Curtains

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A FULL SCALE FIRE TEST METHOD FOR FREE-HANGING CURTAIN AND DRAPERY TEXTILES

Nordtest projekt no 705-87

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STATENS PROVNINGSANSTALT

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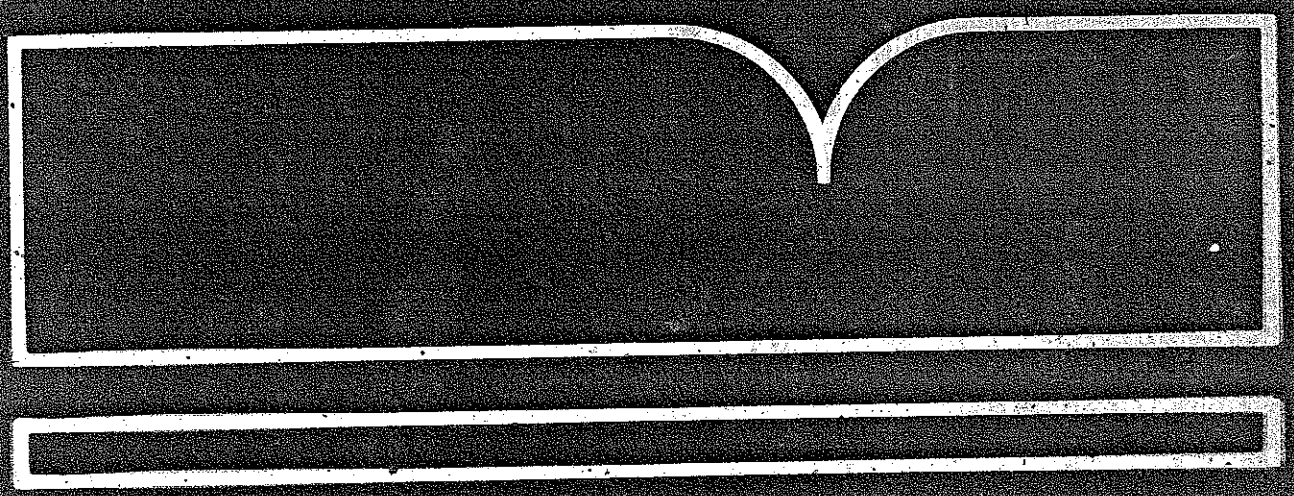
Statens Provningsanstalt, Boras (Sweden)

1988



All the fire gases from the burning item are collected without leakage to achieve accurate results. At the same time the collection of the fire gases is done

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The vertical rate of flame spread for the textiles was also measured during the test series. The vertical

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ABSTRACT

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Key words: Curtains, draperies, full scale test, fire test.

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1 A NEW FULL SCALE FIRE TEST METHOD FOR FREE-HANGING CURTAIN AND DRAPERY TEXTILES

1.1 The method allows for measurement of the fire growth at the early stage of a fire

The fire requirements of building materials are generally well defined in the national building codes through out the world. The fire properties of large curtains are, however, not regulated in most countries despite involving as high or even higher fire hazard. One of the reasons for this situation is the lack of test methods judging the fire risk of these objects in a realistic way. The existing fire test methods normally only measure the ignitability for a small flame thus giving only limited information of the actual burning behaviour of the product.

This proposed Nordtest method allows for measurements of fire growth (rate of heat release) and smoke production of free-hanging curtain and drapery textiles at the early stage of a fire. These measurements are the major parameters needed to define the fire risk. The work on developing the method is reported here, while the test method is published separately.

1.2 A drapery covering a large wall area may become a great fire hazard

A larger free-hanging textile can constitute a major fire risk. If the textile is combustible with air supply on both sides the flame spread rate upwards can be very rapid, and there can also be a significant horizontal spread rate. Some fabrics yield extremely rapid fire growth creating flash-over situations by themselves or inhibiting safe escape. Smoke production may also be significant causing dangerous conditions in the fire room and obstructing escape ways.

