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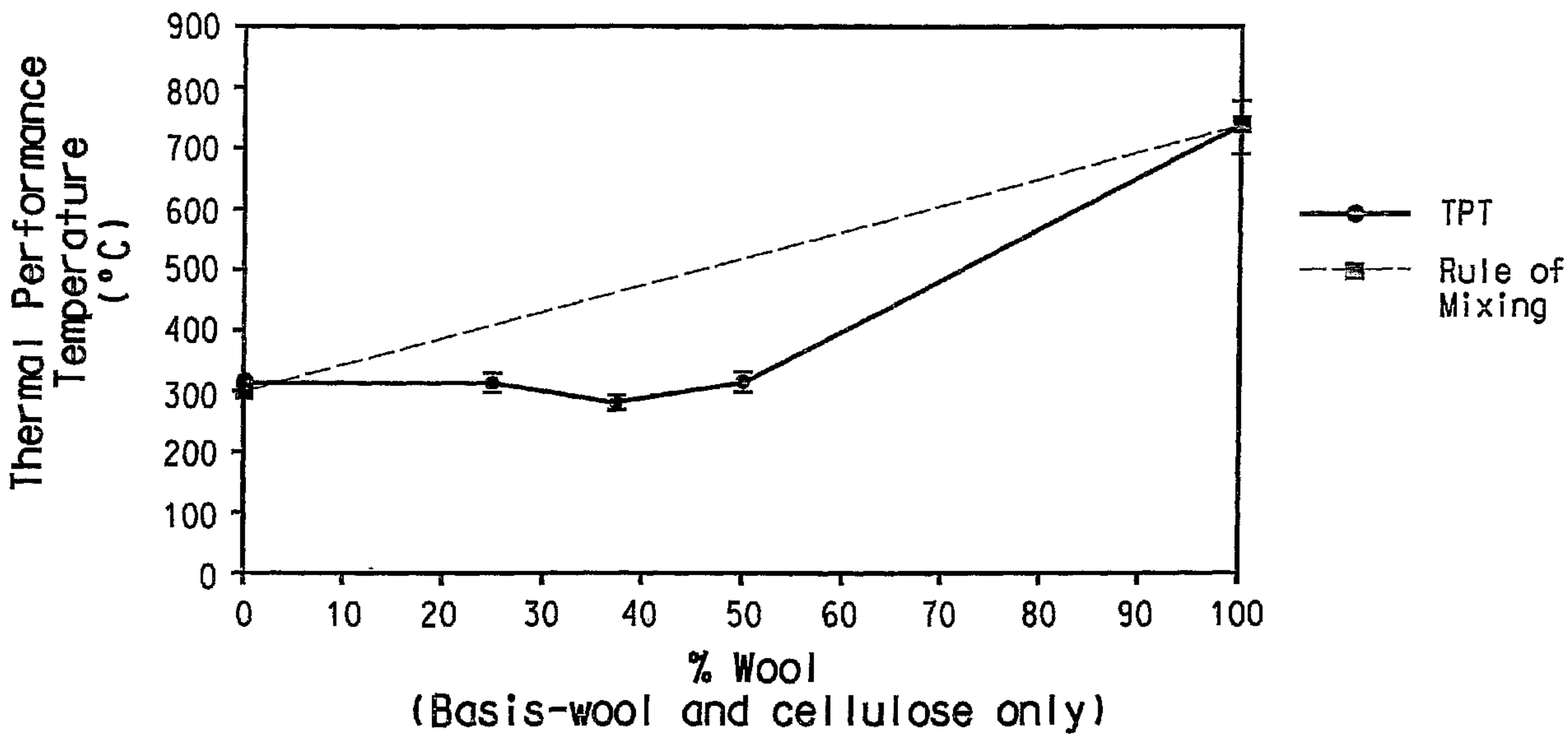
(54) Titre : TISSU ININFLAMMABLE UTILE EN TANT QUE COUCHE OUATEE DANS DES MATELAS ET REMBOURRAGES
(54) Title: FLAME RESISTANT FABRIC USEFUL AS A BATTING IN MATTRESSES AND UPHOLSTERY



(57) Abrégé/Abstract:
Flame resistant fabrics useful as battings such as in mattresses and upholstery contain cellulose fibers (which retain at least 10 percent of their weight when heated in air to 700°C. at a rate of 20°C. per minute) and animal wool.

