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## Burning Behaviour of Clothes: Results of a Survey on the Swiss Market

*Key words:* Textiles, Flammability, Burning behaviour, Nightwear,  
Work clothes, Clothes

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### Introduction

Clothes made of textiles which ignite and burn very quickly, when they are exposed to an open flame or an intensive heat source, involve a potential health risk for the consumer. A British study (cited in (1)) estimates that at least 750 clothing flammability accidents occur per year. Of these only 445 are minor. Approximately 80 are fatal and 225 involve severe burns. The burns are painful and may lead to permanent scarring, depending on the degree of burning and the body surface involved. The medical and sometimes psychiatric treatment required may take a long time and is in many cases very expensive.

Only few data about clothing flammability accidents in Switzerland are available (2). Nevertheless new legal restrictions concerning the burning behaviour of textiles (3) were stipulated for consumer safety, because of the daily risk of contact with heat sources such as candles, matches, gas-stoves and so on. They have been enacted in 1995 and contain the following restrictions for clothes:

- Maximum flame spread rate of 90 mm/s for at least five out of six textile specimens.
- No «surface flash» (rapid spread of flame over the surface of a material, without combustion of the basic structure at that time).

As test method the European standard EN 1103 (4) which refers to the ISO 6941 standard (5) is prescribed.

In Switzerland, state laboratories (kantonale Laboratorien) are responsible for the enforcement of the regulations of the Swiss food law, which also contains the restrictions for consumer goods such as clothes. To our knowledge, only little or few data concerning the burning behaviour of textiles have been collected during the last years (2) because of the lack of suitable instruments. We therefore purchased a new flammability tester called Rhoburn, which fulfils the requirements of several flammability standards, including the mentioned EN 1103 standard. It allows the observation and measurement of ease of ignition and flame spread properties of vertically oriented textile fabrics.

We have been using the Rhoburn flammability tester since autumn 1996. In this paper, test results of nightwear, work clothes and usual clothes up to autumn 1997 are presented and discussed.

## Method

### *Instruments*

Rhoburn Model 480 flammability tester (James H. Heal & Co. Ltd., Richmond Works, Halifax, W. Yorkshire HX3 6EP, England, sold in Switzerland by W. Lüthi, Thurerstrasse 1, 8552 Felben-Wellhausen).

WTB Binder climatic cabinet KBF 240 APT (WTB Binder Labortechnik GmbH, Bergstrasse 14, D-78532 Tuttlingen, sold in Switzerland by E. Merck (Schweiz) AG, Rüchligstrasse 20, 8953 Dietikon).

### *Samples*

Samples were taken by custom officers during import to Switzerland or by us in retail shops of both states.

### *Procedure*

Following the Swiss legal restrictions, the tests were performed according to the European standard EN 1103 (4) which refers to the ISO 6941 (5) standard<sup>1</sup>.

The ISO 6941 standard states that: «A defined ignition flame from a specified burner is applied for a defined period of time to textile specimens which are vertically oriented. The flame spread time is the time in seconds for a flame to travel between marker threads located at defined distances. Other properties relating to flame spread may also be observed, measured and recorded.»

The following characteristics were observed in our tests:

<sup>1</sup> For experimental details see (4) and (5).

- Flame spread time in s, which allows the calculation of the flame spread rate in mm/s.
- Occurrence of a surface flash.
- Occurrence of flaming fabric debris (mostly burning drops), which continue to burn.

*Note:* According to the EN standard, the clothes have to be washed following the indications on the label. In our case we had them washed in a laundry.

## Results and discussion

### *Validation of the method*

Normally international standard methods are considered as validated. Because no validation data are mentioned in EN 1103 (4) and no reference material is available (6), the repeatability of the flame spread time was determined by measuring 6 different specimens of a cotton/synthetic textile fabric. The mean value  $\bar{x}$  of the 6 flame spread times was 55.6 mm/s, with a standard deviation  $s$  of 10.4 (18%). Another test with 10 specimens of a cotton sample gave a relative standard deviation of 16% ( $\bar{x} = 41.3$  mm/s,  $s = 6.7$ ).

