EVALUATION OF CPSC UPHOLSTERED FURNITURE FLAMMABILITY TEST

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Abstract

In the early 1990's a petition was submitted to the Consumer Product Safety Commission (CPSC) asking the agency to address flammability hazards associated with upholstered furniture. CPSC reviewed the petition and granted the portion dealing with hazards of small open flame ignition. CPSC developed a flammability fixture and test similar to the BS-5852 test. BASF used one of these fixtures to test more than 100 fabrics over 4 types of conventional and fire retarded (FR) polyurethane foams using the CPSC test protocol. Many of the fabrics were also treated with flame retardants to improve performance in the test.

The results indicated that there was some pass/fail inconsistency with FR backcoated fabrics which passed the BS-5852 small open flame test. Many of these fabrics did not pass the CPSC test and of those that didn't, there were mixed pass/fail results in most. For cotton fabrics, a solution topical FR treatment was effective. Laminated interliners seem to be effective while loosely wrapped interliners were ineffective for poorly behaved fabrics. The use of even heavily flame retarded urethane foam did not significantly improve the results for poorly behaved fabrics.

Inconsistency in some testing data and other technical issues raised during this evaluation indicate that the currently written CPSC test protocol may not be appropriate for use as a national flammability standard for upholstered furniture. At a minimum it was suggested that a rigorous round robin trial be undertaken to further assess the technical merits of the test protocol.

In July of 1999 a letter of invitation was sent out by CPSC to several laboratories to be part of a round robin testing program. Nine labs agreed to participate in two separate sessions. The ASTM Task Group looking at this issue reviewed the test protocol by September of 1999 and suggested to CPSC that it was premature to proceed with the program until several significant test method questions were answered; however, CPSC decided to go ahead with their plans. Some testing parameters may change as a result of further CPSC evaluation. The second session of the round robin is scheduled to be completed in the first quarter of 2000.

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Introduction

In 1992 and again in 1993, the National Association of State Fire Marshals (NASFM) petitioned CPSC to address flammability hazards associated with upholstered furniture, taking into account small and large open flame ignition as well as cigarette ignition. CPSC reviewed the petition, granted it in part and published an advance notice of proposed rulemaking (ANPR) in the Federal Register on June 14, 1994. CPSC granted the part dealing with small open flame ignition, and the intention to develop a possible test procedure. The large open flame component of the petition was not granted and action on the cigarette ignition component was deferred. The CPSC staff findings were summarized in an October 28, 1997 document to the CPSC commissioners titled, "Regulatory Options Briefing Package on Upholstered Furniture Flammability." By this time the agency had developed a flammability test protocol and an apparatus that could be used to help assess the performance of upholstered furniture mock-up samples.

BASF received this apparatus in August of 1998 to perform evaluations of the test procedure, the test apparatus as well as various fabrics and urethane foams. Part of the interest for BASF is that the author is Chair of an ASTM Task Group, E05.15.03, which has responsibility to evaluate existing small open flame tests or to develop one for upholstered furniture for possible use as an industry voluntary standard.

A significant part of the study was done in concert with the American Textile Manufacturers Institute (ATMI), American Fiber Manufacturers Association (AFMA), and the National Cotton Council. These organizations selected 31 commercial fabrics of various fiber contents, weights and constructions as part of the study. The 31 fabrics were taken to the U.K. and an FR backcoating treatment applied to each of them. The company chosen to backcoat the fabrics was selected because it is an established firm that does this treatment commercially for fabrics that must meet the British BS-5852 small open flame standard. The British standard and the CPSC test protocol are very similar. It would be expected that a fabric/foam combination that would pass one flammability test would normally pass the other. In addition, approximately 150 other fabrics/fabric treatments were collected from various sources for evaluation in the study. Typically, 3 flame tests were conducted on each chair mock-up. More than 1,200 of these individual flame tests were run on the CPSC flammability test apparatus.

Of the fabrics and urethane foams that were flame retarded, specific formulations or compositions are not available. The work done in the BASF laboratories was meant to be an evaluation of the CPSC test protocol to the extent of available resources. It was not meant to be a completely rigorous study with a thorough examination of all test variables, leading to

a recommendation of a flammability test that would be effective and appropriate for this application. Available time, materials and other resources precluded that. At this time the CPSC flammability test encompasses both the back/seat ignition position and a dust cover position, however, all work at BASF focused on the back/seat ignition position.

Table 1 lists the types of fabric treatments evaluated in the study, for example, 48 FR backcoated fabrics were tested, then 42 of the same fabrics were tested after the water soak procedure. Table 2 lists the number of test mock-ups used with different FR levels in the seating foams.

Discussion

Comparison of CPSC and British Standard Tests

It is important to compare the CPSC test protocol[2] with the BS-5852,[3] Source 1 standard because the tests are very similar and fabric/foam combinations designed to pass one test will normally pass the other. Because of this similarity, most of the flame retardant fabric treatments examined in this study were prepared by British companies to pass the BS-5852 test. See Tables A-D in the Appendix for details of the test comparison.

Some of the main differences in the tests are mentioned here. First, the butane gas delivery system for the CPSC test is somewhat more complex. In addition to the BS requirements the CPSC test calls for a maximum pressure regulator and mass flow meter. BASF purchased all of the suggested components in the CPSC gas delivery train. The test calls for control of the gauge pressure, mass flow meter reading, butane gas flow rate at the burner tube, and flame height. While it was possible to match 3 of the 4 requirements, it was not possible to match all 4. With the gauge pressure and observed butane flow rate at the burner tube (with a soap bubble flow meter) set properly, the flame height of 35 mm was obtained. However, the reading on the mass flow meter was consistently too high. This was not resolved even after discussions with CPSC staff and the mass flow meter manufacturer. With the 3 settings established, the stability of the flame height was generally good, but tended to drift over the course of a day's work and the flame height had to be adjusted from time to time.

Both tests call for a low ventilation flow in the test area. BS-5852 allows 0.02 – 0.20 m/sec air flow while the CPSC test calls for 0.20 m/sec. This is a relatively low flow rate, certainly below the typical flow rate in laboratory fume hoods. The flow rate in the location of the BASF test was approximately double this or 0.4 m/sec. Perhaps because of the higher flow occasionally there were flame stability problems. The flame tended to flicker at times which could have had some effect in the test, although this was judged to be a minor contributor to variability. The apparatus was positioned under a ventilation canopy in an alcove with solid side and back walls. The problem of using this apparatus in a low flow ventilation area would have been mainly from an industrial hygiene standpoint. As it was with the higher flow rate, some smoke escaped from under the canopy from time to time. This was a health concern for the people running the test. If a person would do the test regularly it was felt that a respirator would have to be worn, certainly with some discomfort after several hours. In addition, unless the test area was specially designed for flammability testing with secondary smoke removal, escaping smoke from the test apparatus risks setting off facility smoke detectors. In most industrial laboratories these detectors are tied to a central hazard warning system, which when activated frequently alerts local fire departments.

