



*Comparisons of the propensity of fire
safe cigarettes and conventional
cigarettes to ignite textile materials
used in a domestic environment*

Fire Research Report 8



Comparisons of the propensity of fire
safe cigarettes and conventional
cigarettes to ignite textile materials
used in a domestic environment
Fire Research Report 8

BTG Ltd

January 2006

Office of the Deputy Prime Minister: London

The findings and recommendations in this report are those of the consultant authors and do not necessarily represent the views of proposed policies of the Office of the Deputy Prime Minister.

Office of the Deputy Prime Minister
Eland House
Bressenden Place
London SW1E 5DU
Telephone 020 7944 4400
Website www.odpm.gov.uk

© Crown copyright 2006

Copyright in the typographical arrangement rests with the Crown.

This publication, excluding logos, may be reproduced free of charge in any format or medium for research, private study or for internal circulation within an organisation. This is subject to it being reproduced accurately and not used in a misleading context. The material must be acknowledged as Crown copyright and the title of the publication specified.

For any other use of this material, please write to HMSO Licensing, St Clements House, 2-16 Colegate, Norwich NR3 1BQ Fax: 01603 723000 or e-mail: licensing@hmso.gov.uk.

Further copies of this publication are available online via the Office of the Deputy Prime Minister's website.

January 2006

Product code 05 FHSD 03608

CONTENTS

EXECUTIVE SUMMARY	4
CHAPTER 1	5
Introduction	
CHAPTER 2	6
General Background	
CHAPTER 3	11
Selection of test materials	
CHAPTER 4	16
Development of test procedure and test assessment protocols	
CHAPTER 5	20
Test Results	
CHAPTER 6	25
Analysis of Results	
CHAPTER 7	28
Conclusions	
REFERENCES	29
APPENDIX 1	30
BTTG Background	

EXECUTIVE SUMMARY

The purpose of this programme of work was to undertake comparative cigarette ignition tests on a range of textile and related materials used in domestic furnishing that is available at the lower price end of the UK market. Each test sample was subjected to one type of UK typical mass market, “low cost” cigarette and two types of USA Fire Safe Cigarettes, claimed to be of Reduced Ignition Potential (RIP). By incorporating repeat testing a statistically based comparison of the likelihood of ignition of the chosen test samples by each of the three types of cigarette was determined.

The test materials were selected from new materials available at the low price end of the UK market. The selection was divided into different groups of materials as follows.

GROUP 1 MATERIALS

These were textile furnishing materials that are used alone or in contact with other furnishing materials. They were chosen so as to contain at least a significant proportion of cellulose fibre (usually cotton) so that there was a likelihood of combustion with current UK cigarettes.

These materials were representative of bed sheets/blankets, throws, scatter cushion covers and mattress covers.

GROUP 2 MATERIALS

These materials represented those that are used in combination with upholstery, mattress, cushion, pillow, duvet/quilt fillings.

GROUP 3 MATERIALS

These were non-textile but of cellulosic composition. A paper tissue product typically discarded into open waste bins was selected.

The overall conclusion drawn is that the results of the tests indicate that the chosen RIP cigarettes do reduce the risk of inducing flaming ignition or progressive smouldering in the materials tested, but the risk is clearly not eliminated. Typically 91% of the standard UK cigarette caused flaming or smouldering. With RIP cigarettes, this figure reduced to 69% with one type of cigarette and 34% with the other.

CHAPTER 1

Introduction

Cigarettes incorporating a paper having reduced ignition potential (RIP) have been introduced in New York City. We understand that these so-called Fire Safe Cigarettes are expected, by some, to lead to reduced numbers of domestic fires involving textile furnishing materials.

The purpose of this programme of work was to undertake comparative cigarette ignition tests on a range of textile and related materials used in domestic furnishing that is available at the lower price end of the UK market. Each test sample was subjected to one type of UK typical mass market, “low cost” cigarette and two types of USA Fire Safe Cigarettes. By incorporating repeat testing a statistically based comparison of the likelihood of ignition of the chosen test samples by each of the three types of cigarette was determined.

There are at least 25 brands of Fire Safe Cigarettes on the US market. On the basis of the information obtained from websites and via the Fire Experimental Unit of ODPM, five of these brands were purchased in New York. The two cigarette brands chosen for the test programme were confirmed to represent the extremes of smouldering behaviour found within the five brands.

Background information provided by ODPM together with our own experience indicated that the only types of textile material likely to be induced into a combustion mode by contact with smouldering cigarettes are those that contain a significant proportion of cellulose material such as cotton. The test samples were selected almost exclusively from this class of product.

The test procedure was an adaptation of BS, EN, ISO and IMO test methods for determining the ignitability of bedcovers, pillows, upholstered furniture and mattresses. The final test methods used were determined after extensive pre-testing experiments to examine specimen composition, construction, orientation, number of layers of test specimen, underlying furnishing filling material and cover material. These tests concentrated on inducing progressive smouldering/flaming ignition of the various combinations using the UK mass market cigarette.

CHAPTER 2

General Background

2.1 STATISTICS

The Furniture and Furnishings (Fire) (Safety) Regulations⁽¹⁾ came into force in the UK in 1988 and were designed to reduce the risk of fires in domestic upholstery. Despite the introduction of these regulations some 17 years ago and a series of refinements subsequently, the latest Government statistics still list ignition attributed to smokers' materials as the most dangerous type of household fire.

For the purposes of this report "smoker's materials" are defined (see Table 1) as including cigarettes, but excluding matches.

The document detailing the 2003 statistics has a special feature related to the subject. A copy of this item and the latest associated statistics follows overleaf (Tables 1, 2 and 3).

A search of items listed on the Internet reveals similar statistics exist for Canada⁽²⁾, USA⁽³⁾ and Australia⁽⁴⁾.

Two facts shown by the Canadian statistics are:

- 1) Fires ignited by smokers' materials have a much higher fatality rate than those started by cooking equipment, another common ignition source for house fires. One reason given for this is that anywhere from 25% to 60% of cigarette fire related deaths can be attributed to persons smoking whilst intoxicated.
- 2) Fires started by smokers' materials tend to result in more property damage than other fires, on average four times higher than fires caused by other methods.

A further disturbing fact mentioned is that two out of five victims of fires started by smokers' materials are not the smokers themselves but individuals that live in the same building, particularly children and older people.