### *Flame spread rate*

According to EN 1103 (4), 6 specimens (3 cut of the length and 3 cut of the width direction) of each sample should be measured. The repeatability data (see above) indicate that the relative standard deviation of the results is less than 20%. In consideration of this, we decided to measure only 2 specimens of each textile for routine analysis, one cut of the length and one cut of the width direction. Only textiles with a mean flame spread rate of more than 70 mm/s were measured 6 times. Therefore the most of the following results are mean values of 2 specimens.

### *Summary of all results*

150 samples were tested. 40 of them were made of cotton, 46 of synthetic material, 54 of a mixture cotton/synthetic, 4 of viscose and 6 of silk. The flame spread rates of all samples are displayed in figure 1. No sample exceeded the maximum flame spread rate of 90 mm/s. Even the former provisional maximum value of 60 mm/s was exceeded only by 3 samples (2%). Additionally the flame spread rates of cotton, synthetic material and the cotton/synthetic mixture are displayed in figure 2. The data show the surprising result, that synthetic materials burn less than cotton.

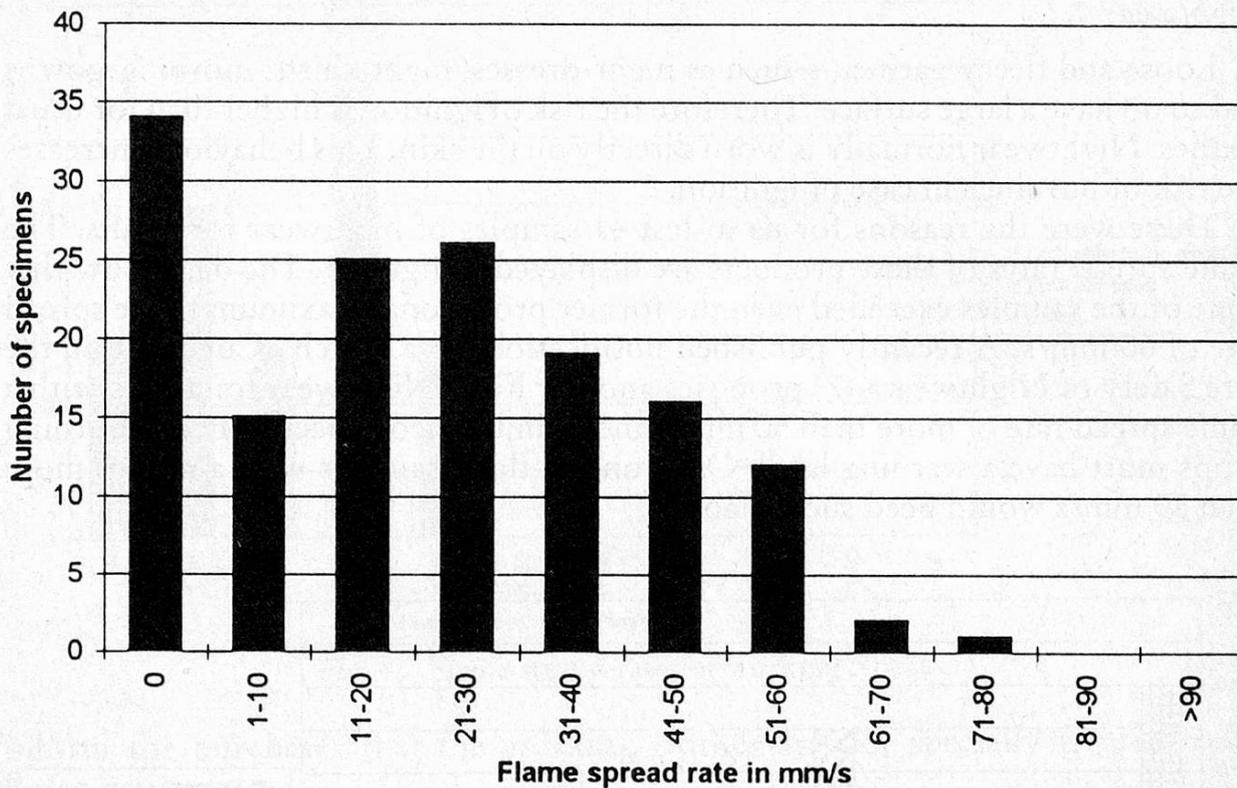


Fig. 1. Flame spread rates of all 150 tested samples

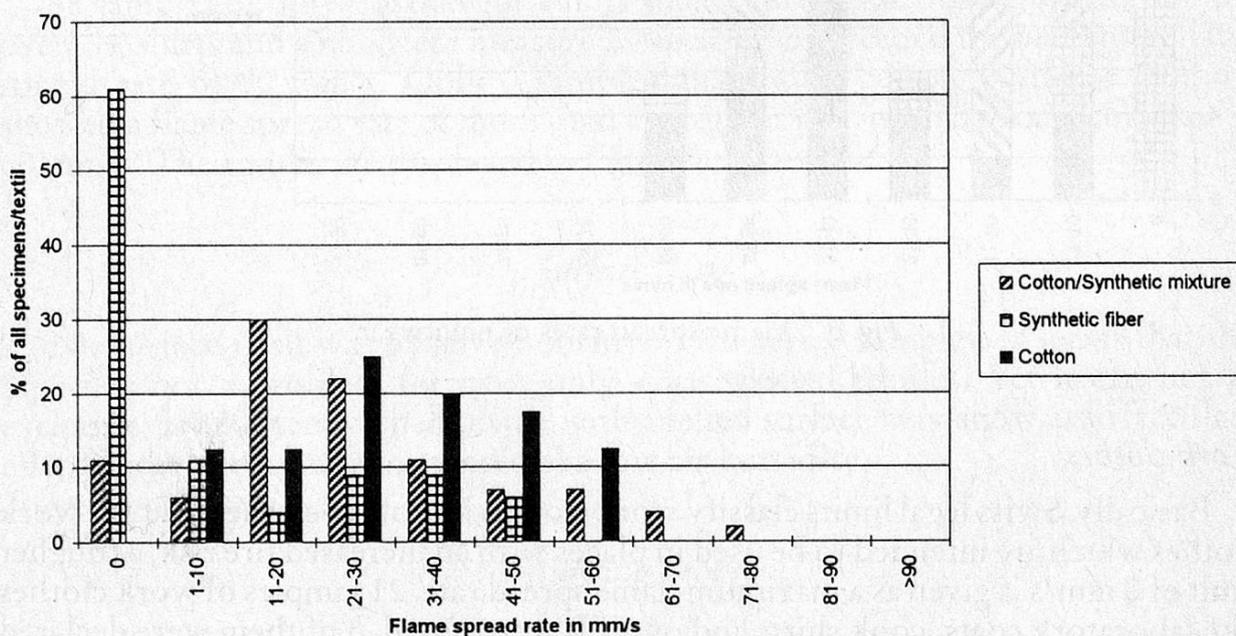


Fig. 2. Flame spread rates of different textile materials<sup>2</sup>

<sup>2</sup> All tested samples, which were made of cotton, synthetic fibres and a mixture cotton/synthetic are taken into consideration. Viscose and silk are left out because of their small sample numbers.

## Nightwear

Loose and fleecy garments such as night-dresses, night-shirts, morning-gowns and so on have a large surface. Therefore the risk of ignition is higher than for usual textiles. Nightwear normally is worn directly on the skin. This behaviour increases the risk of burnings in case of ignition.