As the product is thin and free-hanging the risk of igniting the walls is limited [1]. The flames will impinge on the walls only for a relatively short period of time. The flaming remains very shortly at each position. The only locations where there can be a considerable flame impingement is at the floor level in case of fallen parts of the fabric or a pool fire, and in the wall/ceiling intersection if the fabric is very long. Such curtains are frequent mostly in larger premises like assembly halls. In those areas there are, however, rigorous fire demands implying that the wall and ceiling linings must be of a low flame spread type.

It is more likely that a piece of upholstered furniture in the vicinity catches fire. The curtain and the furniture together may then increase the hazard for flash-over in the fire room [2].

1.3 A large pleated curtain is ignited by a powerful ignition source

The test is principally performed to schematically represent a possible real fire situation. As figure 1 shows, a large, pleated curtain, 3 m by 3 m, is freely hanging against a wall with an airgap of about 0.1 m. A gas burner is placed under the curtain. During the whole test the burner yields a flame, 1-1.5 m high, which is less than half the height of the test specimen. The heat output of the burner is 100 kW. A hood collects all the fire gases. In the exhaust duct from the hood, the smoke production rate is measured. Measurements of volume flow rate and concentrations of oxygen and carbon dioxide in the duct are used to calculate the heat release rate.

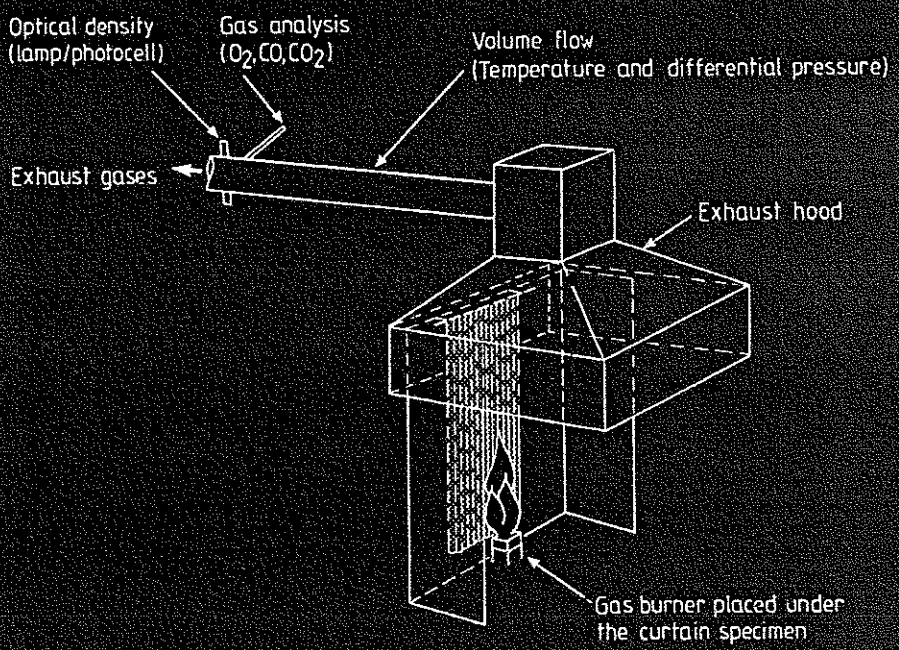

Figure 1 Test principle. The flames from the burner reach half the height of the curtain. The hood collects all the fire gases. The gases are analyzed and the smoke obscuration is measured in the exhaust duct.

1.4 Why this test scenario?

1.4.1 The ignition source is a gas burner simulating a burning waste-paper basket

Textiles may give rise to a continuous flame spread when exposed to larger ignition sources although not ignited by a small flame [3]. Therefore, to attain a real fire risk, an ignition source simulating a burning waste-paper basket filled with paper was chosen [4].

