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### PERSONAL PROTECTIVE VEST ASSEMBLY AND METHODS OF ASSEMBLING SAME

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#### Abstract

A personal protective vest assembly is described herein. The personal protective vest assembly includes a carrier vest including a front vest panel assembly adapted to overlay a chest of the wearer, a rear vest panel assembly adapted to overlay a back of the wearer, and a plurality of attachment straps removably coupled to the front vest panel assembly and the rear vest panel assembly. The front vest panel assembly includes a front vest panel body extending between a front vest upper portion and a front vest lower portion along a vertical axis and between opposing front vest side edges along a horizontal axis. The front vest panel body includes a forward facing outer surface including a pair of lower front vest fastening sections defined along the front vest lower portion orientated in a mirrored relationship along the vertical axis.

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## Background/Summary

CROSS REFERENCE TO RELATED APPLICATION [0001] This application claims priority to U.S. Provisional Patent Application Ser. No. 63/556,311, filed Feb. 21, 2024, the disclosure of which is hereby incorporated by reference in its entirety.

### FIELD OF THE INVENTION

[0002] This invention relates generally to personal protective vests including body armor panels.

### BACKGROUND OF THE INVENTION

[0003] At least some known personal protective vests include rigid ballistic panels that are sown into the vest to provide the wearer protection from small arms fire. These rigid ballistic panels do not allow for a freedom of movement that is desired by security personnel to provide additional comfort and flexibility, while providing a high level of safety protection.

[0004] The present invention addresses one or more of the aforementioned challenges.

### SUMMARY OF THE INVENTION

[0005] In one aspect of the present invention, a personal protective vest assembly is provided. The personal protective vest assembly includes a carrier vest including a front vest panel assembly adapted to overlay a chest of the wearer, a rear vest panel assembly adapted to overlay a back of the wearer, and a plurality of attachment straps removably coupled to the front vest panel assembly and the rear vest panel assembly. The front vest panel assembly includes a front vest panel body extending between a front vest upper portion and a front vest lower portion along a vertical axis and between opposing front vest side edges along a horizontal axis. The front vest panel body includes a forward facing outer surface, an interior facing outer surface, and an inner surface defining a front vest ballistic panel pocket therein. The forward facing outer surface includes a pair of lower front vest fastening sections defined along the front vest lower portion orientated in a mirrored relationship along the vertical axis, with each lower front vest fastening section including hook & loop fabric material extending from a corresponding front vest side edge towards a center of the front vest lower portion and including an interior edge spaced a distance from the corresponding front vest side edge and having a concave arcuate shape extending from an upper end of the front vest lower portion to a bottom edge of the forward facing outer surface. A flexible body armor panel is positioned within the front vest ballistic panel pocket and including a ballistic material panel including a plurality of layered material segments defined between a strike face and a wear face, each of the layered material segments including a different ballistic material.

[0006] In another aspect of the present invention, a carrier vest is provided. The carrier vest includes a front vest panel assembly adapted to overlay a chest of the wearer, a rear vest panel assembly adapted to overlay a back of the wearer, and a plurality of attachment straps removably coupled to the front vest panel assembly and the rear vest panel assembly. The front vest panel assembly includes a front vest panel body extending between a front vest upper portion and a front vest lower portion along a vertical axis and between opposing front vest side edges along a horizontal axis. The front vest panel body includes a forward facing outer surface and an interior facing outer surface. The forward facing outer surface includes a pair of lower front vest fastening sections defined along the front vest lower portion orientated in a mirrored relationship along the vertical axis, with each lower front vest fastening section including hook & loop fabric material extending from a corresponding front vest side edge towards a center of the front vest lower portion and including an interior edge spaced a distance from the corresponding front vest side edge and

having a concave arcuate shape extending from an upper end of the front vest lower portion to a bottom edge of the forward facing outer surface.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0008] FIG. 1 is a perspective view of a personal protective vest assembly including a carrier vest and body armor panels, according to an embodiment of the present invention;

[0009] FIG. 2 is a front view of the carrier vest shown in FIG. 1;

[0010] FIG. 3 is a rear view of the carrier vest shown in FIG. 1;

[0011] FIG. 4 is a left side view of the carrier vest shown in FIG. 1;

[0012] FIG. 5 is a right side view of the carrier vest shown in FIG. 1;

[0013] FIG. 6 is a top view of the carrier vest shown in FIG. 1;

[0014] FIG. 7 is a bottom view of the carrier vest shown in FIG. 1;

[0015] FIG. 8 is a front view of a portion of the carrier vest shown in FIG. 1;

[0016] FIG. 9 is a rear view of a portion of the carrier vest shown in FIG. 1;

[0017] FIG. 10 is a schematic view of attachment straps that may be used with the carrier vest shown in FIG. 1;

[0018] FIGS. 11-18 are perspective views of the personal protective vest assembly shown in FIG. 1;