These were the reasons for us to test 41 samples of nightwear for adults. The flame spread rates of these products are displayed in figure 3. The data show that none of the samples exceeded even the former provisional maximum flame spread rate of 60 mm/s. A recently published notification for a Dutch «Covenant on the Fire Safety of Nightwear» (7) proposes another limit: Nightwear for adults with a flame spread rate of more than 50 mm/s and a simultaneous occurrence of burning drops must have a warning label. Only one of three samples with a rate of more than 50 mm/s would need such a label.

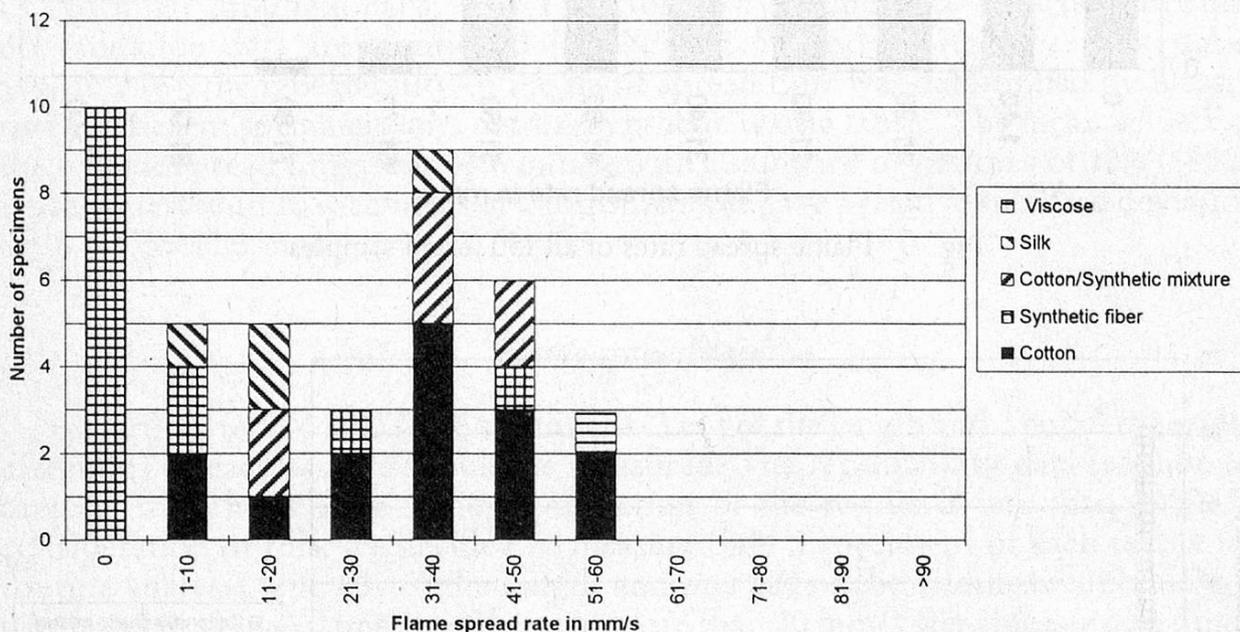


Fig. 3. Flame spread rates of nightwear

## Work clothes

Basically, Swiss legal limits classify work clothes like other clothes. But for work clothes which are intended to be used in places with an increased fire risk, a tougher limit of 0 mm/s is given as a maximum flame spread rate. 21 samples of work clothes like laboratory coats, cook shirts and overalls were tested. 3 of them were declared as «flame-resistant». The results which are displayed in figure 4 indicate that only these three samples show a flame spread rate of 0 mm/s. All other samples burned, but none of the tested work clothes showed a flame spread rate of more than 40 mm/s. These are relatively low values, in comparison with the other tested textiles. Nevertheless many customers may assume that working clothes are flame-resistant and show a flame spread rate of 0 mm/s. Hence dealers were obliged to