Another difference between the tests is the fabric soaking procedure. The British test calls for a 30 min. soak of the fabric in specified hardness water, followed by a rinse and then air drying and conditioning. The CPSC test calls for a 24 hour soak in tap water followed by conditioning. No comparison was made in this study between samples with the two soak procedures. The soak procedure is to guard against FR treatments which may not be durable and could be water leached from the fabric. This will be reviewed in a different section.

The British test calls for ignition of the chair mock-up with the 20 sec. flame in two locations, but on the same test sample, separated by an appropriate distance. In the CPSC test, not only are 3 flame locations called for but also they are to be done on three different sample mock-ups. In this study, for well behaved fabric/foam combinations it was almost always possible to test 3 flame locations on the same sample mock-up. When the test was run properly, the second flame location would not have been affected at all by the presence of the first flame test several inches away and likewise for the third flame position. The requirement of 3 separate mock-ups contributes unnecessarily to the cost of the test, not to mention the additional time and materials necessary for the second and third samples.

There are also some differences in the pass/fail criteria between the two tests. In the CPSC test a failure is recorded when any flaming or smoldering occurs longer than 120 sec. Also, the test is a failure when the sample burns or smolders to any edge, top, sides or seat front. The British test allows smoldering of a test sample if it self extinguishes in less than 15 min. Flaming cannot extend to the sample sides or seat front although a flame can extend up past the top of the seat back, if it recedes and self extinguishes in less than 120 sec. It was observed in this study that a number of cellulosic fabrics tended to smolder longer than 120 sec. (CPSC fail) but if allowed to continue, some of these then self extinguished in less than 15 min (BS-5852 pass). If

smoldering did self extinguish in less than 15 min. the question must be asked if this condition poses a serious fire threat to other building contents. In the case of flaming, there were cases, although not many, where a flame traveled up the back of a test sample, extended higher than the top of the seat back but then receded and self extinguished in under 120 sec. Again, are the somewhat more stringent requirements of the CPSC test justified from a fire safety standpoint?

Although specific data were not available, the BS-5852 standard states that results of interlab testing were "good." In the case of the CPSC test at this point, there are only very limited data on interlab or round robin testing (see Ref. 1 for these data). For a testing standard that would have the financial cost the proposed CPSC standard would have for all residential upholstered furniture sold in the country, additional round robin testing appears to be warranted.

Reproducibility Between Labs

There is a set of data available comparing test results from two different laboratories. Some time earlier than the study at BASF, DuPont ran the CPSC test on 21 fabrics over 3 types of polyurethane foam. The fabrics consisted of both cellulosic and synthetic fibers. The three labeled "Backcoated" in the table were not FR treated. Each of the fabrics was run over conventional, non-FR urethane foam, and then again over urethane foam that met the California Technical Bulletin 117 flammability test (Cal. 117) and finally over urethane foam that met the BS-5852 flammability test for filling materials. As might be expected none of the 21 fabric/foam samples passed the CPSC test. The numbers in the three columns refer to the times at which the flame reached the top of the back cushion and was a test failure. In the DuPont tests, using Cal. 117 foam and then the BS-5852 foam, only one fabric sample passed the test where it had failed with conventional foam, the 10.75 oz. solution dyed 100% nylon.

The Table 3 values shown in parentheses indicate the results (times to failure) at BASF, although only 19 fabrics were run over conventional foam, 3 over Cal. 117 foam and 18 over BS-5852 foam. There were two pass/fail differences or discrepancies between the labs. In the 6.5 oz. 100% solution dyed nylon fabric, DuPont recorded a fail at 93 sec. into the test for BS-5852 type foam whereas BASF recorded a pass for the same test. In the 10.75 oz. 100% solution dyed nylon fabric, DuPont recorded a pass (> 120 sec. flame) whereas BASF recorded a fail at 24 sec. into the test. In the other results, a trend can be seen in the time to failure results, e.g., when samples failed early in one lab they tended to also fail early in the test in the other lab. Where times to failure were longer in one lab they also tended to be longer in the other. However, this was not always true as evidenced by entries in the table. There were several cases where there were significant time differences between labs. In most cases the times to failure were shorter at BASF than DuPont although no test differences could be identified to account for this.

The differences in these data between labs seem to indicate that a wider round robin testing program would be called for and should be conducted with a wide variety of fabrics. The intent of this part of the study was not as a statistically planned round robin but only as an effort to capture some comparison data.

Untreated Fabrics

A total of 75 fabrics with no flame retardant treatment were tested over conventional urethane foam. Of these, only 4 passed the CPSC test requirements. These tended to be heavier weight fabrics but no broader correlation could be made to the pass/fail results. Of the ***64*** fabrics that failed using 3 separate flame test positions on one mock-up, 59 failed each of the three flame tests while 5 had mixed pass/fail results. That is, a fabric may have 'passed' once and 'failed' twice or 'passed' twice and 'failed' once. Of course, if just one of the flame test positions results in a 'fail' the whole sample is said to have failed.

A total of 59 of the 64 untreated fabrics that failed the CPSC test mentioned above were tested over BS-5852 type foam. Only 7 of these samples then passed the test and another 7 had mixed pass/fail results. This indicates that there is only a slight advantage in using this FR type foam. There is no substantial advantage in using BS-5852 type foam to pass the CPSC flammability test.

Flame Retarded Fabrics, Backcoating Treatment

There were 52 fabrics that were FR backcoated and presumably compliant with the BS-5852 test as they were received. However, the fabrics were not received with certificates of analysis against this test. The fabrics came to BASF being represented as passing the BS-5852, Source 1 test, but it was not possible to confirm their compliance. There were 30 of these fabrics that did not pass the CPSC test! Of these failures, 16 had mixed pass/fail results. There was no rationale for this obvious discrepancy in results. The details of the fabric testing are not known to us and could have contributed to the differences.

Data for 31 of the backcoated fabrics made available from ATMI were sorted in a number of ways (by Dr. P. Strickland of Amoco) to look for trends in pass/fail results which might have allowed some prediction in which type of fabric or amount of backcoating was most effective in passing the CPSC test. Please refer to Tables E through J in the Appendix for specific data. Table E has fabrics organized only by an ID letter (A through EE) and each row of information represents one fabric. Here in the cases where a fabric sample failed the test the row has a gray background, as opposed to white. This data organization helps in quickly

looking for trends. The rows are 'grayed out' whether all three flame test positions failed on an individual sample or if only one of the positions failed.

Table F sorts by fabric or fiber type, listing high cotton fabrics first.

Table G sorts the samples by fabric weight. The fabric weights ranged from 3.4 oz/yd^2 to 22.7 oz/yd^2. Table H is sorted by the add-on weight of flame retardant treatment. The FR treatment chemical composition was not made available but was said to be identical for all fabrics. The FR treatment was applied to the fabrics, then flame tested to the BS-5852 standard and if the fabric did not pass, an additional FR treatment was applied. This treatment is commercially used for upholstery fabric sold in the U.K. The add-on weight is recorded in both grams/yd^2 and oz/yd^2. The treatments range from 21 grams/yd^2 to 89 grams/yd^2. The amount of FR treatment to be applied was partially pre-determined through the experience of the fabric finisher.