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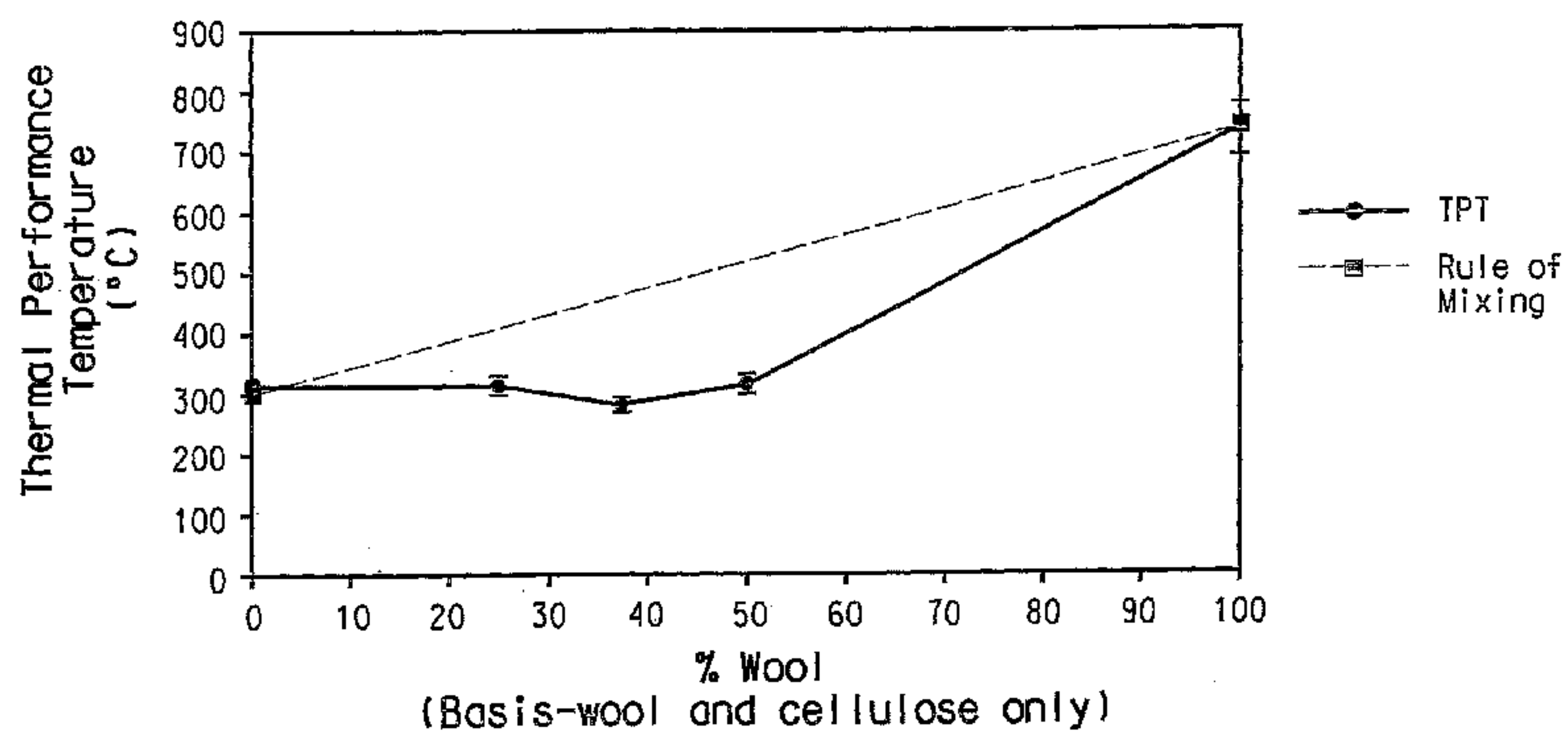
(54) Title: FLAME RESISTANT FABRIC USEFUL AS A BATTING IN MATTRESSES AND UPHOLSTERY



