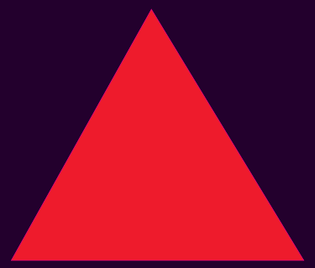

Consumer Safety Research

Assessment of PU Foam Crumb according to SI 1324

dti

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Foreword by Nigel Griffiths

A fire in your home is a frightening prospect. In the UK, more than two people a week are killed in accidental fires at home starting in foam filled furniture.

The UK has the toughest furniture flammability regulations in Europe. These laws, and the effective promotion of smoke alarms through central and local government, safety organisations and industry have helped to curb this tragic loss of life. However, we must leave no stone unturned.

That's why I am determined that any uncertainties about the testing procedures for crumb foam - used in pillows and cushions - must be cleared up once and for all. This research report produced for the DTI by the Rubber and Plastic Research Associations shows that the current laws and tests for crumb foam are reliable. It provides a valuable insight into how to ensure tests results are consistent. I hope Industry will work closely with Trading Standards Departments to ensure that any unsafe crumb foam in household furniture on the market will be eliminated so that we can continue to make our homes a safer place.

Nigel Griffiths MP

Minister for Competition Policy and Consumer Affairs

Assessment of pu foam crumb according to SI 1324

Summary of programme

The programme of work includes the testing of four commercial batches of PU foam crumb and 12 batches of crumb prepared from selected PU foam slabstock from different sources and of different types. All PU foams were tested to SI 1324 Schedule 1 Part II at several different packing densities. Tests were also carried out with PU crumb contained within the standard test specimen and also within pre-sewn bags. The melamine, chlorine and bromine content of the various commercial crumbs were determined by the Laboratory of the Government Chemist.

Conclusions and recommendations

1) The test method defined in SI 1324 Schedule 1 Part II is capable of giving highly repeatable test results when used with some batches of PU crumb foam. Clarification of relatively minor ambiguities of the test procedure are required. The use of pre-sewn bags can give different results to those from the standard test specimen. If used for standard tests the construction details of such bags need to be specified.
2) It is essential that PU crumb foam is tested to SI 1324 Schedule 1 Part II because:
   a) Some commercially purchased batches of PU crumb foam have failed this test (two from four purchased batches).
   b) Not all PU crumb foams prepared from PU slabstock reported to pass Schedule 1 Part 1 (crib 5/60g) test actually pass SI 1324 Schedule 1 Part II (five pass, three fail, one pass at high packing density only). The lower density CMHR foams and the CM ether foams appear to have a greater tendency to fail than the higher density CMHR foams.
   c) PU crumb foam is a variable product from a variable feedstock.
3) PU crumb foam producers should carry out frequent tests and should closely control the selection, processing and quality of their product if it is to be sold with reasonable certainty of meeting legislative controls. Blending operations of feedstock and product would be desirable.
4) PU foam slab producers may need to identify which products meeting the Schedule 1 Part 1 test will produce PU crumb foam meeting the requirements of Schedule 1 Part II because not all PU foams are capable of doing this.
5) PU foam slab producers may need to classify and selectively store PU foam scrap in a more tightly controlled and more specific manner to aid the production of PU crumb foam meeting the requirements of Schedule 1 Parts I and II.
6) The PU crumb foam industry needs to be made aware of a number of important factors because of the relative lack of awareness of some factors by some parts of the industry.

Factors of importance include:

   a) The existence of and also the detail of legislative requirements and test methods.
   b) The necessity of meeting these requirements and of not selling a highly flammable product.
   c) The necessity of carrying out flame tests to SI 1324 Schedule 1 Part II and of proper quality assurance procedures.
   d) The dangers of assuming that scrap from PU foam block reported to pass SI 1324 Schedule 1 Part I will automatically pass Schedule 1 Part II requirements.
   e) The dangers of blending melamine and graphite modified PU foams.

1. Introduction

This report concerns tests carried out using batches of PU foam crumb supplied by various manufacturers to a Rapra order for PU crumb foams conforming to SI 1324 requirements and then to crumb foam prepared from selected block foams.

The work forms part of an investigation into possible problems when BS 5852 part 2 source 2 is used to test PU crumb according to the requirements of SI 1324 Schedule 1 Part II.

The work has been subdivided into a number of different sections. The main work programme was carried out using two large batches of PU crumb foam each supplied by a different manufacturer. Results were then verified using two small batches of PU crumb from different suppliers. In addition PU crumb foams from known PU block foam were also tested. Comparative tests were also carried out with standard and pre-sewn bag specimens. Chemical analysis of the PU foam crumb was carried out by Mr. S. Carter of the Laboratory of the Government Chemist.

2. Test methods and regulatory controls for pu crumb foam

UK controls for PU foam fillings for upholstered furniture are defined in several Statutory Instruments which apply to upholstered furniture.

SI No. 1324, Consumer Protection, The Furniture and Furnishings (Fire) (Safety) Regulations 1988.

SI No. 2358, Consumer Protection, The Furniture and Furnishings (Fire) (Safety) Regulations 1989. Consumer Protection, and

SI No. 207, consumer Protection, The Furniture and Furnishings (Fire) (Safety) Regulations 1993.

The definition of PU foam crumb is contained within SI 1324. The two amendments apply to other aspects of upholstered furniture.

SI 1324 Clause 6, relates to filling materials and states that

1) no furniture shall include any filling material which fails the relevant ignitability test,
2) the foam from which the crumb is derived passes the ignitability test specified in Part 1 Schedule 1 of the Regulations, and
3) the foam in crumb form itself passes the ignitability test specified in Part II of that Schedule.

Schedule 1 Part 1 defines the ignitability test for PU foam in slab or cushion form. In this, the foam is tested to BS 5852, Part 2, 1982, Fire Tests for furniture, Part 2, Methods of Test for the ignitability of upholstered composites for seating by flaming sources, using a cover fabric of 100% flame retarded polyester fibre of plain weave with specified warp and weft yarns. The test specimen is positioned on a weighing balance. The specimen is tested with a No.5 crib (17 grams of wood sticks which typically burn for three minutes). The specimen is required to meet the requirements of BS 5852, Part 2 (all flames cease within 11 minutes, and do not reach the edges of the specimen, except the upper laminated edge), and have a weight loss of less than 60 g and does not smoulder progressively.

The PU crumb foam itself is tested to Schedule 1, Part II, which is similar to Schedule 1, Part 1, except that the ignition source 2 is used (a gas flame approximately 145 mm high at 160 mls/minute of butane for 40 seconds). The 60 gram weight loss criteria is not applied but the flame front is not permitted to pass through the thickness of the specimen.

3. Selection of pu foam crumb

It had originally been planned to obtain the main batch of PU crumb foam from a single supplier known to provide a very good quality product. Unfortunately because of the seasonable nature of the garden furniture industry, this proved impossible since the particular plant would be shut down for four months.

A total of 12 additional companies were contacted but only four confirmed supplying PU crumb foam to the market place. It was stated that much of the PU crumb foam produced was converted into high density reconstituted block foam or was directly used to manufacture cushions, toys etc.

Four batches of PU crumb foam (two large and two small) were ordered, each from a different manufacturer. Of the four batches originally ordered, three were delivered. Eight weeks (!) after receiving the order, the fourth supplier stated that their crumb may not meet SI requirements and refused to supply any material. Additional companies were contacted and one additional batch purchased.

For Phase 2 of the programme and for tests with standard and pre-sewn bag specimens, a number of batches of PU crumb foam made from known batches of PU block foam were obtained via Dr. D. King of Recticel Limited.

4. Test Programme

Ignition Tests

All ignition tests were carried out to SI 1324 Schedule 1 Part II using BS 5852 Part 2.

Test Specimens

Unfortunately the BS 5852 part 2 test rig was developed with rectangular cushion slabs. It was then used with loose filling materials and parts of the test procedures are not as specific as they could be.