Table I sorts the FR treatments by the percent of FR weight compared to fabric weight. This ranges from 5% to 60% of the fabric weight.

In each of these cases, looking at various ways to sort the flammability test data, it is not possible to see trends, e.g., that higher add-on weights of FR treatment result in fabrics that tend to pass the CPSC test and lower add-on weights tend to fail. This means it is not possible to use these factors such as fabric type or amount of FR as predictive tools. If predictions could be made, it might be possible to considerably reduce the total amount of flammability testing required.

Table J shows a sort by pass/fail and then by % pass (of the three flame positions on a sample). This may appear simplistic at first but graphically shows the number of fabrics claimed to be BS-5852 compliant which should have passed the CPSC test but didn't. Also, 9 of the 14 fabrics that didn't pass the test showed a mixed pass/fail result. When developing a test method, this high percentage of mixed results is not desirable.

Flame Retarded Fabrics, Solution Dip Treatment

In another part of the study 11 cotton fabrics were treated with a proprietary solution dip FR treatment. Again, this was a commercial FR treatment that was supposed to be effective for cellulosic fabrics. In fact, all of the fabrics passed the CPSC test, even after a water soak procedure. Unfortunately, the nature of the treatment was not made available.

Effect of Fabric Soaking

A soaking procedure is called for in both the BS-5852 and CPSC small open flame tests. The rationale is reasonable, that is that if there are flame retardant treatments which are water soluble and could be washed away in normal use conditions by spilled liquids or certain upholstered furniture cleaning procedures the protection would not remain. In addition, there may be fabric finishing treatments which could be washed away by a soaking procedure. A total of 16 of the ATMI backcoated fabrics were tested over conventional urethane foam in both an as-received state and again after the prescribed soak procedure. Tables 4 and 5 show the results of this testing for cotton and non-cotton fabrics. In the tables the individual pass/fail results are listed for each sample in the second column. In the 'Smolder' column, Fabric ID 'E' shows self extinguishment in 9 sec. The other values of >120 sec. show continuing smoldering or glowing past the fail point of the test. The times listed in the 'Flame' column are the times to failure in the test. The last 'Result' column shows a '+' sign to indicate a slight to moderate improvement in performance after the soaking procedure. A '++' sign indicates a change in test results from a 'fail' to a 'pass.' A '±' sign indicates no significant change in behavior and a '-' sign indicates a slight to moderate degradation in performance after soaking.

To summarize the results of the fabric soak on this set of fabrics, flammability performance is improved in many cases, not necessarily an expected outcome. In 5 of the 16 cases, fabrics that would have failed the test if tested in the original, non-soaked state then passed after soaking. Another 7 fabrics exhibited slight to moderate improvement in flammability performance. In only two cases was there even a slight decrease in flammability performance.

The increased performance of at least the cellulosic fabrics after soaking, particularly where test failure was due to smoldering and glowing can at least partially be explained by the presence of sodium and potassium cations in the fabrics, an expected occurrence. As seen in Table 6, the level of sodium ions in cotton fabrics drops typically from several hundred ppm to less than a detectable amount (about 30 ppm). Potassium ion concentrations also drop considerably as seen in the table. The level of boron is also considerably decreased after the soaking procedure. It is not clear if the 200 to 300 or so ppm of boron could be associated with boric acid, or what, if any, role boron has in the flammability characteristics of the fabrics. In the case of the elements phosphorus, antimony and bromine, all common flame retardant components, it seems that they are not leached from the FR fabrics examined.

Interliners

The use of an inert fire resistant interliner, for example, fiberglass construction, or flame retardant interliner such as melamine based materials can provide excellent resistance against fire penetration into furniture filling materials. In the case of the melamine based interliner used with the three

fabrics shown in Table 7, it can be seen that there was no difference in the flammability performance with the CPSC test when comparing the fabric/foam samples with the fabric/interliner/foam samples. In these cases, the fabrics had not been water soaked prior to testing. It can also be seen by comparison to earlier data, Table 6, that data generated on the same samples but at different times was not as reproducible as would be hoped. This interliner had been successfully tested with other fabrics in the California T.B. 133 test. Those samples passed the test because the interliner prevented the flames from penetrating into the filling material. In the small open flame CPSC test, the interliner still allowed the fabric to burn sufficiently to fail the test. This may have been because of too much air availability behind the fabric with the loose upholstery construction.

Results with laminated interliners are shown in Table 8. Again, the chemical composition and source of the interliners were not available. In this case, all of the samples passed the CPSC test easily. These fabrics were not part of the set of 31 ATMI fabrics, however. The fact that these samples passed the CPSC test could have been because of the intimate contact of the interliner and fabric, allowing little air to circulate behind the fabric.

Polyester Batting

A quantity of one inch thick commercial polyester fiber batting with a ticking layer on one side was obtained for the study. This batting is frequently used in residential upholstered furniture between the fabric and urethane foam. The object was to see what effect, if any, this material would have on the flammability results of the CPSC test. The test was run with some of the ATMI fabric samples, but they were not pre-soaked for this part of the study. The results are shown in Table 9. In two cases out of 7 a fabric that had failed without the batting passed when the batting was in place, Fabric 'C' and 'F.' In one other case, Fabric 'G,' there was a moderate improvement in pass/fail results. In three cases, Fabrics 'N,' 'P' and 'V' there were what could be described as a moderate reduction in flammability performance. In the last case, Fabric 'Q,' there was no difference in performance. These results seem to indicate that there may be a slight bettering of performance with polyester fiber batting but no predictions could be made because of the variability of results.

Polyurethane Foams

The effect of different levels of FR treatment in polyurethane foams is depicted in Table 10. The fabrics used were all FR backcoated, most from the ATMI set. It can be seen that of the total only half, or 17, fabric/foam samples passed the CPSC test when used over conventional urethane foam. Some of the fabrics that failed this test were then tested over urethane foam compliant with BS-5852, Source 1. Only 15 of the 17 were tested because of a lack of fabric. Only 2 of the fabrics that had failed earlier with conventional foam now passed with the 'moderate' level of flame retardant in the BS-5852 type foam. Most of these fabrics (13) were then tested over heavily flame retarded foam. There is no California T.B. 133 foam but this foam could be viewed as helping upholstered furniture pass the Cal. 133 test when using only lightly FR treated fabric, or perhaps when not using an interliner. Again, in this case, only 2 of the fabrics passed the CPSC test while 11 failed. Nine of the 17 failing fabrics used over conventional foam were tested over California T.B. 117 type urethane foam. None of these fabrics using this lightly FR treated foam passed the CPSC test.

