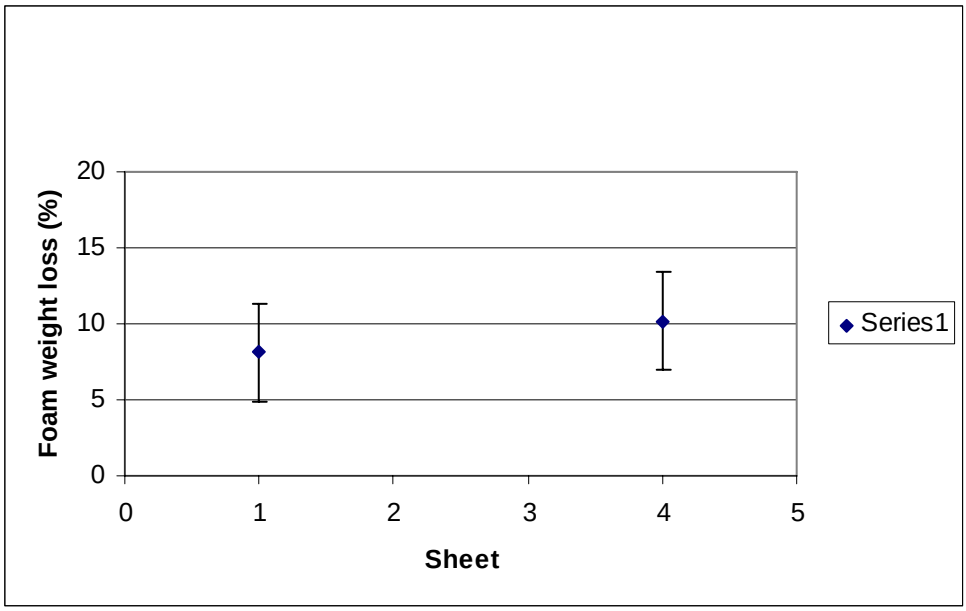

Figure 7. Fabric 24 Foam Z Weight Loss (Mean and Standard Deviation)

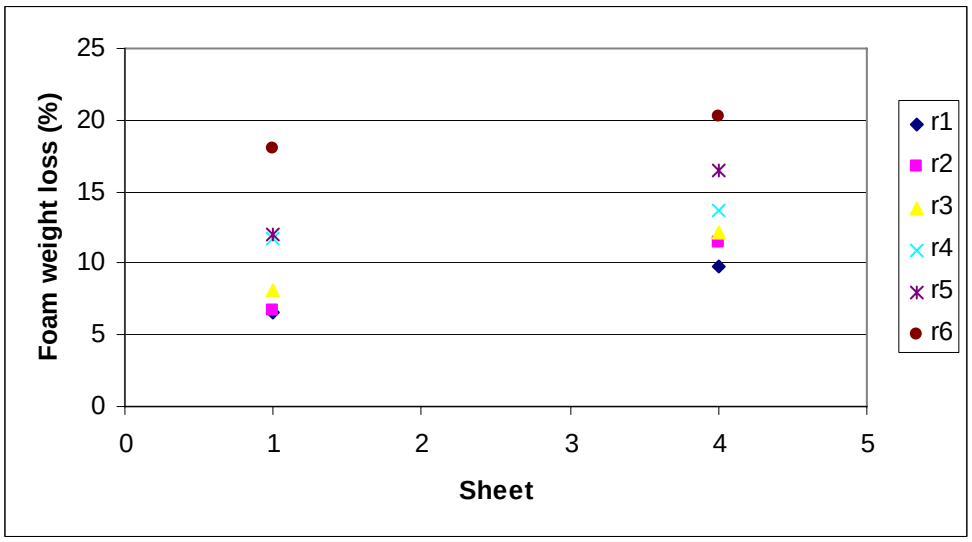

Figure 8. Fabric 24 Foam R Weight Loss (Data Range)

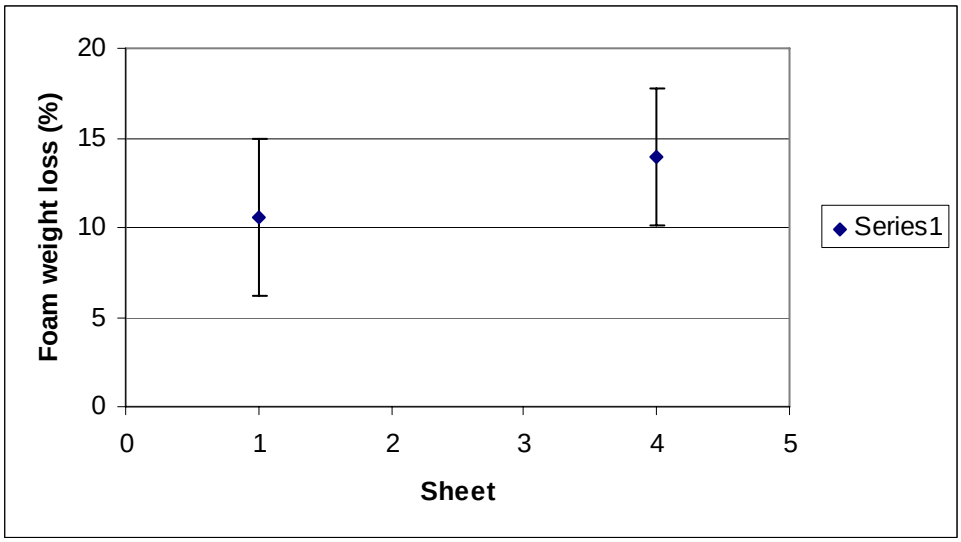

Figure 9. Fabric 24 Foam R Weight Loss (Mean and Standard Deviation)