Table 1 Fire Statistics, UK, 2003 (www.odpm.gov.uk)

Special Feature

Smoking related materials as the source of ignition in accidental dwelling fires

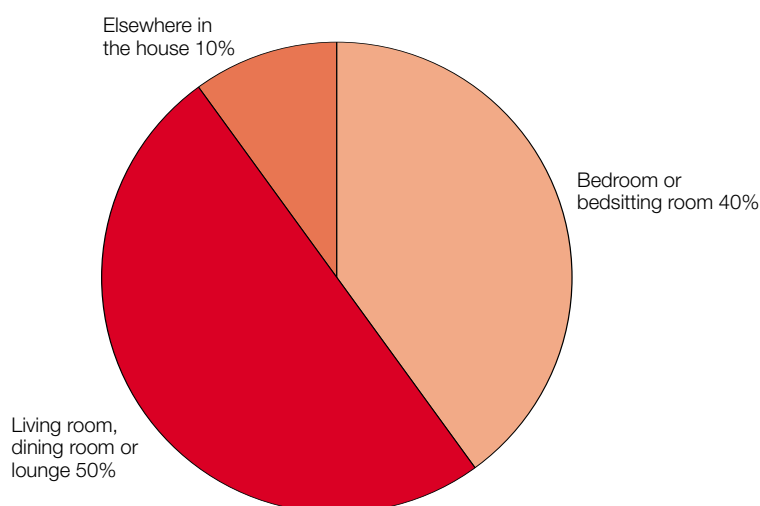
Smoking related fires remain the most dangerous type of household fire. They are attributed to three sources of ignition, namely smokers' materials (including cigarettes, cigars, pipe tobacco), cigarette lighters and matches. This feature concentrates on the most prevalent of these sources, smokers' materials.

Between 1999 and 2003 there were on average 4,200 accidental dwelling fires per year started by smokers' materials with the majority of the fires ignited due to the careless disposal of cigarettes (90% of fires in 2003). Although this only represents 8% of all accidental dwelling fires in 2003, they were responsible for almost a third of all deaths in such fires (giving a fatality rate of 30 deaths per 1,000 fires).

While the number of fires started by smokers' materials has decreased by 14% over the last five years (about the same as the overall fall in accidental fires in the home), the number of deaths in accidental dwelling fires due to this source of ignition has remained broadly constant (122 in 1999, 139 in 2000, 138 in 2001, 123 in 2002 and 125 in 2003).

With respect to non-fatal casualties, numbers were greatest for smokers' materials (1,400 in 2003 – 14% of all injuries in accidental fires in the home), followed by cigarette lighters (300 casualties – 3%) and matches (213 casualties – 2%). These categories are also characterised by non-fatal casualty rates per 1,000 fires greater than the average (209), with the highest for cigarette lighters (565 casualties), followed by matches (474 casualties) and by smokers' materials (340 casualties).

Figure 2.5 Fatal casualties in smoking related household fires by room where fire started, 2003



Just over a third of all accidental dwelling fires ignited by smokers' materials start in living rooms or lounges (1,500 fires in 2003); these fires are responsible for half of all fatalities attributed to fires ignited by smokers' materials (63 in 2003). A further third start in bedrooms or bedsitting rooms (1,300 in 2003) and account for around 40% of all smoking related fatal casualties (50 in 2003). Nearly a third of smoking related fire fatalities in the home happen in fires that were attended between midnight and 6am (39 in 2003).

Table 2 Fire Statistics, UK, 2003 (www.odpm.gov.uk)

Table 2.1 Sources of ignition for accidental dwelling¹ fires, with casualties, 2002 and 2003²

United Kingdom

	Fires		Fatal casualties ³				Non-fatal casualties ⁴			
	2003	2002	Total	<i>Per</i> <i>1,000</i> <i>fires</i>	Total	<i>Per</i> <i>1,000</i> <i>fires</i>	Total	<i>Per</i> <i>1,000</i> <i>fires</i>	Total	<i>Per</i> <i>1,000</i> <i>fires</i>
Total accidental	49,998	50,828	395	8	354	7	10,426	209	11,182	220
Smokers' materials	4,159	3,807	125	30	123	32	1,416	340	1,420	373
Cigarette lighters	531	552	15	28	13	24	300	565	283	513
Matches	449	596	8	18	10	17	213	474	251	421
Cooking appliances	28,353	28,774	66	2	59	2	5,642	199	5,989	208
Space heating appliances	1,621	1,895	29	18	33	17	418	258	499	263
Central and water heating appliances	1,312	1,345	1	1	2	1	120	91	106	79
Blowlamps, welding and cutting equipment	620	634	-	-	-	-	53	85	55	87
Electrical distribution	2,746	2,773	5	2	7	3	304	111	294	106
Other electrical appliances	5,591	5,698	18	3	21	4	803	144	965	169
Candles	1,791	1,972	22	12	19	10	664	371	840	426
Other	2,088	1,973	13	6	5	3	283	136	254	129
Unspecified	737	809	93	126	63	78	209	284	226	279

¹ Includes caravans, houseboats and other non-building structures used solely as a permanent dwelling (see explanatory note 24).

² Fire figures are based on sample data weighted to individual FRS totals. Fire and casualty figures include 'late' call and heat and smoke damage only incidents (see explanatory notes 6 and 7).

³ Includes fire related deaths recorded by the MoD and media with estimates calculated for the breakdown by source of ignition in November 2002 and January and February 2003 during industrial action (see explanatory notes 3 and 4).

⁴ Includes estimates for non-fatal casualties not recorded in November 2002 and January and February 2003 during industrial action (see explanatory notes 3 and 4).