Therefore, it seems clear from this data that higher levels of flame retardant used in polyurethane foam do not significantly aid poorly behaving fabrics in passing the CPSC composite test. This is, of course, judged against the current CPSC pass/fail criteria.

Effects of Variables

Evaluation Findings

The following bullets summarize the variables investigated and discussed earlier for the CPSC small open flame test:

- BS-5852 Compliant B/C Fabrics: Results not consistent
- FR Solution Dipped Fabrics: Effective for cotton fabrics tested
- Loose Interliners: Not effective for poorly behaved fabrics
- Laminated Interliners: Seem to be effective for fabrics tested
- Polyester Batting: Somewhat improves results on fabrics tested
- Fabric Soaking: Improves results
- Urethane Foam: Use of FR foam does not help pass CPSC test

Tables 11 through 14 summarize the concerns raised about the CPSC small open flame test protocol as currently written. These represent test observations by operating personnel and numerous visitors.

Conclusions

Of the concerns and issues raised in these last four tables some are more important than others. Some concerns are relatively minor and easily corrected but others are significant and difficult to answer. The following comments and concerns should be addressed before the test protocol advances to become a mandated national standard. The points raised in Tables 11 to 14 which may be more easily corrected are not discussed further.

In Table 11, test operator safety is the most serious. With the requirement of an essentially draft free test environment some smoke from testing will escape into the laboratory. This was the case in the BASF testing facility even though the air flow around the apparatus was about twice that called for in the CPSC test. If a laboratory was to run the test in a normal fume hood with the hood ventilation off during the test, turning it on immediately after the test, a considerable amount of smoke would likely escape, posing a risk to the operator and the possibility of setting off building smoke detectors and sprinkler systems. The idea of a technician wearing respirator protection throughout the day while running many of these tests is not practical.

Also from Table 11, positioning of the back and seat cushions is very important. It is not difficult for an operator to inadvertently position the cushions with a slight gap between them if not very careful. Having a gap between the two has shown to result in differences in pass/fail results of the test. In addition, positioning of the S.S. burner tube is important. Test results have been seen to be significantly affected if the tube is only slightly mis-positioned. In both of these cases operator judgement and attention to detail plays a key role. It is certainly possible that correct positioning could be accomplished but in running many tests throughout a day, one must be especially careful not to mis-position the components. Specific warnings should be made in the test protocol.

In Table 12 operator interaction also plays a role in the test with regard to the direction and stretch of the fabric. Test results have shown that some fabric constructions may cause differences in burning behavior when put on the test rig in different orientations. They should be applied in the direction that would be used in a final piece of furniture. Consistency in fabric tension must be achieved also to help ensure reproducible results. Now there is no measurement for tension other than operator experience. Soaking of fabrics, particularly cellulosic fabrics, appears to actually help fabrics pass the flammability test, probably by leaching out more flammable fabric treatments or alkali metals ions. This may not have been the result of the soak step and should be reconsidered. However, it may be difficult to call for soaking for some but not all fabrics before testing. The most important element from Table 12 may be that it seems FR treated fabrics show no significant trends towards passing the CPSC test protocol. Therefore, the test cannot easily be used as a predictive tool to reduce the testing burden on the industry.

In Table 13, the use of polyester batting showed mixed test results. Although batting is not specified in the CPSC test, some type of batting is used in most commercial upholstered furniture. Variations in batting construction may lead to significant differences in test results, indicating that not enough laboratory work has been done on the effects of different batting types. Also, a troubling observation is that the use of loosely applied FR interliners did not help some poorly behaving fabrics pass the CPSC test but if used in the California Tech. Bull. 133 test, the fabric/interliner/foam combination could pass. This is because the CPSC test does not allow a flame to reach the top of the mock-up, even though the flame might not penetrate the cushioning materials, i.e., the fabric may burn but not the interliner or foam. Lastly in Table 13, there are many cases where fabrics shown to be BS-5852 compliant did not pass the CPSC test, although they were expected to pass on the basis of the tests pass/fail criteria.

Table 14 points out that sufficient reproducibility and repeatability data have not been generated. There was a limited round robin test run by CPSC with 4 fabrics and 3 labs but that was not statistically significant. A wider interlab test should be conducted, particularly before issuing a standard with such far reaching consequences. The CPSC test protocol calls for testing selected fabrics over conventional polyurethane foam. It does not preclude testing with other components but does not give any direction for doing so or when to do so. To be a test reflective of actual constructions each of the furniture components should be considered in the testing program, unless shown not to contribute to increases in test pass/fail results.

In developing a test approach that truly reduces loss of life and injury from upholstered furniture fires, the test itself must be shown to be effective in accomplishing the stated goals, be based on sound science, be cost effective in the broadest sense, and not create new problems. The currently written CPSC test protocol does not seem to meet these criteria. At this time CPSC is working to further develop its protocol.

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- Dr. Herman Forsten, DuPont, shared testing data generated earlier at the DuPont laboratories, see Table 3.
- CPSC itself, for allowing the use of their test apparatus and numerous helpful conversations on its use.

References

1) "Regulatory Options Briefing Package on Upholstered Furniture Flammability," an October 28, 1997, document directed to the CPSC commissioners.
2) "Regulatory Options Briefing Package on Upholstered Furniture Flammability," October 28, 1997, pp.394-412.
3) British Standard BS-5852 : 1990, "Assessment of the Ignitability of Upholstered Seating by Smouldering and Flaming Ignition Sources," December 1990.

Table 1. Fabric/Treatment Combinations

TREATMENT	# OF FABRICS
NON FR BACKCOATED	75
FR BACKCOATED ORIGINAL	48
FR BACKCOATED SOAKED	42
FR DIPPED ORIGINAL	12
FR DIPPED SOAKED	11
FR BACKCOATED FATIGUED	2
FR FIBERS IN FABRIC	1
WITH LOOSE INTERLINER	1
WITH LAMINATED INTERLINER	17
FR BACKCOATED WITH POLYESTER FIBER BATTING	7
TOTAL	219

Table 2. No. Chair Mock-Ups with PU Foam Types

Convent. Non-FR Foam	279
Cal. 117 Type Foam	9
BS 5852 Type Foam	102
Cal. 133 Type Foam	18
TOTAL	408

