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Burning Behaviour of Curtains and Drapes: Results of a Swiss Market Survey

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Introduction

Curtains and drapes are a simple and affordable way to decorate rooms and to control light entering a room from outdoors. Curtains are made of different fabrics such as cotton, silk or synthetics depending on use and, of course, fashion.

Curtains can pose a fire hazard if they are exposed to an ignition source such as a lighted candle or cigarette. In 1999 about 13000 persons were injured in fire accidents in Switzerland. About 5200 of these were due to non-occupational accidents (1). There are, however, no data regarding fire accidents where curtains were involved.

In Switzerland a legal limit for the maximum flame spread rate is set at 60 mm/s (2). The state laboratories (kantonale Laboratorien) are empowered to supervise the observance of this limit and to ban non-conform products if necessary.

To our knowledge there is no study which refers to flame spread rates of curtains and drapes found on the market. Therefore we would like to present our data which stem from three Swiss market surveys.

Samples

185 samples from the Swiss market were collected in three different years (1998: 41 samples, 2001: 59 samples and 2002: 85 samples).

Methods

Instruments

Rhoburn Model 480 flammability tester (James H. Heal & Co Ltd., Richmond Works, Halifax, W. Yorkshire HX3 6EP, England), WTB Binder climatic cabinet KBF 240 APT (WTB Binder Labortechnik GmbH, Bergstrasse 14, D-78532 Tuttlingen)

Procedure

Flame spread rates were determined according to EN 1102 (3) and ISO 6941 (4). The procedure can be briefly described as follows:

- all samples were washed as recommended by the producer or in the case of lacking indications, according to EN 1102
- specimens were 560 mm long and 150 mm wide
- from each sample three specimens were cut out lengthwise and three in transverse direction
- specimens were conditioned at 20 °C and 65 % relative humidity for 24 hours
- the ignition time was 10 s
- the measured distance for the flame spread was 300 mm
- the test was done according to ISO 6941 (4)

Six specimens were measured in those cases, where samples were large enough for cutting three specimens lengthwise and in transverse direction.

The following parameters were measured or noted:

- flame spread time, which allows the calculation of the flame spread rate in mm/s
- surface density
- fabric composition if labelled

Quality assurance

International standard methods can be considered as validated. As no validation data are mentioned in the standard norms and no reference material was available for testing, we determined the reproducibility of the flame spread time by measuring it in six specimens of a cotton/synthetic textile sample. The mean flame spread time was 55.6 mm/s, with a standard deviation of 10.4 mm/s (rsd = 18 %) (5). Reproducibility also depends on the fabric design: curtains made of symmetrically woven and treated fabric showed much better reproducibility than those containing zones made of different fibres or different surface treatments.

Results and discussion

The following flame spread rates are all mean values derived from measured specimens of a sample.

Summary of all results

All in all 185 samples were tested. The composition of the fabric was labelled on 121 samples. Of these 47 (39 %) were made of cotton, 41 (34 %) of a mixture of cotton with, e.g. linen or synthetics, 26 (22 %) of polyester, 3 (3 %) of linen, 2 (2 %) of polyamide, 1 (1 %) of silk and 1 (1 %) of PVC.