Table 3 Fire Statistics, UK, 2003 (www.odpm.gov.uk)

Table 3 Accidental fires¹ in dwellings and other buildings by source of ignition, 1993-2003²

United Kingdom		Source of ignition										Fires (thousands) ³		
Year	Total	Smokers' materials	Cigarette lighters	Matches	Cooking appliances	Space heating appliances	Central and water heating appliances	Blowlamps, welding and cutting equipment	Electrical distribution	Other electrical appliances	Candles	Other	Un-specified	
Dwellings⁴														
1993	54.5	5.4	0.7	2.9	26.7	3.1	1.1	0.9	3.1	5.8	0.9	3.3	0.6	
1994 ⁵	52.9	5.3	0.5	1.5	27.8	3.1	1.6	1.0	2.0	6.7	1.0	1.9	0.7	
1995	54.8	4.9	0.6	1.2	28.6	2.9	1.5	1.0	2.4	6.4	1.3	2.0	2.0	
1996	57.5	5.1	0.6	1.1	31.0	3.3	1.5	0.9	2.5	7.2	1.5	2.2	0.7	
1997	58.7	4.9	0.6	1.0	32.9	2.6	1.7	0.8	2.5	7.3	1.6	2.0	0.6	
1998	57.7	4.8	0.7	0.8	32.8	2.6	1.4	0.8	2.7	6.8	1.8	2.0	0.7	
1999	58.4	4.8	0.6	0.9	33.5	2.4	1.4	0.6	2.7	6.4	2.0	2.3	0.9	
2000	56.7	4.0	0.5	0.7	33.9	2.4	1.4	0.6	2.8	5.6	2.1	1.9	0.6	
2001	54.3	4.3	0.5	0.7	30.7	2.3	1.4	0.7	2.6	6.0	2.0	2.2	0.8	
2002 ²	50.8	3.8	0.6	0.6	28.8	1.9	1.3	0.6	2.7	5.7	2.0	2.0	0.8	
2003 ²	50.0	4.2	0.5	0.5	28.4	1.6	1.3	0.6	2.8	5.6	1.8	2.1	0.7	
Other buildings														
1993	26.5	2.9	0.1	2.1	3.4	1.1	0.5	1.5	2.2	3.8	0.2	7.7	1.0	
1994 ⁵	24.1	2.8	0.1	0.6	3.9	1.0	0.6	1.5	2.1	6.0	0.2	4.4	0.9	
1995	26.0	3.0	0.1	0.6	4.4	1.2	0.7	1.6	2.1	5.8	0.2	4.6	1.7	
1996	25.7	2.8	0.1	0.6	5.0	1.2	0.6	1.3	2.2	6.7	0.2	4.1	0.9	
1997	25.5	2.6	0.1	0.4	5.6	1.1	0.7	1.3	2.2	6.5	0.2	3.8	0.9	
1998	24.7	2.8	0.1	0.3	5.5	1.1	0.7	1.2	2.3	6.6	0.2	3.1	1.0	
1999	25.7	2.4	0.1	0.3	6.6	0.9	0.7	1.1	2.5	6.3	0.2	3.6	1.2	
2000	23.8	2.1	0.1	0.3	5.8	0.8	0.6	1.2	2.4	6.0	0.2	3.4	0.9	
2001	23.8	2.1	0.1	0.2	5.5	0.9	0.6	1.1	2.3	6.1	0.2	3.6	1.1	
2002 ²	22.7	2.0	0.1	0.3	5.1	0.7	0.5	1.0	2.3	6.1	0.2	3.4	1.0	
2003 ²	23.1	1.9	0.1	0.2	4.9	0.8	0.5	0.7	2.3	6.0	0.2	4.2	1.1	

¹ There were changes in the recording of deliberate and accidental fires, which affect comparisons, before and after 1994 (see explanatory note 12).

² Includes estimates for incidents not recorded in November 2002 and January and February 2003 during industrial action (see explanatory notes 3 and 4).

³ Figures are rounded and the components do not necessarily sum to the independently rounded totals.

⁴ Includes caravans, houseboats and other non-building structures used solely as a permanent dwelling (see explanatory note 24).

⁵ Figures from 1994 are based on sample data weighted to individual FRS totals. They include 'late' call and heat and smoke damage only incidents, which were not recorded prior to 1994 (see explanatory notes 6 and 7).

2.2 REDUCED IGNITION POTENTIAL CIGARETTES

From the above statistics it is not surprising that all the countries mentioned are investigating ways of reducing the risk associated with the unsafe use of smokers' materials in relation to textile materials used in the domestic environment.

The UK initially made a start on this topic by introducing the Furniture and Furnishings (Fire) (Safety) Regulations in 1988⁽⁴⁾ which banned the use of conventional, easily ignited foam in new and re-furnished upholstery to be replaced by Combustion Modified foam. However, from the UK statistics it is apparent that this is not the full solution to the problem, although there will still be a considerable amount of old upholstery in use containing pre-regulation foam.

A way of approaching the problem being favoured by the USA, Canada and New Zealand is by the introduction of so-called Reduced Ignition Potential cigarettes.

The ignition of a textile substrate by a lit cigarette is a complex process that is stated to depend on the following factors: the substrate itself, the area of the burning cigarette ash, the speed of smouldering of the cigarette and the zone of contact between the substrate and the smouldering cigarette. Ignition of the substrate occurs when the burning cigarette enables the textile material to heat up to a point where it, or the adjacent filling, such as foam in furniture, begins to smoulder. The theory is that a cigarette that smoulders less readily must generate less heat or at least transfer less heat to the substrate and thus be of reduced ignition potential.

Four design features have been identified that could be altered to make cigarettes less able to sustain smouldering;

- 1) Reduced tobacco density
- 2) Reduced paper porosity
- 3) Decreased circumference of the cigarette
- 4) Removal of the burn additive placed in the paper by the Industry to enhance the burn rate.

Despite the above, the Reduced Ignition Potential cigarettes currently on the market in the USA, Canada and New Zealand have adopted a different approach by use of a patented paper which has concentric bands of ultra thin paper applied to the conventional cigarette paper. It is claimed that these bands act as "speed bumps" to slow down or stop the spread of smouldering in the cigarette. As can be seen from the above smouldering speed is one of the reasons given for ignition of textile substrates.

A New Zealand study⁽⁵⁾ comparing conventional cigarettes, banded cigarettes and those made from hand rolling paper has shown that all manufactured cigarettes burnt their full length, 73% of the banded cigarettes burnt their full length, whilst none using hand rolled paper cigarettes burnt their full length. The conclusion of this work was that the best way of reducing ignition was to use hand rolling paper – it is unknown by this author if this paper contains any burn additive, although the inference is that it does not.

This research project for ODPM is to investigate the effect on the ease of ignition of various textile materials by use of Reduced Ignition Potential cigarettes using paper with bands when compared to a conventional UK cigarette.

CHAPTER 3

Selection of test materials

3.1 GENERAL

Materials used in the project fall into three distinct groups:

- a) Cigarettes
- b) Backing materials
- c) Test materials.