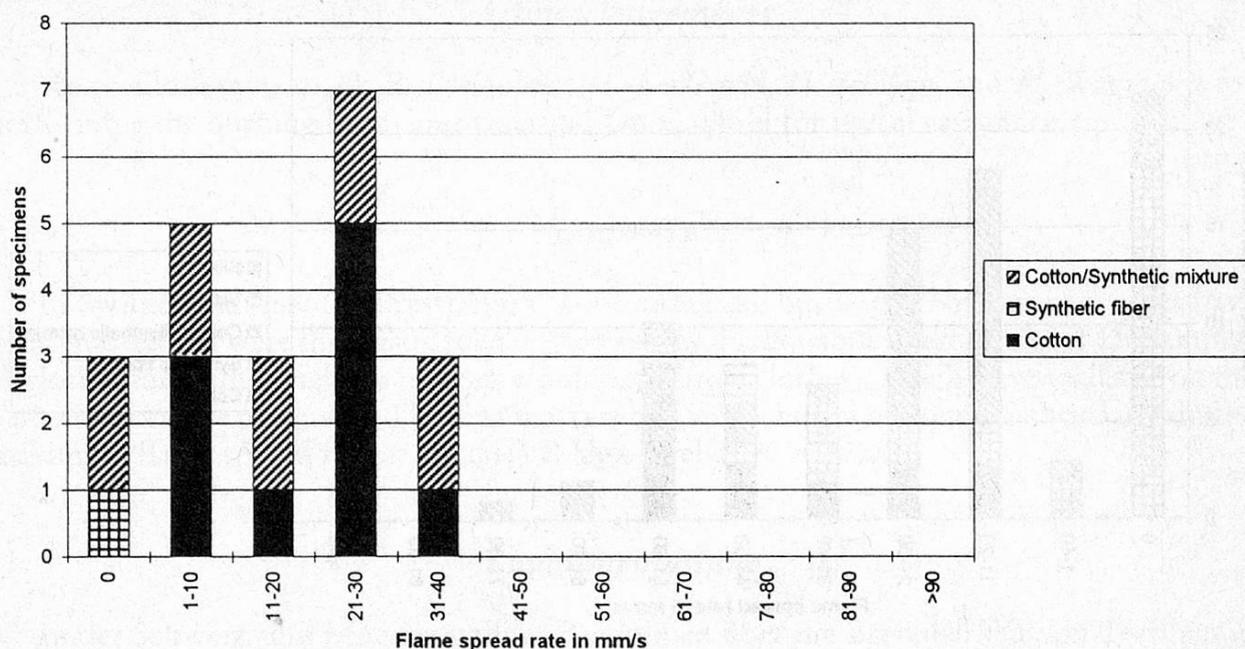


Fig. 4. Flame spread rates of working clothes.

inform the purchaser that the working clothes are not specially treated to be flame-resistant.

#### *Usual clothes*

88 samples of other textiles for adults such as dresses, trousers, skirts, training overalls, shirts and so on were measured. No sample exceeded the maximum flame spread rate of 90 mm/s. Only 3 samples, made of a cotton/synthetic mixture, showed a flame spread rate of more than the former provisional maximum value of 60 mm/s. The results are displayed in figure 5.

#### *Surface flash*

No surface flash was observed on any of the tested samples. It seems that this aspect is not a problem for new, only once washed textiles. Yet it can not be excluded, as an often washed textile with a felted surface may show a surface flash effect under special circumstances like low air humidity.

#### *Burning drops*

Flammable textile fabrics, which generate burning drops, may lead to very severe injuries. 46 (31%) of all 150 tested samples generated burning drops: 22% of the nightwear, none of the working clothes and 42% of the usual clothes. All of the dropping textiles were made of a synthetic material (52% of all tested synthetic fibres) or a mixture cotton/synthetic (41% of all tested cotton/synthetic materials).

