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(54) **FIRE RESISTANT PANEL AND METHODS OF FIRE BLOCKING AN ARTICLE**

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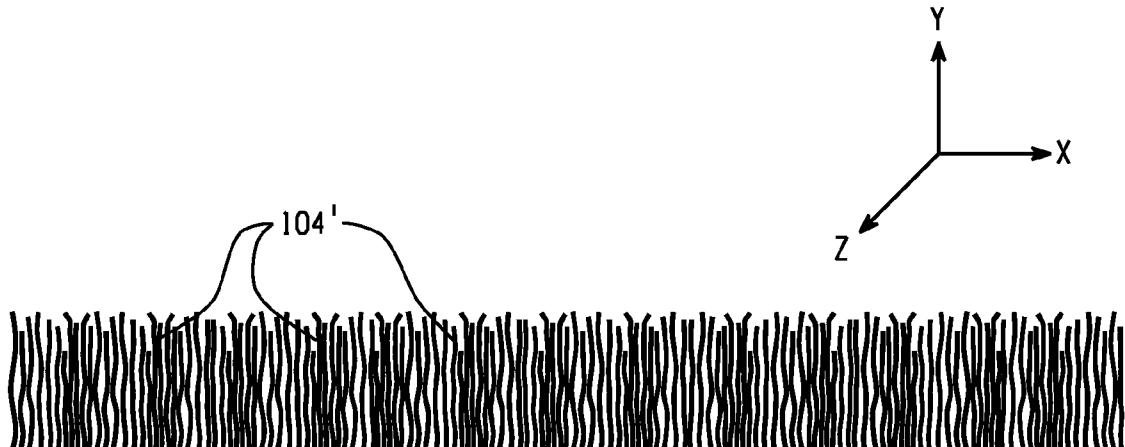
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(57) **ABSTRACT**

Flame retardant panels and methods of manufacture generally include a batting material including a layer having a top surface and a bottom surface, the layer comprising a plurality of substantially vertically oriented flame retardant treated fibers extending from the top surface to the bottom surface; and a binder material.



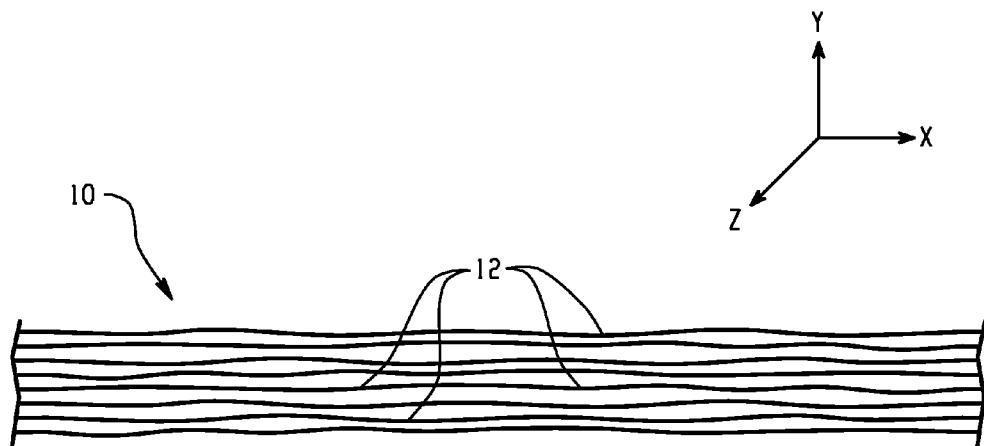


Fig. 1
PRIOR ART

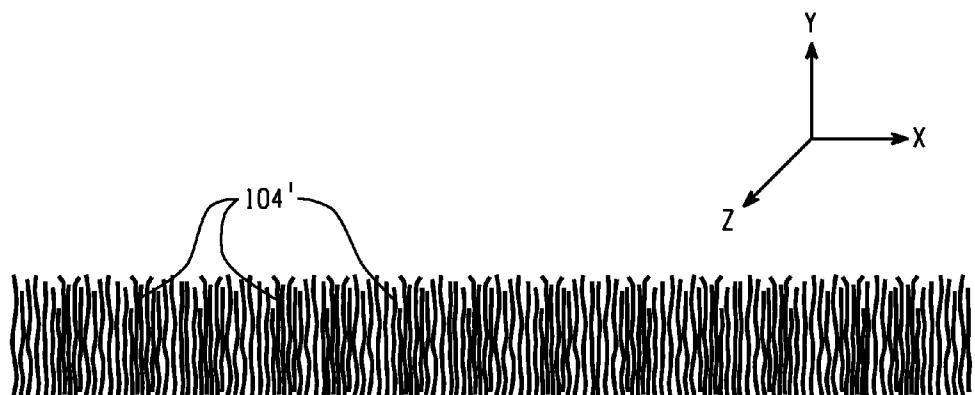
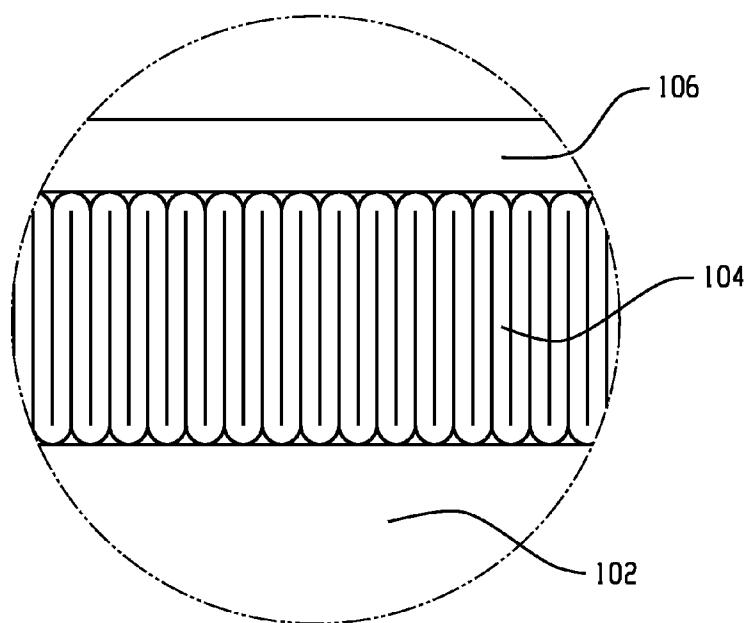
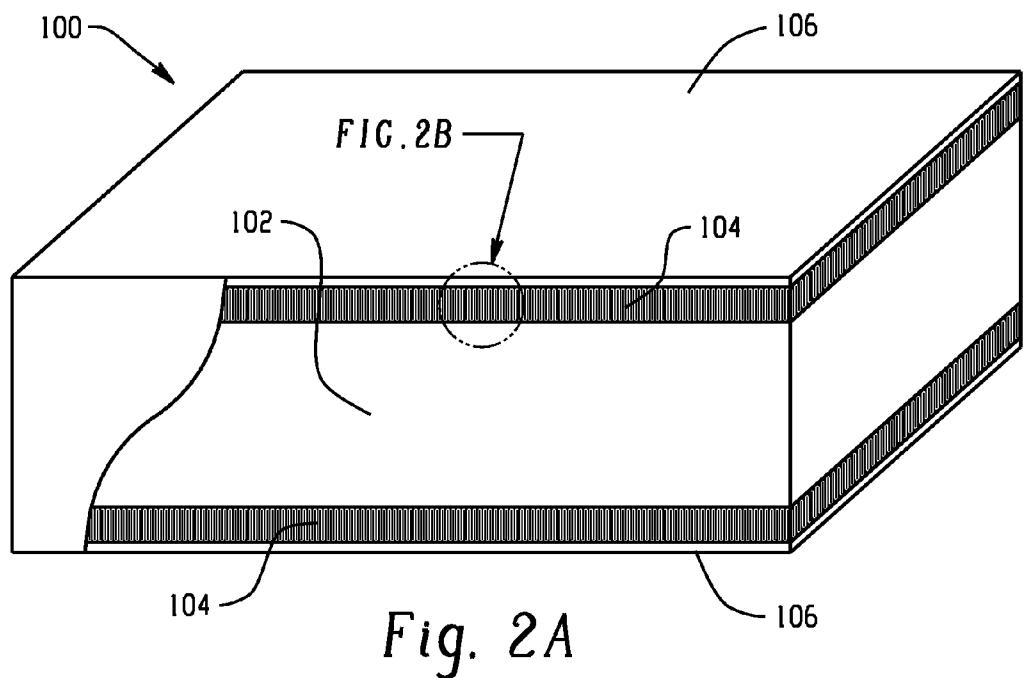
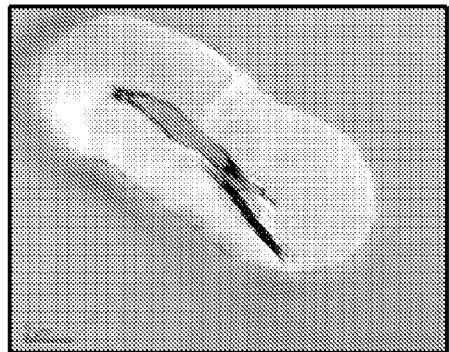
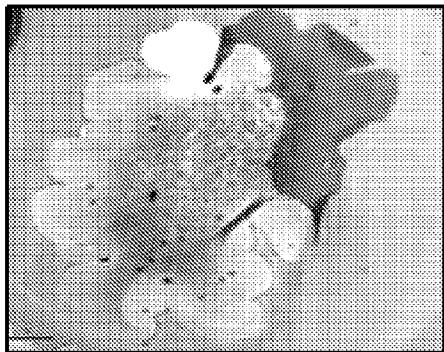