3.2 CIGARETTES

Analysis of the Market

a) UK cigarette

The project contract provided for one brand of low cost, mass market cigarette. Local indications were that one of the most popular brands of cheaper cigarettes is Lambert & Butler King Size; these were chosen as the UK brand.

b) RIP cigarettes

A Harvard School of Public Health report⁽⁶⁾ was used to select five brands of RIP cigarettes available in New York City. Of these five brands two were to be selected for the project. Selection was made based on burn length and rate (full results below); the two selected were Merit as being the lowest burn length/rate and Camel being the highest burn length/rate.

3.3 BACKING MATERIALS

For the testing of upholstery, cushion, sheets and pillowcase material the backing was non-FR polyurethane upholstery foam of density about 22Kg/m³ as specified for qualifying upholstery fabrics according to the UK Furniture and Furnishings (Fire)(Safety) Regulations 1988, as amended⁽¹⁾.

For the purposes of this project report this type of upholstery foam is called “standard” foam.

Preliminary tests using the UK brand cigarettes carried out over backings of polyester fibre and feathers did not manage to induce either flaming ignition or progressive smouldering in any of the test materials and so these backings were discounted.

Thus for all non-upholstery tests 100mm thickness Rockwool was chosen to be the standard backing material. Rockwool was selected as it is a thermal insulator that is used on other fabric flammability tests.

3.4 TEST MATERIALS

3.4.1 Background

The project proposal made the following references.

The test materials will be selected from new materials available at the low price end of the UK market. The selection will be divided into different groups of materials as follows.

a) Group 1 Materials

These will be textile furnishing materials that are used alone or in contact with other furnishing materials. They will be chosen so as to contain at least a significant proportion of cellulose fibre (usually cotton) so that there is a likelihood of combustion with current UK cigarettes.

The intention is to select group 1 materials from bed sheets/blankets, throws and from scatter cushion covers and mattress covers.

The selection is also intended to include materials of different mass/unit area and different proportions of cellulose including 100%.

b) Group 2 materials

It is intended to select materials from those that are used in combination with upholstery, mattress, cushion, pillow, duvet/quilt fillings. It is also intended to consider combinations of these materials that may be created in a domestic environment.

Whilst it should be the case that the UK Furniture and Furnishings (Fire) (Safety) Regulations 1988, as amended⁽¹⁾ eliminate most potentially cigarette ignitable combinations from the domestic market, it was proposed that a few combinations be tested that should not be on the market. This approach can also permit the testing of combinations of cellulosic fabrics and unmodified PU upholstery foam (not CMHR). Testing with conventional cigarettes should induce progressive smouldering in the underlying foam so a comparison with RIP cigarettes will be particularly indicative. The basis for the cigarette test in the UK regulations is to apply a defined cigarette to material combinations incorporating this type of unmodified foam as a worst case situation.

The intention here, as with Group 1 materials, is to try to select ones that lead to combustion occurring with a current UK cigarette and then to compare with the RIP cigarettes.

c) Group 3 materials

These will be non-textile but of cellulosic composition. A paper tissue product (often discarded into open waste bins) and a newsprint product will be selected.

3.4.2 ANALYSIS OF THE MARKET

Prior to commencing the initial product selection testing an analysis of the relevant markets was made. This analysis was made using the Internet, store catalogues and visits to local discount stores.

Group 1: Products selected from sheets, blankets, throws, scatter cushion covers and mattress covers.

- Analysis of the market shows sheets and scatter cushion covers to be composed of 100% cotton, 50/50% cotton polyester, 60/40% cotton polyester, 40/60% cotton polyester and some blends in between.
- Throws tend to be 100% viscose, 100% cotton, 100 % acrylic or 100% polyester. The types of throws fall into two categories, those for beds and those for seating.
- Blankets seem to fall into the same classification as throws for bed use.
- Mattress covers also fall into polyester or poly/cotton blends, apart from “fleece” types which are acrylic/polyester blends with the main component being acrylic.

Group 2: Products to be selected from upholstery, mattress, cushion, pillow, duvet and quilt fillings.

- Generally the covers of these products fall into the same ranges as above with some nylon products also being available.
- Fillings of cushions, duvets, etc seem to be all polyester or hollow fibre (again polyester) apart from feather.

Group 3: Paper products, tissue and news.

With all the above textile products by far the “cheaper” end of the market is met by polyester/cotton blends.

3.4.3 SELECTION OF FURNISHING MATERIALS

It had always been thought that the hardest part of the project would be the selection of materials that would show either progressive smouldering or flaming ignition when tested using the chosen UK cigarette. The project proposal had identified this potential problem and suggested that the materials chosen should be predominantly cellulosic in construction.

In a number of the end uses chosen this remit seemed to be at odds with the types of material available (see above), particularly at the lower end of the respective markets.

In order to rationalise the above, initial tests were conducted using a range of varying weight polyester/cotton materials over both standard foam and Rockwool using the UK cigarettes. No ignition or progressive smouldering could be produced in any case.

Further tests were carried out using double thicknesses of material, the material placed above and below the cigarette and with the cigarette covered with cotton wool padding to try and increase the temperature of the smouldering cigarette. All attempts failed to produce the required effect.

In order to assess if the problem was a cigarette effect similar tests were carried out using the "standard" Senior Service cigarettes, once again the required effect was not produced.

As a result of the above tests it was decided that materials containing a high percentage of polyester would have to be avoided where possible.

Similar tests were then initiated using some predominantly cotton upholstery material which had been soaked in water to remove any water soluble flame retardant treatment. When these tests were carried out using a pad of cotton wool over the UK cigarette progressive smouldering could be induced when the material was tested over either the standard foam or the Rockwool.

As a consequence it was decided that for the main series of tests the cigarettes would be covered with a pad of cotton wool when the materials were tested over either the standard foam or Rockwool.

A range of other materials meeting the project groups were then obtained and preliminary tests carried out using the above testing regime. From this range the final selection of test materials were made.

3.4.4 PAPER PRODUCTS

Initially attempts were made to ignite tissue paper, facial tissues and newspaper by screwing up a number of fixed sized sheets and placing them in a metal waste paper basket. Tests were carried out with the UK cigarettes placed horizontal, vertical and at 45° within the material, no ignition or progressive smouldering could be induced in any of the papers.

Eventually either ignition or progressive smouldering was induced in facial tissues using the following test arrangement. Using the base of the standard test rig, this was first covered with Rockwool followed by 5 sheets of the facial tissue. The cigarette was placed on the tissue and covered with a further 5 sheets of the facial tissue. The area above the cigarette was then covered with a cotton wool pad.