A propane burner with a diffusion flame of 100 kW was deemed the best ignition source to represent the real situation*. A wooden crib is not applicable as it would produce too much smoke for classification purposes. In pretests, we found that a premixed flame would neither accomplish an adequate ignition source. The velocity of the gases would be too high and the radiation from the flame too low for simulating a real life fire ignition source.

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* It is the same ignition source as in the Room/Corner Test according to ISO DP 9705 and NT FIRE 025.

1.4.2 The test specimen is relatively large to enable studies of flame spread and measurements of burning behaviour

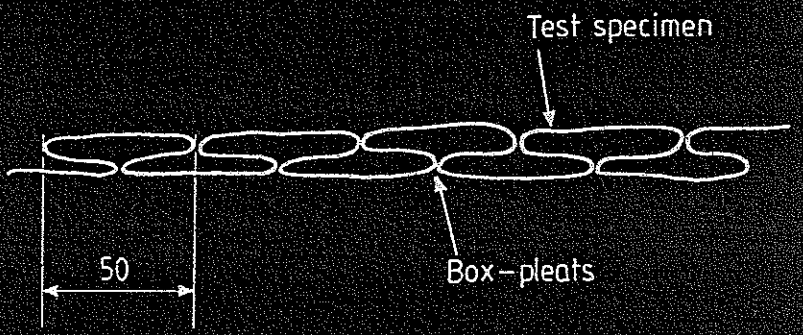
The curtain specimen has to be sufficiently large to facilitate measurements of fire growth. A length of 3 m, which is more than double the flame height of the ignition source, enables observing the flame spread vertically. For the horizontal flame spread observations, the width was optimized to 3 m by placing the ignition source off the centre line of the specimen. This specimen size, 3 m by 3 m, is the smallest possible for studying flame spread over a larger area.

For products narrower than 3 m the specimen width is achieved by sewing together curtain gores.

To simulate the most onerous case the burner is placed under the curtain to give edge ignition. The specimen is hung against a wall with an airgap of about 0.1 m to achieve an interaction between the wall and the flame. Further, the curtain specimen is pleated to one third of the initial width.

The specimen is box-pleated, see figure 2, and the upper edge is fixed around a metal rod with clips. This yields a more reproducable suspension of the test specimen than a sewed top hem would do. Furthermore, pretests indicated that the thread of the hem might burn off so that the curtain falls down.

The curtain is unhemmed at the bottom as well, to facilitate adjustment of the specimen length by cutting when the curtain is placed in the rig.



Dimensions in mm

Figure 2 The curtain specimen is pleated in box-pleats which best simulate a common suspension.

The flame is sensitive to draughts. Therefore there are a wall behind the specimen and two side walls. Although an environment essentially free from draughts, a leaning flame can occur. To avoid these effects, duplicate tests with the burner placed on either side of the sample centreline are performed.

1.4.3 The fire gases are collected and analysed

The fire growth is best defined by measuring the heat release rate from the burning item. The most adequate way to measure the rate of heat release (RHR) is by the oxygen depletion method [5]. The method is based on the fact that the heat produced is constant per unit mass of oxygen consumed by the fire almost independently of fuel. The exhaust duct gases are analyzed of their content of oxygen, carbon dioxide and carbon monoxide. As the exhaust duct volume flow rate is continuously measured it is possible to calculate the total amount of oxygen consumed.

All the fire gases from the burning item are collected without leakage to achieve accurate results. At the same time the collection of the fire gases is done without impeding the natural gas flow in the vicinity of the fire.