(57) Abstract: Flame resistant fabrics useful as battings such as in mattresses and upholstery contain cellulose fibers (which retain at least 10 percent of their weight when heated in air to 700°C. at a rate of 20°C. per minute) and animal wool.

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TITLE OF INVENTION

Flame Resistant Fabric
Useful As A Batting In
Mattresses and Upholstery

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a fire resistant fabric particularly useful as a fire-blocking batting in a mattress and furniture.

2. Description of the Invention

The State of California has led the drive to regulate and reduce the flammability of mattresses and mattress sets in an attempt to reduce the number of lives lost in household, hotel, and institutional fires. In particular, the Bureau of Home Furnishings and Thermal Insulation of the Department of Consumer Affairs of the State of California issued in July 2004 Technical Bulletin 603 "Requirements and Test Procedure for Resistance of a Residential Mattress/Box Spring Set to a Large Open-Flame" to quantify the flammability performance of mattress sets. One measure of screening fabrics to determine suitability as fire blockers is by use of a test that measures thermal performance temperature (TPT) of the fabric, which is a value that is a linear positive function of the amount of heat that passes through the barrier fabric. Low thermal performance temperature values mean the fabric is a good insulator from flame and will help to retard heat transfer to internal areas of an article such as a mattress.

There are several ways to incorporate a fire barrier into a mattress, however, it is preferred in many instances that one of the existing layers of material be converted to one that can act as a fire blocking layer. In particular, most mattresses have a high loft fiber batting, and this batting can provide additional fuel if made from flammable materials. Replacing this high loft material with material having a low thermal performance temperature typically represents an acceptable solution.

Fire resistant cellulosic fibers can be used effectively to thermally protect a mattress, however these battings are typically dense and not soft to the touch.

PCT Publication WO 03/023108 discloses a nonwoven high loft flame barrier for use in mattresses and upholstered furniture. These barriers have very low density, ranging from 5 to 50 kilograms per cubic meter, most preferably 7.5 to 15 kilograms per cubic meter. The preferred nonwoven high loft flame barrier comprises a blend of fibers including fibers that are inherently fire resistant and resistant to shrinkage by direct flame, and fibers from polymers made with halogenated monomers.

United States Patent Application Publication US 2004/0060119 discloses a fire barrier fabric having a fire barrier layer and a thermally insulating layer. The fire barrier layer can be composed of a blend of aramid and modacrylic fibers and the thermally insulating layers can be composed derived from fire resistant viscose and modacrylic fibers.

These patent applications disclose many types of fabrics but do not disclose any desired relationship between the thermal performance temperature of the fabric, density of the fabrics and the desired softness of the fabric. Therefore, what is needed is a fabric useful as a batting in mattresses and furniture having a low thermal performance temperature and a high degree of softness.

SUMMARY OF THE INVENTION

This invention relates to a fire-resistant fabric useful as a batting in fire blocking an article such as a mattress or upholstery and a method of incorporating the fabric into an article. The fabric comprises:

(a) cellulose containing fibers which retain at least 10 percent of their weight when heated in air to 700°C. at a rate of 20°C. per minute, and

(b) wool, wherein (b) is present in a range of from 15 to 70% by weight on a basis of (a) and (b).

In a preferred mode the fabric will have a least one of the following:

(a) a thermal performance temperature in a range from 125°C to 500°C.