Even using this arrangement, neither ignition, nor progressive smouldering could be induced in either tissue paper or newspaper.

3.4.5 MATTRESS

A single bed size mattress was obtained with a filling of Kapok. This mattress was tested with the cigarettes placed on the cover, which were in turn covered by a cotton wool pad.

3.4.6 FINAL SELECTION

Based on the preliminary trials detailed above the following test materials were chosen:

Table 4 Test Materials			
Ref.	Composition	Style	Weight
B	100% Cotton	Upholstery	330g/m ²
C	93% Cotton 7% Linen	Upholstery	250g/m ²
D	93% Cotton 7% Linen	Upholstery	250g/m ²
E	100% Cotton	Upholstery	240g/m ²
G	100% Cotton	Upholstery	240g/m ²
H	100% Cotton	Upholstery	240g/m ²
K	75% Viscose 25% Cotton	Throw	
L	100% Cotton	Throw	
O	100% Cotton	Brushed Sheet	
P	100% Cotton	Sheet (tested double thickness)	
R	50% Cotton 50% Acrylic	Blanket	
Facial Tissue			
Mattress (single bed size filled with Kapok).			

Samples B, C, D, E, G and H were tested over standard foam only.

Samples K, L, O, P and R were tested over both standard foam and Rockwool.

K and L over foam represent scatter cushions and over Rockwool, a typical throw.

O and P over foam represent a pillow and over Rockwool, a sheet over a non-foam mattress.

R over foam represents a scatter cushion and over Rockwool, a blanket.

CHAPTER 4

Development of test procedure and test assessment protocols

4.1 BACKGROUND

Existing BS, BS EN and ISO methods of test for the ignitability of bedding and upholstered furniture were considered as the basis for determining a worst case orientation for test materials.

Bedding fabrics when tested according to BS 7175⁽¹⁰⁾ are oriented horizontally whereas upholstery furniture composites when tested according to BS EN 1021-1⁽¹¹⁾ are oriented in an “L” shaped assembly thus having horizontal and vertical elements each incorporating the test fabric.

Preliminary trials were undertaken to determine if the “L” orientation could be used for all test materials as it was likely to be the one that gives the highest probability of enabling at least the UK reference cigarette to induce combustion. It was envisaged that an inert material of low heat conductivity (Rockwool) would have a role as an underlying layer in the test of some materials not usually found in combination with (or likely to be in contact with) upholstery fillings and related fillings.

The criteria for “pass/fail” set out in the various related BS, BS EN and ISO methods of test, including those used in connection with the UK regulations, would be a start point for the result of each test. The nature of any combustion (smouldering or flaming whether or not it is progressive), would be recorded together with the duration and extent of combustion.

The basis for the development of the British Standard test method cited in the UK Furniture and Furnishings (Fire) (Safety) Regulations⁽¹⁾ was to recreate in small scale the situation in which a smouldering cigarette lies along the junction between the seat rest and back rest of an upholstered settee, see Figs 1 and 2.

Analysis of domestic upholstery fires at that time (the mid 1970’s) indicated that they were often caused by a dropped cigarette rolling to the seat rest junction and then continuing to smoulder after the occupant of the chair had retired to bed. Typically some hours later the smouldering cigarette would cause firstly progressive smouldering in the underlying upholstery foam, and secondly flaming combustion leading to fatal consequences.

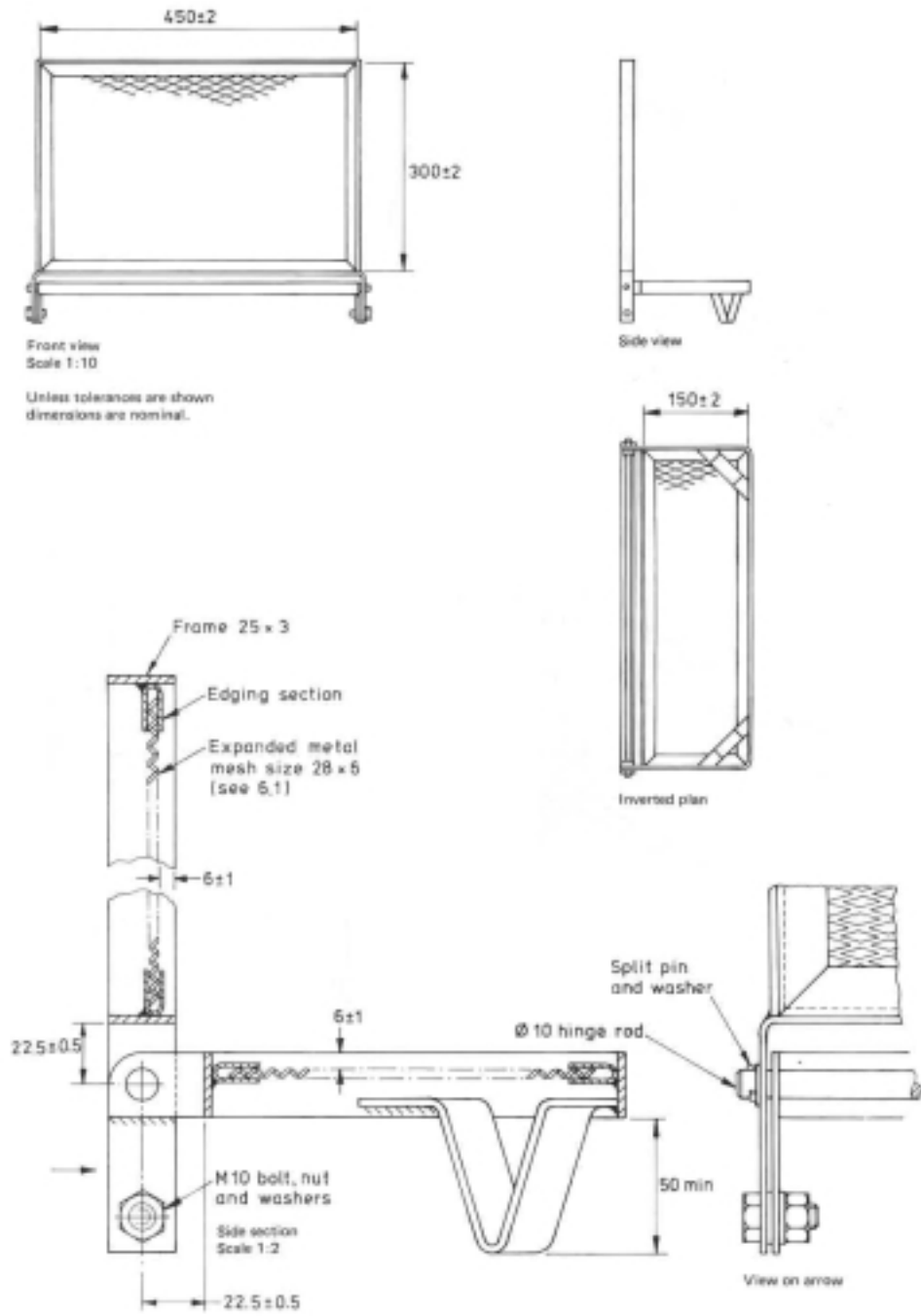
A testing programme in which the contractor was involved clearly demonstrated that many upholstery fabric/foam combinations on the market at that time could be induced by a reference smouldering cigarette to firstly permit progressive smouldering in these combinations which then developed into flaming combustion.