Fig. 3

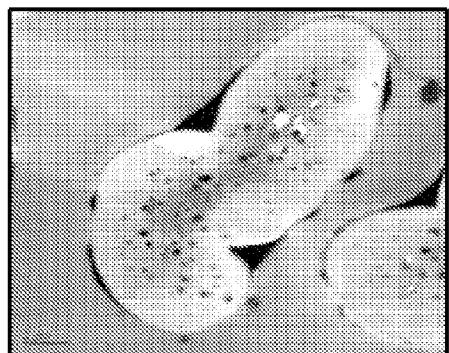




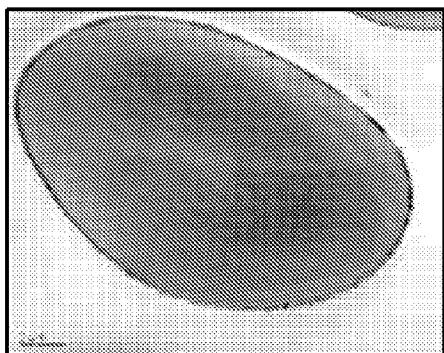
COTTON



VISCOSE

*Fig. 4A**Fig. 4B*

MODAL

Fig. 4C

LYOCELL

Fig. 4D

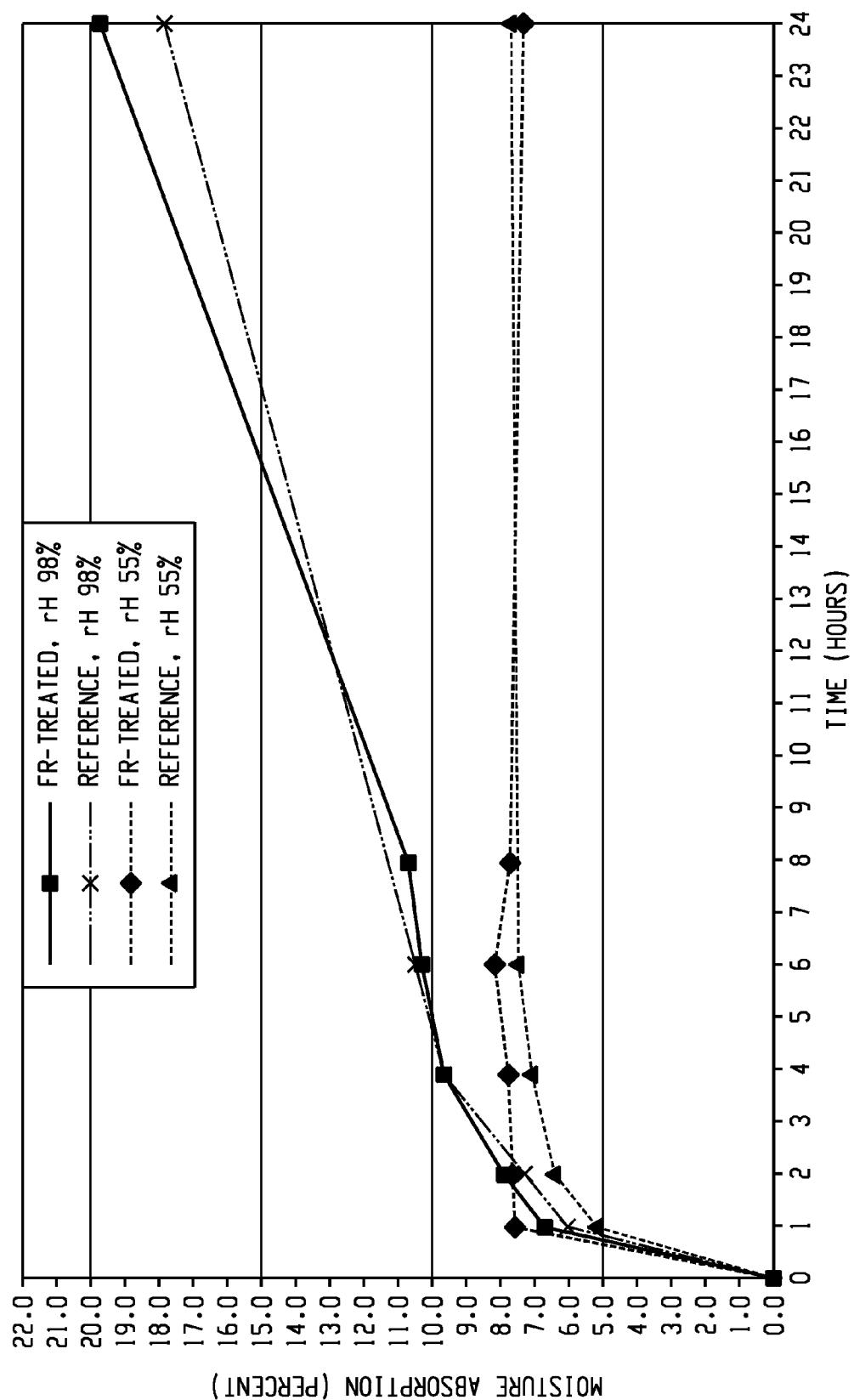


Fig. 5

FIRE RESISTANT PANEL AND METHODS OF FIRE BLOCKING AN ARTICLE

BACKGROUND

[0001] The present disclosure generally relates to fire resistant panels including fire retardant treated fibers, and more particularly, to fire resistant panels including vertically oriented fire retardant treated fibers. Also disclosed are methods of fire blocking an article fire resistant panel.

[0002] Today, there is an increasing interest in adding flame resistant characteristics to mattresses and other furniture. For example, mattress and mattress sets sold in the United States are required to meet an open flame requirement as codified in 16 C.F.R. Part 1633 (2007). While materials used to meet these requirements vary from product to product, the overall approach has generally been to encase the mattress with a flame resistant barrier material underlying the outermost mattress layer e.g., fabric layer, ticking layer, and the like. The materials used by most mattress manufacturers are non-woven high loft or needle punched fiber batting; although, knitted sock-style barrier materials are also used albeit to a lesser extent.

[0003] Commercially available fire resistant battings are typically carded and cross lapped, whereby multiple thin layers of horizontally oriented fiber webs are laid on top of one another, wherein each successive fiber web is laid generally perpendicular to the preceding layer. One process for bonding the web together is via thermal bonding. With a thermal bonding process the layered web is then passed through an oven where a meltable binder such as a low melting polyester or low melting copolymer polyester serves as a binder to bind and hold the web together. Suitable low melting binders such as polyester can have a melting point generally less than 130° C. In some embodiments, the binder is a bi-component material having a core with a higher melting point than a surround encapsulating the core such that during thermal processing the surround is heated to a temperature greater than melting point of the surround but less than the melting point of the core to effect softening and/or melting of the surround, which functions to bind the fibers. Prior art FIG. 1 provides a cross sectional view depicting a non-woven batting 10 including horizontally oriented fibers webs 12. Other commercially available fire resistant batting manufacturers employ the use of needles that penetrate the horizontally oriented fiber layered web through the web layers to effect fiber entanglement as a means to mechanically hold the web together. The resulting cross sectional structure can generally be defined as primarily composed of horizontally oriented fiber webs. Regardless of the method of manufacturer, typically, the fire resistant battings are of a relatively low loft and also of low resilience following compression such as may occur during use.

[0004] While current flame retardant battings may meet the standards set forth in 16 C.F.R. Part 1633, many of these commercial offerings offer little in the way of user comfort. Moreover, commercially available fire resistant battings are generally insulative and do little with regard to temperature management and moisture control.

[0005] Accordingly, there is a need for improved fire resistant panels such as those employed as batting materials for use in mattresses, for use in upholstered furniture, and the like.

BRIEF SUMMARY

[0006] Disclosed herein In one embodiment, a fire resistant batting material comprises a layer having a top surface and a bottom surface, the layer comprising a plurality of substantially vertically oriented flame retardant treated fibers extending from the top surface to the bottom surface; and a binder material.