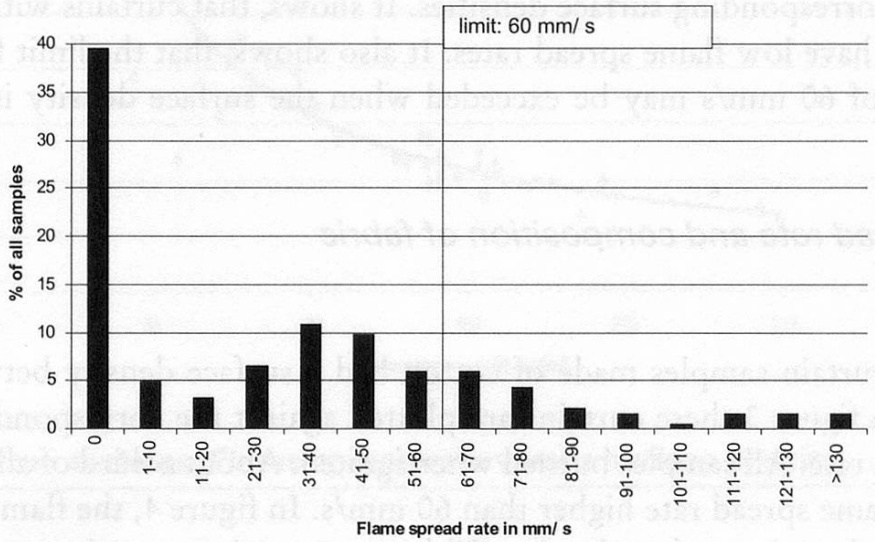

Figure 1 **Flame spread rate (*n*=185)**

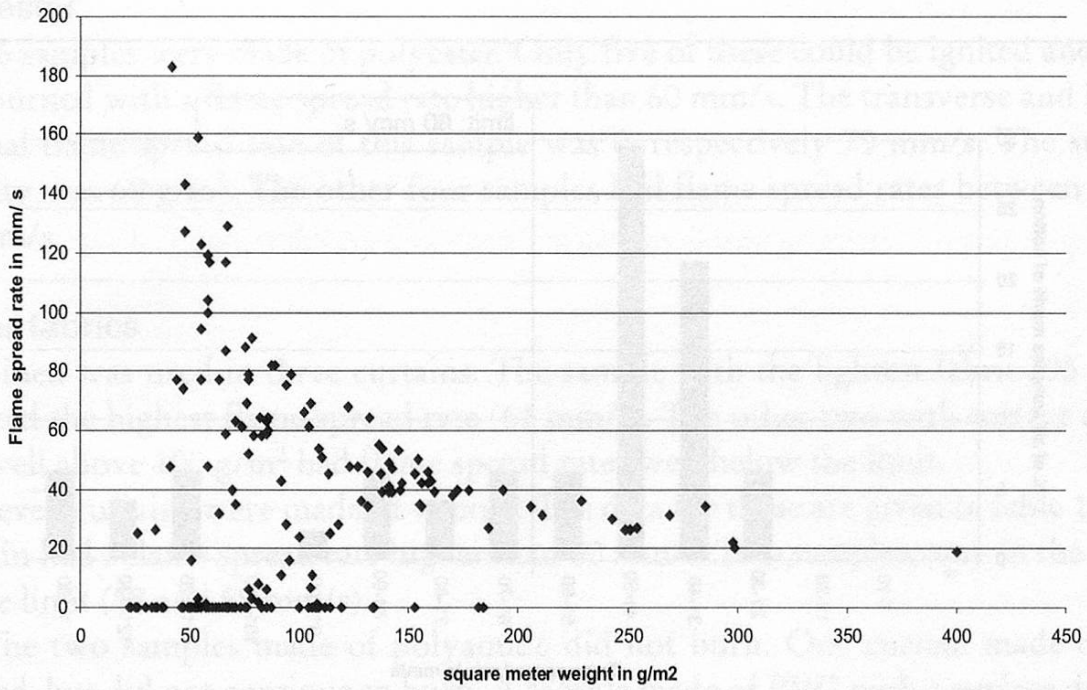

Figure 2 **Flame spread rate versus surface density (*n*=185)**

The proportional distribution of the flame spread rates over all samples is displayed in figure 1. 72 curtains or 39% of all samples did not burn. 36 (19%) exceeded the maximum flame spread rate of 60 mm/s as given by the Ordinance on Combustibility (2). 6 (3%) had a flame spread rate over 120 mm/s, which is twice the limit.

Curtain fabrics vary not only in composition but also in thickness which can be expressed as surface density (g/m²). In figure 2, flame spread rates are plotted against the corresponding surface densities. It shows, that curtains with a high surface density have low flame spread rates. It also shows, that the limit for the flame spread rate of 60 mm/s may be exceeded when the surface density is lower than 150 g/m².