Section 8.3 paragraph 4 of the standard states that some kinds of loose filling materials (e.g. crumb foam) may be evaluated by this method of test. Where necessary a finer grid of material or air porous fabric may be laid over the expanded metal of the test rig to retain the filling.

Section 8.3 paragraph 5 of the standard states that if, in use, the loose in-fill is enclosed in an interlining (or ticking) it is acceptable to make up two bags of the interlining material suitably filled and to the overall dimensions of the test specimen.

The nature of PU crumb foam is such that a number of batches can contain a proportion of very small pieces and consequently Section 8.3 should arguably apply. Unfortunately the nature or porosity of the air porous material is not defined but for reasons of consistency, availability and ease of specification, it is suggested that the FR polyester fabric defined in SI 1324 should be used to cover the expanded metal of the BS 5852 part 2 test rig.

In many applications, the PU foam is used to fill cushions, etc. and it is less frequently contained in interliner bags as described in paragraph 5 of 8.3 and this test modification should not be used. However, it is understood that some manufacturers prefer to use pre-sewn bags to contain the PU crumb foam for testing and tests were carried out for standard and bagged specimens of 2 PU crumb foams at 2 packing densities (see Section 7).

For these reasons, the test specimen used for the PU crumb foam tests has been built directly onto the BS 5852 part 2 but a single layer of the FR polyester fabric was used to cover the expanded metal of the test rig.

The test specimens consisted of the specified FR polyester fabric cut to size and clipped to the test rig. The rear of the specimen expanded grid was covered by a single layer of the FR polyester fabric. The PU foam crumb was pushed into the cavity to form a cushion. It was not possible to form a square uniform cushion but the foam crumb was packed as uniformly as practicable. The top of the foam cushions was then clipped and the test specimen smoothed by hand.

Polyurethane crumb foams can be packed at different densities to give products which range from very soft low density cushions to hard pouffes. In order to investigate the possible

effects of packing density, a series of test specimens were prepared with densities 25, 35, 45 and 55 kg/m3.

It has been claimed that the PU crumb foam test can give variable test results. For this reason a total of five replicate specimens were tested for each test condition. Each test condition was tested with two flame applications per test rig (as permitted in BS 5852 part 2 1982) and also with one application per test specimen. The latter is the only test system now permitted with crib tests since work showed that difficulties were sometimes caused when two replicate tests were carried out on the same test specimen.

Conditioning of Test Specimens

All fabrics and PU foam crumbs were stored in a warm laboratory before conditioning for at least 24 hours at 22°C and 50% RH.

Chemical analysis of PU crumb foam

Samples of the PU crumb foams were sent to the Laboratory of the Government Chemist for the determination of melamine, chlorine and bromine content.

5. Phase 1, commercial PU crumb foam batches

It had been intended to investigate the effects of packing density and test specimen shape using two batches of PU foam crumb in replicate tests and to confirm the conclusions drawn using other, smaller batches of PU crumb. One of the batches selected (Crumb A) proved to be unsuitable and the main evaluation work was carried out with Crumb B and additional tests with C and D.

The PU crumb foam suppliers have been coded A, B, C, D etc.

5.1 Manufacturers certification of PU foam crumb

Each PU crumb foam supplier was requested to send a copy of the relevant test certificate showing that the material supplied conformed to the requirements of SI 1324.

Crumb A

Certificates were not available and it was understood that the PU crumb itself had not been tested. The manufacturer verbally assured the writer that the feedstock PU foam met the crib 5/60 g mass loss requirements.

Crumb B

A fax of a test certificate was received. This referred to a test carried out by a UKAS accredited, external laboratory and gave a pass result for a product described as crumb foam, colour blue. The certificate was dated 23rd June 1995.

The writer was informed that only feedstock foam complying with the crib 5/60 g mass loss requirements was used, that the test certificate was the most recently available and that crumb foam was tested on a monthly basis by a UKAS accredited laboratory.

In fact the test certificate was dated about four months before the PU crumb foam was received, and whereas the certificate referred to blue foam, that received was mainly yellow with some white (two bags) and then mainly white with various mixed colours.

Crumb C

The test certificate sent to Rapra referred to the PU foam block feedstock only. It was dated and referred specifically to the Rapra invoice number and was generated by the PU crumb foam supplier. A test certificate for the PU foam crumb was requested but the writer was informed that it was difficult to test from since it could only be tested in its end use form as stuffed cushions. It did not appear that the person contacted was aware of formal test requirements but stated that PU foam crumb could give variable test results because of the variable feedstock, its density etc.

Crumb D

Two test certificates were sent. Both were for SI 1324 Schedule 1 Part II (i.e. No. 2 flame test for crumb).

The first referred to CMHR crumb foam, reference blue crumb and was dated February 1990 and the second to the CMHR crumb foam reference yellow and was dated July 1990. Both certificates were issued by an independent UKAS accredited test house.

The foam received was delivered in October 1995 and was predominately mauve in colour with a minor amount of other coloured foam pieces.

5.2 Effect of packing density on test specimen shape

The shape of the test specimen is directly affected by the packing density of the PU foam crumb (see photographs in appendix).

The test specimen of the original BS 5852 part 2 test rig consists of two flat rectangular blocks with flat surfaces against which the ignition flame is applied. In contrast the shape of the PU crumb foam specimen will be curved although it can approximate to a trapezoided section. The nett result is that the shape of the ignition flame target area is significantly different from that of the original flat rectangular (see photographs).

The shape of the test specimen is also dependant on the bulk density of the PU foam crumb. Thus a low bulk density foam crumb will give a more rounded test specimen than a higher bulk density crumb even when packed to the same density.

A further effect of the PU foam bulk density and the packing density is that it affects the tension of the fabric. This in turn affects the way the fabric splits open once it is exposed to the flame source. Medium density foams at a low packing density can give slack fabric coverings.

The effect of foam packing density on specimen test shape is generally similar for all crumb foams although the degree of distortion and/or slackness varies with the density of the foam itself.

The approximate bulk density of each PU foam crumb was determined by weighing a specific volume of crumb.

5.3 Examination of PU foam crumb batches

Each batch of PU crumb foam has been considered separately.

5.3.1 PU crumb foam A

Ignition test results to SI 1324 Schedule 1 Part II

These test results (Table 1) show that crumb foam A failed the test at every packing density tested.

Table 1 Fire test results for PU crumb foam A

Packing Density	Result
25 kg m^3	Fail 1. Burn for more than 2 minutes. 2. Escalating fire. 3. Flames reach edge of specimen. 4. Flames through depth of specimen. 5. Extinguished by operator.
35 kg m^3	Fail 1. Burn for more than 2 minutes. 2. Escalating fire. 3. Flames reach edge of specimen. 4. Flames through depth of specimen. 5. Extinguished by operator. 6. Progressive smouldering leading to flaming combustion.
45 kg m^3	Fail 1. Burn for more than 2 minutes. 2. Escalating fire. 3. Flames reach edge of specimen. 4. Flames through depth of specimen. 5. Extinguished by operator.
55 kg m^3	Fail 1. Burn for more than 2 minutes. 2. Escalating fire. 3. Flames reach edge of specimen. 4. Flames through depth of specimen. 5. Extinguished by operator. 6. Progressive smouldering leading to flaming combustion.

Ad hoc ignition test

A limited number of ad hoc tests have been carried out in which small piles of PU foam crumb A were exposed to the No. 1 gas flame of BS 5852. Variable results were obtained but in a number of tests the foams burned in a sustained manner.

Chemical analysis of PU crumb foam A

This foam has been analysed by Laboratory of the Government Chemist. Visual inspection indicated that the PU crumb is probably a blend of melamine containing foams, graphite containing foam and reconstituted foam. The chemical analysis of the crumb is shown below.