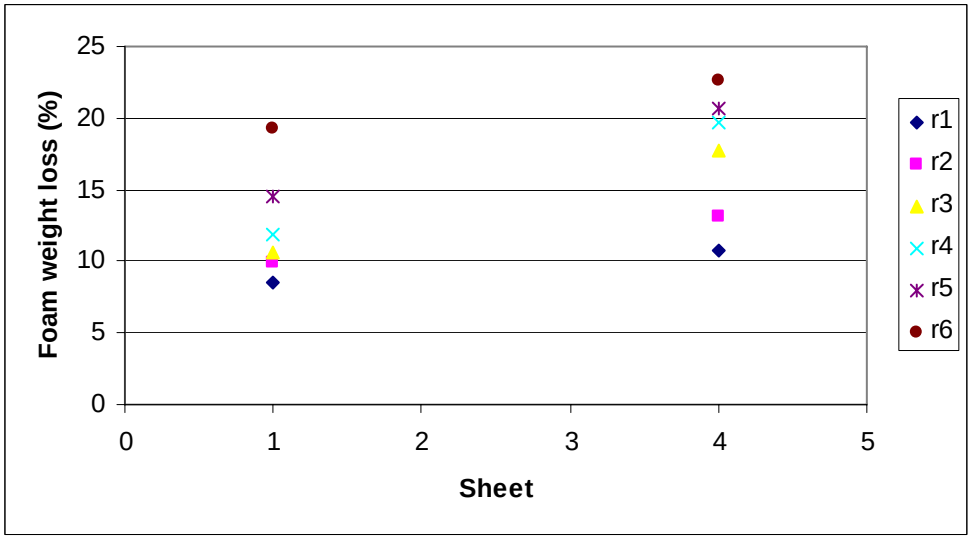

Figure 10. Fabric 24 Foam S Weight Loss (Data Range)

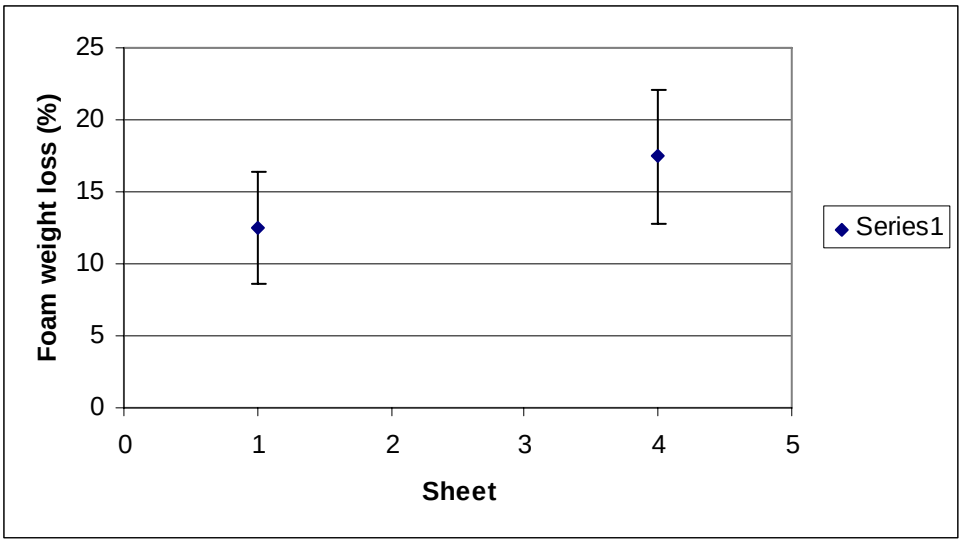

Figure 11. Fabric 24 Foam S Weight Loss (Mean and Standard Deviation)

Conclusions

The differences in foam weight losses using laundered and unlaundered sheeting fabrics are small compared to the larger data range in foam weight losses using the same sheeting fabric. The test results indicated that the effect of laundering the sheeting fabric is too small to be recognized within the inherent variability of the testing.

The specifications for the sheeting material specified in various standards are very broad and vary between those standards. Comparison tests using sheeting materials near the extremes of the specified range of thread count/weight and with and without laundering suggest that such variations have an insignificant impact on the performance of materials subject to the smoldering ignition test as specified in this standard. These tests do demonstrate that the use of high thread count/high weight sheeting, regardless of laundering, yields slightly less variation between replicate tests in some specific tests, but not necessarily in all tests. These tests do not demonstrate that laundering the sheeting material has any discernible effect on the outcome of these tests. Laundering does require an additional pre-test process and additional attention to every test setup, e.g., to examine the sheeting for loose threads on edges, excessive shrinkage, etc. that could affect the outcome of a test.

LS Staff Recommendation

Based on the test results, LS staff recommends that the sheeting fabric used for smoldering ignition tests is laundered or unlaundered, white, 100% cotton sheets or sheeting material, not treated with a chemical finish which imparts a characteristic such as permanent press or flame resistance, 19 - 33 threads per square centimeter (120–210 threads per square inch), fabric weight – 125 ± 28 g/m^2 (3.7 ± 0.8 oz/yd^2).

The smoldering ignition test specified in this standard may be conducted with laundered or unlaundered sheeting with pre-laundered thread count and weight within the range specified.

Acknowledgement

USDA Southern Regional Research Center Textile Testing Lab for air permeability testing.

References

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2. Memorandum to Dale Ray from Weiying Tao, LS, Evaluation of Test Method and Performance Criteria for Cigarette Ignition (Smoldering) Resistance of Upholstered Furniture Materials, Consumer Product Safety Commission, May, 2005.
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