Flame spread rate and composition of fabric

Cotton

The 47 curtain samples made of cotton had a surface density between 41 and 250 g/m². In figure 3 these curtains are plotted against the corresponding range of flame spread rate: All samples burned when ignited. About a third of all cotton samples had a flame spread rate higher than 60 mm/s. In figure 4, the flame spread rate is plotted against the surface density. With one exception, curtains made of cotton with a surface density below 100 g/m² showed flame spread rates higher than the limit. Curtains with higher surface densities were between 27 and 55 mm/s. We found that the flame spread rate (y) could be described as a function of the surface

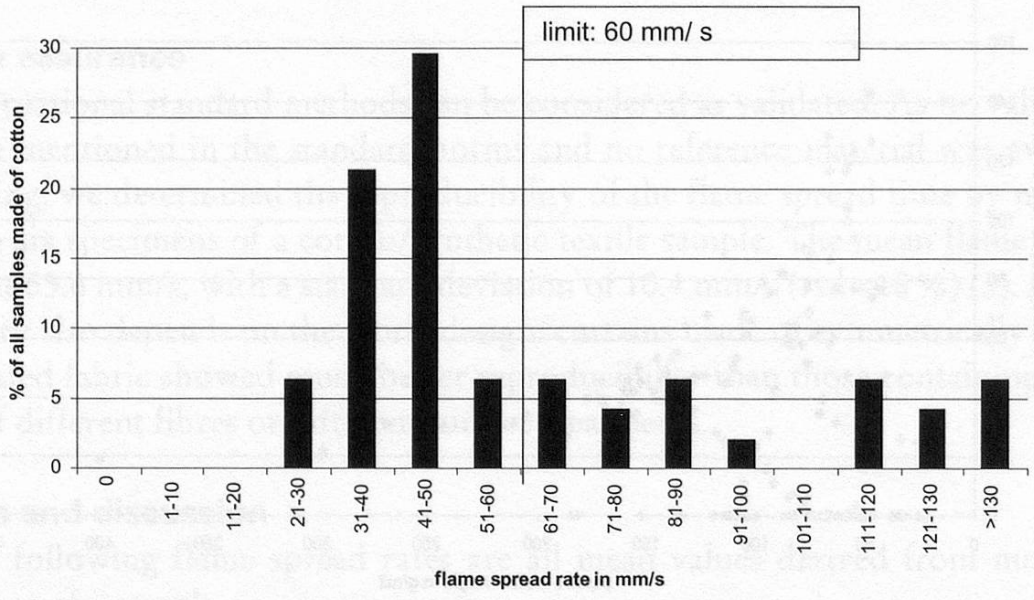

Figure 3 **Cotton curtains (*n*=47): Flame spread rate**

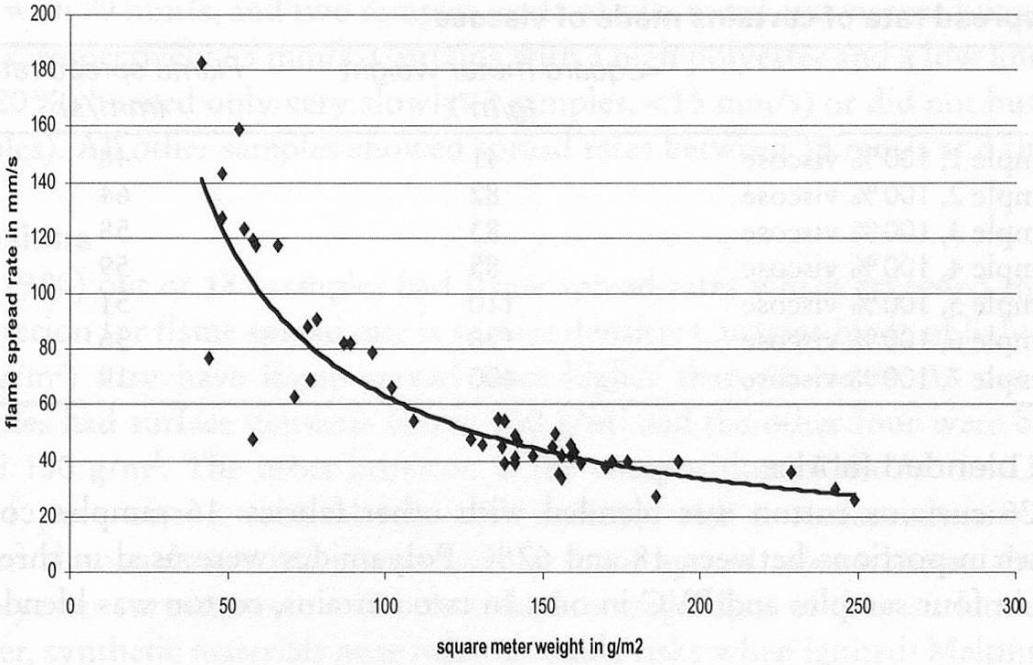

Figure 4 **Cotton curtains: Flame spread rate versus surface density**

density (x) by the mathematical function: $y=f(x)=ax^{-b}$. With a square correlation coefficient of 0.83, the function describes fairly well the burning behaviour of cotton curtains.

Polyester

26 samples were made of polyester. Only five of these could be ignited and only one burned with a flame spread rate higher than 60 mm/s. The transverse and longitudinal flame spread rate of this sample was 0, respectively 79 mm/s. The surface density was 69 g/m^2. The other four samples had flame spread rates between 1 and 14 mm/s.

Other fabrics

Linen was used in three curtains. The sample with the lightest fabric (95 g/m^2) showed the highest flame spread rate (61 mm/s). The other two with surface densities well above 100 g/m^2 had flame spread rates well below the limit.