Colour	Chlorine % m/m	Bromine % m/m	Melamine mg/g
White	1.25	<0.3	119, 119
Yellow	1.15	<0.3	118, 121
Orange	1.47	<0.3	54, 61
Blue	1.75	<0.3	99, 116
Turquoise	<0.3	<0.3	98, 98
Pink	<0.3	<0.3	115, 124
Light-grey	0.37	<0.3	41, 42
Dark-grey	<0.3	<0.3	44, 44
Graphite	<0.3	<0.3	3, 3

The above table indicates that this batch of PU crumb foam contains materials of high and low melamine content and also high and low chlorine content with a single graphite modified foam component. It is considered unlikely that some of these PU crumb foams would have met the requirements of SI 1324 Schedule 1 Part I.

Visual analysis of PU foam crumb A

Visual examination of PU foam crumb A showed that it comprised fairly regular, pieces of approximately uniform size. Seven different coloured foams were observed. Of these, five appeared to be of a similar type which differed in colour. The sixth type was a brown foam which appeared to contain small black speckles. The seventh type consisted of pieces of reconstituted foam which in turn consisted of a number of different coloured pieces of foam. Pieces of foam crumb were between 6 and 46 mm across with a typical size of 25 mm.

Bulk Density

The bulk density of PU crumb foam A was 17 kg/m^3.

Packing of crumb A

Crumb A was relatively easy to pack into the test specimens. The crumb held together and test specimens did not “fall apart” until the fire had developed considerably.

Discussion of results of crumb foam A

This crumb foam was a medium, regular sized crumb which packed easily into the test specimen and appeared to be fairly uniform in size and shape. Schedule 1 Part II tests gave complete fail results with no passes.

The results of this test series were sent to the PU crumb foam supplier. Apparently the PU crumb foam had been made from scrap foam blocks and off-cuts which conformed to the No. 5 crib/mass loss requirements. The scrap was granulated, blended and bagged. Apparently neither the batch supplied to Rapra nor any other batches were tested to the No. 2 flame test and it was apparently assumed by the company that if the base material met the crib 5/mass loss requirements, then crumb made from the feed stock would also be satisfactory.

When the 1988 regulations were introduced, Rapra Technology carried out a limited number of tests with melamine PU foam and graphite PU foam blocks. Each individually passed the crib 5/60 g mass loss test but burned to completion if tested as a layered composite. The flame retarding mechanisms of the melamine modified HRPU foam is that it shrinks away from the igniting flame. In contrast, the graphite modified PU foam chars when exposed to a flame. Mixing these two mutually antagonistic flame retardant mechanisms together results in sustained flaming since the melamine HRPU melts onto the char forming graphite foam where it ignites and hence both burn together. Graphite modified PU foam can also smoulder and this probably accounts for the re-establishing of flaming combustion of the extinguished test specimens.

It is suggested that the presence of quantities of graphite modified foam in the crumb led to the poor ignition resistance of this crumb and to it failing the test of SI 1324. This situation was also partly caused by the presence of significant amount of PU foam with relatively low melamine and flame retardant (chlorine) additives, some of which are considered unlikely to be able to meet the requirements of SI 1324 Schedule 1 Part I.

The crumb foam supplier expressed surprise that mixing the two types of combustion modified PU foam could have this effect. The fail results would have become readily apparent to the supplier had the relevant specified tests been carried out before it was supplied to a customer.

5.3.2 PU crumb foam B

Ignition tests results to SI 1324, Schedule 1, Part II.

These tests results, given in Table 2 show that crumb foam B gives rather variable results. Pass and fail results can both occur with the same experimental conditions. It should be noted that the proportion of crumb B foam passes, increases as the packing density is

increased. There may also be a tendency for single flame test specimens to give a high proportion of double test specimens but this needs to be checked because of variable nature of the test specimens (Table 4).

Table 2 Two test flame applications per single test rig (Schedule 1, Part II)

Packing Density kg/m3	Test Bag No.	no. of Tests Rigs	Result Test 1	Result Test 2	Result Final	Comment
25	1/2	5	4P/1F	2P/F	2P/3F	EBO, 3 mins. through tickness
35	1/2	5	5P/0F	4P/1F	4P/1F	
45	1/2	5	5P/0F	5P/0F	5P/0F	
55	1/2	5	5P/0F	5P/0F	5P/0F	

Table 3 Single test flame per single test specimen (includes single flame test data from Table 2)

Packing Density kg/m3	Test Bag No.	no. of Tests Rigs	Result Pass/Fail	Comment
25	3	10	4/6	Six fails EBO escalating fire at 2 m 20 s, most through thickness.
25	1/2	5	4/1	One EBO, as above.
35	6	10	6/4	Four EBO as above.
35	1/2	5	5/0	All specimens passed.
45	5	10	7/3	Three EBO as 25 kg/m3 above.
45	1/2	5	5/0	All specimens passed.
55	4	10	8/2	Two EBO as 25 kg/m3 above.
55	1/2	5	5/0	All specimens passed.

Table 4 Composition of PU crumb foam bags

Bag 1	Mainly yellow mixed with some other colours, particularly white
Bag 2	General mixed colours, mainly yellow with some white
Bag 3	Mixed colours, mainly white with yellow, pink, grey and blue
Bag 4	Mixed colours, white with yellow, green, pink
Bag 5	Mixed colours, mainly white with green blue, pink, yellow and grey
Bag 6	Mixed colours mainly white with smaller amounts of yellow, blue, pink. grey, orange, lemon

Chemical analysis of PU foam crumb B

Chemical analysis of foam B is shown below in Table 5.

PU foam crumb B comprised significant amounts of yellow, white and blue foams with varying amount of other colours.

Table 5 Chemical analysis of PU crumb foam B

PU Crumb foam	Chlorine % mm	Bromine % mm	Melamine mg/g
Yellow 1	0.53	<0.3	86
Yellow 2	1.04	-	76
White 1	<0.03	<0.3	83
White 2	0.07	-	98
Blue 1	1.24	<0.3	109
Blue 2	2.01	-	78/90
Golden (Amber)	1.09	-	76
Orange	1.76	-	96 (87 - 101)
Pink	0.63	-	125
Grey	1.62	-	97

These results show that there is a considerable spread of melamine and chlorine contents within PU crumb foam B.

Samples of foam crumb were taken from test rigs which had passed or failed the No. 2 flame test. The proportions of the different colours and their estimated melamine content is given below in Table 6. These results should be treated with caution because of the volatile nature of the melamine additive used.

Table 6 Composition of samples of PU foam crumb

Batch Test Result	B3/1 Fail	B3/2 Fail	B3/3 Pass
% Mass Yellow	29.5	38.5	26.3
White	43	41.0	-
Blue	27.5	-	73.7
Mixed	-	20.5	-
Average melamine content	91	84	102
Average chlorine content	0.5	0.26	0.91

The above results indicate that the fail results occur with the lower melamine and chlorine contents.

Visual examination of foam B

The first two bags of crumb foam B were primarily yellow in colour with pieces of white foam mixed together. The next three bags of crumb foam B were primarily white but with pieces of pink, blue, yellow see Table 4. Other bags were of mixed colours. Pieces of foam crumb were about 7 - 56 mm across with a typical size of 40 mm.

Bulk Density of foam B

The bulk density of PU crumb foam B was typically 13 kg/m3.

Packing of foam B

Crumb foam B was relatively easy to pack into the test specimens. The crumb held together and did not fall out of the specimen when the fabric split open in the flame tests.

Discussion of results of crumb foam B

This foam crumb varied in the colours of the bags received. Two bags were predominantly yellow with white pieces while three bags were predominantly white with pieces of pink, blue and yellow.

The foam crumb was said by the manufacturers to have been made from foam block which was known to pass Schedule 1, Part 1 of the SI 1324 regulations. The test certificate supplied by the company had been dated about four months before the batch was received. The certificate also referred to blue foam crumb.

The company stated they tested PU crumb at an external UKAS accredited laboratory on a monthly basis. However, the test certificate supplied was unlikely to have applied to the actual foam batch delivered. This illustrates the difficulties of testing a variable product such as crumb foam and also the limited value of occasional tests.