The smoke production rate is measured in the exhaust duct by a lamp-photocell system. The white light lamp and the photocell, having the same spectral sensitivity as the human eye, are mounted diagonally across the exhaust duct. The smoke production rate is calculated as [6]:

$$S = 10/L \log(I/I_0)*V \quad (dBm^2 s^{-1})$$

where

S = smoke production rate

L = light path length in duct

I = actual response from the photocell

I_0 = photocell response in absence of smoke

V = the volume flow rate at actual temperature

1.4.4 The flame spread is observed during the test

In addition to the RHR measurements the fire growth is described by observations during the test. The flame spread is expressed as the weight loss, and the undamaged, still hanging material. These two parameters are reasonably easy to record. They are also very important when considering larger curtains and draperies than the one tested.

The vertical rate of flame spread for the textiles was also measured during the test series. The vertical rate of flame spread varying from 0.1 - 0.5 m/s, was not a decisive parameter as it did not correspond to the burning intensity of the curtains.

The hazard of burning material falling down is easiest described as flame height from burning material on the floor.

Non-combustibility is not tested in this method. For fully non-combustible textiles no further information is achieved in the tests.

1.5 When is the test method applicable?

The test method is designed and intended to be used for large free-hanging vertical textiles which can be found in public halls, cinemas, theatres etc.

Textiles consisting of fundamentally different materials can be tested in the method but the test results must then be carefully analyzed and interpreted.

Products that can not be pleated can also be tested but it should be emphasized that it is a deviation from the authentic test method. The criteria proposal as presented below is, however, not adapted for these kinds of products.

Ordinary curtains for domestic use and other smaller curtains can be tested although the test method is not primarily intended for these products. The specimen size and the ignition source should, however, always be kept as stated in the method.

2 CRITERIA FOR APPROVAL ARE PROPOSED

2.1 The criteria proposal contains five classes

The proposed criteria are intended for classifying free-hanging curtain and drapery textiles covering a large wall area. The criteria are mainly intended for public assembly halls etc, but can also to some extent be applied to smaller rooms.

The test duration for all classes is 5 minutes. Two tests shall be performed. The average of the two tests of

- the maximum rate of heat release (RHR)
- the maximum rate of smoke production
- the maximum weight loss and
- the maximum flame height

shall not exceed the values in table 1. The burner heat output shall be constant at 100 kW. The burner output (heat and smoke) is included in the values given.

The headings of table 1 have the following meaning:

The maximum rate of heat release in kW is expressed as the 10 second mean value at the peak of the curve.

The maximum rate of smoke production in dBm^2/s is expressed as the 10 second mean value at the peak of the curve.

The weight loss is expressed as percentage of the initial weight of the specimen. Undamaged, charred or melted material still hanging or fallen down shall be included in the residue.

Total flame spread is deemed to be achieved when there is virtually no undamaged material still hanging after the test.

The maximum flame height produced by the burning material on the floor is measured from the floor level to the highest point where the flames reach. Flames from the burner are not included.

Table 1 Criteria for evaluation of curtain and drapery textiles.

Class	Maximum RHR (10 s) kW	Maximum smoke(10 s) $dBm^2 s^{-1}$	Maximum weight loss %	Total flame spread	Maximum flame height from burning material on the floor, m
I	150	5	50	Not allowed	None
II	800	20	90	"	None
III	1 300	-	-	Allowed	1.0
IV	-		-	"	-

2.2 What are the consequencies of the proposed critera?

From the test results obtained, listed in table 3 under paragraph 3.2, it it possible to distinguish between at least three different types of burning behaviour:

1) Textiles that do not ignite thus producing no heat and smoke.

2) Textiles that have limited horizontal flame spread. The product may burn and produce heat and smoke but the tested object will not be completely consumed by the fire.

3) Textiles that burn and spread flames both vertically and horizontaly. The product will be completely consumed at the end of the test.

Type 3 can be devided into two subcategories due to various heat release rates and occurence of burning drops and pieces of material on the floor.

The classes as defined in table 1 can be characterized as below. The typical products mentioned for each class refer to the results obtained in this investigation. Quality and type of flame retardant treatment can alter the classification.

Class I corresponds to materials that do not burn or produce smoke, typically glass and Trevira CS. This class is appropriate for public areas with very high fire safety requirements.