[0019] FIGS. 19-22 are schematic views of a body armor panel that may be used with the personal protective vest assembly shown in FIG. 1;

[0020] FIGS. 23 and 24 are schematic cross-sectional views of the body armor panel shown in FIGS. 19-22;

[0021] FIG. 25 is a cross-sectional view of the body armor panel shown in FIG. 23;

[0022] FIG. 26 is a partial view of a strike face of the body armor panel shown in FIG. 23;

[0023] FIG. 27 is a partial view of a wear face of the body armor panel shown in FIG. 23;

[0024] FIGS. 28 and 29 are flowcharts illustrating a method of manufacturing the body armor panel;

[0025] FIG. 30 is a schematic view of a system used to manufacture the body armor panel; and

[0026] FIGS. 31-34 are schematic views of a brass mold and ballistic material panel assembly used to form the body armor panel.

[0027] Corresponding reference characters indicate corresponding parts throughout the drawings.

### DETAILED DESCRIPTION OF THE INVENTION

[0028] In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of various embodiments of the present invention. Also, common but well-understood elements that are useful or necessary in a commercially feasible embodiment are often not depicted in order to facilitate a less obstructed view of these various embodiments of the present invention. It will be apparent, however, to one having ordinary skill in the art that the specific detail need not be employed to practice the present invention. In other instances, well-known materials or methods have not been described in detail in order to avoid obscuring the present invention.

[0029] In general, the present invention describes a personal protective vest system that includes a soft-flexible armor panel that is inserted into a personal protective vest. In some embodiments, the personal protective vest system includes the Hyperline™ soft-flexible armor panel provided by

[0030] Referring to FIGS. **1-27**, in the illustrated embodiment, the present invention includes a personal protective vest assembly **10** that includes a wearable personal protective carrier vest **12** and one or more body armor panels **14** inserted into the carrier vest **12**. In some embodiments, the carrier vest **12** is configured to be worn by a person covering a portion of the person's torso. In other embodiments, the personal protective vest assembly **10** may include other wearable protective articles that cover other areas of a person's body such as, for example, wearable protective articles covering the lower body, arms, legs, and head.

[0031] In some embodiments, the carrier vest **12** includes the Hyper Concealable™ Carrier™ provided by Safe Life Defense™ (shown in FIGS. **1-18**). The carrier vest **12** is composed of: a main body fabric weighing less than: 0.39 lbs per square foot; a lightweight Velcro; the main garment (not including straps) contains materials that are overlapped and stitched or welded onto one another; and stitching composed of flatlock seams without overlapping materials. This carrier vest **12** uses materials and assembly methods to be as low profile as possible at only 0.03" thick. The carrier vest **12** includes the following features: Engineered specifically for Hyperline™ Soft Armor Panels; Incredibly thin: Only 0.03" thick; 12 point adjustable with Low Profile Ultrasonic Comfort Straps; Capable of being worn comfortably directly on the skin; DTF Ultra low profile non-itch tags; Water Resistant brushed polyester fabric; Flat Stitching.

[0032] In the illustrated embodiment, the carrier vest **12** includes a front vest panel assembly **16** and a rear vest panel assembly **18**. In some embodiments, the front vest panel assembly **16** may be removable coupled to the rear vest panel assembly **18** with a vest fastening assembly **20**. The vest fastening assembly **20** may include, for example, a Velcro™ assembly, a button assembly, and/or any suitable fasteners that allow the front vest panel assembly **16** to removable attach to the rear vest panel assembly **18**.

[0033] Each vest panel assembly **16, 18** includes an outer surface **22** and an interior facing outer surface **24** adapted to be positioned adjacent to the person's body with the carrier vest **12** worn by the person, and an inner surface **25** defining a ballistic panel pocket **26**. The ballistic panel pocket **26** is defined between the outer surface **22** and the interior facing outer surface **24**. The ballistic panel pocket **26** is sized and shaped to receive a body armor panel **14** therein such that the body armor panel **14** is positioned within the ballistic panel pocket **26**. In some embodiments, the interior facing outer surface **24** also includes a slot **28** defined along the interior facing outer surface **24** to provide access to the ballistic panel pocket **26** to insert and/or remove body armor panel **14**. A slot fastening assembly **30** may be defined along the slot **28** to allow the ballistic panel pocket **26** to be selectively sealed. The slot fastening assembly **30** may include, for example, a Velcro assembly, a button fastener assembly, and/or any suitable fasteners that allow the slot **28** and ballistic panel pocket **26** to be sealed.