The test results of Table 2 clearly show that of five tests at 25 kg/m3 made with material from the first two backs of material 3 will clearly fail. When tested at higher packing densities the proportion of failures becomes less.

The results of these tests were sent to the supplier who was asked to comment. The verbal reply was followed by a letter and suggested that occasional batches of PU crumb foam are known to fail the Schedule 1, Part II test but pointed out the variability of the scrap foam feedstock. A number of other comments were made including questions concerning the claimed validity of the test method, the performance specification, the specification of the test, the difficulty of testing a variable product etc.

While sympathising with some of these comments, it appears strange that few batches are tested of a product known to vary and to fail its specification.

The analysis of this PU crumb foam indicates considerable variation in its composition although most pieces of crumb appear to have melamine contents in the range of 83 - 109 mg/g.

5.3.3 PU crumb foam C

Ignition tests to SI 1324 Schedule 1, Part II

These results show that crumb foam C passed all tests at all packing densities and with one and two flame applications to a single test rig.

Table 7 Ignition tests to SI 1324, Schedule 1, Part II for crumb foam C

Packing Density kg/m³	No. of flame tests per specimen	Total No. of tests	Results	Comment
25	2	5	Pass	All test specimens burned for less than 2 minutes after the test flame was removed, did not burn to the edges or through the specimen, and did not smoulder progressively
35	2	5	Pass	
45	2	5	Pass	
55	2	5	Pass	
25	1	5	Pass	
35	1	5	Pass	
45	1	5	Pass	
55	1	5	Pass	

Chemical analysis of foam C

A limited number of analyses were carried out because the crumb foam C was apparently uniform in nature.

The results are given below in Table 8.

Table 8 Chemical Analysis of PU crumb foam C

Chlorine % m/m	Bromine %m/m	Melamine mg/g
2.76	<0.3	113

Visual examination of foam C

Visual examination showed that crumb foam C was relatively uniform between different bags. It comprised fairly uniform shaped, medium size pieces of white foam of typically 31 mm with an overall size range of 4 - 56 mm.

Bulk Density of foam C

The bulk density of crumb foam C is 12 kg/m3.

Packing of foam C

This crumb foam was easily packed into the test specimens and did not fall out once the covering fabric split open when the flame was applied.

Discussion of results of crumb foam C

This foam crumb appeared to be relatively uniform in nature with relatively little variation between bags. It is understood that this foam was granulated and then blown into a storage silo before bagging and dispatch. It is possible that this process causes some blending of the PU foam crumb and reduces the variability of the product due to its possibly variable feedstock.

This foam crumb was understood to have been prepared from block foam meeting the requirements of SI 1324 Schedule 1 Part I (certificate supplied) but had not been tested to Part II. The fact that this foam actually passed Schedule 1 Part II of the regulations may therefore have been due to good management and raw material (feedstock) control or may have been fortuitous.

These results show that the test itself is capable of giving repeatable test results.

5.3.4 PU crumb foam D

Ignition tests to SI 1324 Schedule 1 Part II

These results show that crumb foam D passed all tests at all packing densities and with one and two flame applications to a single test rig in Table 9.

Table 9 Ignition tests to SI 1324 Schedule 1 Part II for crumb foam D

Packing Density kg/m³	No. of flame tests per specimen	Total No. of tests	Results	Comment
25	2	5	Pass	All test specimens burned for less than 2 minutes after the test flame was removed, did not burn to the edges or through the specimen and did not smoulder progressively.
35	2	5	Pass	
45	2	5	Pass	
55	2	5	Pass	
25	1	5	Pass	
35	1	5	Pass	
45	1	5	Pass	
55	1	5	Pass	

Chemical analysis of foam D

Relatively few analyses were carried out because this crumb appeared to be uniform. The results are given below in Table 10.

Table 10 Chemical analysis of PU crumb foam D

Chlorine % m/m	Bromine %m/m	Melamine mg/g
<0.3	<0.3	108

Visual examination of foam D

Visual examination showed that crumb foam D is relatively uniform in colour (three bags were predominantly mauve, one contained some other colours). This crumb had a significant proportion of small pieces of 5 - 15 mm across. The upper size was about 45 mm with a typical size of 30 mm.

Bulk Density of foam D

The bulk density of crumb foam D was 16 kg/m≥ .

Packing of foam D

The crumb foam was easily packed into the test specimen and did not fall out once the covering fabric split open when the flame was applied.

Discussion of results of crumb foam D

This foam also gave complete pass results to Schedule 1 Part II of the test procedure. It was a fairly uniform material and packed well into the test rig. The two test certificates supplied were about five years old and consequently could not have applied to the crumb foam tested in this programme. The pass results may therefore have arisen by good management and control of the feedstock or by chance.

Table 11 Comparison of PU foam crumbs

Foam	A	B	C	D
Bulk density kg/m≤	17	13	12	16
Largest piece	46	56	56	45
Smallest piece	6	7	4	5
Typical piece	25	40	31	30
No. of colours	9 E+G	Yellow white + other colours	Mainly white	Mainly mauve
Variation between bags	3 bags similar	Considerable	Little	
Schedule 1 Part I feedstock	Claimed	Claimed	Cert.	Claimed
Schedule 1 Part II	Not tested	Cert. 4 months old	Not tested	2 x cert.5 year old
Schedule 1 Part II Test (2 test/rig)	0% P	40 - 100% P*	100% P	100% P
Schedule 1 Part II Test (1 test/rig)	0% P	40 - 100% P*	100% P	100% P

E = Dense surface pieces G = Graphite foam * = Varies with foam and packing density.

These results show that not all PU foams claimed to meet Schedule 1 Part I will produce satisfactory PU crumb and shows the potential consequences of relying solely on the nature of the feedstock and of not carrying out tests to Schedule 1 Part II.

The question arises of blending PU foam crumb of different types. Obviously melamine and graphite modified PU foams should not be blended together but the consequences of blending other types of PU crumb together need to be carefully considered. This aspect is worthy of further study and should form part of the manufacturer's future work programme.

The question of graphite modified PU foam crumb also needs to be considered. Material 12 comprised a mixture of several graphite containing PU foams. The test rigs burned beyond the specified times and were extinguished by a water spray. The residue then smouldered progressively and had to be soaked with water.

6. Phase 2, PU crumb foams prepared from known block PU foam

It was decided to carry out a series of tests on PU crumb foam prepared from block foam from a known source. This was organised by Dr. D. King of Recticel who arranged through BRMA for different PU foam blocks to be granulated and sent to Rapra. The following PU foam crumbs were received.

Table 12 Identification and type of specially prepared PU crumb foams

Code	Foam Type	Nominal Foam Density kg/m³	High/low
1	CM HR	33 - 34	H
2	CM Ether	33 - 34	H
3	CM Ether	21 - 23	L
4	CMHR	21 - 23	L
5	CM Ether	21 - 23	L
6	CM Ether	33 - 34	H
7	CMHR	21 - 23	L
8	CMHR	33 - 34	H
9	CM Ether	21 - 23	L
10	CM Ether	33 - 34	H
11	CMHR	33 - 34	H
12	CMPU (Graphite)	60	H

It is understood that foams of nominally the same type and density were from different manufacturers.

Tests to SI 1324 Schedule 1 Part II

The test specimens, test method conditioning etc. used for this phase of the work were the same as those used for Phase 1 tests with commercial batches of PU crumb foam.

Test results are given below in Table 13 and show that the higher density CMHR foams pass the test whereas the lower density CMHR foams and the CM ether foams have a greater proportion of failures.

