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(54) KNIT TUBE FLAME RESISTANT BARRIERS

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(57) **ABSTRACT**

The invention relates to the use of a flame resistant knit tube, made with either a seamless or seamed circular knit or a seamed or tubular warp knit fabric, used to protect a mattress, foundation, upholstery cushion, pillow, office panel, transportation seat or any other article requiring flame resistant protection. In this invention, a tubular knit fabric is formed utilizing flame resistant yam and then optionally heat-set to prevent curling during subsequent cutting and processing. Heat-setting the knit fabric is especially preferred for circular knit constructions to prevent curling in subsequent processing. The knit tube is then cut to the length of the article to be flame protected, allowing enough additional length to sew a pocket closure on one end and a standard closure on the other end. First, one end of the tubular knit sock is sewn with a pocket closure seam, using a flame resistant thread or a suitable substitute. The open end of the tubular knit sock is then rolled up to the sewn pocket closure end so that it can be easily positioned over the article to be protected from flame. The rolled up knit sock is then unrolled down the length of the article to be flame protected. The second closure seam is then sewn with flame resistant thread, or a suitable substitute, over the open end of the article to completely encapsulate and protect the article. The invention has particular applicability in the formation of fire resistant foam mattresses and foundations that require passage of large open flame tests such as California's Test Bulletin 603 and Test Bulletin 129 and in the formation of fire resistant foam upholstery cushions that require passage of California's Test Bulletin 133 or British Standard 5852 using the crib 5 ignition source.

KNIT TUBE FLAME RESISTANT BARRIERS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 60/607,366, filed Sep. 7, 2004, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The invention relates to the use of a flame resistant knit tube, made with either a seamless or seamed circular knit or a seamed or tubular warp knit fabric, used to protect a mattress, foundation, upholstery cushion, pillow, office panel, transportation seat or any other article requiring flame resistant protection. In this invention, a tubular knit fabric is formed utilizing flame resistant yarn and then optionally heat-set to prevent curling during subsequent cuffing and processing. Heatsetting the knit fabric is especially preferred for circular knit constructions to prevent curling in subsequent processing. The knit tube is then cut to the length of the article to be flame protected, allowing enough additional length to sew a pocket closure on one end and a standard closure on the other end. First, one end of the tubular knit sock is sewn with a pocket closure seam, using a flame resistant thread or a suitable substitute. The open end of the tubular knit sock is then rolled up to the sewn pocket closure end so that it can be easily positioned over the article to be protected from flame. The rolled up knit sock is then unrolled down the length of the article to be flame protected. The second closure seam is then sewn with flame resistant thread, or a suitable substitute, over the open end of the article to completely encapsulate and protect the article. The invention has particular applicability in the formation of fire resistant foam mattresses and foundations that require passage of large open flame tests such as California's Test Bulletin 603 and Test Bulletin 129 and in the formation of fire resistant foam upholstery cushions that require passage of California's Test Bulletin 133 or British Standard 5852 using the crib 5 ignition source.

[0004] 2. Description of the Related Art

[0005] It is well known in the textile industry to produce fire resistant products for use in upholstered furniture, mattresses, foundations, automotive seating, public transportation seating, aircraft seating and the like, using needlepunched, highloft, spunbond or spunlace nonwoven or woven or conventional knit fabrics formed of natural or synthetic fibers, and then treating these fabrics with fire retarding chemicals. Conventional fire retarding (FR) chemicals include borate-based, halogen-based, phosphorus-based, melamine-based and/or antimony-based chemicals. Unfortunately, such treated fabrics are heavier than similar types of non-fire retardant fabrics, and have reduced wear life. Although FR chemically treated fabrics will self-extinguish and exhibit limited melt behavior when a flame is removed, they typically form brittle chars, shrink and crack open after exposure to a direct flame allowing the underlying materials to ignite. When fabrics made with FR treated cotton, FR polyester and other FR treated fabrics are used in composite articles such as upholstered furniture and mattresses and foundations, these composite article are usually deemed unsuited for passing the more stringent open flame tests such as: California Test Bulletin 133 (TB 133), California Test Bulletin 129 "Flammability Test Procedure for Mattresses for use in Public Buildings", October 1992 (TB 129), California Test Bulletin 603 (TB603), and British Standard 5852—Crib 5 (BS5 852) without the use of an additional flame barrier or FR backcoating materials.