The manner in which this test method (BS 5852⁽¹²⁾ in the UK regulations) was, and is still used, is to require upholstery fabrics to be tested in combination with the standard non-FR upholstery foam, but then to prevent the use of this type of foam in upholstered furniture – it was replaced by combustion modified foam, CMHR. Thus since the regulations came into force upholstered furniture on the market should not be ignitable by smouldering cigarettes!

4.2 TEST RIG

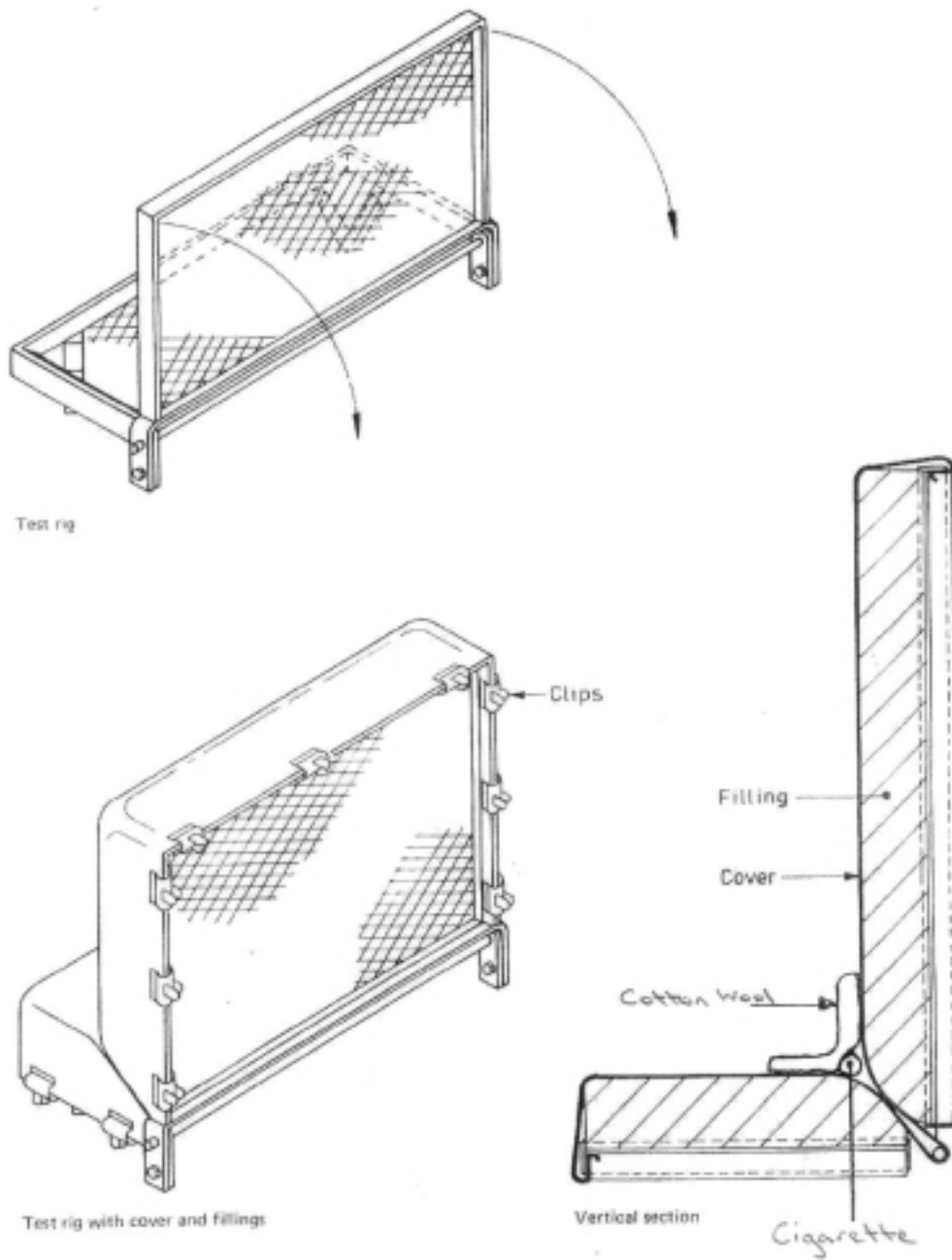
On the basis of the above the test rig selected was that detailed in BS 5852⁽¹²⁾, Fire Tests for Furniture, and is shown below, as cited in UK Furniture and Furnishings (Fire) (Safety) Regulations⁽¹⁾.

Fig 1 BS 5852 Part 1: 1979 Test Rig



(Reproduced with permission from BSI)

Fig 2 BS 5852 Part 1: 1979 Test Rig



(Reproduced with permission from BSI)

CHAPTER 5

Test Results

5.1 CIGARETTES – MEASURED CHARACTERISTICS IN ISOLATION

Tests were carried out to determine the distance that each cigarette burns and how long taken to extinguishment, when left to smoulder in air. The tests were carried out in a draught proof environment with the horizontal cigarettes lit and left to smoulder without inducement.

Table 5 Distance Burnt (mm)					
UK	Merit	Camel	Marlboro	Marlboro Light	Naturals
57	24	57	22	34	68
57	40	57	55	46	74
57	50	57	45	53	74
57	51	57	32	50	74
57	51	57	22	56	59
57	18	57	44	56	74
57	49	57	55	40	72
57	50	57	45	56	74
57	7	57	55	42	74
57	13	57	33	56	74
Mean 57	35	57	41	49	72
*57	*51	*57	*55	*56	*74

* Maximum potential burn length.