Table 13 Flame tests for specially prepared PU crumb foam

Code No.	Packing Density kg/m³	No. of Test Rigs	No. of Flame Appls	No. of Passes Single	No. of Passes Duplicate	No. of Full Tests	No. of Passes	
1	35 55	3 3	6 6	6 6	3 3	6	6	100%
2	35 55	3 3	6 6	6 6	3 3	6	6	100%
3	35 55	3 3	6 6	6 6	3 3	6	6	100%
4	45 55	2 2	4 4	2 2	1 1	4	2	50%
5	35 55	2 2	4 4	0 0	0 0	4	0	0%
6	35 45 55	2 1 3	4 2 6	0 2 4	0 1 2	6	3	50%
7	45 55	2 2	4 4	4 4	2 2	4	2	100%
8	45 55	2 2	4 4	4 4	2 2	4	2	100%
9	45 55	2 2	4 4	2 4	1 2	4	3	75%
10	45 55	2 2	4 4	4 2	2 1	4	3	75%
11	45 55	2 2	4 4	4 4	2 2	4	4	100%
12	45 55	2 2	2 2	0 0	0 0	4	0	0%

* Additional tests carried out because of variable results.

Table 14 Flame test results for specially prepared PU crumb foams

Code No.	Packing Density kg/m³	Burn Time Max. secs.	Burn Time Min. Secs.	To edges	Through Thickness	Smoulder
1	35 55	52 58	49 50	N N	N N	N N
2	35 55	70 78	47 51	N N	N N	N N
3	35 55	80 75	47 50	N N	N N	N N
4	45 55	57 220	50 60	- N	- N	- N
5	35 55	>160 >160	- -	- -	- -	- -
6	35 45 55	>160 >160 >160	- 60 55	- - -	- - -	- - -
7	45 55	79 85	67 60	N N	N N	N N
8	45 55	132 100	52 60	N N	N N	N N
9	45 55	>160 119	60 50	- N	- N	- N
10	45 55	73 >160	58 60	N -	N -	N -
11	45 55	85 70	49 50	N N	N N	N N
12	45 55	>160 >160	- -	- -	- -	Y Y

Note: Times include 40 seconds flame application time.

The chemical analysis (Laboratory of the Government Chemist) of the different PU foam crumb is given in Table 15. Where more than a single result is given, it refers to different components in the batch of PU crumb. It should be noted that there is no obvious correlation between the chemical composition of the PU foam crumb and their pass or fail results in the Schedule 1 Part II test.

Table 15 Composition of some flexible PU foams supplied for production of crumb foam

PU Foam	Melamine mg/g	Chlorine % m/m	Bromine % m/m
1	85	1.1	N
2	73	2.42	N
3	86	3.73	N
4	106	0.81	N
5	128	?	N
6	111	1.87	N
7	105	0.75	N
8/1	118/142	<0.3	N
8/2	124	<0.3	N
9	125	2.72	N
10	97	1.87	N
11	109	0.59	N
12/1*	<1	1.22	<0.3
12/2*	<1	0.77 - 1.96	<0.3
12/3*	<1	0.92	<0.3

7. Comparison of PU crumb foams using standard and filled bag test specimens

7.1 Test Method and Specimens

SI 1324: Schedule 1: Part 2 specifies that PU crumb foam shall be tested to BS 5852: Part 2: 1982 using ignition source 2. The latter can be interpreted in two ways, one in which the PU crumb foam is stuffed into the covering fabric which is clipped to the test frame, and a second in which the PU foam is contained within sewn bags. The latter should arguably only be used when the PU foam crumb is to be used within an interliner but certain parts of the industry consider this to be the preferred test method. The purpose of this work is to compare two PU foam crumbs, in the standard method and also when encased in sewn bags.

7.2 Experimental Method

Two batches of PU foam crumb, coded E and F, were prepared from PU foam slab and supplied by a UK PU foam manufacturer and both PU crumb foams were tested at two packing densities, 35 and 45 kg/m3.

BS 5852: Part 2 requires that two flame applications shall be made for a single test specimen. This procedure was adopted for these tests but a total of five test specimens were tested for each test sample and density.

The two types of test specimens were prepared as given below

Standard Test Specimens

These were prepared according to BS 5852: Part 2: 1982 and included a strip of FR polyester fabric, about 450mm wide placed against the inner surface of the test rig to retain the PU foam crumb. The outer FR polyester fabric was clipped onto the test rig, stuffed with PU foam crumb to the required density, and the test specimen top clipped to the test rig. The two parts of the test rig were then flattened and shaped to provide a reasonably flat flame target area.

Sewn Bag Specimens

These were stuffed with PU crumb foam. The bags comprised two pieces of FR polyester fabric cut to the dimensions specified in BS 5852: Part 2: 1982. These were sewn across the centre line between the vertical and horizontal parts of the specimen. The ‘sides’ were also sewn together at their mid-points to give a bag of similar volume to that of the specified foam filling slabs. The two parts were folded along the centre line. the lower part of the horizontal section was clipped to the BS 5852: Part 2 test rig. The top and front were also clipped to the test rig. The actual test specimen was generally similar in shape to that of BS 5852: Part 2 filled with PU crumb but was more rounded at the edges and had a sharper junction between the vertical and horizontal parts.

7.3 Discussion of Results

Test results are given in Table 16 for PU crumb foam E and in Table 17 for PU crumb foam F.

PU crumb foam E gave both pass and fail results. At the lower density of 35 kg/m3, PU crumb foam E gave one fail out of five tests with the standard test specimen but gave three fails with the bag test specimen. This crumb foam gave five passes at the higher density (45kg/m^3), with the standard test rig but gave two fails with the bag specimen.

PU crumb foam F gave all passes with the standard test rig but again gave a proportion of fails with the bag test specimen.

There is a possibility that the second flame application will cause more failures than the second flame application to the same test rig but the is not always the case and examples exist where the first flame application will fail the test and the second will pass it.

There is also a relatively strong tendency for the bag specimen to fail the test and for the standard specimen to pass it. This appears to be due to the distended overhang of the vertical part of the test specimen which results in the ignition flame penetrating more deeply into the test specimen.

It is preferable that a single test method and test specimen should be used to specify PU crumb foams and the standard test specimen is preferred to the sewn bag because it corresponds more closely with the wording of BS 5852: Part 2.

If both methods are to be permitted, the material tested by the bag method may be more likely to fail the test and if the bag test specimen is to be used, it is important that it is both standardised and specified because the implications of this work are that the shape of the test specimen may have a critical effect on the test results.

Table 16 Comparison of ignition test results to SII324 Schedule 1, Part 2 for PU Crumb Foam E

PU Crumb Foam	Packing Density KG/M^3	Test Specimen	Flame Appl No	Test Number 1	2	3	4	5	No of Non-Ignits	Percent Passes
Crumb E	35	Bag	1	2	2	0	0	2	3	
			2	0	2	2	2	2	4	
			Result	0	2	0	0	2	2	40
Crumb E	35	Std	1	2	2	2	2	2	5	
			2	2	0	2	2	2	4	
			Result	2	0	2	2	2	4	80
Crumb E	45	Bag	1	2	2	2	2	2	5	
			2	2	0	2	0	2	3	
			Result	2	0	2	0	2	3	60
Crumb E	45	Std	1	2	2	2	2	2	5	
			2	2	2	2	2	2	5	
			Result	2	2	2	2	2	5	100

Code 2 = non Ignition O = Ignition

Table 17 Comparison of ignition test results to SII324 Schedule 1, Part 2 for PU Crumb Foam F

PU Crumb Foam	Packing Density KG/M³	Test Specimen	Flame Appl No	Test Number 1	2	3	4	5	No of Non-Ignits	Percent Passes
Crumb F	35	Bag	1	2	2	0	2	2	4	
			2	2	0	2	2	2	4	
			Result	2	0	0	2	2	3	60
Crumb F	35	Std	1	2	2	2	2	2	5	
			2	2	2	2	2	2	5	
			Result	2	2	2	2	2	5	100
Crumb F	45	Bag	1	2	0	0	2	2	3	
			2	2	0	2	2	0	3	
			Result	2	0	0	2	0	2	10
Crumb F	45	Std	1	2	2	2	2	2	5	
			2	2	2	2	2	2	5	
			Result	2	2	2	2	2	5	100

Code 2 = non Ignition O = Ignition

8. Discussion of current situation and test results

8.1 Manufacture, Testing and Specification of PU foam crumbs

SI 1324 requires that PU crumb foam shall be made from PU foam which meets the crib 5/60 g mass loss test and which additionally resists the No. 2 flame. BS 5852 Part 2 1982 forms the basis of both test methods which are defined in SI 1324 Schedule 1 Part I for block PU foam and Schedule 1 Part II for PU crumb foam.