Class II corresponds to materials that have limited burning and smoke production and no burning material falling down; typically flame-retardant treated cotton. This class is appropriate for public areas with limited fire safety requirements.

Class III corresponds to materials that burn and do spread fire but with moderate production of burning material on the floor; typically cotton, mod-acrylic and flame-retardant treated wool. This class is appropriate for domestic use if fire safety requirements are requested.

Class IV corresponds to all other products producing much heat, smoke or burning material on the floor.

2.3 The criteria limits correspond to distinct types of burning behaviour

The total heat release rate limit of 150 kW as given in table 1 leaves only 50 kW to be released by the product when the burner output of 100 kW is subtracted. The 800 kW level allows a little more intense burning of the material while 1 300 kW is quite an intense fire for normal textiles.

The smoke production requirements are intended for products producing smoke with only limited burning. The 5 dBm^2/s is for products that hardly burn at all. 20 dBm^2/s is the moderate smoke production rate limit.

The limits of weight loss together with the requirement of undamaged material still hanging will provide for limited flame spread properties. The weight loss limit of 50 per cent will restrict the flame spread to the area directly above the burner.

The limitation of flame height from the floor is a way of determining if and how much of the burning that occurs on the floor. Burning material falling to the floor will increase the risk of ignition of furnishing and wall linings and is not acceptable in the two public-area classes.

3 A SERIES OF PRODUCTS WAS TESTED ACCORDING TO THE PROPOSED METHOD

3.1 The tested products were curtain fabrics of various types

The 21 products tested according to the method were curtain fabrics available in Sweden. Swedish producers were consulted to get as representative products as possible. Only products that could be assumed to be used as pleated curtains were tested.

The tested products are listed in table 2.

Table 2 Curtain fabrics tested according to the proposed method.

Product name	Surface weight g/m^2	Product description	Test no
Glass	210	Glassfiber, woven fabric	14R
Trevira CS	75	Flame-retardant polyester, warp knitted fabric	23L
Trevira CS	150	Flame-retardant polyester, loosely woven fabric	22L
Trevira CS	250	Flame-retardant polyester, closely woven fabric	6R
Ord polyester	120	Ordinary polyester, warp knitted fabric	19R
FR cotton	220	Flame-retardant treated cotton, closely woven single cloth	11R
FR cotton	370	Flame-retardant treated cotton, pile fabric	16R

Table 2 continued

Product name	Surface weight g/m^2	Product description	Used in test no
FR cotton	320	Flame-retardant treated cotton, closely woven double cloth	21L, 2R
FR wool	520	Flame-retardant treated wool, closely woven single cloth	12R, 29L
Mod-acrylic	190	Mod-acrylic, loosely woven fabric	17R, 30L
Polyester/ flax	130	Polyester/flax 75/25, loosely woven fabric	18R
Cotton	300	Cotton, pile fabric	15R
Cotton	190	Cotton, closely woven single cloth	20L
Cotton	340	Cotton, closely woven double cloth	4R, 31L
Cotton	350	Cotton, closely woven double cloth, similar to the 340 gram fabric	7R, 10R
Cotton	465	Cotton, closely woven single cloth	3L
Cotton/flax viscose	200	Cotton/flax/viscose 64/18/18, closely woven fabric	25L
Acrylic	260	Acrylic, closely woven double cloth	13R
Acrylic	205	Acrylic, loosely woven single cloth	27R, 26L
Acrylic	360	Acrylic, pile fabric	5R, 8R
Acrylic/ cotton	280	Acrylic/cotton, loosely woven single cloth	24L

3.2 The tested products are ranked according the criteria proposal

The results from the tests are compiled in table 3. The headings have the following meaning:

- Test number refers to the numerical order in which the test was performed. L and R refers to left or right position of the burner.

- Product name and surface weight refers to the product descriptions in table 1.