[0034] In the illustrated embodiment, the front vest panel assembly **16** is adapted to overlay a chest of the wearer and the rear vest panel assembly **18** adapted to overlay a back of the wearer. The front vest panel assembly **16** includes a front vest panel body **400** extending between a front vest upper portion **402** and a front vest lower portion **404** along a vertical axis **406**, and between opposing front vest side edges **408** along a horizontal axis **410**. The front vest panel body **400** includes a forward facing outer surface **412**, an interior facing outer surface **414**, and an inner surface **25** defining a front vest ballistic panel pocket **26** therein. The front vest upper portion **402** defines a front vest upper width **416** of the front vest panel assembly **16** along the horizontal axis **410** and the front vest lower portion **404** defines a front vest lower width **418** of the front vest panel assembly **16** along the horizontal axis **410** that is larger than the front vest upper width **416**.

[0035] The forward facing outer surface **412** includes a pair of lower front vest fastening sections **420** defined along the front vest lower portion **404** and orientated in a mirrored relationship along the vertical axis **406**. Each lower front vest fastening section **420** includes hook & loop fabric material **422** (e.g., Velcro™) extending from a corresponding front vest side edge **408** towards a

center of the front vest lower portion **404**. Each lower front vest fastening section **420** includes an interior edge **424** that is spaced a distance from the corresponding front vest side edge **408** and has a concave arcuate shape extending from an upper end **426** of the front vest lower portion **404** to a bottom edge **428** of the forward facing outer surface **412** such that a lower end **430** of the interior edge **424** adjacent the bottom edge **428** of the forward facing outer surface **412** is closer to the center of the front vest lower portion **404** than a top end **432** of the interior edge **424**. The pair of lower front vest fastening sections **420** are orientated in a mirrored relationship along the vertical axis **406** such that a lower gap **434** is defined between the lower ends **430** of the opposing interior edges **424**, and an upper gap **436** is defined between the top ends **432** of the opposing interior edges **424** that is larger than the lower gap **434**.

[0036] The front vest upper portion **402** also includes opposing shoulder portions **438** defining an arcuate concave neckline **440**. The forward facing outer surface **412** includes a pair of opposing upper front vest fastening sections **442** defined along the front vest upper portion **402** and orientated in a mirrored relationship along the vertical axis **406**. Each upper front vest fastening section **442** includes hook & loop fabric material **422** extending across a corresponding shoulder portion **438** and including a bottom edge **444** extending from the neckline **440** to a corresponding front vest side edge **408** at a downward oblique angle such that an upper gap **446** is defined between the top ends of the opposing bottom edges **444** and a lower gap **448** is defined between the lower ends of the opposing bottom edges **444** that is larger than the upper gap **446**.

[0037] The front vest panel assembly **16** also includes a front vest central portion **450** having a smooth surface extending between each lower front vest fastening section **420** and each upper front vest fastening section **442**. In some embodiments, the front vest central portion **450** is coupled to the lower front vest fastening sections **420** and to the upper front vest fastening sections **442** via flat stitching formed along the interior edges **424** of the lower front vest fastening sections **420** and the bottom edges **444** of the upper front vest fastening sections **442**.

[0038] A first flexible body armor panel **14** is positioned within the front vest ballistic panel pocket **26** and includes a ballistic material panel including a plurality of layered material segments defined between a strike face and a wear face with each of the layered material segments including a different ballistic material. In some embodiments, the first flexible body armor panel **14** defines a perimeter shape that is substantially the same as a perimeter shape of the front vest panel body **400**.

[0039] In the illustrated embodiment, the rear vest panel assembly **18** includes a rear vest panel body **452** extending between a rear vest upper portion **454** and a rear vest lower portion **456** along the vertical axis **406**, and between a first rear vest side edge **458** and an opposing second rear vest side edge **460** along the horizontal axis **410**. The rear vest upper portion **454** defines a rear vest upper width **462** of the rear vest panel assembly **18** along the horizontal axis **410** and the rear vest lower portion **456** defines a rear vest lower width **464** of the rear vest panel assembly **18** along the horizontal axis **410** that is larger than the rear vest upper width **462**. In some embodiments, the rear vest upper width **462** is larger than the front vest upper width **416** of the front vest panel assembly **16**, and the rear vest lower width **464** is substantially equal in length to the front vest lower width **418**.

[0040] In the illustrated embodiment, the rear vest panel body **452** includes a rear vest forward facing outer surface **466** and a rear vest interior facing outer surface **468**. The rear vest panel body **452** also includes a rear vest inner surface **25** defining a rear vest ballistic panel pocket **26** therein. A second flexible body armor panel **14** is positioned within the rear vest ballistic panel pocket **26** and may include a ballistic material panel that is similar to the ballistic material panel of the first flexible body armor panel **14**. In some embodiments, the second flexible body armor panel **14** defines a perimeter shape that is substantially the same as a perimeter shape of the rear vest panel body **452**.