It must be acknowledged that the tests and specifications included in SI 1324 were developed within a relatively brief period for a number of reasons. The PU foam block test was developed first and the No. 2 flame test then applied to non PU foam block fillings, fibre fillings and then to PU foam crumb. It must also be acknowledged that the PU crumb foam test was developed by the PU foam manufacturers themselves and it is reasonable to suppose that the industry were satisfied with both the test and the performance of their products when so tested.

It must also be acknowledged that considerable developments have taken place since the tests of the 1988 Regulations were developed. Not only have formulations been improved but new types of combustion modified foams have been introduced.

The major new PU foam is a melamine modified polyether product which is understood to be based on a different polyol system to that used when the regulative tests were developed. It is therefore possible that the original relationship between PU block foam passing the crib 5/60 gram mass loss test and confidently passing the No. 2 flame test for PU crumb could have changed for some products but it is logical for this to have been observed and allowed for by the industry.

The potential variability of the feedstock (PU block foam) must be acknowledged. There are a number of different PU foam types (melamine HRPU, melamine polyether and graphite PU) which are available in a number of different densities, hardnesses etc. Even PU foams of similar types will vary between different manufacturers because individual formulations will need to be tailored to specific foam production machines. Added to these are the harder surfaces of PU foam loaves and pieces of polyethylene release films which may be included in scrap PU foam and which may be the feedstock of PU crumb foam production. It has been claimed that dense foam skins and polyethylene film etc. are excluded from PU crumb foam but this is not always the case. Similar claims that graphite and melamine modified PU foams are not blended are also clearly not always valid.

In this situation, it is inevitable that PU crumb foam will be a variable product and that variations will occur both in the chemical composition, physical properties and density. In view of this and the legal fire requirements, it is very surprising that relatively few batches appear to be actually flame tested. It is also surprising that large scale blending of foam feedstocks and of PU crumb also appear to be rarely carried out although this may reflect the nature of the PU crumb foam itself since it is, often a product manufactured from off-

cuts and scrap from the PU foam block process. Instead, the view that crib 5/60 gram block PU foam should produce crumb foam which ought to pass the No. 2 flame test appears to be accepted at least by some.

To the layman, all PU foam (including the more highly flammable grades) are very similar in appearance and certain grades cannot be distinguished without considerable analysis. This essentially means that the composition of a particular bale of scrap can be very uncertain and it relies primarily on the separation of production batches of dissimilar materials by the PU block manufacturers and converters to ensure a satisfactory feed for the PU crumb foam process.

8.2 Supply and certification of PU foam crumb

A number of manufacturers listed in the trade directory as suppliers of PU crumb foam were asked to supply batches of crumb foam (20 to 80 kg) meeting the requirements of SI 1324. Of these two thirds stated that their product was for in-house only while one manufacturer declined (after eight weeks) to supply because his product may not meet test requirements.

Each of the four companies actually supplying PU crumb foam were asked for test certificates to SI 1324. Three of the companies supplied test certificates. The company responses are summarised in Table 18.

Table 18 Certification of commercial batches of PU crumb foam

Foam Supplier	Crib 5	Source 2	Comment
A	Verbal assurance of compliance.	Uncertain of test.	Assurance all crumb was satisfactory and low flammability. Assurance that crumb was satisfactory.
B	Verbal assurance of compliance.	One test certificate. Five months old. (UKAS Lab.)	Assurance that crumb was tested on a monthly basis.
C	Verbal assurance of compliance.	Two test certificates. Five years old. (UKAS Lab.)	
D	Test Certificate.	Uncertain of test.	Assurance that crumb was satisfactory.

At this stage, it became very apparent that PU crumb manufacturers recognised that their feedstock PU block foam (off-cuts, scrap etc.) was a very variable product and most acknowledged that because of this it was possible to obtain both passes and fails to the SI 1324 Schedule 1 Part II test. It was also suggested (by at least one) that the test requirements of SI 1324 were incorrect and could not be achieved and also that the test itself gave very variable results and was not reliable. It was suggested that controls should be scrapped or changed to comply with “worst case” product performance.

It was also apparent that knowledge of the actual test requirements was varied and often confused and that in-house quality assurance tests were infrequent.

The nett conclusion is that in spite of legislative controls for the fire behaviour of crumb foam (SI 1324 Schedule 1 Parts 1 and II) and in spite of general acceptance of the potential variability of the feedstock, quality assurance testing is infrequent. The release of outdated test certificates or of incomplete certificates merely confirms this view. A somewhat extreme view but one with at least some relevance is that a verbal assurance that a bale of scrap passes crib 5 may be considered sufficient assurance that the resulting PU crumb will meet all of the SI 1324 requirements.

8.3 Test method SI 1324 Schedule 1 Part II

The test method for PU crumb foam is laid down in SI 1324 and based on BS 5852 part 2 1982 and ignition source 2. The test is not defined in absolute terms in BS 5852 part 2 since the latter permits minor variations when testing loose upholstery fillings. However it is suggested that the option of containing the PU crumb in closed interliner bags is unacceptable because most PU crumb foam is not contained in bags when used in furniture. The other option is whether or not to use a porous fabric against the metal grid and if so what fabric to use. It is recommended that a fabric is used because some PU foams have very small pieces and in order to reduce variability, it is suggested that the FR polyester fabric specified in SI 1324 should be used. This procedure has been used at Rapra for a number of years and is easy to standardise. It has been used for most of the tests described in this report.

BS 5852 part 2 states that the tests should be carried out at the packing density which is used in the actual furniture application. In practice this is difficult to define or determine since manufacturers typically fill cushion, mattress beds etc. “until it feels right” and then apply deep buttoning. This work has inferred (rather than proved) that PU crumb foam is more likely to pass if tested at a higher packing density. Clearly the nett effect will depend on the actual bulk density of the PU crumb (which will vary between batches) but 45kg/m3 would be a reasonable packing density to test if a packing density were to be recommended. 25 kg/m2 produces a rather slack cushion white densities of 55 kg/m3 may cause a distorted test specimen. If a single packing density is required, then 45 kg/m3 is recommended.

The test results infer, albeit weakly that a test carried out in which a single flame application per test rig may give a more favourable result than if two flame tests were carried out. BS 5852 part 2 states that two flame tests should be carried out. Two crib tests were originally with a single test specimen but this was reduced to a single test in the 1990 revision of the test. This overcame ambiguity in the interpretation of test results, made the test more easy to pass for the newer fabrics which tended to burn horizontally rather than vertically and

was considered to improve repeatability. It is suggested that a single flame test per test rig could be recommended although the benefits from this could be relatively small.

These points have not been proved to result in better test results but their adoption would eliminate the ambiguity which exists with the current tests.

8.4 Test results on PU crumb foam to SI 1324 Schedule 1 Part II

The four batches of commercial PU crumb foam were purchased on the open market and each was tested to the following programme:

a) Determination of Bulk Density.

b) Chemical analysis of foam to determine amounts of melamine, chlorine and bromine. (This was carried out by Laboratory of the Government Chemist).

c) No. 2 flame ignition tests to BS 5852 part 2 1982 using FR Polyester fabric to SI 1324 Schedule 1 Part II.

Note: It was not possible to carry out tests to SI 1324 Schedule 1 Part I on block foam for obvious reasons.

The tests in section C were carried out at a PU crumb foam packing density of 25, 35, 45 and 55 kg/m3 and with one and two flame applications per test rig. The results of these tests are given in Table 19.

Table 19 Results of tests on PU crumb foam to SI 1324, Schedule 1 Part II Commercial Batches

PU Crumb Foam Manufacturer	No. of flame applications	No. of complete tests	Result
A	16	16	100% fail, sustained flaming and complete destruction.
B	80	40	Variable results 20 - 100% passes dependant on packing density and foam selected.
C	80	40	100% pass. No fail results.
D	60	30	100% pass. No fail results.