[0006] Some of the flame barrier fabrics currently being used with the goal to pass the more stringent open flame tests, such as TB 129, TB 133 and TB603 include:

[0007] 1) A woven polymer coated 100% fiberglass flame barrier (Sandel® Fabric, Sandel International Inc.)

[0008] 2) A woven or knit core-spun yarn based flame barrier where natural and/or synthetic fibers are wrapped around a multifilament glass and/or a spun p-aramid core yarn and then optionally treated with FR chemicals and/or a coating of thermoplastic polyvinyl halide composition, such as polyvinyl chloride (Firegard® Seating Barriers, Intek; Firegard® Brand Products, Chiquola Fabrics, LLC, Alessandra FR barrier cloth, McKinnon-Land, LLC)

[0009] 3) A nonwoven hydroentangled spunlace flame barrier made of 100% p-aramid (Thermablock™ Kevlar® Z-11, DuPont Company)

[0010] 4) A nonwoven flame resistant highloft barrier made from blends of inherently FR or FR chemically treated fibers and fibers containing halogenated monomers (Protech™ FR Highloft, Carpenter Co.)

[0011] The disadvantages of the above mentioned flame baffler solutions for more stringent open-flame applications in upholstered furniture, mattress, foundations and other fiber-filled applications include:

[0012] a) Woven flame bafflers, especially when coated with FR materials, impart a stiff "hand" to the composite article, which negatively affect the feel of the final product.

[0013] b) Many woven, nonwoven and conventional knit flame barriers must be either laminated to the decorative fabric or double upholstered during manufacturing. This increases the number and complication of the dress cover fabrics, thereby increasing manufacturing costs.

[0014] c) 100% fiberglass flame bafflers have poor durability due to glass-to-glass abrasion.

[0015] d) Natural fiber wrapped core-spun yarn fabrics require additional FR chemical treatments and/or coatings of a thermoplastic polyvinyl halide composition, such as polyvinyl chloride to be effective in passing the more stringent open-flame tests. This negatively impacts the workplace by having to handle these chemicals and increases the exposure of chemicals to the consumer who uses the composite article.

[0016] e) Hydroentangled nonwoven spunlace flame barriers, containing significant amounts of p-aramid fibers, which impart a yellow color to the flame barrier and negatively effect the look of the composite article, especially when used directly under white or light-colored decorative upholstery and/or mattress ticking fabrics and are negatively affected by UV light.

[0017] f) Flame resistant highloft barrier fabric, although well suited for applications where fill power and bulk are desired characteristics, are a detriment in barrier applications where thin barrier materials are desired for increased manufacturing speed and/or aesthetic appeal.

SUMMARY OF THE INVENTION

[0018] To overcome or conspicuously ameliorate the disadvantages of the related art, it is an object of the present invention to provide a novel tubular knit flame barrier that is easily applied to articles for which flame resistant protection is desired. In its preferred usage in the present application, the term "flame barrier" means a product incorporated into or on top of a composite article that when tested with a composite type test method, such as: California Test Bulletin 129 (TB 129) or California Test Bulletin 603 (TB603) for mattresses and foundations and California Test Bulletin 133 (TB 133) for upholstered furniture, the flame barrier allows for the continued use of conventional materials such as dress cover fabrics, fiber-fillings and polyurethane foams, while still passing these stringent large open flame tests. It is understood by someone skilled in the art that flame bafflers made of the tubular knit flame barriers described in this invention, even at overall lower basis weights, can be made to pass less stringent open flame tests such California's Revised Test Bulletin 117 (TB 117—draft 02/02 version) and British Standard 5852.