[0007] In another embodiment, a method of fire blocking an article, comprises combining a layer of a fabric ticking or upholstery, a layer of batting material, and an optional stitch backing layer, wherein the layer of batting material comprises a top surface, a bottom surface, a plurality of substantially vertically oriented flame retardant treated fibers extending from the top surface to the bottom surface and a binder material; sewing the layers together to form a composite; and incorporating the composite into the article.

[0008] The disclosure may be understood more readily by reference to the following detailed description of the various features of the disclosure and the examples included therein.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0009] Referring now to the figures wherein the like elements are numbered alike:

[0010] Prior Art FIG. 1 illustrates a cross-sectional view of a non-woven batting material with carded and horizontally cross lapped fibers.

[0011] FIG. 2A illustrates a cross-sectional view of a non-woven batting material with vertically oriented flame retardant treated pleated fibers in accordance with the disclosure.

[0012] FIG. 2B illustrates an enlarged cross-sectional view of the non-woven batting material with vertically oriented flame retardant treated fibers of FIG. 2A in accordance with the disclosure.

[0013] FIG. 3 illustrates a cross-sectional view of a non-woven batting material with vertically oriented flame retardant treated fibers in accordance with the disclosure.

[0014] FIG. 4A-D depicts cross sectional images depicting moisture absorption profile for different fibers.

[0015] FIG. 5 graphically illustrates moisture absorption as a function of time for fire retardant treated fibers and untreated fibers.

DETAILED DESCRIPTION

[0016] Disclosed herein are flame resistant panels for use in cushioning articles. By way of example, the flame resistant panels can be employed in mattresses as a batting material, wherein the fibers are substantially vertically oriented and at least a portion are flame retardant treated fibers. By use of the term "treated" it is meant that a fire retardant is applied to the fiber, wherein the fibers by themselves may have varying degrees of flame retardancy depending on the composition. Applicants have discovered that orienting the fire retardant treated fibers in a substantially vertical direction increases resiliency and the product's ability to recover due primarily to the change in fiber orientation from horizontal to vertical. The increase in resiliency has been found to translate into higher levels of comfort and product durability. Moreover, increased airflow was observed by orienting the fibers in the substantially vertical direction. Three dimensional thermal imaging has confirmed that mattress assemblies configured with flame resistant batting comprising substantially vertically oriented flame retardant treated fibers exhibited less retained heat

compared to conventional cross-lapped and horizontally oriented fiber layers such as that shown in Prior Art FIG. 1.

[0017] Turning now to FIGS. 2A and 2B, there is depicted a mattress 100 in accordance with an embodiment. The mattress 100 includes a central core layer 102 between pleated middle upholstery layers 104 (also referred to herein as a fiber batting material), and a quilt layer 106 provided on the outer face of the pleated middle upholstery layers 104. The quilt layer 106 can extend around the sides of the mattress, where it is shown partially cut away to reveal layers behind quilt layer 106. Other layers such as an insulator layer or the like (not shown) may also be included as may be desired for different applications.

[0018] FIG. 2B illustrates an enlarged view of the mattress 100 corresponding with the circle indicated in FIG. 2A. The core layer 102 may comprise one or more foam layers, a coil spring layer, and combinations thereof. The quilt layer 106 is a composite layer of the mattress and can be made of foam or a cross-laid non-woven web of fibers stitched to the underside of a protective fabric cover, e.g., ticking layer, which provides a soft surface texture to the mattress.