(b) a compression of at least 40% measured at 24 hours in accordance with modified ASTM D 6571-01

(c) a density in a range from 0.3 to 6.0 pounds per cubic foot (5 to 96 kilograms per cubic meter) and

(d) a basis weight of 3 to 18 ounces per square yard (102 to 610 grams per square meter).

The present invention also relates to a method of incorporating the fabric into a final article of manufacture such as a batting in a mattress or furniture.

BRIEF DESCRIPTION OF THE DRAWING

FIGURE 1 is a graph of thermal performance temperature versus wool content in a fabric on a basis of cellulose fiber and wool. All fabrics displayed in this figure have a nominal basis weight of 5.0 ounces per square yard (169.5 grams per square meter) 20% of which is binder fiber.

DETAILED DESCRIPTION OF THE INVENTION

A first necessary material in the present invention is a cellulose fiber which retains at least 10 percent of weight when heated in air at a rate of 20°C. per minute.

A preferred cellulose fiber is one formed from viscose fiber containing hydrated silicon dioxide in the form of a silicic acid with aluminum silicate sites. Such fibers, and methods for making such fibers are generally disclosed in U.S. Pat. Nos. 5,417,752 and PCT Pat. Appl. WO9217629. Viscose fiber containing silicic acid is sold under the trademark Visil® by Sateri Oy Company of Finland.

A second necessary material in the present invention is animal wool such as from sheep and goats. Sheep's wool is preferred due to availability and cost. The amount of wool present in the fabric will be in a range from 15 to 70% by weight on a basis of the cellulosic fiber and wool.

Preferably, the wool will be in a range from 20 to 50 % on the same basis of cellulosic fiber and wool.

Weight as employed herein can also be expressed as basis weight measured in accordance with ASTM D 6242-98.

Although both woven and non-woven fabrics are within the scope of the present invention, a preferred embodiment is a non-woven fabric that contains a binder. The preferred non-woven fabrics are high loft battings having thermoplastic binders.

Preferred binders are activated by the application of heat. A preferred binder is in the form of a fiber, namely a sheath/core bicomponent fiber having a core of polyester homopolymer and a sheath of copolyester such as are commonly available from Unitika Co., Japan (e.g., sold under the trademark MELTY®). Other binders such as thermoplastic powders or fibers commonly used to bind fibers in webs may be used.

Preferably the fire-resistant fabric will have a thermal performance temperature in a range from 125°C to 500°C. More preferably the range will be from 200 to 400°C.

As employed herein, thermal performance temperature is measured using the same instrument employed for NFPA1971 Standard on Protective Ensemble for Structural Fire Fighting 2000 Edition Section 6-10. The instrument is operated in a data acquisition mode. A 2 $cal/cm^2/second$ (8.38 $J/cm^2/second$) heat flux is imposed on a fabric for 90 seconds. During this time, the heat passing through the material is measured using a calorimeter placed in direct contact with the back face (base layer) of the fabric. This calorimeter slightly compresses the tested material. The temperature of the calorimeter thermocouple at the end of the 90 seconds exposure represents the thermal performance temperature. This temperature is a linear positive function of the amount of heat transferred through the test specimen and therefore, can be used to compare the thermal insulating performance of one fabric to another.

A further desirable property in a preferred embodiment of the flame resistant fabric is that it is perceived as soft and comfortable. One way of describing such comfort is its capability to compress at a minimum applied load. Although this property may be measured in different ways, in the present case, compression is measured in ASTM standard D 6571-01 but modified with use of a 17.6 pound (8 kilogram) weight, a fabric sample size of twelve by twelve inches (30.4 x 30.4 centimeters).