[0019] In accordance with a first aspect of the invention, a fire resistant yarn is converted to a circular or warp knit fabric. The fire resistant yams include open-end, ring, air-jet, corespun or other spun yarn types; where the staple fibers in the yarn are selected so that the blended fibers have a Limiting Oxygen Index (LOI) of at least 22 (as measured by ASTM D 2863). The staple fibers selected for blending consist of one or more fiber types selected from the following two categories:

a) Inherently flame-retardant fibers such as;

[0020] melamine (i.e. BASOFIL by Basofil Fibers LLC), meta-aramids such as poly (m-phenylene isophthalamide), for example, those sold under the tradenames NOMEX by E. I. Du Pont de Nemours and Co., TEIJINCONEX by Teijin Limited and FENYLENE by Russian State Complex; para-aramids such as poly (p-phenylene terephthalamide), for example, that sold under the tradename KEVLAR by E. I. Du Pont de Nemours and Co., poly (diphenylether para-aramid), for example, that sold under the tradename TECINORA by Teijin-Twaron Limited, and those sold under the tradenames TWARON by Teijin-Twaron Limited and FENYLENE ST (Russian State Complex); polybenzimidazole such as that sold under the tradename PBI by Celanese AG, polyimides, for example, those sold under the tradenames P-84 by Inspec Fibers and KAPTON by E. I. Du Pont de Nemours and Co.; polyamideimides, for example, that sold under the tradename KERMEL by Argos Soditic; partially oxidized polyacrylonitriles, for example, those sold under the tradenames FORTAFIL OPF by Fortafil Fibers Inc., AVOX by Textron Inc., PYRON by Zoltek Corp., PANOX by SGL Technik, THORNEL by American Fibers and Fabrics and PYROMEX by Toho Rayon Corp.; novoloids, for example, phenol-formaldehyde novolac, for example, that sold under the tradename KYNOL by Gun Ei Chemical Industry Co.; poly (p-phenylene benzobisoxazole) (PBO), for example, that sold under the tradename ZYLON by Toyobo Co.; poly (p-phenylene benzothiazoles) (PBT); polyphenylene sulfide (PPS), for example, those sold under the tradenames RYTON by American Fibers and Fabrics, TORAY PPS by Toray Industries Inc., FORTRON by Kureha Chemical Industry Co. and PROCON by Toyobo Co.; flame retardant viscose rayons, for example, those sold under the tradenames LENZING FR by Lenzing A.G. and VISIL by Sateri Fibers Oy Finland, which is a viscose rayon that includes an aluminum silicate modified silica; polyetheretherketones (PEEK), for example, that sold under the tradename ZYEX by Zyex Ltd.; polyketones (PEK), for example, that sold under the tradename ULTRAPEK by BASF; polyetherimides (PEI), for example, that sold under the tradename ULTEM by General Electric Co.; Chloropolymeric fibers, such as those containing polyvinyl chloride or polyvinylidene homopolymers and copolymers, for example, those sold under the tradenames THERMOVYL L9S & ZCS, FIBRAVYL L9F, RETRACTYL L9R, ISOVYL MPS by Rhovyl S.A; PIVIACID, Thueringische; VICLON by Kureha Chemical Industry Co., TEVIRON by Teijin Ltd., ENVILON by Toyo Chemical Co. and VICRON, made in Korea; SARAN by Pittsfield Weaving, KREHALON by Kureha Chemical Industry Co. and OMNI-SARAN by Fibrasomni, S.A. de C.V.; and modacrylics which are vinyl chloride or vinylidene chloride copolymer variants of acrylonitrile fibers, for example, those sold under the tradenames PROTEX by Kaneka and SEF by Solutia; Fluoropolymeric fibers such as polytetrafluoroethylene (PTFE), for example, those sold under the tradenames TEFLON TFE by E. I. Du Pont de Nemours and Co., LENZING PTFE by Lenzing A.G., RASTEX by W.R. Gore and Associates, GORE-TEX by W.R. Gore and Associates, PROFILEN by Lenzing A.G. and TOYOFLON PTFE by Toray Industries Inc., poly (ethylene-chlorotrifluoroethylene) (E-CTFE), for example, those sold under the tradenames HALAR by Albany International Corp. and TOYOFLON E-TFE by Toray Industries Inc., polyvinylidene fluoride (PVDF), for example, those sold under the tradenames KYNAR by Albany International Corp. and FLORLON (Russian State Complex), polyperfluoroalkoxy (PFA), for example, those sold under the tradenames TEFLON PFA by E. I. Du Pont de Nemours and Co. and TOYOFLON PFA by Toray Industries Inc., polyfluorinated ethylene-propylene (FEP), for example, that sold under the tradename TEFLON FEP by E. I. Du Pont de Nemours and Co.; and combinations thereof.;

b) Non-flame-retardant fibers such as:

[0021] Cotton, wool, silk, mohair, cashmere, kenaf, jute, sisal, nylons, polyesters, polyolefins, rayons, lyocells, acrylics, cellulose acetates and polylactides, such as those available from fibers made with polylactide polymers from Cargill Dow Polymers; low-melt bicomponent polyesters, such as CELBOND sold by Kosa company; low melt copolyester fibers, typical "low-melt" fibers (polyester and polyolefins) used in the industry have melting points of 100 C to 210 C while standard polyester fiber melts at approximately 260 C; polypropylenes, such as T-1 51 as sold by Fiber Innovation Technology or by American Fibers and Yams Co.; and combinations thereof.