Table 6 Time to Extinguish (s)					
UK	Merit	Camel	Marlboro	Marlboro Light	Naturals
599	457	614	436	544	1018
598	669	602	798	729	1100
519	892	577	717	814	1089
576	882	570	616	675	986
540	1017	606	471	892	820
547	421	623	805	715	1063
525	832	589	801	598	962
546	825	574	860	879	1142
600	285	562	758	645	1049
579	358	575	674	620	1037
Mean 563	664	589	694	711	1027

Based on the averages this gives rates of burn as:

UK	0.10 mm/sec
Merit	0.05 mm/sec
Camel	0.10 mm/sec
Marlboro	0.06 mm/sec
Marlboro Light	0.07 mm/sec
Naturals	0.07 mm/sec

Positioning of Bands

In addition to the above tests the positioning of the bands within the two brands of cigarette selected was measured to see if they were always in the same position relative to the end of the cigarette. The tests were carried out by carefully dissecting the paper used to wrap the tobacco and measuring the position of the bands on the inside of the paper. The full results are given below, distances from non-filter (original ignition) end.

Table 7 Positioning of Bands					
Merit (mm)			Camel (mm)		
1st Band	2nd Band	3rd Band	1st Band	2nd Band	3rd Band
21	48		0	24	48.5
0	29		10.5	35.5	
11	38		14.5	39.5	
21	49		0	24	48.5
21	49		11.5	36.5	
21	49		0	26	51
6	32		2.5	28	52.5
16	45		13	38	
2	32		12	37	
4	29		2	28	53

As can be seen from the above the number and positioning of the bands both within and between brands is variable. It would be expected that this variability explains the different burn lengths and times given in the tables above.

Burning temperature of the Cigarettes

An attempt was made to determine the temperature within the selected cigarettes when they were smouldering horizontally in air without inducement. To do this a point thermocouple was inserted into each test cigarette at right angles to the length of the cigarette. The point of the thermocouple was arranged to be as near as possible in the centre of the cigarette diameter and 10mm from the ignition end of the cigarette.

At least 10 tests were made per sample, however the results were found to be very variable and the best comments to be made are given below;

Table 8 Burning Temperature of the Cigarettes
<p>Lambert & Butler Maximum temperature in range high 300°C to mid 400°C, highest being 443°C</p> <p>Camel Maximum temperature in range low 400°C to high 400°C, highest being 490°C</p> <p>Merit Maximum temperature in range mid 200°C to high 400°C, highest being 490°C but lowest being 255°C</p>

5.2 CIGARETTES – IN RELATION TO THE MATERIALS

A summary of the test results obtained is given below:

The classification is the number of cigarettes to induce flaming and/or smouldering in the test material and whether the cigarette burns to a band or to its end.

Six repeats were carried out per sample.

Table 9 Samples over Standard Foam

Sample Reference	Lambert & Butler		Camel			Merit		
	Smoulder	Burn to end	Smoulder	Burn to end	Burn to Band	Smoulder	Burn to end	Burn to Band
B	4	2	3				3	3
C	3	3	2	2	2		4	2
D	5	1	2	1	3		3	3
E	3	3	5	1			3	3
G	4	2	2	1	3		5	1
H	6		1	1	4	1	3	2
K	6		4		2		4	2
L	3	3	1	2	3	1	2	3
O	5	1	6				6	
P (double thickness)	5	1	5	1		1	5	
R	6		2	1	3	2	2	2

Table 10 Samples over Rockwool, Tissue and Mattress											
Ref.	Lambert & Butler			Camel				Merit			
	Flame	Smoulder	End	Flame	Smoulder	End	Band	Flame	Smoulder	End	Band
Over Rockwool											
K		5	1	4			2	3		3	
L		6		5			1	4		1	1
O	2	4		6				4	2		
P (double thickness)	2	4		3	2	1			4		2
R		6		3	2		1	3			3
Tissue Paper		6			6				6		
Mattress		1	5			5	1			5	1

CHAPTER 6

Analysis of Results

6.1 SUMMARY

For this type of experiment where individual specimens are concerned without lengths measured or times recorded the best, and most meaningful, analysis can be provided by simple totals.

Results of specimen totals per cigarette and end result over standard foam, over Rockwool and on the mattress.

Table 11 Summary of Results											
Ref.	Lambert & Butler			Camel				Merit			
	Flame	Smoulder	End	Flame	Smoulder	End	Band	Flame	Smoulder	End	Band
Standard Foam	0	50	16	0	33	10	23	0	5	40	21
Rockwool	4	31	1	21	10	1	4	14	12	4	6
Total	4	81	17	21	41	11	27	14	17	44	27
Mattress	0	1	5	0	0	5	1	0	0	5	1
Grand Total	4	82	22	21	41	16	28	14	17	49	28
Percentages	91%			69%				34%			

6.2 COMMENTS

6.2.1 General

- The standard BS test method had to be adapted to ensure either flaming ignition or progressive smouldering occurred with UK cigarettes on various materials over either standard foam or Rockwool to get a base line with which to compare the RIP cigarettes.
- Progressive smouldering or ignition could not be induced by any means on any material over polyester or feather fillings.
- Materials representing the lower end of the markets are primarily composed of polyester/cotton blends and progressive smouldering or ignition could not be induced in these materials by any of the means tried.

- The positioning of the bands in the RIP cigarettes is variable with regards to the end of the cigarette; this means that the length of burn of the cigarettes is also variable where the stopping position is based on the bands.
- Results of the burn length/time tests of the RIP cigarettes confirms results quoted from USA tests as being variable both within, and particularly, between brands.