The test procedure in the present invention involves compressing the sample under a 17.6 pound (8 kilogram) weight for 6 hours, removing the load, allowing the sample to recover for a 10 minute period and then measuring the sample thickness. This sample thickness, designated the initial sample thickness, is the starting value upon which % compression is finally determined. Immediately after measuring the initial thickness as described above, the sample is again compressed under the 17.6 pounds (8 kilogram) weight for 24 hours after which period the thickness of the loaded and compressed sample is measured. This thickness value is designated the final thickness. From these initial and final thicknesses the % compression is computed from the following formula:

% compression = [(Initial thickness – final thickness)/initial thickness]x100

This test procedure is labeled herein as modified ASTM D6571-01. The test procedure may be described as performing a 6 hour compression period and a 10 minute recovery period to obtain a starting conditioned sample upon which a then a 24 hour period is required to obtain a final compressed thickness from which the % compression is computed.

The starting fabric sample is considered to relate to fabric such as a batting which is typically stored in roll form prior to actual use in the final material such as a portion of a mattress, upholstery, sleeping bag, comforter, etc. Illustratively, the fabric as a batting in a mattress when tested according to the State of California test standard TB603 can result in a peak rate of heat release less than 200 kW during the 30 minutes test duration and a total heat release less than 25 MJ within 10 minutes of test start.

An important property which can be obtained with fabrics of the present invention is an ability of the fabric to be evaluated as soft. It is understood that softness is a subjective term and it will vary from person to person. Also, there is no sharp line between a fabric which is perceived as soft as opposed to not being soft. Also, a fabric perceived as soft such as in use as upholstery may not be perceived as soft as part of a mattress construction. However, for purposes of the present invention, a soft fabric has a compression of at least 40% when measured in accordance with modified ASTM D6571-01 as previously described.

If higher thermal performance is required, the total basis weight of the cellulose and wool batting can be increased. If higher thermal performance combined with increased structural integrity during the flame resistant test is required, it may be desirable to add a further material to the cellulose fiber and wool. Illustratively, these materials are heat resistant and include aramid, especially para-aramid, polybenzazole polybenzimidazole and polyimide. Generally, the material will be present as a fiber.

Preferably, the fire resistant fabric will have a density in a range from 0.3 to 6.0 pounds per cubic foot (5 to 96 kilograms per cubic meter) and more preferably a density in a range from 0.3 to 4.3 pounds per cubic foot 5 to 70 kilograms per cubic meter).

Another property of the fire resistant fabric that influences the thermal performance temperature is the weight per unit area, or basis weight. A suitable basis weight is in a range of 3 to 18 ounces per square yard (102 to 610 grams per square meter and more preferably 4 to 12 ounces per square yard (136 to 407 grams per square meter). Basis weight can be measured in accordance with ASTM D6242-98.

If the flame resistant fabric is employed as a batting and additional durability or strength is desired, such fabric can be contacted and joined with another fabric such a woven or nonwoven scrim fabric such as by sewing or use of an adhesive.

In the following examples all parts and percentages are by weight and degrees in centigrade unless otherwise indicated. The test measurements were as previously described. In addition, compression also was measured at different time periods as noted.

In the following examples the following materials were employed:

binder:	a copolymer polyester sheath/polyester core fiber having a melting temperature of about 120°C and an individual filament denier of 4 dpf (4.4 dtex) and average cut length of 2 inches (51 mm) supplied by Samyang Corporation.
fire resistant cellulose:	type 33 AP Visil® cellulose fiber having having an individual filament denier of 3.5 dpf (3.9 dtex) and average cut length of 2 inches (51 mm) available from Sateri Oy.
wool:	sheep's wool of 54S numerical count grade scoured and combed and average cut length of 2 inches (51 mm).
aramid:	poly(paraphenylene terephthalamide) supplied as Kevlar® Type 970 by E. I. du Pont de Nemours and Company having an individual filament denier of 2.25 dpf (2.50 dtex) average cut length of 2 inches (51 mm).