PU crumb foam A

Consisted of foam pieces of many different colours. Chemical analysis and physical analysis showed that this PU crumb foam contained the following:

a) High levels of additives and likely to give a satisfactory fire test result.

b) Low levels of melamine and chlorine and unlikely to give a satisfactory fire test result.

c) Intermediate levels of melamine and chlorine.

d) Graphite particles.

The preparations of PU foam with high and low levels of additives will obviously affect the fire test result and a dominance of either one or the other could potentially give a pass or a fail result and would also be potentially capable of giving variable pass/fail results.

The presence of the graphite is very significant. Melamine and halogenated additives tend to cause melting and shrinking of the PU foam, whereas graphite causes charring. These two mechanisms are mutually antagonistic and when products of these two types are mixed even as two layers in a composite, they can burn to completion. It appears that the crumb manufacturer concerned was completely unaware of this. The reason why PU crumb foam A burned was probably due to the mixture of PU foams meeting the crib 5 requirements but using antagonistic flame retarding systems (melamine and graphite) combined with a proportion of PU foam unlikely to meet the crib 5 requirements.

PU crumb foam B

This foam is more difficult to define since it not only contained foams of different colour but it varied considerably between individual bags. PU crumb from different bags gave different proportions of pass/fail flame test results. For example the first few bags were predominately yellow in colour and gave 40 - 100% passes whereas the next few bags were mainly yellow and white and gave 40 - 80% passes. Chemical analysis suggested that the higher melamine content tended to give a higher proportion of passes but the actual differences in melamine contents was relatively small (but see comments on chemical analysis).

The reasons for the variable results with PU crumb foam B are probably linked to the PU crumb foam itself since foam from different individual foam bags gave different results and also showed a significant difference in composition (i.e. colour of foam pieces).

PU crumb foams C and D

Both foams were reasonably consistent in size and with most of the crumb having a single colour. Chemical analysis showed that the PU foam itself was likely to perform well in the fire tests.

Both of these PU foam batches (from different suppliers) gave complete pass results in 60 - 80 flame applications with tests specimens of 25 - 55 kg/m3.

Specially prepared batches of PU crumb foam

A second series of PU crumb foams were obtained in which each batch was prepared from a different and known batch of PU foam block. These materials were supplied via BRMA and although the general identity of the PU foams were indicated, the manufacturers were not identified.

PU crumbs 1, 2, 3, 7, 8 and 11 give 100% passes at different packing densities whereas materials 4, 9 and 10 gave 50-75% passes. Material 5 and 12 gave 100% fail results. See Table 20.

Table 20 Results on specially prepared batches of PU crumb foam to SI 1324 Schedule I Part II

PU Crumb Foam	Type	No. of Passes/No. of tests Packing Density kg/m³			Total	Pecentage Passes
		35	45	55		
1	H - U	3/3		3/5	6/6	100%
2	H - E	3/3		3/3	6/6	100%
3	L - E	3/3		3/3	6/6	100%
4	L - U		1/2	1/2	2/4	50%
5	L - E	0/2		0/2	0/2	0%
6	H - E	0/2	1/1	2/3	3/6	50%
7	L - U		2/2	2/2	2/2	100%
8	H - U		2/2	2/2	2/2	100%
9	L - E		1/2	2/2	3/4	75%
10	H - E		2/2	1/2	3/4	75%
11	H - U		2/2	2/2	4/4	100%
12	G		0/2	0/2	0/4	0%

E = melamine polyether U = melamine HRPU G = graphite PU
L = low density H = high density

All of these foams were of the combustion modified HRPU or ether types except for material 12 which comprised a mixture of three graphite containing foams.

Materials which failed or which gave a proportion of fails tended to be the low density HR foams or the ether type foams. There is also a tendency for the materials which gave less than 100% passes to fail at the lower packing densities.

Each of the different PU foam manufacturers were asked to supply PU foam blocks for the preparation of PU foam crumb and it is reasonable to assume that all of the blocks supplied would have met the requirements of SI 1324 Schedule 1 Part I. The most logical conclusion to be drawn from Table 2 is that not all of the PU block foams which meet SI 1324 Schedule 1 Part I will meet SI 1324 Schedule 1 Part II when reduced to crumb. It is therefore important that products of these two types are identified and segregated by the manufacturers. It may be possible to blend some PU foams of various types with foams known to produce satisfactory crumb but the ratio of the various fractions and the blending

operation will need to be carefully established and controlled if satisfactory PU foam crumb is to be produced.

The alternative would be for the block foam manufacturers either to ensure that unsuitable PU foam scrap is not incorporated into crumb or to reformulate their PU foam block such that all scrap block would produce satisfactory crumb.

8.5 Tests with Standard and Pre-sewn Bag Test Specimens

Tests with two batches of PU crumb foam have shown that both test specimens are feasible but that the bag specimen has a greater tendency to give a fail result. The results in Table 21 indicate that PU crumb foam E gave a rather higher proportion of pass results when tests are carried out using the standard test specimen than when the bag specimen was tested. Material F shows all passes with the standard test rig but gave a number of failures with the bag test specimen. This may be because the shape of the bag test specimen is more distended and the flame can penetrate further into the vertical part of the specimen. It is preferable to use the standard tests specimen because it corresponds more closely to the wording of BS 5852, Part 2, 1982 but if the bag test specimen is to be used, it is important that it is both standardised and specified because the implications of this work are that the shape of the test specimen may have a critical effect on the test results.

Table 21 Average Number of Pass Results for Two Batches of PU Crumb Foam tested at 35 and 45 kg/m3.

Test Specimen	Percentage Pass Results	
	PU Crumb E	PU Crumb F
Standard Specimens	90	100
Pre-sewn Bags	50	50

9. Acknowledgements

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Appendix 1 to CTR 29921 Photographs showing the variable nature of PU crumb foam

PU Crumb Foam A

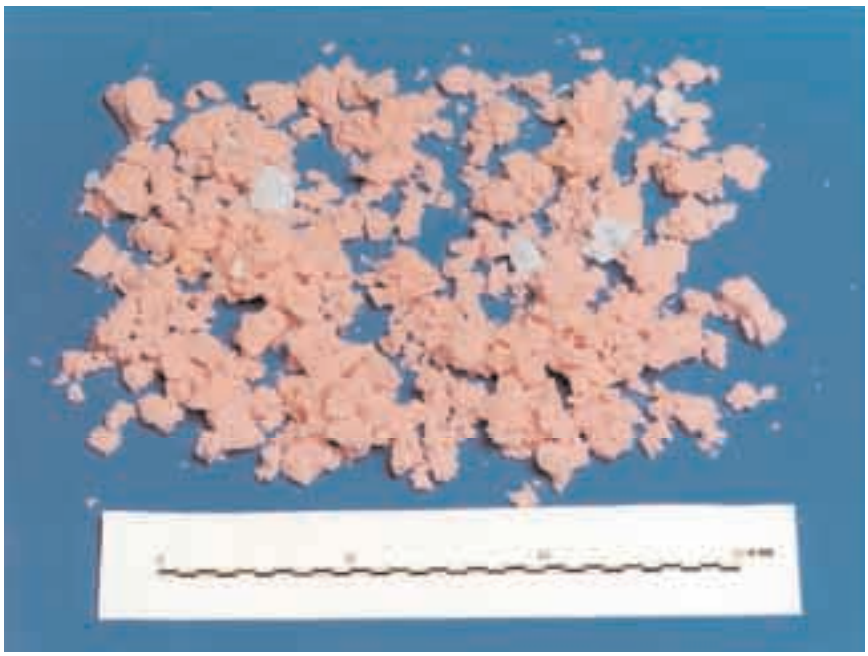
PU Crumb Foam B(1)

PU Crumb Foam B(4)

PU Crumb Foam B(5)

PU Crumb Foam B(6)

PU Crumb Foam C



PU Crumb Foam D

Appendix 4 Testing of PU crumb foam to SI 1324 Schedule 1, Part II -

Guidance Notes to Operators

BS 5852, Part 2, was developed with rectangular slabs and was subsequently adapted to test loose fillings. As a consequence, parts of the test procedure are not as specific as they should be. The following clarifications and modifications are recommended when testing PU crumb foam.