Table 3. Comparison of Flammability Data between DuPont and BASF Labs

		Time to Failure, sec.		
Sample Identification	Wt.-oz./sq. yd.	Std. PU Foam	Cal 117 Foam	BS-5852 Foam
Nylon contract fabric	6.85	4	14	38
100% solution dyed nylon 6	6.5	22 (11)	86	93 (pass)
100% solution dyed nylon 6	10.75	23 (15)	pass	> 120 (24)
100% rayon	7.8	20 (13)	17.5	21 (13)
100% rayon	7.8	2 (9)	11	13 (8)
100% rayon	9.0	22 (19)	23	28 (12)
100% cotton	8.0	24 (14)	23	26 (15)
100% cotton	11.6	45 (29)	46	57 (36)
70% cotton/30% PE	11.7	23 (19)	33	33 (20)
52% rayon/48% PE	7.9	12 (3)	7	12 (3)
100% PP Plain weave	6.1	0 (0)	0	95 (71)
100% PP Jacquard Backcoated	7.1	0 (0)	0 (22)	80 (0)
100% PP Velvet Backcoated	12.7	30 (21)	23 (0)	52 (22)
60% PP/40% PE Chenille Backcoated	8.8	0 (0)	0 (0)	0 (0)
53% PP/47% PE Jacquard	9.6	10 (0)	14.5	37 (0)
48% PP/27% PE/25% Acy Jacquard	10.8	2 (0)	0	0 (1)
Pile 100% Acrylic Velvet	13.3	25 (12)	14.5	19.5 (13)
Pile 50% Acry/50% Ray-PE Velvet	12.9	40 (23)	29	35 (29)
50% Acry/28% PE/22% PP	10.3	0 (0)	0	12
56% Acry/41% PE/3% Nylon	14.5	7	0	3
70 den. PE warp, 20/2 spun rayon fill	5.9	5 (0)	5.5	4.5 (0)

Times indicate time to test failure. Time numbers in parentheses indicate BASF tests for comparison to earlier DuPont run tests.
Note: All samples run with 20 sec. ignition time (Zero denotes failure during ignition period).

Table 4. Effect of Soaking on Pass/Fail

ATMI Cotton Fabrics				
Fabric ID	**Pass/Fail**	**Smolder**	**Flame**	**Result**
E – Original	P,P,P	9 sec.	-	
- Soaked	P,P	-	-	+
G – Original	F,F,F	>120 sec.	-	
- Soaked	P,P,F	>120 sec.	-	+
H – Original	P,F,F	>120 sec.	14 sec.	
- Soaked	P,P	-	-	++
T – Original	F,F,F	-	0 sec.	
- Soaked	F,F	-	8 sec.	+
Y – Original	F,F,F	>120 sec.	12 sec.	
- Soaked	P,F	>120 sec.	-	+
BB – Original	F,F,F	>120 sec.	6 sec.	
- Soaked	F,F	>120 sec.	11 sec.	+
CC – Original	P,F,F	-	3 sec.	
- Soaked	P,F,F	-	8 sec.	+

Table 5. Effect of Soaking on Pass/Fail

ATMI Non-Cotton Fabrics				
Fabric ID	**Pass/Fail**	**Smolder**	**Flame**	**Result**
A – Original	P,F,F,F	-	35 sec.	
- Soaked	P,P,F	-	50 sec.	+
B – Original	F,F	-	11 sec.	
- Soaked	F,F	-	13 sec.	±
C – Original	F,F,F	>120 sec.	18 sec.	
- Soaked	P,P	-	-	++
F – Original	P,P,P,F	>120 sec.	-	
- Soaked	P,P,P	-	-	++
P – Original	P,P,F	-	46 sec.	
- Soaked	P,F	-	26 sec.	-
R – Original	P,P,F,F	-	27 sec.	
- Soaked	P,P	-	-	++
U – Original	P,F,F	-	30 sec.	
- Soaked	P,P	-	-	++
X – Original	F,F,F	-	21 sec.	
- Soaked	F,F	-	22 sec.	±
Z- Original	P,P,F	>120 sec.	-	
- Soaked	P,F,F	-	13 sec.	-

Table 6. Effect of Soaking - Chemical Composition, ppm

Fabric ID	B	Na	K	P	Sb	Br
E – Original	280	265	29	1250	8750	3%
- Soaked	71	<30	<20	1100	8500	3%
G – Original	305	675	165	1450	8900	4%
- Soaked	42	<30	26	1250	9000	4%
H – Original	310	510	<20	1030	8650	4%
- Soaked	56	125	<20	945	7950	4%
T - Original	245	320	51	645	7150	2%
- Soaked	81	<30	<20	590	7200	2%
Y – Original	200	395	<20	900	8900	3%
- Soaked	45	93	<20	800	8900	3%
BB – Original	190	625	37	1150	9150	3%
- Soaked	64	120	20	995	8550	3%
CC – Original	175	335	72	1200	8150	2%
- Soaked	31	30	33	840	7350	2%

Table 7. Effect of Loose Interliner

	Flaming Time to Failure	
Fabric ID	**Original Fabric**	**w/ Interliner**
G	29 sec.	28 sec.
H	27 sec.	25 sec.
Y	18 sec.	19 sec.

Table 8. Effect of Laminated Interliners

- 8 of 8 Fabrics Pass CPSC Test

- 5 100% Woven Vinyls
- 2 100% Polyesters
- 1 100% Nylon

Table 9. Effect of Polyester Battingwith

Fabric ID	Original	PE Batting	Result
C	F,F,F	P,P,P	++
F	F,P,P	P,P,P	++
G	F,F,F	F,F,P	+
N	F,P,P	F,F,F	-
P	F,P,P	F,F,F	-
Q	F,P,P	F,P,P	±
V	F,F,P	F,F,F	-

Table 10. Effect of PU Foam Type Foams tested with FR backcoated fabrics, Limited Sampling

Foam Type	Pass	Fail
Conventional	17	17
Cal. 117	0	9
BS-5852	2	13
"Cal. 133" type	2	11

Table 11. Evaluation Findings: Test/Test Rig Concerns

- Gas train does not provide stable gas flow
- Cannot match all CPSC gas requirements
- Gas train too complicated/expensive
- Cannot have a draft free environment
- Safety of operator most important
- Flickering flame leads to inconsistency
- Position of back/seat important (operator)
- Position of burner tube critical (operator)
- Test rig too heavy for ergonomic reasons
- Difficult to position some fabric edge clips
- Is the sample size appropriate?

Table 12. Evaluation Findings: Fabric Concerns

- Direction of fabric may be important (operator)
- Stretch of fabric may be very important (operator)
- Soaking cotton fabrics appears to actually improve flammability results
- Some synthetics and cottons would pass BS-5852 but not the CPSC test
- FR fabrics show no trends in CPSC pass/fail (cannot be used as predictive tool)

Table 13. Evaluation Findings: Pass/Fail Concerns

- Flaming fail should be based on sustained flame Flickering flame failure sometimes a problem
- Burning droplets in some tests can lead to inconsistency in results
- Polyester batting could play a role in pass/fail but not included in test protocol
- Use of loose fitting interliners did not allow fabrics to pass CPSC test
- 14 of 31 BS-5852 compliant fabrics did not pass 9 of 14 failing fabrics not consistent in pass/fail

Table 14. Evaluation Findings: Overall Concerns

- Appropriate reproducibility and repeatability data not available
- No appropriate round robin data available
- 14 of 31 BS-5852 compliant fabrics did not pass
- 9 of 14 failing fabrics not consistent in pass/fail, indicating large possible test operator dependency
- Test cannot be used as predictive tool so fabrics cannot be class tested, leading to a large testing burden for the industry
- CPSC test apparatus too complex and costly, testing could be done with more manual equipment
- Fiber batting used over foam, found in high percentage of furniture, not subject to test conditions
- Cushion construction not tested in an upholstered furniture 'as sold' basis