[0041] The rear vest forward facing outer surface **466** includes a lower rear vest fastening section **470** that is defined along the rear vest lower portion **456** and includes hook & loop fabric material

**422** extending from a top end **472** of the rear vest lower portion **456** to a bottom edge **474** of the rear vest forward facing outer surface **466**, and from the first rear vest side edge **458** to the opposing second rear vest side edge **460**.

[0042] The rear vest upper portion **454** also includes opposing rear vest shoulder portions **476** defining an arcuate concave rear vest neckline **478** therebetween. The rear vest forward facing outer surface **466** includes a pair of opposing upper rear vest fastening sections **480** defined along the rear vest upper portion **454** and orientated in a mirrored relationship along the vertical axis **406**. Each upper rear vest fastening section **480** includes hook & loop fabric material **422** extending across a corresponding rear vest shoulder portion **476** and including a bottom edge **482** extending from the rear vest neckline **478** to a corresponding rear vest side edge **458**, **460** at a downward oblique angle such that a rear vest upper gap **484** is defined between the top ends of the opposing bottom edges **482** and a rear vest lower gap **486** is defined between the lower ends of the opposing bottom edges **482** that is larger than the rear vest upper gap **484**.

[0043] The rear vest panel assembly **18** includes a rear vest central portion **488** having a smooth surface extending between the lower rear vest fastening section **470** and each of the upper rear vest fastening sections **480**. The rear vest central portion **488** is coupled to the lower rear vest fastening section **470** and to the upper rear vest fastening sections **480** via flat stitching formed along a top edge **490** of the lower rear vest fastening section **470** and the bottom edges **482** of the upper rear vest fastening sections **480**.

[0044] The vest fastening assembly **20** includes a plurality of attachment straps **492** that are removably coupled to the front vest panel assembly **16** and the rear vest panel assembly **18**. Each attachment strap **492** includes a pair of opposing fastening tabs **494** that each including hook & loop fabric material **422** defined along an outer surface to facilitate removable coupling the attachment strap **492** to the corresponding hook & loop fabric material **422** defined along the front vest forward facing outer surface **412** and the rear vest forward facing outer surface **466**. Each attachment strap **492** also includes a flexible section **496** including an elastic material extending between the opposing fastening tabs **494** to enable the wearer to adjust a width and overall fit of the carrier vest **12** around the wearer's body.

[0045] In the illustrated embodiment, the vest fastening assembly **20** includes a pair of upper attachment straps **498** that are removably coupled to a corresponding upper front vest fastening section **442** and a corresponding upper rear vest fastening section **480**. The vest fastening assembly **20** also includes two pairs of side attachment straps **500** with each pair of side attachment straps **500** removably coupled to the lower rear vest fastening section **470** and a corresponding lower front vest fastening section **420**. Each pair of side attachment straps **500** includes an upper side attachment strap **502** and a lower side attachment strap **504**. The lower side attachment strap **504** is positioned closer to a bottom of the carrier vest **12** than the upper side attachment strap **502**, and includes a length **506** defined between corresponding opposing fastening tabs **494** that is longer than a length **508** of the upper side attachment strap **502**.

[0046] By providing the forward facing outer surface **412** having opposing lower front vest fastening sections **420** with concave arcuate shape interior edges **424** and corresponding side attachment straps **500** including upper and lower side attachment straps **502**, **504**, the ability of the wearer to adjust the width and overall fit of the carrier vest **12** is improved.

[0047] In the illustrated embodiment, the body armor panel **14** includes an outer cover **32** that defines a panel assembly cavity **34** and a ballistic material panel assembly **36** that is positioned within the panel assembly cavity **34**. The outer cover **32** may include a 30 denier thermoplastic polyurethane laminated nylon fabric. In some embodiments, the body armor panel **14** includes a cross-sectional shape substantially similar to the cross-sectional shape of the corresponding vest panels **16**, **18**. In other embodiments, the body armor panel **14** may include any suitable cross-sectional shape to facilitate covering any portion of a person's body.

[0048] The ballistic material panel assembly **36** includes a plurality of layered material segments

**38, 40, 42, 44** defined between a strike face **46** and a wear face **48**, with each of the layered material segments **38, 40, 42, 44** including a different ballistic material. When positioned within the ballistic panel pocket **26** the strike face **46** is orientated near the outer surface **22** of the corresponding vest panel **16, 18** and the wear face **48** is orientated near the interior facing outer surface **24** of the corresponding vest panel **16, 18** such that the wear face **48** is closer to a person's body than the strike face **46** with the carrier vest **12** worn by the person.

[0049] In the illustrated embodiment, the plurality of layered material segments includes a first layered material segment **38** that includes a layer of a first ballistic material **50**, a second layered material segment **40** that is adjacent the first layered material segment **38** and includes a plurality of layers of a second ballistic material **52**, a third layered material segment **42** that is adjacent the second layered material segment **40** and includes a plurality of layers of a third ballistic material **54**, and a fourth layered material segment **44** that is adjacent the third layered material segment **42** and includes a plurality of layers of a fourth ballistic material **56**. The first layered material segment **38** defines the strike face **46** and the fourth layered material segment **44** defines the wear face **48**. A number of layers of the third ballistic material **54** is greater than a number of layers of the second ballistic material **52**, and a number of layers of the fourth ballistic material **56** is less than the number of layers of the third ballistic material **54**.