[0019] The pleated middle upholstery layers 104 comprise a pleated (vertically lapped) web of cross-laid fibers. In the pleated layer, the pleats are formed from a cross-laid non-woven web of fibers as will be described in greater detail below.

[0020] In an alternative embodiment, the non-woven fiber batting material for the middle upholstery layer 104' can include a plurality of individual flame retardant treated fibers 102 substantially oriented in a vertical direction, i.e., generally transverse (y-direction) to a horizontal plane (x-direction) of the batting material.

[0021] The term "non-woven" as used herein in connection with fabrics, fibrous compositions, textiles, materials, products and similar items means a structure that is produced by attaching, bonding and/or interlocking two or more of the same or different components, such as filaments, microfibers, fibers, fibrous compositions, threads or yarns, together, generally by loosely bonding them together, and using one or more of a variety of techniques that generally does not involve weaving or interlacing, but employs mechanical, chemical, thermal and/or solvent means, for example, using known needle punching, melt-blowing, spun bonding, wet-forming and various bonded carded web processes. Non-woven materials may be manufactured using fusing or chemical bonding techniques (with the use of binding agents, such as PVA or polyester) or similar techniques, which are known by those of skill in the art. This term generally does not include fabrics, textiles, fibrous compositions or materials that are woven, knitted, tufted, or those made using wool or other felting processes.

[0022] The upholstery layer, i.e., batting material, including the flame retardant treated fiber in the substantially vertically oriented orientation of the present disclosure is also cost effective, soft, yet durable and suitable for various cushioning articles including, but not limited to a mattress component, mattress covers, comforters, bedspreads, quilts, coverlets, duvets, pillows, pillow covers, cushions, in addition to other home uses, protective apparel applications, and industrial end-use applications.

[0023] The fibers employed in the vertically oriented flame retardant treated fiber batting material are not intended to be limited so long as a fire retardant can be applied and retained in an amount effective to provide the panel with a fire resis-

tance that meets or exceeds 16 C.F.R. Part 1633. The fibers can be natural fibers and/or synthetic fibers. The use of natural fibers in bedding components is desirable due to the softness and durability associated with these fibers as well as the absorption properties of most natural cellulosic fibers. Suitable fibers include, without limitation, polyester, polyolefins such as a polypropylene and polyethylene, cellulosic fibers, cotton, rayon, wool, silk, acetate, nylon, lyocell, flax, ramie, jute, angora, kenaf, and the like, and mixtures thereof.

[0024] The fibers may have varying diameter and denier, be hollow or solid, or may be crimped. Blending different types of fibers may further contribute to resiliency of the batting material. The amounts will vary generally depending on the fiber composition, and flame retardant employed.

[0025] In one embodiment, the flame retardant treated fiber is lyocell, which is a regenerated cellulose fiber made from dissolving pulp (bleached wood pulp) and is commercially available as fibers under the brand name Tencel from Lenzing AG. The US Federal Trade commission defines lyocell as "a cellulose fiber that is obtained by an organic solvent spinning process" and classifies the lyocell fiber as a sub-category of rayon. Some main characteristics of lyocell fibers are that they are soft, absorbent, very strong when wet or dry, and resistant to wrinkles; all of which are generally desirable for a batting material. The moisture absorption properties provide improved moisture wicking, which is highly desirable for mattress applications.

[0026] FIGS. 4A-4D depict cross sections of various cellulosic fibers after immersion in dyed water, wherein lighter regions indicate minimal moisture absorption and darker regions indicate maximum moisture absorption. The various cellulosic fibers included cotton, a rayon commercially available under the trademark VISCOSE from the Lenzing Group, a modified rayon commercially available under the trademark MODAL from the Lenzing Group; and lyocell commercially available under the trademark TENCEL from the Lenzing Group. As shown, lyocell exhibited the greatest and most uniform moisture absorption as evidenced by the uniform dark color throughout the cross section. In contrast, moisture absorption for the MODAL and VISCOSE materials was observed to be confined to pores within the cross-sectional structure whereas moisture absorption in cotton was in centrally located pore. It is further noted that lyocell had a relatively smooth outer surface compared to VISCOSE and MODAL, which is believed to result in improved carding and provide a softer touch relative to materials having complex cross-sectional shapes.

[0027] Man-made fibers can be produced to any desired cut length, which is generally determined by the equipment and product performance. For the vertically oriented batting material, the fibers to be fire retardant treated generally have a length of 0.25 to 4 inches; in other examples, a length of 0.5 to 3 inches, and in still other examples, a length of 1.5 to 3 inches. By way of example, for lyocell, rayon and/or polyester fibers, the cut lengths for carding are generally between 1.5 and 3 inches. For natural fibers such as cotton, the fiber length can generally vary from 0.5 to 1.6 inches. The non-woven fiber batting material when vertically oriented can also have a total thickness or loft of 0.5 inches (1.25 centimeters) or greater. While there is no real limitation on how thick the batting can be, for many typical applications, the thickness of the high loft batting need not be higher than 3 inches (7.6 cm), and for many mattress applications less than 2 inches (5 cm) is useful. The batting material can also generally have a basis

weight of about 5 to 18 ounces per square yard (169 to 610 grams per square meter) and are preferably 8 to 11 ounces per square yard (271 to 373 grams per square meter). The total density of the batting material is generally aligned with the basis weights described above. Denser battings generally do not have the resiliency desired for use as cushioning in mattresses and other articles. As for battings that are less dense, the batting materials are oftentimes bulky to handle during fabrication and are generally compressed into the preferred density range when incorporated into a quilted composite. Thinner and denser battings also do not provide the desired softness, aesthetics, and may lack durability in application and with FR protection.

[0028] The fire retardant treated fibers may be chemically, thermally or mechanically bonded to improve structural integrity. Chemical binders can generally be applied to the flame retardant treated fibers by impregnating, coating and/or spraying. Exemplary chemical binders include, without limitation, acrylate polymers, styrene-butadiene copolymers, and vinyl acetate polymers. Thermally bonded fibers generally include the addition of low melting polymeric materials, e.g., low molecular weight polyester fibers, to the flame retardant treated fibers, wherein further processing to form the web results in melting and/or partial melting of the low molecular weight binder so as to form bonds under controlled heating between the fibers of the batting material. As for mechanical bonding, a web of fibers including the flame retardant treated fibers can be processed to increase fiber entanglement. There are generally two types of mechanical bonding: needle punching and hydro-entanglement. Needle punching can be used on most fiber types and generally includes the use of specially designed needles that are pushed and pulled through the web to entangle the fibers. Webs of different characteristics can be needled together to produce a gradation of properties difficult to achieve by other means. Hydro-entanglement employs water jets to effect entanglement.

[0029] The flame resistant panels made using treated fire retardant fibers are comprised of a blend in an amount that meets and/or exceeds the flammability standards set forth in 16 CFR 1633. Flame resistance generally depends on the fiber composition, flame retardant chemical that is applied, and the flame retardant loadings. In most embodiments, at least 50% of the fibers are fire retardant treated fibers. In other embodiments, at least 60% of the fibers are fire retardant treated fibers; and in still other embodiments, at least 80% of the fibers are fire retardant treated fibers. The remaining fibers in the panel composition can comprise untreated fibers, binder fibers, and the like.