Appendix

Table A. CPSC/BS-5852 Comparison

BS-5852		CPSC
450x300 mm, back 450x150 mm, seat	**Rig Size**	450x300 mm, back 450x150 mm, seat
S.S. Tube 200 mm long 6.5 mm ID x 8.0 m O.D.	**Burner**	S.S. Tube 200 mm long 6.07 mm ID x 8.05 m O.D.
Cylinder Regulator On/Off Valve Fine Control Valve Flow Meter	**Gas System**	Cylinder Regulator On/Off Valve Max Pressure Regulator Pressure Gauge Fine Control Valve Flow Meter On/Off Valve

Table B. CPSC/BS-5852 Comparison

BS-5852		CPSC
Butane ~ 35 mm flame height 45 ± 2 mL/min 2.8 kPa	**Gas**	Butane, 99.0% 35 mm flame height 45 ± 2 mL/min 2.75 kPa
23° ± 7 °C 45 ± 25% R. H. > 20 m^3 room size 0.02 - 0.20 m/sec air flow	**Test Area**	10° - 30°C 20 - 70% R. H. > 20 m^3 room size 0.20 m/sec air flow

Table C. CPSC/BS-5852 Comparison

BS-5852		
650 x 800 mm	**Fabric**	799 x 1016 mm
75 x 300 x 450 mm (12") x 458 mm (18") x 458 mm	**Non-FR Foam**	76 (3") x 305 76 x 83
75 x 150 x 450 mm		1.5 - 1.8 lb/ft^3, 25 - 30 IFD, polyether
20° ± 5 °C 50 ± 20 % R. H. 72 Hours Fabric Soak, 30 min.	**Conditioning**	25° ± 2 °C 40 - 55% R.H. 24 Hours **Fabric Soak, 24 Hours**
20 ± 1 sec. 2 Test positions	**Ignition**	20 sec. **3 Test positions**

Table D CPSC/BS-5852 Comparison

BS-5852		CPSC
> 15 min. To side or front edge	**Smoldering Pass/Fail**	> 120 sec. **To any edge**
> 120 sec. To side or front edge Through filling	**Flaming Pass/Fail**	> 120 sec. **To any edge**
Interlab tests = "good"	**Test R & R**	**Very limited interlab tests or round robin data**

Appendix, continued **TABLE E - ATMI/AFMA Fabrics**

Sorted by Fabric ID

Fabric ID	Coated	Pass/Fail	% Pass	Failure Mode	Add-on (g)	Add-on (oz)	% Add-on	Wt (oz/yd2)	Warp(epi)	Fill (ppi)	% Cotton	% PP	% PET	% Rayon	% Nylon	% Acrylic	%Acetate	% Linen	% Wool	% Silk
A	Yes	F	67	F	61	2.14	9	22.7	178	74	60			12	28					
B	Yes	F	0	F	65	2.28	17	13.7	95	47		5				95				
C	Yes	P	100	na	26	0.91	5	18.7	95	51			4	96						
D	Yes	P	100	na	58	2.03	12	16.4	178	54	66		2		16				16	
E	Yes	P	100	na	28	0.98	15	6.7	178	90	100									
F	Yes	P	100	na	27	0.95	7	13.9	178	44	38			62						
G	Yes	F	67	Smolder	79	2.77	22	12.8	178	82	100									
H	Yes	P	100	na	48	1.68	17	10	89	60	100									
I	Yes	P	100	na	64	2.24	11	20.2	59	25	92			8						
J	Yes	P	100	na	65	2.28	28	8.2	41	33		22	24			54				
K	Yes	F	33	F	89	3.12	26	12	17.3	28			100							
L	Yes	P	100	na	54	1.89	30	6.4	111	66			100							
M	Yes	F	0	F	28	0.98	12	8.5	150	38	57		43							
N	Yes	F	67	F	68	2.38	28	8.4	75	12		52	48							
O	Yes	P	100	na	37	1.30	19	6.7	100	22			100							
P	Yes	F	67	F	54	1.89	25	7.5	75	12	7	52	41							
Q	Yes	P	100	na	42	1.47	13	11.3	150	77	69		31							
R	Yes	P	100	na	75	2.63	27	9.7	150	44	10		34	56						
S	Yes	P	100	na	81	2.84	23	12.6	63	32	14		36			50				
T	Yes	F	0	F	45	1.58	21	7.5	96	56	100									
U	Yes	P	100	na	78	2.73	37	7.4	29	17.5	0	100								
V	Yes	F	33	F	?			9.1	48	15.2		100								
W	Yes	P	100	na	?			9.4	30	87			48	52						
X	Yes	F	0	F	72	2.52	17	15				5					95			
Y	Yes	F	50	S	49	1.72	16	10.7	35	58	100									
Z	Yes	F	33	F	21	0.74	10	7.6	68	25	41							59		
AA	Yes	P	100	na	75	2.63	21	12.3	11	13					100					
BB	Yes	F	0	F/S	50	1.75	25	6.9	30	30	100									
CC	Yes	F	33	F	32	1.12	17	6.6	28	84	100									
DD	Yes	P	100	na	58	2.03	60	3.4												100
EE	Yes	P	100	na	29	1.02	7	14.5	45	31				50	50					