Seven curtains were made of viscose. The data for these are given in table 1. One curtain had a flame spread rate higher than 60 mm/s. Two samples were in the range of the limit (58 and 59 mm/s).

The two samples made of polyamide did not burn. One curtain made of silk ignited, but did not continue to burn. A sample made of PVC with a surface density of 55 g/m^2 had a flame spread rate of 77 mm/s.

Table 1
Flame spread rate of curtains made of viscose

	Square meter weight (g/m²)	*Flame spread rate (mm/s)*
1998 sample 1, 100 % viscose	41	48
1998 sample 2, 100 % viscose	82	64
1998 sample 3, 100 % viscose	83	58
1998 sample 4, 100 % viscose	85	59
1998 sample 5, 100 % viscose	110	51
1998 sample 6, 100 % viscose	128	36
2002 sample 7, 100 % viscose	400	19

Cotton blended fabrics

In 26 curtains cotton was blended with other fabrics. 16 samples contained polyester in portions between 18 and 67 %. Polyamides were used in three cases, viscose in four samples and PVC in one. In two curtains, cotton was blended with silk.

With two exceptions, the burning behaviour of these samples, as shown in fig. 5 resembled that of pure cotton samples. One of the two fireproof samples was made of 80 % polyamide and had a surface density of 51 g/m². The other sample was a 50 % polyester blend with a surface density of 133 g/m².

Other blended fabrics

16 curtains were made of other blended fabrics. Most blends were a combination of polyester with either viscose, linen or polyamide. Three samples had flame spread