6.2.2 Based on Analysis of the Results

- All brands of cigarettes induced progressive smouldering in some materials when tested over standard foam.
- All brands of cigarettes induced either flaming ignition or progressive smouldering in some materials when tested over Rockwool.
- When taken overall the UK cigarettes induced more flaming ignition/progressive smouldering than the RIP cigarettes with 86 fails, the next was the Camel RIP cigarettes with 64 fails followed by the Merit RIP cigarettes with 31 fails.
- The difference in results over standard foam were more emphatic; with UK 50 fails, Camel 33 fails and Merit only 5 fails.
- For testing over Rockwool the results were UK 35, Camel 31, Merit 26.
- Generally the number of RIP cigarettes that burnt to a band and self extinguished were the same in both cases, over Standard Foam and Rockwool. The main difference was in the number of each cigarette that burn their full length, 16 in the case of Camels and 40 in the case of Merit.
- The implications from the above are that a) the presence of the bands does stop some of the cigarettes from smouldering over their full length and b) there appears to be some other reason why the Merit cigarettes react more favourably with the test materials than the Camel cigarettes. Indications are that this may be due to smouldering temperature. This latter effect is less pronounced over Rockwool than standard foam.
- A cause of concern is why do materials flame when tested over Rockwool and not over foam? A possible answer to this question is that as Rockwool is an insulator the cigarettes may be inducing higher temperatures into the substrate material thereby inducing ignition. When tested over foam the foam is absorbing some of the heat and so the temperature may not be high enough to induce flaming in the material.
- The limited tests carried out into temperature of burn of the cigarettes indicates very variable results, however it does indicate that they do burn at different temperatures. This could be due to tobacco density, mix of tobacco used or porosity of paper. The presence of the bands in the Reduced Ignition Potential cigarettes does not seem to decrease the maximum temperature attainable, although they do seem to produce a large variability of temperature in the Merit cigarettes. The same effect is not shown by the Camel cigarettes.

- Based on the fire statistics in Table 2, smokers' materials, excluding matches and lighters, accounted for 4,159 fires, 123 fatalities and 1,416 non-fatal casualties in 2003. If the results from this limited programme of work are truly representative of (a) the differences between typical UK cigarettes and typical USA RIP cigarettes, and (b) the furnishing materials actually ignited in UK domestic fires, the probability of ignition could be reduced from 91% to 69% for Camel and 34% for Merit. Further extrapolation shows:

	Standard	Camel	Merit
Number of Fires	4,159	3,277	1,615
Fatalities	123	93	45
Non-Fatal Casualties	1,416	1075	530

CHAPTER 7

Conclusions

In our opinion the results of the tests indicate that RIP cigarettes do reduce the risk of inducing ignition or progressive smouldering in the materials tested, but the risk is clearly not eliminated. Typically 91% of the standard cigarette caused flaming or smouldering. With RIP cigarettes this figure reduces to 69% with one type of cigarette and 34% with the other.

However, this project has raised questions which remain unanswered:

- The contract allowed for one UK cigarette, chosen to be from the low cost, mass market range. It is possible that within this range there is a wide variation of smouldering characteristics, and hence different ignition properties. This opinion is supported by the fact that the chosen RIP cigarettes exhibited differing smouldering rates and likelihood of igniting the test materials.
- The statistics show that a considerable number of fires are attributed to smokers' materials, defined in the statistics as cigarettes, cigars and tobacco and therefore excluding matches; igniting both upholstery and bedding. This is contrary to our experience where we had difficulty inducing either progressive smouldering or flaming ignition when testing such materials selected from the current ranges available.
- The reasons for the difference in burning characteristics of the cigarettes themselves in respect of rate of smouldering and temperature of smouldering.

The difference between types of UK cigarettes and between types of RIP cigarettes will need to be addressed if the introduction of the latter is to be as effective as possible in reducing fires.

REFERENCES

BACKGROUND LITERATURE

- 1) The Furniture and Furnishings (Fire) (Safety) Regulations 1988 (as amended in 1989 and 1993). Statutory Instruments 1988/1324, 1989/2358, 1993/207.
- 2) Regularity Proposal for Reducing Fire Risks, 2.1 Cigarette fires cause the highest number of fire-related fatalities in Canada.
www.hc-sc.gc.ca/hl-vs/pubs/tobac-tabac/ripc-cpar/propos02_e.html
- 3) The Case for fire safe cigarettes made through industry documents, Tobacco Control Online, <http://tc.bmjournals.com/cgi>
- 4) Time to legislate for fire-safe cigarettes in Australia, eMJA 2004;181(6):292-293, www.mja.com.au
- 5) Hand rolling cigarette papers as the reference point for regulating cigarette fire safety. <http://tc.bmjournals.com/cgi/content/abstract/12/4/406>
- 6) “Fire Safer” Cigarettes: The effect of the New York State cigarette fire safety standard on ignition propensity, smoke toxicity and the consumer market. Preliminary Report January 2005, Harvard School of Public Health.

Other references consulted but not cited in the report.

- 7) *NIST Technical Note 1454: Robustness of Measuring the Ignition Strength of Cigarettes with ASTM Method E2187-02b.*
- 8) *Regulatory Proposals for reducing Fire Risks from cigarettes – Section 4 Technology overview, Section 5 Regulatory proposal. Health Canada.*
- 9) *News article ID: 9256. Canada’s cigarettes less likely to burn.*
- 10) BS 7175, Methods of test for the ignitability of bedcovers and pillows by smouldering and flaming ignition sources.
- 11) BS EN 1021 – 1 Furniture. Assessment of the ignitability of upholstered furniture. Ignition source: smouldering cigarette.
- 12) BS 5852, Methods of test for assessment of the ignitability of upholstered seating by smouldering and flaming ignition sources.

APPENDIX 1

BTTG Background

BTTG is a UK based independent commercial organisation offering consultancy, testing, certification, investigation and training services to clients on a worldwide basis in the field of textile and related technologies. The organisation was founded in 1988 by the amalgamation of two textile research associations, Shirley Institute and the Wool Industry Research Association, originally formed by government initiative around 1920.

BTTG has two fire test laboratories, one in Leeds and one in Manchester, both of which are in BTTG Advanced Materials Services Limited and both of which use the brand “BTTG Fire Technology Services”. Each laboratory has at least a forty year history of developing and undertaking routine and ad hoc fire tests on products that now range from construction products and furnishings through to personal protective equipment and marine equipment.

We have been involved with the flammability of furnishing materials since 1975 when we became founder members of the BSI committee that developed the upholstered furniture ignitability test methods cited in the UK Furniture & Furnishings (Fire) (Safety) Regulations 1988, as amended.

We have also been directly involved in the subsequent development by BSI of related ignitability tests for bedcovers, mattresses and pillows.

Following the introduction of the ignitability test methods for furnishings both of our test laboratories have been continuously working in this field by providing a testing and consultancy service. Both test laboratories have long standing accreditation for these ignitability tests via the United Kingdom Accreditation Service (UKAS), this accreditation now being to the requirements of EN ISO/IEC 17025.

This programme of work was undertaken by our Leeds laboratory.