[0050] In some embodiments, as shown in FIG. **23**, the first layered material segment **38** includes a single layer of the first ballistic material **50**, the second layered material segment **40** includes four layers of the second ballistic material **52**, the third layered material segment **42** includes eight layers of the third ballistic material **54**, and the fourth layered material segment **44** includes four layers of the fourth ballistic material **56**. In other embodiments, each segment **38, 40, 42, 44** may include any suitable number of layers of corresponding ballistic material.

[0051] The first ballistic material **50** includes an ultra-high molecular weight polyethylene fiber based composite laminate having an Areal density of about between 226 g/m.<sup>sup.2</sup> and 240 g/m.<sup>sup.2</sup> including four single layers of unidirectional sheet cross plied at 90 degrees to each other and consolidated with a rubber based matrix. In some embodiments, the first ballistic material may include DSM Dyneema® HB50 with the first layered material segment **38** includes a single layer of DSM Dyneema® HB50.

[0052] The second ballistic material **52** includes an ultra-high molecular weight polyethylene fiber based composite laminate having an Areal density of about between 208 g/m.<sup>sup.2</sup> and 224 g/m.<sup>sup.2</sup> including six single layers of unidirectional sheet cross plied at 90 degrees to each other and consolidated with a rubber based matrix. In some embodiments, the second ballistic material may include DSM Dyneema® SB117 with the second layered material segment **40** including four layers of DSM Dyneema® SB117.

[0053] The third ballistic material **54** includes para-aramid unidirectional material including four plies of para-aramid unidirectional material cross-plied in 0°/90°/0°/90° configuration. In some embodiments, the third ballistic material **54** may include Barrday Advanced Material Solutions™ U611 with the third layered material segment **42** including eight layers of Barrday Advanced Material Solutions™ U611.

[0054] The fourth ballistic material **56** includes a woven and laminated material having an Areal density of about 516 g/m.<sup>sup.2</sup>. In some embodiments, the fourth ballistic material **56** may include Barrday Advanced Material Solutions™ FCKER1017160-01129 with the fourth layered material segment **44** including four layers of Barrday Advanced Material Solutions™ FCKER1017160-01129.

[0055] As shown in FIG. **24**, in some embodiments, the plurality of layered material segments includes the first layered material segment **38** including a single layer of the first ballistic material **50**, the second layered material segment **40** including six layers of the second ballistic material **52**, the third layered material segment **42** including six layers of the third ballistic material **54**, and the fourth layered material segment **44** including a plurality of layers of the third ballistic material **54**.

and a plurality of layers of the fourth ballistic material **56** positioned in an alternating layered arrangement such that each layer of the third ballistic material **54** is positioned between corresponding layers of the fourth ballistic material **56**. For example, the fourth layered material segment **44** may include four layers of the fourth ballistic material **56** interlaced with three layers of the third ballistic material **54** such that a top layer of fourth ballistic material **56** is adjacent a bottom layer of third ballistic material **54** of the third layered material segment **42**, and a bottom layer of fourth ballistic material **56** defines the wear face **48**.

[0056] In some embodiments, as shown in FIGS. **19-21**, the body armor panel **14** includes a cross-sectional shape defining a lower portion **70** and an upper portion **72** extending from the lower portion **70**. The upper portion **72** has a first width **74**, and the lower portion **70** has a second width **76** that is larger than the first width **74** of the upper portion **72**. The body armor panel **14** also has a pair of opposing side walls **78, 80** that extend from the lower portion **70** to the upper portion **72** at opposing oblique angles. The upper portion **72** also includes an arcuate surface **82** defined along a top edge **84** of the upper portion **72**. In other embodiments, as shown in FIG. **22**, the body armor panel **14** may include a substantially rectangular cross-sectional shape.

[0057] FIG. **28** is a flowchart illustrating a method **200** of manufacturing the body armor panel **14**. The method includes a plurality of steps. Each method step may be performed independently of, or in combination with, other method steps. In the illustrated embodiment, the method **200** includes positioning the ballistic material panel assembly **36** within a dual platen heated press including placing the layered material segments **38, 40, 42, 44** within the dual platen heated press such that the first layered material segment **38** defines the strike face **46**, the second layered material segment **40** is between the first layered material segment **38** and the third layered material segment **42**, and the fourth layered material segment **44** is adjacent the third layered material segment **42** and defines the wear face **48**.