The fibers used in this invention retain a portion of their fiber weight when heated to high temperature at a specific heating rate. This fiber weight was measured using a Model 2950 Thermogravimetric Analyzer (TGA) available from TA Instruments (a division of Waters Corporation) of Newark, Delaware. The TGA gives a scan of sample weight loss versus increasing temperature. Using the TA Universal Analysis program, percent weight loss can be measured at any recorded temperature. The program profile consists of equilibrating the sample to 50 degrees C, placing the sample in a 500 microliter ceramic cup (PN 952018.910) sample container and ramping the temperature of the air, as measured by a thermocouple placed directly above the lip of the sample container, at 20 degrees C per minute from 50 to 1000 degrees C, using air supplied at 10 ml/minute. The testing procedure is as follows. The TGA was programmed using the TGA screen on the TA Systems 2900 Controller. The sample ID was entered and the planned temperature ramp program of 20 degrees per minute selected. The empty sample cup was tared using the tare function of the instrument. The fiber sample was cut into approximately 1/16" (0.16 cm) lengths and the sample pan was loosely filled with the sample. The sample weight should be in the range of 120 to 60 mg. The TGA has a balance therefore the exact weight does not have to be determined beforehand. None of the sample should be outside the pan. The filled sample pan was loaded onto the balance wire making sure the thermocouple is close to the top edge of the pan but not touching it. The furnace is raised over the pan and the TGA is started. Once the program is complete, the TGA will automatically lower the furnace, remove the sample pan, and go into a cool down mode. The TA Systems 2900 Universal Analysis program is then used to analyze and produce the TGA scan for percent weight loss over the range of temperatures.

Part 1

Fabrics in the form of battings as set forth in Table 1 were blended using conventional carding/garnet machines and crosslappers that opened and blended the fibers. The fabrics were heat set using a through-air oven and then cooled at room temperature.

For each of fabric samples A through E and for sample F, which had no fabric sample mounted in the instrument, 10 different measurements were recorded. An average basis weight and an average thermal performance temperature was calculated. Additionally a 95% confidence limit was also calculated both for the basis weight and thermal performance temperature. The values are set forth in Table 1.

Table 1

SAMPLE

	A	B	C	D	E	F
% Wool	0	25	38	50	100	0
Nominal Basis Weight	5 (170)	5 (170)	5 (170)	5 (170)	5 (170)	0.0 (0.0)
Average Basis Weight	4.8 (163.7)	5.4 (183.1)	5.1 (172.9)	4.8 (162.7)	6.2 (210.2)	0.0 (0.0)
95% Confidence Limit of Average Basis Weight	0.2 (6.8)	0.2 (6.8)	0.3 (10.2)	0.3 (10.2)	0.2 (6.8)	0.0
Density	17.6 (0.018)	18.1 (0.018)	18.3 (0.018)	21.9 (0.022)	19.4 (0.019)	0 (0.0)
Average of Thermal Performance Temperature	315	316	285	324	730	678
95% Confidence Limit of Average Thermal Performance Temperature	15	16	12	13	32	11

(1) All weight in ounces per square yard (grams per square meter).

(2) % wool on basis of wool and cellulose only.

(3) All samples (except the sample labeled F with no fabric) include binder fiber at 20% of the total sample basis weight.

(4) Density in ounces per cubic foot (grams per cubic centimeter) measured by ASTM D6242-98.

(5) Temperature in °C.

From Table 1, the following observations were made:

(a) For Sample F, i.e. no fabric was present for thermal performance temperature measurement. The temperature was lower compared to Sample E with no cellulose (i.e., only wool and binder)

(b) Samples A through E were compared against expected thermal performance temperatures calculated from a "rule of mixing" which is considered to predict that the thermal performance temperature of a wool/cellulose fabric should equal the weight percent of wool times the thermal performance temperature of wool plus the weight percent of cellulose times the thermal performance temperature of cellulose.

Fig. 1 shows an unexpected improvement in thermal performance temperature from the "rule of mixing" as the wool percent is increased on a basis of the wool and cellulose present in the fabric. The fabric samples had a nominal basis weight of 5 ounces per square yard (169 grams per square meter) and 20% of the fabric weight was binder.