Note: BS 5852: Part 2: 1982 may be interpreted in two ways, one in which the PU crumb foam is stuffed into the covering fabric which is clipped to the test frame, and a second in which the PU foam is contained within sewn bags. The latter should arguably only be used when the PU crumb foam is to be used within an interliner.

It is prefereable that a single test method and test specimen should be used to specify crumb foams and the standard specimen is preferred to the sewn bag because it corresponds more closely with the wording of BS 5852: Part 2. If the bag test specimen is to be used, it is important that it is both standardised and specified because the implications of this work are that the shape of the tests specimen may have a critical effect on the test results.

BS 5852, Part 2, 1982.

Section 8.3, Paragraph 4.

A piece of the FR polyester fabric defined in SI 1324 Schedule 1, Part 1, shall be cut to size and fitted against the expanded metal supports of both the vertical and horizontal parts of the test rig.

Section 8.3, Paragraph 5.

The PU crumb shall not be contained in a bag but shall be retained between the outer cover fabric and the fabric panel over the expanded metal (see above).

Because the packing density of the PU foam crumb can affect the test results, it is recommended that PU foam crumb should be tested with a packed density of 45kg/m3.

Preparation of Test Specimen

(Clause numbers refer to BS 5852 Part 2, 1982)

9.1.2 Open out the test rig and thread the outer covering fabric behind the hinge bar and the backing fabric.

Note: The backing fabric strip should be 445 ± 10 mm wide and 970 ± 10 mm.

9.1.3 Clip the ends of the backing fabric to the ends of the test rig frames ensuring that

the fabric covers the full width of the test rig and is reasonably taut. Clip the edges of the outer covering fabric to the sides of the test rig allowing approximately 20 mm of the fabric to wrap around the inside of the frame. At least three clips will be needed for the longer part of the test rig, and at least two for the shorter part.

9.1.4 Lock the frames at right angles by the bolts or pins ensuring that the fabrics are not displaced.

9.1.5 Fill the upper and lower parts of the test specimen with the crumb foam ensuring that the foam is as uniformly packed as possible, and that the fabrics are not displaced or unreasonably distorted. Clip the upper and lower extremities in position (using at least three clips each) and ensuring that approximately 20 mm of the covering fabric is wrapped around the frame of the test rig. Gently smooth the test specimen to ensure even fabric tension and uniformity of packing.

9.2 Butane Flame Test

Because of the distortion of the PU crumb foam test specimen compared to the flat, rectangular shape of that of the foam slab, it is suggested that a single flame application should be applied to the centre of the test rig and that two test specimens should be used for the full ignition test.

Appendix 5 SI 1324 1988, Consumer Protection, Furniture and Furnishings (Fire) (Safety) Regulations 1982 relating to the testing of PU crumb foam

Made 26th July 1988

Laid before Parliament 28th July 1988

Coming into force in accordance with regulation 1(2)

Filling material

(1) Subject to paragraphs (3) and (4) below, no furniture shall include any filling material which fails the relevant ignitability test.

(2) No furniture shall include as filling any foam in crumb form unless both-

(a) the foam from which the crumb is derived passes the ignitability test specified in Part 1 of Schedule 1 to these Regulations; and

(b) the foam in crumb form itself passes the ignitability test specified in Part II of that Schedule.

(3) A cushion may include filling material which does not pass the ignitability test specified in Part I or Part II (or both such parts) of Schedule 2 to these Regulations if the cushion has a primary cover and, with that cover, passes the ignitability test in Part III of that Schedule.

(4) A pillow may include filling material which does not pass the ignitability test specified in Part I or Part II (or both such parts) of Schedule 2 to these Regulations if the pillow, when tested with its primary cover, passes the ignitability test in Part III of that Schedule.

Loose fillings

No person shall supply any filling material which fails the relevant ignitability test, or which contains foam in crumb form which may not be included in furniture by virtue of regulation 6(2) above, in any case where he knows or has reasonable cause to believe that the material will be used-

(a) for filling a cushion or a pillow; or

(b) for the purpose of upholstering or re-upholstering furniture.

SCHEDULE 1 Regulations 3, 6 and 7

PART 1

Ignitability test for polyurethane foam in slab or cushion form.

1 The foam shall be tested in accordance with the method set out in BS 5852 Part 2 using cover fabric corresponding to the specification set out in paragraph 2 below.

2 The fabric shall be made of 100 per cent flame retardant polyester fibre. Its construction shall be woven to a plain weave. The yarn in the warp shall be of 1.6 decitex fibre, spun to a linear density of 37 tex, Z twist at 420 turns per metre. The fabric shall be woven to 20.5 yarn threads per centimetre in the warp.

The yarn in the weft shall be of 3.3 decitex fibre spun to a linear density of 100 tex; Z twist at 550 turns per metre. The fabric shall be woven to between 12.6 and 13 threads per centimetre in the weft.

The fabric finish shall be scoured and heat set. Its mass shall be 220g per m^2 plus or minus 5 per cent.

3 The test rig as specified in clause 6.1.1 of BS 5852 Part 2 shall have expanded steel platforms of not less than 28 x 6mm mesh size. The test rig is placed on a metal tray of sufficient dimensions to collect any debris falling from specimens being tested. The rig and debris tray shall be mounted on a weighing balance with a remote readout having a full-scale deflection of at least 0 to 20kg to an accuracy of 2g.

4 The foam under test, cut to the specified dimensions is placed on the test rig, covered with the fabric specified in paragraph 2 above and tensioned with clips as set out in BS 5852: Part 2. An ignition source 5 crib is placed in position. The mass of the complete assembly is determined ("initial mass"). The test shall be carried out in accordance with BS 5852: Part 2. In particular flaming or smouldering failure shall be determined against the criteria of clause 4 of BS 5852: Part 2.

After flaming and smouldering has ceased, debris which has become detached from the specimen shall be removed. The remaining mass of the assembly ("final mass") is then recorded.

5 If failure against the criteria of clause 4 of BS 5852 Part 2 has occurred but only by way of damage exceeding the limits defined in clauses 4.1(e), 4.1(f) and 4.2(f) and provided that the resultant mass loss (initial mass less final mass) is less than 60g the foam passes the ignitability test.

PART II

Ignitability test for polyurethane foam in crumb form.

1 The foam shall be tested in accordance with the method set out in BS 5852: Part 2 using cover fabric corresponding to the specification set out paragraph 2 below.

2 The fabric shall be made of 100 per cent flame retardant polyester fibre. Its construction shall be woven to a plain weave. The yarn in the warp shall be of 1.6 decitex fibre, spun to a linear density of 37 tex, Z twist at 420 turns per metre. The fabric shall be woven to 20.5 yarn threads per centimetre in the warp.

The yarn in the weft shall be of 3.3 decitex fibre spun to a linear density of 100 tex, Z twist at 550 turns per metre. The fabric shall be woven to between 12.6 and 13 threads per centimetre in the weft.

The fabric finish shall be scoured and heat set. Its mass shall be 220g per m^2 plus or minus 5 per cent.

3 The test rig panels are lined with fabric specified in paragraph 2 above. Sufficient crumb foam shall be placed upon the seat and back panels so that when the cover fabric piece is placed over them, both are stuffed to the density used in the furniture as intended. The test is then carried out in accordance with BS 5852 Part 2 using ignition source 2 as specified therein.

4 If smouldering or flaming failure against the criteria of clause 4 of BS 5852: Part 2 has not occurred or has occurred only by way of damage exceeding the limits defined in Clauses 4.1(e), 4.1(f) and 4.2(f), the crumb foam passes the ignitability test.

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