[0058] The dual platen heated press is then operated to apply a heat process to the ballistic material panel assembly **36** including applying heat at a first temperature from the strike face **46**, applying heat at a different second temperature from the wear face **48**, and applying pressure to the ballistic material panel assembly **36** during the heat process. In some embodiments, the first temperature is between about 250 and 300° Fahrenheit and the second temperature is between about 150 and 225° Fahrenheit, with the applied pressure at about 80 psi.

[0059] The ballistic material panel assembly **36** is then removed from the dual platen heated press after a first predefined elapsed period of time. For example, in some embodiments, the first predefined elapsed period of time is about 1.5 minutes. The ballistic material panel assembly **36** is allowed to cool for a second elapsed period of time and then cut to a desired shaped. In some embodiments, the second predefined elapsed period of time is about 30 seconds.

[0060] In some embodiments, the Hyperline™ soft armor panel is constructed by layering ballistic material in a 0°/0° orientation in a layered material configuration from strike face to wear face including: 1 Layer—DSM Dyneema® HB50; 4 Layers—DSM Dyneema® SB117; 8 Layers—Barrday Advanced Material Solutions™ U611; and 4 Layers—Barrday Advanced Material Solutions™ FCKER1017160-01129. The layered materials are feed into a dual platen heated press that is used to apply heat at a temperature of 250-300 degrees Fahrenheit from the strike face layer. A temperature of 150-225 degrees Fahrenheit is applied from the opposite platen to the wear face layer. Pressure is applied during the heat process at no less than 80 psi. After a minimum of 1.5 minutes the press is released and the materials is removed from the machinery and is allowed to cure for a period of no less than 30 seconds. The armor packet may be consolidated in a full sheet from which shapes may be cut by using a multi ply cutter, precision rotary blade or die cutter, or, layers may be pre-cut into uniform shapes that are layered and consolidated using the above process.

[0061] The ballistic material panel assembly **36** is sealed inside an outer cover **32** including water resistant TPU material such as, for example, Brookwood™ Cover HST 30d. The TPU is sealed



using a High Frequency Ultrasonic Welding Machine. In some embodiments, the body armor panel **14** includes a High Frequency Weld (HFW) seal **58** about the perimeter of the ballistic material panel assembly **36** having a width of about 0.25 inches+/-0.25 inches, with a maximum gap **60** between the ballistic panel **36** and the HFW seal **58** of about 0.25 inches+/-0.2 inches, with an overcut **62** having a maximum allowable width equal to 0.5 inches. A thermal label with an adhesive backing is then applied to the wear face of the sealed ballistic panel.

[0062] FIG. **29** is a flowchart illustrating another method **300** of manufacturing the body armor panel **14**. FIG. **30** is a schematic view of a system **100** used to manufacture the body armor panel **14**. In the illustrated embodiment, the system **100** includes a fabric spreading and cutting machine **102**, a first industrial conveyor oven machine **104**, a hydraulic press machine **106**, a high frequency ultrasonic welding machine **108**, a second industrial conveyor oven machine **110**, and a belt press machine **112**. In method step **302**, the plurality of layered material segments are fed through the fabric spreading and cutting machine **102** and cut to predefined cross-sectional shapes to form a pre-cut, layered ballistic material panel assemblies **36**.

[0063] In method step **304**, a first heat treatment is applied to a pre-cut, layered ballistic material panel assembly **36** to increase a temperature of the ballistic material panel assembly to a predefined temperature. The first heat treatment may be applied to increase the temperature of the ballistic material panel assembly to the predefined temperature between about 150° and 190° Fahrenheit. For example, the pre-cut, layered ballistic material panel assembly **36** may be positioned within an industrial heat tunnel, i.e., the first industrial conveyor oven machine **104**, for a predefined period of time to increase the temperature of the ballistic material panel assembly to the predefined temperature between about 150° and 190° Fahrenheit. In some embodiments, applying the first heat treatment includes operating the industrial heat tunnel at an internal temperature between about 300° and 350° Fahrenheit, and positioning the ballistic material panel assembly within the heat tunnel for an elapsed heating time between about 1 minute and 2 minutes. For example, the first heat treatment may include feeding the pre-cut, layered ballistic material panel assembly **36** through the first industrial conveyor oven machine **104** operated with a heated environment of about 335° F. for 1 minute and 50 seconds. In some embodiments, a reflective adhesive vinyl sticker **86** is applied onto a top layer (i.e., the strike face **46**) of the ballistic material panel assembly **36** prior to the first heat treatment.