Appendix, continued **TABLE F - ATMI/AFMA Fabrics**

Sorted by Fabric Type

Fabric ID	Coated	Pass/Fail	% Pass	Failure Mode	Add-on (g)	Add-on (oz)	% Add-on	Wt (oz/yd2)	Warp(epi)	Fill (ppi)	% Cotton	% PP	% PET	% Rayon	% Nylon	% Acrylic	%Acetate	% Linen	% Wool	% Silk
BB	Yes	F	0	F/S	50	1.75	25	6.9	30	30	100									
CC	Yes	F	33	F	32	1.12	17	6.6	28	84	100									
E	Yes	P	100	na	28	0.98	15	6.7	178	90	100									
G	Yes	F	67	Smolder	79	2.77	22	12.8	178	82	100									
H	Yes	P	100	na	48	1.68	17	10	89	60	100									
T	Yes	F	0	F	45	1.58	21	7.5	96	56	100									
Y	Yes	F	50	S	49	1.72	16	10.7	35	58	100									
I	Yes	P	100	na	64	2.24	11	20.2	59	25	92			8						
Q	Yes	P	100	na	42	1.47	13	11.3	150	77	69		31							
D	Yes	P	100	na	58	2.03	12	16.4	178	54	66		2		16				16	
A	Yes	F	67	F	61	2.14	9	22.7	178	74	60			12	28					
M	Yes	F	0	F	28	0.98	12	8.5	150	38	57		43							
Z	Yes	F	33	F	21	0.74	10	7.6	68	25	41							59		
F	Yes	P	100	na	27	0.95	7	13.9	178	44	38			62						
S	Yes	P	100	na	81	2.84	23	12.6	63	32	14		36			50				
R	Yes	P	100	na	75	2.63	27	9.7	150	44	10		34	56						
P	Yes	F	67	F	54	1.89	25	7.5	75	12	7	52	41							
U	Yes	P	100	na	78	2.73	37	7.4	29	17.5	0	100								
K	Yes	F	33	F	89	3.12	26	12	17.3	28			100							
L	Yes	P	100	na	54	1.89	30	6.4	111	66			100							
O	Yes	P	100	na	37	1.30	19	6.7	100	22			100							
N	Yes	F	67	F	68	2.38	28	8.4	75	12		52	48							
W	Yes	P	100	na	?			9.4	30	87			48	52						
J	Yes	P	100	na	65	2.28	28	8.2	41	33		22	24			54				
C	Yes	P	100	na	26	0.91	5	18.7	95	51			4	96						
V	Yes	F	33	F	?			9.1	48	15.2		100								
B	Yes	F	0	F	65	2.28	17	13.7	95	47		5				95				
X	Yes	F	0	F	72	2.52	17	15				5					95			
AA	Yes	P	100	na	75	2.63	21	12.3	11	13					100					
DD	Yes	P	100	na	58	2.03	60	3.4												100
EE	Yes	P	100	na	29	1.02	7	14.5	45	31				50	50					

Notes:% Pass = % of tests run which were passes. Failure Mode: F = Flame, S = Smolder Normally 3 tests per sample were run.

Appendix, continued **TABLE G - ATMI/AFMA Fabrics**

Sorted by Fabric Weight

Fabric ID	Coated	Pass/Fail	% Pass	Failure Mode	Add-on (g)	Add-on (oz)	% Add-on	Wt (oz/yd2)	Warp(epi)	Fill (ppi)	% Cotton	% PP	% PET	% Rayon	% Nylon	% Acrylic	%Acetate	% Linen	% Wool	% Silk
DD	Yes	P	100	na	58	2.03	60	3.4												100
L	Yes	P	100	na	54	1.89	30	6.4	111	66			100							
CC	Yes	F	33	F	32	1.12	17	6.6	28	84	100									
E	Yes	P	100	na	28	0.98	15	6.7	178	90	100									
O	Yes	P	100	na	37	1.30	19	6.7	100	22			100							
BB	Yes	F	0	F/S	50	1.75	25	6.9	30	30	100									
U	Yes	P	100	na	78	2.73	37	7.4	29	17.5	0	100								
P	Yes	F	67	F	54	1.89	25	7.5	75	12	7	52	41							
T	Yes	F	0	F	45	1.58	21	7.5	96	56	100									
Z	Yes	F	33	F	21	0.74	10	7.6	68	25	41							59		
J	Yes	P	100	na	65	2.28	28	8.2	41	33		22	24			54				
N	Yes	F	67	F	68	2.38	28	8.4	75	12		52	48							
M	Yes	F	0	F	28	0.98	12	8.5	150	38	57		43							
V	Yes	F	33	F	?			9.1	48	15.2		100								
W	Yes	P	100	na	?			9.4	30	87			48	52						
R	Yes	P	100	na	75	2.63	27	9.7	150	44	10		34	56						
H	Yes	P	100	na	48	1.68	17	10	89	60	100									
Y	Yes	F	50	S	49	1.72	16	10.7	35	58	100									
Q	Yes	P	100	na	42	1.47	13	11.3	150	77	69		31							
K	Yes	F	33	F	89	3.12	26	12	17.3	28			100							
AA	Yes	P	100	na	75	2.63	21	12.3	11	13					100					
S	Yes	P	100	na	81	2.84	23	12.6	63	32	14		36			50				
G	Yes	F	67	Smolder	79	2.77	22	12.8	178	82	100									
B	Yes	F	0	F	65	2.28	17	13.7	95	47		5				95				
F	Yes	P	100	na	27	0.95	7	13.9	178	44	38			62						
EE	Yes	P	100	na	29	1.02	7	14.5	45	31				50	50					
X	Yes	F	0	F	72	2.52	17	15				5					95			
D	Yes	P	100	na	58	2.03	12	16.4	178	54	66		2		16				16	
C	Yes	P	100	na	26	0.91	5	18.7	95	51			4	96						
I	Yes	P	100	na	64	2.24	11	20.2	59	25	92			8						
A	Yes	F	67	F	61	2.14	9	22.7	178	74	60			12	28					

Notes: % Pass = % of tests run which were passes. Failure Mode: F = Flame, S = Smolder Normally 3 tests per sample were run.

Appendix, continued **TABLE H - ATMI/AFMA Fabrics**

Sorted by add-on weight

Fabric ID	Coated	Pass/Fail	% Pass	Failure Mode	Add-on (g)	Add-on (oz)	% Add-on	Wt (oz/yd2)	Warp(epi)	Fill (ppi)	% Cotton	% PP	% PET	% Rayon	% Nylon	% Acrylic	%Acetate	% Linen	% Wool	% Silk
Z	Yes	F	33	F	21	0.74	10	7.6	68	25	41							59		
C	Yes	P	100	na	26	0.91	5	18.7	95	51			4	96						
F	Yes	P	100	na	27	0.95	7	13.9	178	44	38			62						
M	Yes	F	0	F	28	0.98	12	8.5	150	38	57		43							
E	Yes	P	100	na	28	0.98	15	6.7	178	90	100									
EE	Yes	P	100	na	29	1.02	7	14.5	45	31				50	50					
CC	Yes	F	33	F	32	1.12	17	6.6	28	84	100									
O	Yes	P	100	na	37	1.30	19	6.7	100	22			100							
Q	Yes	P	100	na	42	1.47	13	11.3	150	77	69		31							
T	Yes	F	0	F	45	1.58	21	7.5	96	56	100									
H	Yes	P	100	na	48	1.68	17	10	89	60	100									
Y	Yes	F	50	S	49	1.72	16	10.7	35	58	100									
BB	Yes	F	0	F/S	50	1.75	25	6.9	30	30	100									
P	Yes	F	67	F	54	1.89	25	7.5	75	12	7	52	41							
L	Yes	P	100	na	54	1.89	30	6.4	111	66			100							
D	Yes	P	100	na	58	2.03	12	16.4	178	54	66		2		16				16	
DD	Yes	P	100	na	58	2.03	60	3.4												100
A	Yes	F	67	F	61	2.14	9	22.7	178	74	60			12	28					
I	Yes	P	100	na	64	2.24	11	20.2	59	25	92			8						
B	Yes	F	0	F	65	2.28	17	13.7	95	47		5				95				
J	Yes	P	100	na	65	2.28	28	8.2	41	33		22	24			54				
N	Yes	F	67	F	68	2.38	28	8.4	75	12		52	48							
X	Yes	F	0	F	72	2.52	17	15				5					95			
AA	Yes	P	100	na	75	2.63	21	12.3	11	13					100					
R	Yes	P	100	na	75	2.63	27	9.7	150	44	10		34	56						
U	Yes	P	100	na	78	2.73	37	7.4	29	17.5	0	100								
G	Yes	F	67	Smolder	79	2.77	22	12.8	178	82	100									
S	Yes	P	100	na	81	2.84	23	12.6	63	32	14		36			50				
K	Yes	F	33	F	89	3.12	26	12	17.3	28			100							
V	Yes	F	33	F	?			9.1	48	15.2		100								
W	Yes	P	100	na	?			9.4	30	87			48	52						

Notes % Pass = % of tests run which were passes. Failure Mode: F = Flame, S = Smolder Normally 3 tests per sample were run.