Part II

Table 2 contains % compression data obtained in accordance with modified ASTM D 6571-01 described above

Two of the samples did not contain aramid each of which are identified at the end of Table 2. Samples A and D were identical to Samples A and D of Part I. Thickness values are in inches (centimeters)

Table 2

		Initial Thickness	Final Thickness
Sample A	THICKNESS	1.44 (3.66)	0.94 (2.39)
	% COMPRESSION	0	34.7%
Sample D	THICKNESS	1.38 (3.51)	0.69 (1.75)
	% COMPRESSION	0	50.0%
Sample G	THICKNESS	3.06 (7.77)	1.94 (4.93)
	% COMPRESSION	0	36.6%
Sample H	THICKNESS	2.50 (6.35)	1.25 (3.18)
	% COMPRESSION	0	50.0%

Sample A was 80% cellulose and 20% binder (i.e. 0% wool).

Sample D was 40% wool, 40% cellulose and 20% binder (i.e. 50% wool on basis of wool and cellulose)

Sample G was 40% cellulose, 20% binder and 40% aramid (i.e. 0% wool)

Sample H was 29% wool, 29% cellulose, 13% binder and 29% aramid (i.e. 50% wool on basis of wool and cellulose)

Sample A (which did not contain wool or aramid) and Sample H (which did not contain wool but contained aramid) did not reach a minimum compression of at least 40%

Sample D (which contained wool but did not contain aramid) and Sample H (which contained both wool and aramid) had a compression of 50%.

CLAIM(S)

What is claimed is:

1. A flame resistant fabric comprising:
   (a) cellulose containing fibers which retain at least 10 percent of their weight when heated in air to 700°C at a rate of 20°C per minute, and
   (b) wool,

   wherein (b) is present in a range from 15 to 70% by weight on a basis of (a) and (b).

2. The fabric of claim 1 wherein wool is present in a range from 15 to 70 % by weight on a basis of the cellulosic fiber and wool.

3. The fabric of claim 1 with a thermal performance temperature in a range from 125°C. to 500°C.

4. The fabric of claim 3 with a thermal performance temperature in a range from 200°C. to 400°C.

5. The fabric of claim 1 with a compression at least 40% measured at 24 hours in accordance with modified ASTM D6571-01.

6. The fabric of claim 1 wherein the cellulose containing fiber contains silicic acid.

7. The fabric of claim 1 with a density in a range from 0.3 to 6.0 pounds per cubic foot (5 to 96 kilograms per cubic meter).

8. The fabric of claim 1 having a basis weight in a range from 3 to 18 ounces per square yard (102 to 610 grams per square yard).

9. The fabric of claim 9 having a basis weight in a range from 4 to 12 ounces per square yard (136 to 407 grams per square yard).

10. The fabric of claim 1 when tested in a mattress according to the State of California test standard TB603 results in a peak rate of heat release less than 200 kw during the 30 minute test duration and a total heat release less than 20 MJ within 10 minutes of test start.

11. The fabric of claim 1 which additionally contains a heat resistant fiber.

12. The fabric of claim 11 wherein the heat resistant fiber is aramid, polybenzazole, polybenzimidazole or polyimide.

13. The fabric of claim 12 wherein the aramid is poly(paraphenylene terephthalamide).

14. The fabric of claim 1 present as a batting in an article of manufacture.

15. The fabric of claim 1 present in a mattress.

16. The fabric of claim 1 present in furniture.

17. A method of joining a flame resistant fabric with an additional fabric comprising:

(a) contacting directly or through an adhesive the flame resistant fabric with the additional fabric;

(b) joining both fabrics wherein the flame resistant fabric is defined as in claim 1.