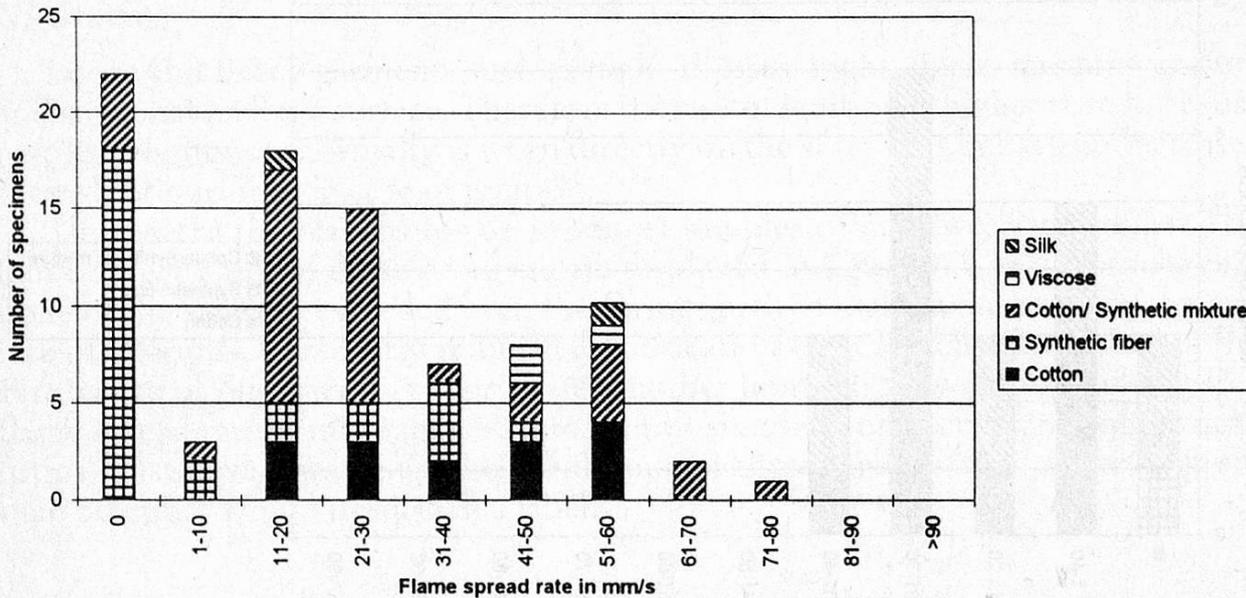


Fig. 5. Flame spread rates of usual clothes.

In Switzerland this burning behaviour is only forbidden for «flame resistant» working clothes.

### Conclusions

None of the tested samples exceeded the maximum flame spread rate of 90 mm/s. Only 2% of all samples exceeded the former provisional maximum flame spread rate of 60 mm/s. This result indicates that it is not a technical problem to produce textiles with a flame spread rate of less than 60 mm/s.

At a flame spread rate of 90 mm/s, it takes only six (!) seconds until a whole shirt is on fire. According to the EN 1103 standard the tests have to be performed at an air humidity of 65%. Lower air humidity as is likely in winter, may even shorten this time. Because of this risk and the technical possibility to produce textiles which fulfil stronger requirements, we strongly advocate a maximum flame spread time of 60 mm/s at the most.

31% of all tested samples generated burning drops. Because of the severe injuries caused by burning drops, we recommend a value of less than 60 mm/s for the textiles in question. A possible way could be the mentioned Dutch «Covenant on the Fire Safety of Nightwear».

Our paper only describes results of tests on clothes for adults. It has to be pointed out that children's wear and household textile products such as drapes and curtains have not been taken into consideration. The performance of flammability tests on such products is planned.