[0030] In some embodiments, multiple layers of vertically oriented fibers are stackedly arranged to provide a desired thickness for the batting material application. The stacked layers may be subjected to chemical, thermal and/or mechanical bonding to provide the desired amount of structural integrity between layers. For example, a binder such as a low molecular weight polyester and/or adhesive may be used intermediate the layers to provide structural integrity or the stacked arrangement may be needle punched to effect fiber entanglement.

[0031] Unexpectedly, it has also been discovered that when converted into a vertically oriented product using the treated fibers such lyocell or rayon, less flame retardant treated fibers are required to form the panel and provide an equivalent fire rating compared to prior art carded and cross-lapped horizontally oriented materials having a similar loft. For example, a

fiber batting material at a density of 1 ounce per square foot that met and/or exceeded the product safety standard codified in 16 C.F.R PART 1633 required only 70% of substantially vertically oriented fire retardant fibers compared to 80% required for fire retardant treated fibers that had been horizontally oriented and cross-lapped as shown in Table 1.

TABLE 1

COMPONENT	LOFT (inches)	HORIZONTAL TEMPURATURE (° F.)	CHAR FORCE (lbs.)	CHAR ELONGATION (inches)
Horizontally Oriented 80% Fire Retardant Treated Rayon ¹	0.81	563	1.08	0.33
Vertically Oriented 70% Fire Retardant Treated Lyocell ²	0.78	602	1.11	0.51

¹Comparative

²Inventive

[0032] It has further been discovered that an ammonium polyphosphate fire retardant treated lyocell fiber batting material at a density of 0.8 ounces per square foot also met and/or exceeded the product safety standard codified in 16 C.F.R Part 1633 required, which represents a significant and unexpected result compared to prior art batting materials. As noted above, the prior art batting materials generally needed 80% fire retardant treated fibers at a density of 1 ounce per square foot to meet this codified standard whereas the data provided in Table 2 below indicates that only 70% of substantially vertically oriented fire retardant fibers at density of 0.8 ounce per square foot was needed to meet the product safety standard. The results provide a significant commercial advantage since less basis weight and materials are needed to meet the standards provided in 16 C.F.R 1633. The data further suggests that even lower percentages of flame retardant treated fibers and/or lower basis weights may be possible and still meet the product safety standard codified in 16 C.F.R Part 1633.

TABLE 2

Vertical Fiber	Peak Heat Release Rate (kilowatts)	Time to Peak Heat (minutes)	Total Heat in 10 minutes (mega joules)
Test 1	40	0.5	6.6
Test 2	40	0.5	6.4
Test 3	38	0.5	5.0

[0033] Moreover, it has been discovered that unlike most conventional fire retardant fibers, application of a fire retardant chemical permeates substantially throughout the cross sectional area of the lyocell fiber, which, without being bound by theory, attributes to lower amounts of flame retardant treated fibers required in the product blend to meet and/or exceed flammability standards described in 16 CFR Part 1633.

[0034] At least a portion of the fibers are treated with flame retardant chemistry, which may be provided as a durable or a non-durable finish. Durable flame retardant finishes are not removed by exposure to water or handling. Exemplary fire retardants include, without limitation, chlorinated flame

retardant compounds, such as chlorinated hydrocarbons, chlorinated phosphate esters, chlorinated polyphosphates, chlorinated organic phosphonates, chloroalkyl phosphates, polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and dibenzofurans are molecules containing a high concentration of chlorine that generally act chemically in the gas phase. They are often used in combination with antimony trioxide and/or zinc borate as a synergist. Three main families of chlorinated compounds include: (a) chlorinated paraffins; (b) chlorinated alkyl phosphates; and (c) chlorinated cycloaliphatic compounds.

[0035] Examples of chlorinated compounds include dodecachlorodimethanodibenzocyclooctane, tris(2-chloroethyl)phosphate, tris(2-chloro-1-methylethyl)phosphate, tris(2-chloro-1-(chloromethyl)ethyl)phosphate (TDPP), tris(chloropropyl)phosphate, tris(dichloropropyl)phosphat-e, tris(2-chloroethyl)phosphite, ammonium chloride, chlорo-dic acid, chlорo-enc anhydride, tris(dichlorobropropyl)phosphite, Bis(hexachlorocyclopentadieno)cyclooctane, tris(dichloropropyl)phosphite, bis [bis(2-chloroethoxy)-phosphinyl]isopropylchloro-ethyl phosphate and MIREX® (1,1a,2,2,3,3a,4,5,5,5a,5b,6-dodecac-hloroocta-hydro-1,3,4-metheno-1H-cyclobuta(cd)pentalene).

[0036] Brominated fire retardant compounds, such as brominated organic compounds and brominated hydrocarbons, exhibit fire retardant efficiency in many materials. The three main families of brominated fire retardants include: (a) aliphatic brominated compounds; (b) aromatic brominated compounds; and (c) brominated epoxy fire retardants. Aliphatic brominated compounds include, for example, trisbromoneopentylphosphate, trisbromoneopentyl alcohol, dibromoneopentyl glycol, hexabromocyclohexane, hexabromocyclododecane, tetrabromo cyclopentane, hexabromo cyclohexane, hexabromo cyclooctane, hexabromo cyclodecane and hexabromo cyclododecane. Aromatic brominated compounds include, for example, hexabromo benzene, decabromobiphenyl, octabromodiphenyl oxide, hexabromobenzene, tris(tribromophenyl)triazine, tetrabromobisphenol A bis (2,3 dibromo propyl ether), dibromoneopentyl glycol, poly(pentabromobenzyl acrylate), pentabromodiphenyl ether, octabromodiphenyl oxide, octabromodiphenyl ethane, decabromodiphenyl oxide, decabromodiphenyl ether, tetrabromobisphenol A and brominated trimethylphenyl indan. Brominated epoxy fire retardants include brominated epoxy oligomers and polymers.

[0037] Other brominated fire retardant compounds include brominated diphenyl ethers, polybrominated diphenyl ethers, dimethyl-3-(hydroxymethyl-lamino)-3-oxopropyl phosphonate, pentabromo toluene, tetrabromo chlorotoluene, pentabromo phenol, tribromo aniline, dibromobenzoic acid, pentabromotoluene, decabromodiphenyl oxide, tribromophenol, hexabromocyclododecane, brominated phosphorous, ammonium bromide, decabromobiphenyl oxide, pentabromobiphenyl oxide, decabromobiphenyl ether, 2,3-dibromopropanol, octabromobiphenyl ether, octabromodiphenyl oxide, tetrabromobiphenyl ether, hexabromocyclododecane, bis(tetrabromophthalimido) ethane, bis(tribromophenoxy)ethane, brominated polystyrene, brominated epoxy oligomer, poly-pentabromobenzyl acrylate, tetrabromobisphenol compounds, dibromopropylacrylate, dibromohexachlorocyclopentadienocyclooctane, N.sup.1-ethyl(bis)dibromonon-boranedicarboximide, decabromodiphenyloxide, decabromodiphenyl, hexabromocyclohexane, hexabromoc-