18. The method of claim 17 wherein the joining is by sewing.

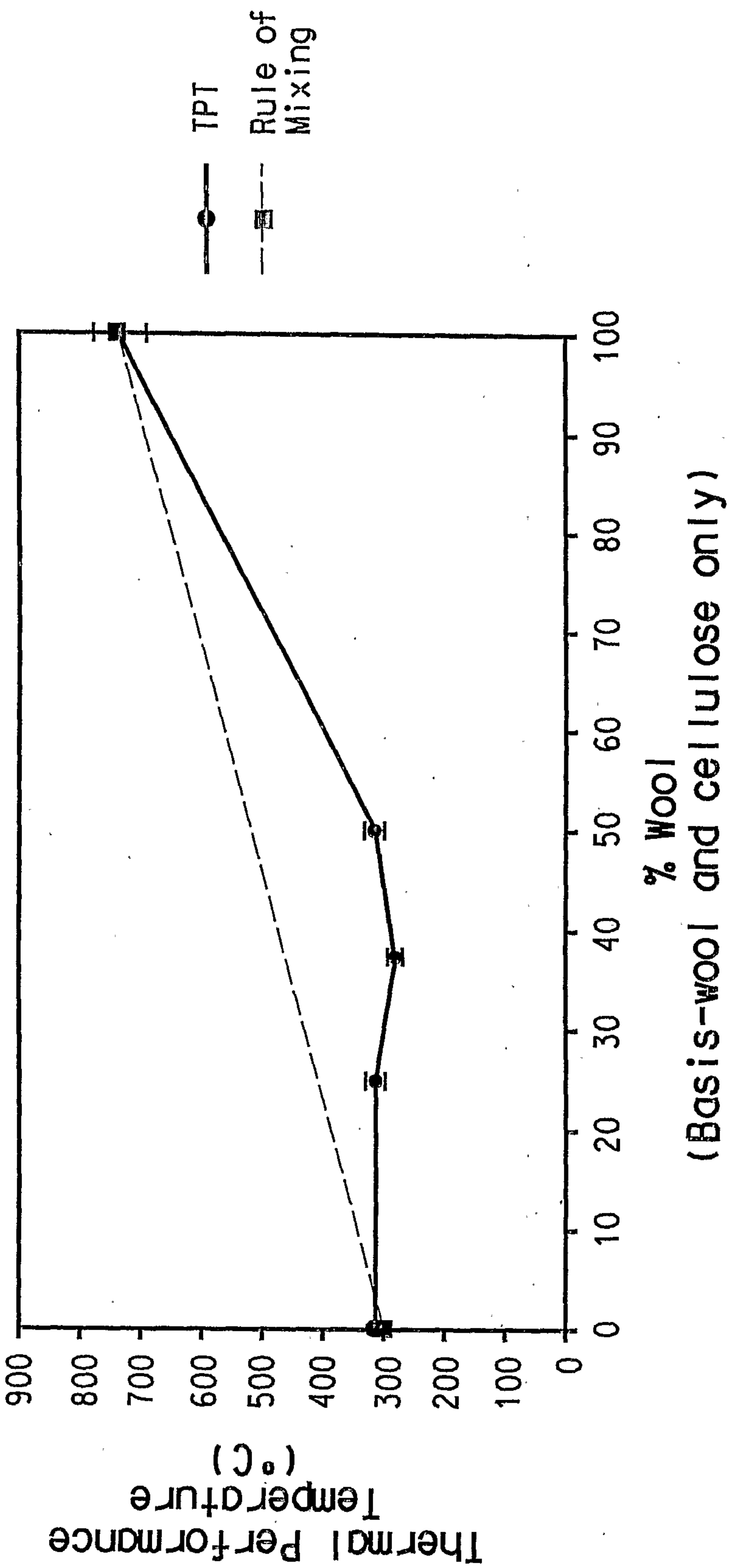
TPT
Rule of Mixing
Thermal Performance Temperature (°C)
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
% Wool
(Basis-wool and cellulose only)

FIG. 1

Thermal Performance Temperature (°C)
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
% Wool
(Basis-wool and cellulose only)
TPT
Rule of Mixing