



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. *Andrew Stadnik*  
Associate Executive Director, Directorate for Laboratory Sciences

FROM : Edward W. Krawiec, P.E.  
Director, Division of Electrical and Flammability Engineering, Laboratory  
Sciences  
Weiying Tao, Ph.D. *WT* *Edward W. Krawiec*  
Textile Technologist, Division of Electrical and Flammability Engineering

SUBJECT : Review of Proposed Requirement for Reconditioning Cigarette Ignition  
Mockup Foam for Post-Test Weight Loss Measurement

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 staff's test protocol for cigarette ignition is based on the Upholstered Furniture Action Council (UFAC) Voluntary Program for testing and evaluating the cigarette ignition resistance of fabric, filling, and barrier materials (1). The staff's test uses the UFAC mockup configuration, but uses the measurement of the foam weight loss to replace the char length requirement in the UFAC protocol (2). When the smoldering test is terminated, the foam is then removed from the test assembly and the charred portions of the foam are removed from the horizontal and vertical test panels. The weight of the non-burned portion of the foam is then recorded immediately after the test.

The foam weight loss is calculated as follows:

$$\text{Weight loss (\%)} = (\text{pre-weight} - \text{post-weight}) / \text{pre-weight} \times 100\%$$

The CPSC Staff 2005 Draft Standard for Flammability of Upholstered Furniture (3) was initially developed with a requirement that the burned, cleaned off foam be reconditioned for 24 hours before recording the weight of the non-burned foam portion. This memorandum reports and compares the foam weight loss data measured without reconditioning and with 24 hour reconditioning to determine the effect of the reconditioning on the test results and whether the reconditioning requirement is necessary.

\* 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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## **Goal**

The main goal of this evaluation was to determine the effect of reconditioning on the mockup smoldering ignition test results in order to recommend whether or not reconditioning of foam for the smoldering test is needed.

## **Test Method**

The same test method as described in a previous report (2) was used for this study. All testing materials were conditioned at a temperature of  $21\pm 3^{\circ}\text{C}$  and between 50% and 66% relative humidity for at least 24 hours before testing according to the draft standard. The weight of each piece of foam was recorded before each test. When the smoldering test was terminated, 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 immediately after the test, i.e. within 5 to 15 minutes. The non-burned foam portions were then reconditioned for 24 hours, the foam weights were recorded and the foam weight losses were calculated again.

The tests were conducted using fabric 5 (rayon/polyester/cotton blend), fabric 23 (100% cotton twill), and fabric 24 (100% cotton velvet, proposed standard test fabric). Four different sheeting fabrics were used to cover the cigarettes during the tests. These sheeting fabrics were those used in a study to determine the effect of different sheeting fabrics on smoldering mockup test results (4).

## **Results**

Test results of foam weight losses with and without 24 hour reconditioning are listed in Table 1. Table 1 shows that foam weight loss after reconditioning the burned foams for 24 hours decreased for the different mockups tested because the non-burned foam portions gained moisture during reconditioning. The decrease was small. For the 16 mockup configurations tested, the average % difference in weight loss was approximately 0.55% and ranged from 0.07% to 0.88%. The CPSC 2005 Staff Draft Standard for Flammability of Upholstered Furniture requires that the foam weight loss not be greater than 10% to pass the test. The average difference of 0.5% foam weight loss with and without reconditioning would only affect borderline upholstery materials (foam weight loss near the 10% threshold). These materials may fail the test if the non-burned foam portion weight was measured right after the test, but may pass the test if the weight was measured after 24 hours of reconditioning because of the potential for absorption of moisture.