[0064] In method step **306**, a compression treatment is applied to the heated ballistic material panel assembly at a predefined pressure and a predefined period of time to form a hardened ballistic material panel assembly. For example, upon completion of the first heat treatment, the heated ballistic material panel assembly is removed from the first industrial conveyor oven machine **104** and positioned onto the hydraulic press machine **106**. The hydraulic press machine **106** is then operated to apply the compression treatment including applying a pressure between about 100 to 500 tons to the heated ballistic material panel assembly. The compression treatment may include, for example, applying a pressure between about 100 to 500 tons to the heated ballistic material panel assembly for a period of 30 seconds. In some embodiments, the compression treatment may include applying 200 tons of pressure to the heated ballistic material panel assembly for a period of 30 seconds to form a hardened ballistic material panel assembly.

[0065] In embodiments in which the reflective adhesive vinyl sticker **86** has been applied onto the strike face **46** of the ballistic material panel assembly **36** prior to the first heat treatment, the compression treatment embeds the reflective adhesive vinyl sticker **86** into the strike face **46** such that surface of reflective adhesive vinyl sticker **86** is substantially flush with the strike face **46** of the hardened ballistic material panel assembly.

[0066] In method step **308**, the hardened ballistic material panel assembly **36** is positioned within the outer cover **32** and the outer cover **32** is welded to form a perimeter seam about a perimeter of the hardened ballistic material panel assembly to seal the hardened ballistic material panel assembly within the outer cover to form a body armor panel **14**. For example, as shown in FIGS.

**29-34**, the upon completing the compression treatment, the hardened ballistic material panel assembly **36** may be positioned between two layers of pre-cut outer cover material (e.g., Brookwood™ Cover HST 30d) having a cross-sectional shape substantially similar to the hardened ballistic material panel assembly **36**, and placed on a bottom plate **114** of the high frequency ultrasonic welding machine **108**. A brass mold assembly **116** having cross-sectional shape substantially similar to the hardened ballistic material panel assembly **36** is positioned over a top layer of the pre-cut outer cover material such that the hardened ballistic material panel assembly **36** is positioned within a cavity **118** defined through the brass mold assembly **116**. A compressible insert **120** is then placed within the cavity **118** on top of the hardened ballistic material panel assembly **36** and outer cover **32**. The compressible insert **120** includes a thickness **122** such that a top surface **124** of the compressible insert **120** is spaced a vertical distance **126** above an upper surface **128** of the brass mold assembly **116** with the compressible insert **120** contacting the outer cover **32**. As shown in FIG. **34**, as a top plate **130** of the high frequency ultrasonic welding machine **108** is moved to contact the brass mold assembly **116**, the top plate **130** contacts the compressible insert **120** to cause the compressible insert **120** to compress and apply pressure onto the hardened ballistic material panel assembly **36** and outer cover **32** to force air trapped between the hardened ballistic material panel assembly **36** and outer cover **32** towards the perimeter of the outer cover **32** before the top plate **130** contacts the brass mold assembly **116**. Once the top plate **130** is in contact with the brass mold assembly **116**, the high frequency ultrasonic welding machine **108** is operated to weld a perimeter seam along the outer cover **32** via the brass mold assembly **116** to form a vacuum seal between the hardened ballistic material panel assembly **36** and the outer cover **32**. [0067] In some embodiments, the high frequency ultrasonic welding machine **108** is operated to seal the hardened ballistic material panel assembly **36** within a water resistance thermo-plastic packaging. The water resistance thermo-plastic packaging may include a semi-transparent thermo-plastic material such that the reflective adhesive vinyl sticker **86** is visible through the water resistance thermo-plastic outer cover. In some embodiments, the compressible insert **120** includes a Nomex® material positioned within the brass mold assembly **116**. As the high frequency ultrasonic welding machine **108** operates the top plate **130** to lower and contact the brass mold assembly **116**, the top plate **130** contacts the Nomex insert to apply pressure to the top layer of water-resistance material to remove air between top/bottom layers of material and the hardened ballistic material panel assembly **36** to facilitate eliminating air from the body armor panel **14**. The high frequency ultrasonic welding machine **108** then applies high frequency radio waves to water resistance material layers through brass mold assembly to form the perimeter weld to seal the hardened ballistic material panel assembly **36** within the water resistant outer cover packaging and form an air-tight seal. The air-tight seal facilitates maintaining the shape of the assembled panel. [0068] In another embodiment, the first heat treatment and the compression treatment are applied to only a portion of the plurality of the plurality of layered material segments **38**, **40**, **42**, **44**. For example, in some embodiments, the first heat treatment and the compression treatment are applied only to the first and second layered material segments **38**, **40** to form a partially hardened ballistic material panel assembly. The partially hardened ballistic material panel assembly is then layered onto the third layered material segment **42** and/or the fourth layered material segment **44** to form the completed ballistic material panel assembly, which is then placed within the outer cover **32** and into the high frequency ultrasonic welding machine **108** to weld the perimeter seam about the completed ballistic material panel assembly. [0069] In other embodiments, the first heat treatment and the compression treatment are applied only to the third layered material segment **42** and/or the fourth layered material segment **44** to form the partially hardened ballistic material panel assembly. The first and second layered material segments **38**, **40** are then layered on top of the partially hardened ballistic material panel assembly to form the completed ballistic material panel assembly prior to welding the outer cover **32** onto the completed ballistic material panel assembly.