- The percentage weight loss is determined by weighing the specimen before and after the test. The rest hanging on the rod after the test is weighed together with the parts that have fallen down. Melted and deformed material are included.

- Peak RHR(10 s), peak smoke(10 s) and flame height refers to the descriptions given in paragraph 2.1.

- Proposed class refers to the criteria proposal but is based on single tests only instead of the proposed double tests. Stars show parameters decisive for the class in particular.

The tests were performed at the fire laboratory of Swedish National Testing Institute during August-October 1988.

Table 3 Test results according to the proposed test method for full scale fire testing of curtain and drapery textiles.

Test no	Product name	Surface weight $g\ m^{-2}$	Weight loss %	Peak RHR (10 s) kW	Peak smoke (10 s) $dBm^2\ s^{-1}$	Flame height from floor m	Proposed class
14R	Glass	210	2	< 110	1.4	0	I
23L	Trevira CS	75	29 [1)]	< 110	<1	0	I
22L	Trevira CS	150	29 [1)]	< 110	<1	0	I
6R	Trevira CS	250	5	< 110	<1	0	I
19R	Ord polyester	120	19 [1)]	< 110	1.5	0	I
11R	FR cotton	220	49*	480*	6*	0	II
16R	FR cotton	370	66 [2)]*	410*	7*	0	II
21L	FR cotton	320	78*	550*	6*	0	II
2R	FR cotton	320	- [3)]	500*	16*	0	II
12R	FR wool	520	58 [2)]	385	3	0.75*	III
29L	FR wool	520	52 [2)]	370	5	0.75*	III
17R	Mod-acrylic	190	80 [2)]	365	78*	0.5*	III
30L	Mod-acrylic	190	67 [2)]	235	48*	0	III
18R	Polyester/flax	130	100*	180	7	0.75*	III
15R	Cotton	300	100*	710	1	0.75*	III
20L	Cotton	190	100*	810*	2	0.5*	III
4R	Cotton	340	100*	630	1	- [3)]	III
31L	Cotton [4)]	340	100*	810*	1.5	0.5*	III
7R	Cotton	350	100*	950*	1.5	0.25*	III
10R	Cotton [5)]	350	100*	920*	2	0.25*	III
3L	Cotton	465	100*	1 210*	1.5	- [3)]	III
25L	Cotton/flax/ viscose	200	100	900	4	1.25*	IV
13R	Acrylic	260	100	930	23	3.5*	IV
27R	Acrylic	205	100	1 000	23	3.5*	IV
26L	Acrylic	205	100	1 200	20	3.5*	IV
5R	Acrylic	360	100	1 350*	6	2.5*	IV
8R	Acrylic [5)]	360	100	1 400*	15	1.75*	IV
24L	Acrylic/cotton	280	100	1 700*	45	3.5*	IV

Notes on table 3:

1) 20-30% of the curtain melted and dripped away, not included.

2) Charred residue or parts that had fallen down are not included.

3) Not recorded.

4) Very low exhaustion, see paragraph 3.3.

5) Particle board on wall behind curtain.

3.3 The test method gives repeatable results

Typical curves of rate of heat release and smoke production rate are shown in figure 2 and 3, respectively. The diagrams illustrate the results from some representative products of each of the proposed classes.

Duplicate tests with the burner in the same position showed very good repeatability, within about 5 % for RHR. Duplicate tests with the burner placed at either sides of the specimen showed some difference in results, typically about 15 %.

The five criteria for evaluation will, however, accomplish a correct and repeatable classification. The four parameters - RHR, weight loss, flame spread and flame height - complete each other.

In addition, the production of carbon monoxide was measured. Although the method allows measurements of carbon monoxide, no limits of the production of toxic gases are included in the criteria proposal. For certain applications and careful fire technical design the production of toxic gases can, however, be measured. During these tests the maximum production rate of carbon monoxide was 2 g/s typically.