## *Acknowledgements*

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## *Summary*

In Switzerland new legal restrictions concerning the burning behaviour of textiles have been enacted and were the reason for a market survey. Flammability test results of 150 samples of clothes for adults (nightwear, work clothes and usual clothes), which were available on the Swiss market, are presented. The data indicate that no technical reasons exist to maintain the maximum flame spread rate at the critical high level of 90 mm/s.

## *Zusammenfassung*

In der Schweiz sind neue gesetzliche Richtlinien über die Brennbarkeit von Textilien in Kraft getreten. Es wurden deshalb 150 in der Schweiz erhältliche Kleidungsstücke für Erwachsene (Nachtbekleidung, Arbeitskleidung, gewöhnliche Kleider) auf ihre Entflammbarkeit überprüft. Die Resultate dieser Untersuchungen werden vorgestellt. Sie zeigen, dass keine technischen Gründe dagegen sprechen, die maximale Flammenausbreitungsgeschwindigkeit von 90 mm/s auf einen weniger kritischen Wert herabzusetzen.

## *Résumé*

Des nouveaux textes légaux concernant le comportement au feu des textiles sont entrés en vigueur en Suisse. Par conséquent, l'inflammabilité de 150 vêtements pour adultes (vêtements de nuit, de travail et usuels) en vente en Suisse a été testée. Les résultats de ces examens sont présentés. Ils indiquent qu'aucune raison technique n'existe pour maintenir la vitesse maximale de propagation des flammes à la valeur critique de 90 mm/s.

## *Literature*

1. European Commission: Directorate-General XXIV Consumer Policy Directorate A – Community actions in favour of consumers Unit A3 – Products, Committee on «Standards and Technical Regulations», Possible mandate on fire resistance of nightwear, Doc. 7/97-EN M/254, Brussels, 7<sup>th</sup> of April 1997.
2. *Martin, E. P.*, kriminaltechnische Abteilung der Staatsanwaltschaft Basel-Stadt: Zur Frage der Brennbarkeit moderner Textilgewebe. *Chimia* **18**, 48–56 (1964).
  - In Basle, only a little data are available about burning accidents caused by flammable clothes since 1964 (Personal information from I. Ziörjen, Staatsanwaltschaft Basel-Stadt, kriminaltechnische Abteilung and R. Kenzelmann, Erkennungsdienst Kantonspolizei Basel-Landschaft).
  - Data of the Bundesamt für Gesundheit (BAG) between 1979 and 1995 show that the sum of all textile samples, which had been tested in all state laboratories in Switzerland,

on an average did not exceed the number of 50 per year. It could not even be found out, if all these samples had been tested on their burning behaviour.

3. Verordnung über die Brennbarkeit textiler Materialien (Brennbarkeitsverordnung, BrbV) vom 26. Juni 1995, SR 817.043.1. Eidg. Drucksachen- und Materialzentrale, Bern.
4. SN EN 1103, Textilien – Brennverhalten – Bekleidungstextilien – Detailliertes Verfahren zur Bestimmung des Brennverhaltens von Bekleidungstextilien (Textiles – Burning behaviour – Fabrics for apparel – Detailed procedure to determine the burning behaviour of fabrics for apparel), Schweizerische Normen-Vereinigung, Mühlebachstrasse 54, 8008 Zürich, SN EN 1103: 1996 de.
5. SN EN ISO 6941, Textilien – Brennverhalten – Messung der Flammenausbreitungseigenschaften vertikal angeordneter Proben (ISO 6941: 1984, einschliesslich Änderung 1: 1992) (Textile fabrics – Burning behaviour – Measurement of flame spread properties vertically oriented specimens (ISO 6941: 1984, including Amendment 1:1992)), Schweizerische Normen-Vereinigung, Mühlebachstrasse 54, 8008 Zürich, SN EN ISO 6941: 1995 de.
6. Referring to information of the manufacturer of the Rhoburn flammability tester.
7. Covenant on the fire safety of nightwear (970193 NL-EN 970418 Projet), WTO notification 97.223 NL.

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