Table 1. Comparison of Foam Weight Loss with and without Reconditioning

Mockups	Replicates	Foam weight loss without reconditioning (%)		Foam weight loss with reconditioning (%)		Foam weight loss difference (%)
		Average	Standard Deviation	Average	Standard Deviation	
Foam T, fabric23, sheet1	9	11.45	4.61	10.77	4.61	0.68
Foam T, Fabric23, sheet2	9	11.12	2.60	10.38	2.63	0.74
Foam T, fabric23, sheet3	9	14.68	2.69	14.00	2.71	0.68
Foam T, fabric23, sheet4	9	11.14	2.95	10.37	2.97	0.77
Foam T, fabric24, sheet1	6	11.41	6.07	10.80	6.23	0.61
Foam T, fabric24, sheet2	9	13.96	4.59	13.29	4.58	0.67
Foam T, fabric24, sheet3	3	7.00	NA*	6.12	NA*	0.88
Foam T, fabric24, sheet4	3	9.21	NA*	8.45	NA*	0.76
Foam T, fabric5, sheet1	1	0.53	NA*	0.11	NA*	0.42
Foam T, fabric24, sheet1, interliner M	1	2.34	NA*	2.27	NA*	0.07
Foam T, fabric24, sheet1, interliner D	1	3.30	NA*	2.73	NA*	0.57
UFAC foam, fabric5, sheet1	1	0.88	NA*	0.55	NA*	0.33
UFAC foam, fabric23, sheet1	1	5.28	NA*	5.00	NA*	0.28
UFAC foam, fabric24, sheet1	1	1.2	NA*	0.83	NA*	0.37
Foam Y, fabric24, sheet1	1	0.75	NA*	0.41	NA*	0.34
Foam P, fabric24, sheet1	1	1.01	NA*	0.43	NA*	0.58

Sheet1. Pre-cut 100% cotton sheeting, unlaundered, used in LS test program

Sheet2. Pre-cut 100% cotton sheeting, laundered

Sheet3. 100% cotton sheeting purchased for mattress compliance testing, unlaundered

Sheet4. 100% cotton sheeting purchased for mattress compliance testing, laundered

\*Not enough data points to calculate standard deviation

Figures 1 and 2 compare the ranges of foam weight loss data with and without 24 hour reconditioning for fabric 23 and fabric 24 mockups. A smaller number of tests using fabric 24 were conducted because of the limited supply of that fabric which was needed for other tests. Most of the fabric 24 data was obtained in a prior test series. Consequently, replicates of fabric 24 tests were not conducted and both with/without reconditioning data are not available for all fabric 24 tests. These figures show that foam weight loss data are variable in themselves with an average well over 5% and ranged up to 20%. It is also seen from Table 1 that the standard deviations within the same mockup tests are much higher than the difference in foam weight loss with and without reconditioning. Variations in foam weight losses are very large because of the variables associated with such fire tests and far exceed the difference in foam weight loss resulting from reconditioning.