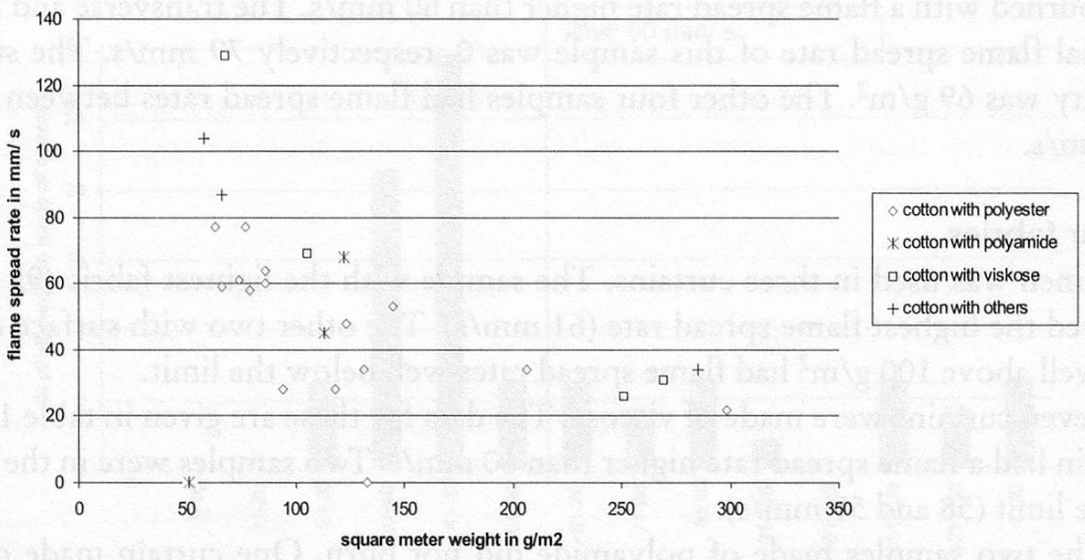

Figure 5 **Curtains made of cotton blends: Flame spread rate versus surface density (*n*=26)**

rates which exceeded the limit. One sample made of 70 % linen and 30 % polyester burned with 79 mm/s, and two samples made of silk, metal and viscose burned with 75 mm/s, respectively 63 mm/s. Curtains with a high polyester and a low linen content (<20 %) burned only very slowly (3 samples, <15 mm/s) or did not burn at all (4 samples). All other samples showed spread rates between 15 mm/s and the limit.

Conclusions

36 (19 %) out of 185 samples had flame spread rates which exceeded the limit. One criterion for flame spread rate is surface density: Curtains made of light fabrics (<150 g/m^2) may have flame spread rates higher than 60 mm/s. 32 out of the 36 samples had surface densities below 100 g/m^2 and the other four were between 100 and 150 g/m^2. The other criterion is the composition of the fabric. Curtains made of pure cotton (and blends with cotton) with a surface density below 100 g/m^2 almost always had unsatisfactory flame spread rates whereas almost all pure polyester curtains were well below the limit regardless of their surface density. However, synthetic materials pose other possible risks when ignited: Melting fabric forms burning drops which can inflict serious wounds on persons and can easily ignite other materials. Up to this date no legal restriction considers this fact. Other dangerous burning forms (e.g. surface flash) were not observed in our study.

Linen and viscose both show a similar burning behaviour to cotton. However, we did not have enough samples for a statistical evaluation.

Our study gives an overview of the flame spread rates under standard conditions. It does not give information about ignition time and burning behaviour when a larger ignition source is involved (6). This would be the content of a future study. Further investigations will be necessary because the percentage of objected curtains was high and because curtains and their fabrics change with fashion.

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Summary

In Switzerland the flame spread rate of curtains is limited by legal restrictions. Flammability test results of 185 curtains from the Swiss market show that 19 % of the tested curtains exceeded the limit. Flame spread rates depended on surface density and fabric composition. Curtains made of cotton or cotton blends with surface densities below 100 g/m^2 always showed high flame spread rates. On the other hand, curtains made of polyester or polyester blends normally burned very slowly but may form dangerous burning drops.

Zusammenfassung

In der Schweiz ist die Brennbarkeit für Vorhänge gesetzlich geregelt. Im Rahmen einer Marktkontrolle wurden 185 in der Schweiz erhältliche Vorhänge und Gardinen auf ihre Brennbarkeit geprüft. 19 % der getesteten Proben überschritten bezüglich der Flammenausbreitungsgeschwindigkeit die Limite von 60 mm/s. Unsere Untersuchung zeigte, dass die Flammenausbreitungsgeschwindigkeit vom Material und vom Flächengewicht abhängig ist.

Résumé

En Suisse le comportement au feu des rideaux est réglementé par la loi. L'inflammabilité de 185 rideaux et courtines en vente en Suisse a été testée. 19 % des échantillons ont surpassé la vitesse de propagation de flamme qui est limitée à 60 mm/s. Nos examens ont montré que cette vitesse dépend de la matière utilisée et de la masse surfacique.

Key words

Curtains, Burning behaviour, Flame spread rate, Inflammability, EN 1102

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