[0022] A flame resistant yarn with a cotton count between 2's to 50's is produced with fibers selected from the above

group and according to the Limiting Oxygen Index criteria described above. The flame resistant yarn is knitted into a circular or warp construction. A non-limiting list of specific knitting constructions that are applicable to this invention include; simplex tricot, double needle bar tricot, V bed, rib, interlock, double knit and jersey. Jersey knit constructions, that do not have seams and are suitable for this invention, can be made with flame resistant yarns that are converted into 6.5 ounces per square yard fabrics on knitting machines with diameters from 9 inches to 60 inches. The tubular jersey knit can then be heat-set to produce finished widths with controlled stretch. This is especially preferred for jersey, and other circular knits, that tend to curl when they are cut.

[0023] If a warp knit construction is utilized the fabric must be seamed with flame resistant thread, or a suitable substitute, to form a knit tube. The knit tube is then cut to the length of the article to be flame protected, allowing enough additional length to sew a closure seams to both ends of the tubular knit sock. First, one end of the tubular knit sock is sewn with a pocket closure seam, using a flame resistant thread. Then the open end of the sewn tubular knit sock is rolled up to the pocket closure end so that it can be easily positioned over the article to be protected from flame. The rolled up knit tube sock is then unrolled down the length of the article to be flame protected. A second closure seam is then sewn with a flame resistant thread, or a suitable substitute, over the open end of the article to completely encapsulate and flame protect the article. This invention has particular applicability in the formation of fire resistant foam mattresses and foundations that require passage of large open flame tests such as California's Test Bulletin 603 and Test Bulletin 129 and in the formation of fire resistant foam upholstery cushions that require passage of California's Test Bulletin 133 or British Standard 5852, crib 5.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

EXAMPLE I

[0024] A flame resistant corespun yarn (ALES SANDRA, by McKinnon Land LLC) is produced on a Murata air-jet spinning frame, consisting of a dual core of continuous filament fiberglass and continuous nylon yarn wrapped with a triblend sliver of modacrylic (PROTEX PBX), melamine (BASOFIL) and polyester staple fibers to form a corespun yarn with a yarn count of 15.5's.

[0025] The above formed corespun yarn is then knitted into a 6.95 ounce per square yard 1×1 rib knit construction and seamed together with p-aramid (Kevlar) thread to form a tubular shape. The tubular knit sock is then cut to the length necessary to cover a 7" thick all-foam twin size mattress, consisting of a 4" base of standard polyurethane foam and a 3" top layer of viscoelastic polyurethane foam and both ends of the mattress.

[0026] One end of the tubular knit sock is seamed together with p-aramid (KEVLAR) thread to form a pocket closure seam. The knit tube sock is rolled up from the open end to the pocket closure end and placed on one end of the all-foam mattress. The knit tube sock is then rolled down the all-foam mattress and the open end is then sewn closed with p-aramid (KEVLAR) thread.

[0027] The above constructed mattress was tested at Underwriters Laboratories (Northbrook, Ill.) according to California Test Bulletin 603. The Peak Rate of Heat Release was 55 KW (maximum allowable rate of heat release is 200 KW) and the Total Heat Release was 8.0 MJ (maximum allowable in first 10 minutes is 25 MJ). This test was considered a significant pass of CAL TB 603.

EXAMPLE II

[0028] A flame resistant corespun yarn (ALES SANDRA, by McKinnon Land LLC) is produced on a Murata air-jet spinning frame, consisting of a dual core of continuous filament fiberglass and continuous nylon yarn wrapped with a triblend sliver of modacrylic (PROTEX PBX), melamine (BASOFIL) and polyester staple fibers to form a corespun yarn with a yarn count of 15.5's.