Appendix, continued **TABLE I - ATMI/AFMA Fabrics**

Sorted by % Add-on

Fabric ID	Coated	Pass/Fail	% Pass	Failure Mode	Add-on (g)	Add-on (oz)	% Add-on	Wt (oz/yd2)	Warp(epi)	Fill (ppi)	% Cotton	% PP	% PET	% Rayon	% Nylon	% Acrylic	%Acetate	% Linen	% Wool	% Silk
C	Yes	P	100	na	26	0.91	5	18.7	95	51			4	96						
F	Yes	P	100	na	27	0.95	7	13.9	178	44	38			62						
EE	Yes	P	100	na	29	1.02	7	14.5	45	31				50	50					
A	Yes	F	67	F	61	2.14	9	22.7	178	74	60			12	28					
Z	Yes	F	33	F	21	0.74	10	7.6	68	25	41							59		
I	Yes	P	100	na	64	2.24	11	20.2	59	25	92			8						
M	Yes	F	0	F	28	0.98	12	8.5	150	38	57		43							
D	Yes	P	100	na	58	2.03	12	16.4	178	54	66		2		16				16	
Q	Yes	P	100	na	42	1.47	13	11.3	150	77	69		31							
E	Yes	P	100	na	28	0.98	15	6.7	178	90	100									
Y	Yes	F	50	S	49	1.72	16	10.7	35	58	100									
B	Yes	F	0	F	65	2.28	17	13.7	95	47		5				95				
H	Yes	P	100	na	48	1.68	17	10	89	60	100									
X	Yes	F	0	F	72	2.52	17	15				5					95			
CC	Yes	F	33	F	32	1.12	17	6.6	28	84	100									
O	Yes	P	100	na	37	1.30	19	6.7	100	22			100							
T	Yes	F	0	F	45	1.58	21	7.5	96	56	100									
AA	Yes	P	100	na	75	2.63	21	12.3	11	13					100					
G	Yes	F	67	Smolder	79	2.77	22	12.8	178	82	100									
S	Yes	P	100	na	81	2.84	23	12.6	63	32	14		36			50				
P	Yes	F	67	F	54	1.89	25	7.5	75	12	7	52	41							
BB	Yes	F	0	F/S	50	1.75	25	6.9	30	30	100									
K	Yes	F	33	F	89	3.12	26	12	17.3	28			100							
R	Yes	P	100	na	75	2.63	27	9.7	150	44	10		34	56						
J	Yes	P	100	na	65	2.28	28	8.2	41	33		22	24			54				
N	Yes	F	67	F	68	2.38	28	8.4	75	12		52	48							
L	Yes	P	100	na	54	1.89	30	6.4	111	66			100							
U	Yes	P	100	na	78	2.73	37	7.4	29	17.5	0	100								
DD	Yes	P	100	na	58	2.03	60	3.4												100
V	Yes	F	33	F	?			9.1	48	15.2		100								
W	Yes	P	100	na	?			9.4	30	87			48	52						

Notes: % Pass = % of tests run which were passes. Failure Mode: F = Flame, S = Smolder Normally 3 tests per sample were run.

Appendix, continued **TABLE J - ATMI/AFMA Fabrics**

Sorted by Pass/Fail and then % Pass

Fabric ID	Coated	Pass/Fail	% Pass	Failure Mode	Add-on (g)	Add-on (oz)	% Add-on	Wt (oz/yd2)	Warp(epi)	Fill (ppi)	% Cotton	% PP	% PET	% Rayon	% Nylon	% Acrylic	%Acetate	% Linen	% Wool	% Silk
B	Yes	F	0	F	65	2.28	17	13.7	95	47		5				95				
M	Yes	F	0	F	28	0.98	12	8.5	150	38	57		43							
T	Yes	F	0	F	45	1.58	21	7.5	96	56	100									
X	Yes	F	0	F	72	2.52	17	15				5					95			
BB	Yes	F	0	F/S	50	1.75	25	6.9	30	30	100									
K	Yes	F	33	F	89	3.12	26	12	17.3	28			100							
V	Yes	F	33	F	?			9.1	48	15.2		100								
Z	Yes	F	33	F	21	0.74	10	7.6	68	25	41							59		
CC	Yes	F	33	F	32	1.12	17	6.6	28	84	100									
Y	Yes	F	50	S	49	1.72	16	10.7	35	58	100									
A	Yes	F	67	F	61	2.14	9	22.7	178	74	60			12	28					
G	Yes	F	67	Smolder	79	2.77	22	12.8	178	82	100									
N	Yes	F	67	F	68	2.38	28	8.4	75	12		52	48							
P	Yes	F	67	F	54	1.89	25	7.5	75	12	7	52	41							
C	Yes	P	100	na	26	0.91	5	18.7	95	51			4	96						
D	Yes	P	100	na	58	2.03	12	16.4	178	54	66		2		16				16	
E	Yes	P	100	na	28	0.98	15	6.7	178	90	100									
F	Yes	P	100	na	27	0.95	7	13.9	178	44	38			62						
H	Yes	P	100	na	48	1.68	17	10	89	60	100									
I	Yes	P	100	na	64	2.24	11	20.2	59	25	92			8						
J	Yes	P	100	na	65	2.28	28	8.2	41	33		22	24			54				
L	Yes	P	100	na	54	1.89	30	6.4	111	66			100							
O	Yes	P	100	na	37	1.30	19	6.7	100	22			100							
Q	Yes	P	100	na	42	1.47	13	11.3	150	77	69		31							
R	Yes	P	100	na	75	2.63	27	9.7	150	44	10		34	56						
S	Yes	P	100	na	81	2.84	23	12.6	63	32	14		36			50				
U	Yes	P	100	na	78	2.73	37	7.4	29	17.5	0	100								
W	Yes	P	100	na	?			9.4	30	87			48	52						
AA	Yes	P	100	na	75	2.63	21	12.3	11	13					100					
DD	Yes	P	100	na	58	2.03	60	3.4												100
EE	Yes	P	100	na	29	1.02	7	14.5	45	31				50	50					

Notes: % Pass = % of tests run which were passes. Failure Mode: F = Flame, S = Smolder Normally 3 tests per sample were run.