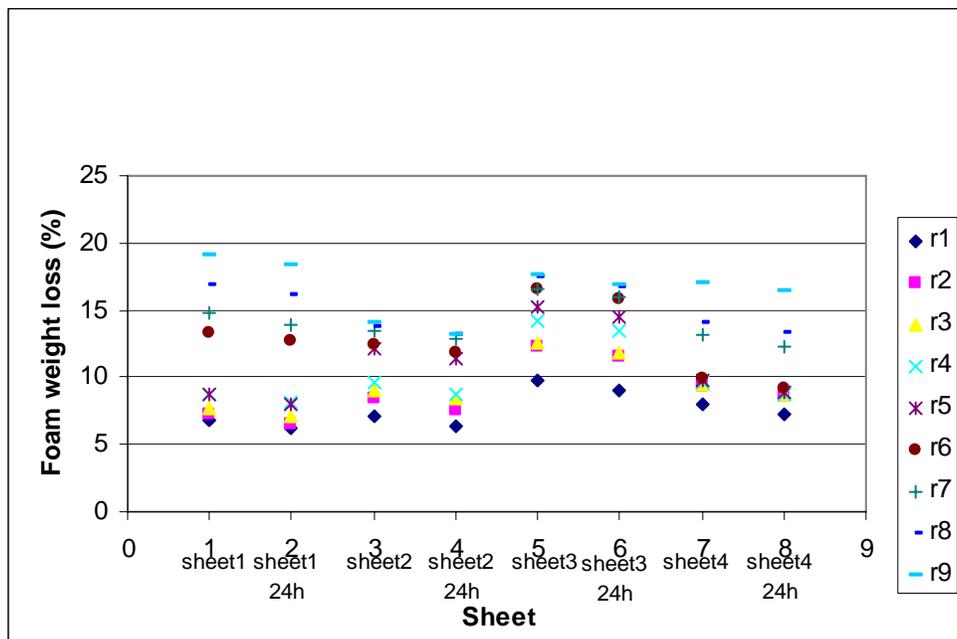


Figure 1. Fabric 23 Foam T Weight Loss with and without 24 hour Reconditioning

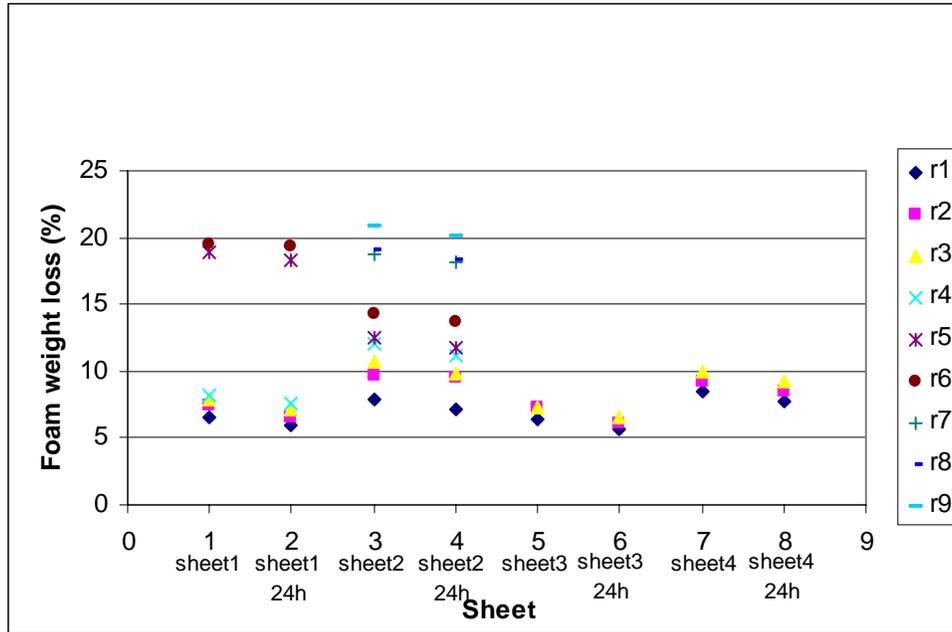


Figure 2. Fabric 24 Foam T Weight Loss with and without 24 hour Reconditioning

## Discussion

The preferred method of determining the risks associated with the combustion of household products is to determine the rate of and the total energy released during the process. The quantitative values can then be related to the development of untenable conditions in structures of differing sizes, geometries, and having differing ventilation rates. Heat release (energy) values are generally determined by oxygen depletion calorimetry in which in the combustion products from free-burning samples are measured by instrumentation embedded in an exhaust system designed to capture the entire combustion plume. This approach requires specialized test facilities and technicians resulting in costs that are generally regarded as too burdensome for all but the largest producers of consumer products.

A less precise but generally acceptable approach to assessing the risks associated with burning household products substitutes weight-loss for heat release measurements. Reasonable correlations between heat release and weight-loss can be developed for the combustion of a specific material or combination of materials. In most instances involving household products, a single value of percent weight-loss and or combination of percent weight-loss and rate of weight-loss can provide the basis for limiting risks. This approach can be used by even the smallest of producers since it involves little more than an accurate scale (sized for the weight of the material or combination of materials to be evaluated) and a non-instrumented exhaust system. Even the optimal embodiment of this approach using automated data acquisition systems and real-time displays will have costs that are a small fraction of those associated with calorimetry.