[0029] The above formed corespun yarn is then knitted into a jersey knit fabric of 6.5 ounces per square yard on a 33 inch diameter knitting machines to produce a tubular fabric without a seam. The knit fabric is then heat-set to produce a roll of tubular fabric with controlled stretch that has minimum curl after cutting.

[0030] The tubular knit sock is then cut to the length necessary to cover a 7" thick all-foam twin size mattress, consisting of a 4" base of standard polyurethane foam and a 3" top layer of viscoelastic polyurethane foam and both ends of the mattress.

[0031] One end of the tubular knit sock is seamed together with p-aramid (KEVLAR) thread to form a pocket closure seam. The knit tube sock is rolled up from the open end to the pocket closure end and placed on one end of the all-foam mattress. The knit tube sock is then rolled down the all-foam mattress and the open end is then sewn closed with p-aramid (KEVLAR) thread.

[0032] If the above constructed mattress was tested at Underwriters Laboratories (Northbrook, Ill.) according to California Test Bulletin 603, it is believed that the results the test would be considered a significant pass of CAL TB 603.

What is claimed is:

1. A flame-resistant barrier material comprising a knitted tubular fabric formed from at least one flame resistant yarn.

2. The barrier material of claim 1, wherein the knitted tubular fabric is heat-set.

3. The barrier material of claim 1, wherein the knitted tubular fabric is a circular or warp knit fabric.

4. The barrier material of claim 1, wherein the flame resistant yarn is a core spun yarn.

5. The barrier material of claim 1, wherein the flame resistant yarn has a Limiting Oxygen Index (LOI) of at least 22 (ASTM D 2863).

6. The flam resistant barrier material of claim 1, wherein one end of the knitted tubular fabric is sewn shut using a flame resistant thread.

7. The flame resistant barrier material of claim 1, wherein the knitted tubular fabric is seamed or seamless.

8. The flame resistant barrier material of claim 1, wherein the flame resistant yarn is an open-end, ring, air-jet, core-spun or spun yarn.

9. The flame resistant barrier material of claim 1, wherein the knitted tubular fabric is of a simplex-tricot, double needle bar tricot, V bed, rib, interlock, double knit or Jersey construction.

10. The flame resistant barrier material of claim 1, wherein the flame resistant yarn is selected from the group consisting of melamine, meta and para-aramids, poly(diphenylether)p-aramid, polybenzimidazole, polyimides, polyamideimides, partially oxidized polyacrylonitriles, novoloids, poly(p-phenylene)benzobisoxazole, polyphenylene sulfide, flame resistant viscose rayons, polyethertherketones, polyketones, polyetherimides, chloropolymeric fibers, modacrylics, fluoropolymer fibers and mixtures thereof.

11. The flame resistant barrier material of claim 10, which further includes a non-flame resistant fiber.

12. The barrier material of claim 4, wherein the core spun yarn comprises a dual core of glass fiber filaments and nylon yarn wrapped with a triblend sliver of modacrylic, melamine and polyester staple fibers.

13. A method of making a flame resistant barrier material which comprises:

(a) forming at least one flame resistant yarn into a knitted tubular fabric;

(b) cutting the knitted tubular fabric to a desired length;

(c) optionally, heat-setting the tubular fabric; and

(d) sealing one end of the tubular fabric.

14. The method of claim 13, wherein one end of the knitted tubular fabric is sealed by sewing with a flame resistant thread.

15. The method of claim 13, wherein the knitted tubular fabric is a circular or warp knit fabric.

16. The method of claim 13, wherein the flame resistant yarn is a core spun yarn.

17. An article requiring flame resistant protection enclosed within the flame resistant barrier material of claim 1.

18. A mattress, foundation, upholstery cushion, pillow, office panel or transportation seat encapsulated within the flame resistant barrier material of claim 5.

19. A method of providing flame resistant protection to an article in need thereof which comprises:

preparing a knitted tubular fabric, sealing one end of the tubular fabric, surrounding the article to be protected with the tubular fabric, and sealing a remaining open end of the tubular fabric to encapsulate and protect the article.

20. The method of claim 19, wherein the article in need of fire resistant protection is a mattress, foundation, upholstery cushion, pillow, office panel or transportation seat.

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