clododecane, tetrabromo bisphenol A, tetrabromobisphenol S, N'N'-ethylbis(dibromononbonene)dicarboximide, hexachlorocyclopentadieno-dibromocyclooctane, tetrabromodipenta-erythrito-1, pentabromoethylbenzene, decabromodiphenyl ether, tetrabromophthalic anhydride, hexabromobiphenyl, octabromobiphenyl, pentabromophenyl benzoate, bis-(2,3-dibromo-1-propyl)phthalate, tris(2,3-dibromopropyl)phosphate, N,N'-ethylene-bis-(tetrabromophthalimide), tetrabromophthalic acid diol [2-hydroxypropyl-oxy-2-2-hydroxyethyl-ethyl-tetrabromophthalate]-, polybrominated biphenyls, tetrabromobisphenol A, tris(2,3-dibromopropyl)phosphate, tris(2-chloroethyl)phosphite, tris(dichlorobromopropyl)phosphite, diethyl phosphite, dicyandiamide pyrophosphate, triphenyl phosphite, ammonium dimethyl phosphate, bis(2,3-dibromopropyl)phosphate, vinylbromide, polypentabromobenzyl acrylate, decabromodiphenyl oxide, pentabromodiphenyl oxide, 2,3-dibromopropanol, octabromodiphenyl oxide, polybrominated dibenzo-p-dioxins, dibenzofurans and bromo-chlorinate paraffins.

[0038] Phosphorous-based fire retardants are compounds that include phosphorous, such as halogenated phosphates (chlorinated phosphates, brominated phosphates and the like), non-halogenated phosphates, triphenyl phosphates, phosphate esters, polyols, phosphonium derivatives, phosphonates, phosphoric acid esters and phosphate esters, which are the largest class of phosphorous flame retardant compounds. Phosphorous-based fire retardants are usually composed of a phosphate core to which is bonded alkyl (generally straight chain) or aryl (aromatic ring) groups. Halogenated phosphate compounds are often introduced to decrease total halogen concentration. Non-halogenated phosphate compounds include, for example, red phosphorous, inorganic phosphates, insoluble ammonium phosphate, ammonium polyphosphate, ammonium urea polyphosphate, ammonium orthophosphate, ammonium carbonate phosphate, ammonium urea phosphate, diammonium phosphate, ammonium melamine phosphate, diethylenediamine polyphosphate, dicyandiamide polyphosphate, polyphosphate, urea phosphate, melamine pyrophosphate, melamine orthophosphate, melamine salt of boron-polyphosphate, melamine salt of dimethyl methyl phosphonate, melamine salt of dimethyl hydrogen phosphate, ammonium salt of boronpolyphosphate, urea salt of dimethyl methyl phosphonate, organophosphates, phosphonates and phosphine oxide. Phosphate esters include, for example, trialkyl derivatives, such as triethyl phosphate and trioctyl phosphate, triaryl derivatives, such as triphenyl phosphate, and aryl-alkyl derivatives, such as 2-ethylhexyl-diphenyl phosphate.

[0039] Other examples of phosphorous-based fire retardants include methylamine boron-phosphate, cyanuramide phosphate, cresyl diphenyl phosphate, tris(1-chloro-2-propyl)phosphate, tris(2-chloroethyl)phosphate, tris(2,3-dibromopropyl)phosphate, triphenyl phosphate, magnesium phosphate, tricresyl phosphate, hexachlorocyclopentadiene, isopropyl triphenyl phosphate, tricresol phosphate, ethanolamine dimethyl phosphate, cyclic phosphonate ester, monoammonium phosphate and diammmonium phosphate, which permit a char formation as a result of esterification of hydroxyl groups with the phosphoric acid, trialkyl phosphates and phosphonates, such as triethyl phosphate and dimethyl, aryl phosphates, such as triaryl phosphates, isopropyl triphenyl phosphate, octylphenyl phosphate, triphenylphosphate, ammonium phosphates, such as ammonium phosphate, ammonium polyphosphate and potassium ammonium

phosphate, cyanuramide phosphate, aniline phosphate, trimethylphosphoramide, tris(1-aziridinyl)phosphine oxide, triethylphosphate, Bis(5,5-dimethyl-2-thiono-1,3,2-dioxaphosphorinamyl)oxide, Bis(2-chloroethyl)vinyl phosphate, dimethylphosphono-N-hydroxymethyl-3-propionamide, tris(chloropropyl)phosphate, tris(2-butoxyethyl)phosphate, tris(2-chloroethyl)phosphate, tris(2-ethylhexyl)phosphate, tris(chloropropyl)phosphate, tetrakis(hydroxymethyl)phosphonium salts, such as tetrakis(hydroxymethyl)phosphonium chloride and tetrakis(hydroxymethyl)phosphonium sulfate, n-hydroxymethyl-3-(dimethylphosphono)-propionamide, urea phosphate, melamine pyrophosphate, a melamine salt of boron-polyphosphate, an ammonium salt of boron-polyphosphate, dicyandiamide pyrophosphate, triphenyl phosphite, ammonium dimethyl phosphate, fyroltex HP, melamine orthophosphate, ammonium urea phosphate, ammonium melamine phosphate, a urea salt of dimethyl methyl phosphonate, a melamine salt of dimethyl methyl phosphonate, a melamine salt of dimethyl hydrogen phosphite, polychlorinated biphenyls, a variety of alkyl diaryl phosphates and mixtures of monomeric chloroethyl phosphonates and high boiling phosphonates.

[0040] Metal hydroxide fire retardants include inorganic hydroxides, such as aluminum hydroxide, magnesium hydroxide, aluminum trihydroxide (ATH) and hydroxycarbonate.

[0041] Melamine-based fire retardants are a family of non-halogenated flame retardants that include three chemical groups: (a) melamine(2,4,6-triamino-1,3,5 triazine); (b) melamine derivatives (including salts with organic or inorganic acids, such as boric acid, cyanuric acid, phosphoric acid or pyro/poly-phosphoric acid); and (c) melamine homologues. Melamine derivatives include, for example, melamine cyanurate (a salt of melamine and cyanuric acid)), melamine-mono-phosphate (a salt of melamine and phosphoric acid), melamine pyrophosphate and melamine polyphosphate. Melamine homologues include melam (1,3,5-triazin-2,4,6-tri-amine-n-(4,6-diamino-1,3,5-triazine-2-yl), melem (2,5,8-triamino 1,3,4,6,7,9,9b-heptaazaphenalene) and melon (poly[8-amino-1,3,4,6,7,9,9b -heptaazaphenalene-2, 5-diyl]. Other melamine-based fire retardant compounds are set forth hereinabove.

[0042] Borate fire retardant compounds include zinc borate, borax (sodium borate), ammonium borate, and calcium borate. Zinc borate is a boron-based fire retardant having the chemical composition $x\text{ZnO}_y\text{B}_2\text{O}_3z\text{H}_2\text{O}$. Zinc borate can be used alone, or in conjunction with other chemical compounds, such as antimony oxide, alumina trihydrate, magnesium hydroxide or red phosphorous. It acts through zinc halide or zinc oxyhalide, which accelerate the decomposition of halogen sources and promote char formation.