The accuracy of any correlation between heat release and weight-loss for a given material is based on the premise that the calorimetry captures all of the combustion products and weight-loss captures all of the change in mass as the test assembly burns. Moisture in the material(s)

under evaluation will be converted to vapor and driven-off during the test. The energy required to convert the moisture from liquid to vapor is obtained from the combustion process. Depending on the instrumentation used, oxygen depletion calorimetry accounts for the energy required to convert the moisture in either a direct or indirect manner. Weight-loss accounts for the energy required to convert the moisture directly as a component of the mass that is lost during combustion.

For physically small samples, as is envisioned to be tested under the draft proposed regulation, the mass of the moisture in a sample may be significant when the acceptance criteria include a small percent weight-loss during a definite but relatively short test period. Since the intent of accepting weight-loss measurements in place of calorimetry is to make low cost, reasonably repeatable and reproducible test protocols available to even small producers for design and quality control purposes, it is important to minimize practices that weaken the correlation between heat release and weight-loss. One obvious example is that the weight of the sample must be determined immediately at the end of the test period. Any long time (in excess of 15 minutes for our purposes) exposure of the remnants to normal or high ambient humidity may result in absorption of enough moisture to affect the acceptability of a sample using “go, no go” criteria, such as a percent weight loss. An organized approach to “stripping” a test fixture and removing deposits from a sample to be weighed will not result in enough exposure time to permit significant absorption of ambient moisture. Even if the mockup is still smoldering when the test is terminated, the combustion is generally so limited that the components can be dis-assembled and the charred portions removed (“stripped”) and the residue separately extinguished without risk of injury and without the need to expose the entire assembly to an extinguishing agent.

Adherence to this approach raises two questions with regard to the draft proposed requirements for evaluating components for upholstered furniture. They are: (1) the need for post test “reconditioning” of samples in general, and (2) the need for such reconditioning when an extinguishing agent other than a gas, e.g., CO<sub>2</sub>, is used.

### **Conclusion and Recommendation**

Test data from several foams and fabrics show that the average foam weight loss decreased less than 0.6% after reconditioning the burned foams for 24 hours. This difference is smaller than the variation in the test itself and would only affect whether borderline materials pass or fail. Based on the CPSC Lab’s testing, the relatively small sized samples evaluated under the draft requirements will rarely require extinguishment by other than CO<sub>2</sub>, but, in those instances when water or other materials are required for extinguishment because of personnel or facility safety concerns, it is likely that the sample has exceeded the draft acceptance criteria anyway. For instances in which post test drying and reconditioning are required, but which yield performance within the acceptance criteria, the results should be evaluated on a case-by-case basis.

In order to maintain the correlation between heat release and weight-loss, Laboratory Sciences (LS) staff recommends that after the charred portion of the foam is removed that the foam weight is determined immediately within 15 minutes. In the rare instance where water must be used as an extinguishing agent, the sample should be dried for 24 hours, and weighed, and then, the sample weight should be checked every three hours (consistent with normal working hours) until

the weight change is not more than 5% from the initial measurement after the 24 hour drying period. The sample is then reconditioned for 24 hours and the weight recorded as the final weight. In order to avoid wetting the sample, LS staff recommends that the standard should also suggest that a gas such as CO<sub>2</sub> or N<sub>2</sub> be used when an extinguishing agent is needed if the stripping method discussed above can not be used. The standard should further note that the 24 hour drying period is best done using a laboratory type air hood with the foam sample placed on an open rack to allow air flow on all sides.

## **References**

1. UFAC Test Methods, Upholstered Furniture Action Council, 1990.
2. Memorandum to Dale Ray from Weiyang Tao, LS, Evaluation of Test Method and Performance Criteria for Cigarette Ignition (Smoldering) Resistance of Upholstered Furniture Materials, Consumer Product Safety Commission, May, 2005.
3. Draft Standard for Flammability of Upholstered Furniture, R. Khanna, Engineering Sciences, May, 2005.
4. Memorandum to Dale Ray from Weiyang Tao, LS, Review of Sheeting Fabric Specification for Cigarette Ignition Mockup Tests, May, 2005.