Two tests were performed where a particle board was applied behind the specimen. The particle board was ignited by the curtain fire only at the most intense zone of fire. As the fire in the curtain progressed to new areas, the flame impingement on the wall ceased and the flames in the particle board died out. The pool fire in one of the tests ignited the particle board which then burnt as long as the pool did. The heat flux to the wall behind the curtain 2 m above the burner surface was measured during all the tests. For the textiles that burnt most intencely the maximum heat flux was 15 kW/m^2 during a short period of time, less than 30 seconds. As the tests with the particle board on the back wall showed this was not sufficient for sustained ignition of the wall. This is in accordance with small scale ignitability data [7].

During test no 31 the exhaustion was kept very low, approximately 1 m^3/s. As can be seen from table 3 there is no significant difference between the results from this test and other tests on the same material. This indicates that the exhaustion does not affect the results.

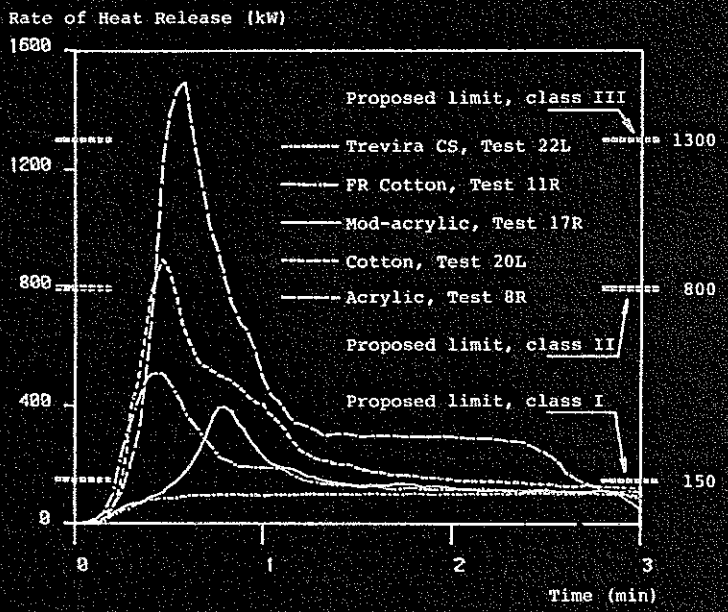


Figure 2 Typical rate of heat release curves for five products representing the proposed four classes

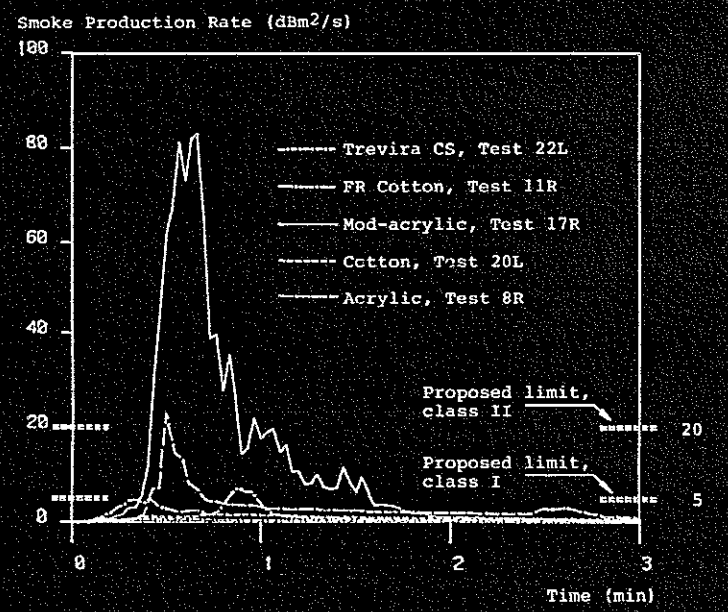


Figure 3 Rate of smoke production curves for five products representing the proposed four classes

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