[0043] Silicon-based materials include linear and branched chain-type silicone with (hydroxy or methoxy) or without (saturated hydrocarbons) functional reactive groups.

[0044] Phosphonic acid derivatives include phosphonic acid, ethylenediamine salt of phosphonic acid, tetrakis hydroxymethyl phosphonium chloride and n-methyl dimethylphosphono propionamide.

[0045] Examples of intumescent substances include, but are not limited to, ammonium polyphosphate, boric acid, chlorinated paraffin, DI-pentaerythritol, melamine, monoammonium phosphate, pentaerythritol, phosphate esters,

polytetrafluoroethylene, tributoxyethyl phosphate, triethyl phosphate, tris(2-ethylhexyl)phosphonate, urea, xylene and zinc borate.

[0046] Examples of powdered metal containing flame retardant substances, which can be employed alone or in combination with other flame retardant substances, include, but are not limited to, magnesium oxide, magnesium chloride, talcum, alumina hydrate, zinc oxide, zinc borate, alumina trihydrate, alumina magnesium, calcium silicate, sodium silicate, zeolite, magnesium hydroxide, sodium carbonate, calcium carbonate, ammonium molybdate, iron oxide, copper oxide, zinc phosphate, zinc chloride, clay, sodium dihydrogen phosphate, tin, molybdenum and zinc.

[0047] Examples of fire retardant substances that can be applied to the fibers also include boric acid, boron oxide, calcium borate, alumina trihydrate (alumina hydroxide), alumina carbonate, hydrated aluminum, aluminum hydroxide, antimony oxide, antimony trioxide, antimony pentoxide, sodium antimonate, magnesium trioxide, potassium fluorotitanate, potassium fluorozirconate, zinc oxide, hunite-hydromagnesite, ammonium octamolybdate, ammonium bromide, ammonium sulfate, ammonium carbonate, ammonium oxylate, barium metaborate, molybdenum trioxide, zinc hydroxystannate, sodium tungstate, sodium antimonate, sodium stannate, sodium aluminate, sodium silicate, sodium bisulfate, ammonium borate, ammonium iodide, tin compounds, molybdc oxide, sodium antimonate, ammonium sulfamate, ammonium silicate, quaternary ammonium hydroxide, aluminum tryhydroxide, tetrabromobisphenol A, titanium compounds, zirconium compounds, other zinc compounds, such as zinc stannate and zinc hydroxy-stannate, dioxins, diethyl phosphite, methylamine boron-phosphate, cyanoquanidine, thiourea, ethyl urea, dicyandiamide and halogen-free phosphonic acid derivatives.

[0048] The chemistry may be added to the fibers using application methods known to those skilled in the art. The flame retardant may be singular, or in combination with other finishing chemistries like antistats, lubricants, binders, antimicrobials, color, water and oil repellents, surfactants, and other chemical auxiliaries known to the art. Following the application of the chemistry, which may be done using water or other solvents as a vehicle for uniformly distributing the treatment, the substrate is centrifuged and dried. Exemplary application processes are disclosed in U.S. Pat. No. 7,736,696 to Tintoria-Piana, incorporated herein by reference in its entirety.

[0049] By way of example, a closed-loop system and process can be used for applying fire retardant chemicals to the fibers. The untreated fibers are first positioned in a vessel such as a dye machine, which circulates the fire retardant chemicals. The fire retardant chemicals may be in the form of a solution, a dispersion or emulsion. In some embodiments, the fire retardant chemicals are in the form of an aqueous solution. The fire retardant chemical solution, dispersions, emulsion or otherwise may be at room temperature or at an elevated temperature. In most embodiments, the fire retardant chemical solution, dispersions, emulsion or otherwise will be at a temperature from about 4° C. to about 100° C.; in other embodiments, from 20 to 50° C. and in still other embodiments, at about ambient temperature.

[0050] After absorption of the fire retardant composition on and/or into the fibers, non-absorbed fire retardant chemicals are recovered and re-used on subsequent batches of fibers. In some embodiments, the re-use of fire retardant chemicals can

take place in the same vessel that is used to treat successive batches of fiber. Alternatively, recovery can be achieved by directing the non-absorbed fire retardant composition into a second dye machine containing additional fibers, or by extracting the fire retardant composition by centrifugation or other means, or by a combination of the two processes. The treated fibers may then be rinsed and dried. Alternatively, the fire retardant may be applied to the fibers at a subsequent stage of manufacturing, e.g., after blending with the binder fibers or forming the non-woven web, or after the non-woven web has been pleated.

[0051] Advantageously with respect to applying a fire retardant to lyocell fibers, because of its high moisture absorption and fiber cross section, it has been discovered that the fire retardant can be selected to permeate substantially throughout the cross sectional fiber structure unlike many types of fibers where the fire retardant coats exposed surfaces with minimal or no impregnation of the fire retardant into the fiber core. In one embodiment, ammonium polyphosphate can be applied to the lyocell fiber and has been found to permeate substantially throughout a cross section of the lyocell fiber.

[0052] The batting from the treated fibers may be formed using one of several processes for converting a source of fiber into vertically oriented fibers as is generally known in the art. By way of example, the vertically oriented fibers can be formed as described in U.S. Pat. No. 5,702,801, incorporated herein by reference. In some embodiments, the peaks of the vertically oriented fibers in the batting material may be brushed or needle punched to improve the entwining of individual fibers of one peak into adjacent peaks. Adjacent peaks of vertically oriented fibers may be of substantially the same height, or alternatively may have different heights in a repeating pattern.

[0053] In some embodiments, the vertically oriented fibers can be in the form of pleats as discussed above. The pleats are formed from a cross laid non-woven web of fibers that can be less than 5 millimeters (mm) (i.e., about 0.2 inches) thick before pleating and in other embodiments, about 2 mm thick (e.g., a mattress approximately 2000 mm long can have about 500 pleats, each or two sheets). As previously described above, in most embodiments, the fibers are 0.25 to 4 inches long. During manufacture, once pleated, the pleated layer can be cross-needled to provide additional structural strength.

[0054] The pleating can provide a pleated layer having a thickness less than about 2 inches. By means of a carding process when the fibers are laid, greater than 75%, and greater than 90% in other embodiments of the fibers of the non-woven web are aligned substantially vertically oriented relative to the plane defined by an underlying mattress or cushioning article, for example.

[0055] As noted above, the non-woven web or the pleated layer can also include a binder fiber, which bonds the fibers to form a fiber mat. The binder fiber can be a bi-component fiber having a standard polyester core, e.g., having a melting point of about 250° C. within a low melting temperature polyester surround having a melting point of about 130° C. During manufacture, the non-woven web can be heat treated above the melting temperature of the fiber surround but beneath the temperature of the fiber core to cause the bi-component fibers to bind the fire retardant treated fibers. After pleating, the non-woven web can be cross-needled to enhance its strength. Optionally, the pleated layer may be cut during the manufacturing process as a result of the vertically lapped arrangement of fibers.

[0056] Flame retardant loading generally depends of the type of flame retardant and is generally at a loading of 13 to 20% based on a total weight of the fiber and the fire retardant.

[0057] Due to the vertical arrangement of the fibers in the pleated layer, when a load is applied to the cushioned article, e.g., mattress, the vertical arrangement of the fibers in the layer supports the load in a spring-like manner, compressing vertically to accommodate the shape of the load without flattening in the neighboring regions. In effect, the vertically oriented fibers, e.g., the vertically lapped formed pleats, act as vertical springs with cross needling to effect limited attachment between pleats but without causing pleats to flatten except under load. Moreover, when load is removed, the vertically oriented fibers readily recover its shape due to the independently spring-like nature of the vertically oriented fibers.

[0058] Advantageously, the vertically oriented fibers, e.g., vertically lapped formed pleats, have a low area density, which may result in lighter products and correspondingly less expensive manufacture and transport.

[0059] In order that the disclosure may be more readily understood, reference is made to the following examples, which are intended to illustrate the invention, but not limit the scope thereof.

EXAMPLES

Example 1

[0060] In this example, the fibers used to produce the vertically oriented fire retardant treated fiber batting product represented a blend of 70% ammonium polyphosphate treated lyocell with 30% low melt copolymer PET binder fiber. The fire retardant treated lyocell was treated via dye bath process under temperature and pressure to consistently load the fire retardant chemistry into the lyocell fiber.

Example 2

[0061] In this example, a batting material layer including a plurality of substantially vertically oriented flame retardant treated lyocell fibers 1 was formed. The flame retardant treated lyocell fibers of Example 1 were mixed low molecular weight polyester at a weight ratio of 70:30. Lyocell fibers used were 3 denier per filament (dpf)×2.5 inch cut length and were treated with ammonium polyphosphate. The low melt copolymer binder fiber was 4 dpf×2.5" cut length. The batting material had a basis weight of 1 ounce per square foot and was subjected to a fire test in accordance with 16 CFR Part 1633. The results provided with three samples are shown below in Table 3.

TABLE 3

Vertical Oriented Lyocell Fiber	Peak Heat Release Rate (kilowatts)	Time to Peak Heat (minutes)	Total Heat in 10 minutes (mega joules)
Test 1	38	0.5	4.3
Test 2	38	0.6	5.4
Test 3	41	0.5	6.7

[0062] The results shown above for the flame retardant treated lyocell fibers exceed the minimum requirements provided in 16 CFR Part 1633. For example, according to the standard applied to mattresses, the peak heat release cannot exceed 200 kilowatts and the total energy released in the first

ten minutes of the test cannot exceed 15 megajoules. As shown above, the peak heat release was 38-41 kilowatts, which is significantly less than 200 kilowatts; and the total energy released in the first ten minutes was 4.3 to 6.7, which is significantly less than the standard maximum of 15 megajoules.

Example 3

[0063] In this example, a comparison of moisture uptake was made between flame retardant treated lyocell fibers and untreated lyocell fibers. The flame retardant treated lyocell fibers were treated with ammonium polyphosphate via a dye bath process, rinsed, and dried. The fibers were exposed at room temperature to 55% and 98% relative humidity. The results are graphically shown in FIG. 5. As shown, there was no difference in moisture uptake between the treated and untreated lyocell fibers.

[0064] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to make and use the invention. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

1. A fire resistant batting material, comprising:
a layer having a top surface and a bottom surface, the layer comprising a plurality of substantially vertically oriented flame retardant treated fibers extending from the top surface to the bottom surface, wherein the substantially vertically oriented flame retardant treated fibers are fire retardant treated lyocell fibers having a substantially uniform fire retardant throughout a cross section thereof; and
a binder material, wherein the substantially vertically oriented flame retardant treated fibers are greater than 50 percent of the layer.
2. (canceled)
3. The fire resistant batting material of claim 1, wherein the lyocell fibers have an average length of 1.5 to 3.0 inches.
4. (canceled)
5. (canceled)
6. The fire resistant batting material of claim 1, wherein the fire resistant batting material has a basis weight of 5 to 18 ounces per square yard.
7. The fire resistant batting material of claim 1, wherein a loading of the fire retardant material of the substantially vertically oriented flame retardant fibers treated is in an amount effective to meet a flammability standard defined in 16 CFR Part 1633 (2007).
8. The fire resistant batting material of claim 1, wherein the fire retardant material of the substantially vertically oriented flame retardant treated fibers comprises halogenated compounds, phosphorous containing compounds, metal hydroxides, borates, silicon based compounds, melamine based compounds, phosphonic acid derivatives, intumescence compounds, and mixtures thereof.
9. The fire resistant batting material of claim 1, wherein the batting material has a thickness greater than 0.5 inches to 3 inches.
10. The fire resistant batting material of claim 1, wherein the substantially vertically oriented flame retardant treated lyocell fibers are treated with ammonium polyphosphate.
11. (canceled)
12. The fire resistant batting material of claim 1, wherein the substantially vertically oriented flame retardant treated fibers extending from the top surface to the bottom surface are in the form of pleats.
13. (canceled)
14. (canceled)
15. A mattress comprising the fire resistant batting material of claim 1.
16. A method of fire blocking an article, comprising:
combining layers comprising a fabric ticking, a layer of batting material, and an optional stitch backing layer, wherein the layer of batting material comprises a top surface, a bottom surface, a plurality of substantially vertically oriented flame retardant treated lyocell fibers extending from the top surface to the bottom surface, and a binder material;
sewing the layers together to form a composite; and
incorporating the composite into the article.
17. The method of claim 16, further comprising a foam layer intermediate the layer of batting material and the optional stitch backing layer.
18. (canceled)
19. (canceled)
20. The method of claim 16, wherein the layer of the batting material has a thickness of 0.5 to 3.0 inches.
21. The method of claim 16, wherein the layer of the batting material has a basis weight of 5 to 18 oz/yd².
22. The method of claim 16, wherein the composite is quilted.
23. The method of claim 16, wherein the fibers of the substantially vertically oriented flame retardant fibers have an average length of 0.5 to 3.0 inches.
24. The method of claim 16, wherein the fire retardant material of the substantially vertically oriented flame retardant fibers comprises halogenated compounds, phosphorous containing compounds, metal hydroxides, borates, silicon based compounds, melamine based compounds, phosphonic acid derivatives, intumescence compounds, and mixtures thereof.
25. The method of claim 16, wherein a loading of the fire retardant material in and/or on the substantially vertically oriented flame retardant treated is in an amount effective to meet the flammability standard defined in 16 CFR 1633 (2007).
26. The method of claim 16, wherein the substantially vertically oriented flame retardant treated fibers are greater than 50 percent of the layer.
27. The method of claim 16, wherein the binder material is a bi-component polyester having a surround melting point of less than 130° C.
28. The method of claim 16, wherein fire retardant treated lyocell fibers comprise ammonium polyphosphate.
29. The method of claim 16, wherein plurality of substantially vertically oriented flame retardant treated fibers extending from the top surface to the bottom surface are in the form of pleats.

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