[0070] In method step 310, a second heat treatment is applied to the body armor panel 14 to increase a temperature of the body armor panel 14 to a second predefined temperature. For example, after the hardened ballistic material panel assembly 36 has been welded within the outer cover 32 to form the sealed body armor panel 14, the sealed body armor panel 14 is then placed into the second industrial conveyor oven machine 110 for a predefined period of time to increase the temperature of the sealed body armor panel 14 to facilitate increasing a flexibility of the sealed body armor panel 14. The second industrial conveyor oven machine 110 is operated at a lower internal temperature than the first industrial conveyor oven machine 104.

[0071] In method step 312, a conditioning treatment is then applied to the heated body armor panel 14 to increase a flexibility of a conditioned body armor panel 14. For example, after the second heat treatment is completed, the heated body armor panel 14 is fed through a belt press machine 112 that includes a pair of opposing conveyor belt systems that form roller pairs of varying heights. As the heated body armor panel 14 is moved through the roller pairs the heated body armor panel 14 is moved through various vertical positions, thereby breaking-in the heated body armor panel 14 to increase the flexibility of the finished, conditioned body armor panel 14.

[0072] Obviously, many modifications and variations of the present invention are possible in light of the above teachings. The invention may be practiced otherwise than as specifically described within the scope of the appended claims.

[0073] Although specific features of various embodiments of the disclosure may be shown in some drawings and not in others, this is for convenience only. In accordance with the principles of the disclosure, any feature of a drawing or other embodiment may be referenced and/or claimed in combination with any feature of any other drawing or embodiment.

[0074] This written description uses examples to describe embodiments of the disclosure and also to enable any person skilled in the art to practice the embodiments, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the disclosure 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 language of the claims.

## Claims

1. A personal protective vest assembly comprising: a carrier vest including: a front vest panel assembly adapted to overlay a chest of the wearer; a rear vest panel assembly adapted to overlay a back of the wearer; and a plurality of attachment straps removably coupled to the front vest panel assembly and the rear vest panel assembly; the front vest panel assembly including a front vest panel body extending between a front vest upper portion and a front vest lower portion along a vertical axis and between opposing front vest side edges along a horizontal axis; the front vest panel body including a forward facing outer surface, an interior facing outer surface, and an inner surface defining a front vest ballistic panel pocket therein; the forward facing outer surface including a pair of lower front vest fastening sections defined along the front vest lower portion orientated in a mirrored relationship along the vertical axis; each lower front vest fastening section including hook & loop fabric material extending from a corresponding front vest side edge towards a center of the front vest lower portion and including an interior edge spaced a distance from the corresponding front vest side edge and having a concave arcuate shape extending from an upper end of the front vest lower portion to a bottom edge of the forward facing outer surface; and a first flexible body armor panel positioned within the front vest ballistic panel pocket and including a ballistic material panel including a plurality of layered material segments defined between a strike face and a wear face, each of the layered material segments including a different ballistic material.
2. The personal protective vest assembly of claim 1, wherein the front vest upper portion includes

opposing shoulder portions defining an arcuate concave neckline, the forward facing outer surface includes a pair of opposing upper front vest fastening sections defined along the front vest upper portion and orientated in a mirrored relationship along the vertical axis, each upper front vest fastening section including hook & loop fabric material extending across a corresponding shoulder portion and including a bottom edge extending from the neckline to a corresponding front vest side edge at a downward oblique angle.

**3.** The personal protective vest assembly of claim 2, wherein the front vest panel assembly includes a front vest central portion having a smooth surface extending between each lower front vest fastening section and each upper front vest fastening section.

**4.** The personal protective vest assembly of claim 2, wherein the rear vest panel assembly includes: a rear vest panel body extending between a rear vest upper portion and a rear vest lower portion along the vertical axis and between a first rear vest side edge and an opposing second rear vest side edge along the horizontal axis; the rear vest panel body including a rear vest forward facing outer surface and a rear vest interior facing outer surface; and the rear vest forward facing outer surface including a lower rear vest fastening section defined along the rear vest lower portion including hook & loop fabric material extending from a top end of the rear vest lower portion to a bottom edge of the rear vest forward facing outer surface and from the first rear vest side edge to the opposing second rear vest side edge.

**5.** The personal protective vest assembly of claim 4, wherein the rear vest panel body includes a rear vest inner surface defining a rear vest ballistic panel pocket therein, the carrier vest includes a second flexible body armor panel positioned within the rear vest ballistic panel pocket.

**6.** The personal protective vest assembly of claim 4, wherein the rear vest upper portion includes opposing rear vest shoulder portions defining an arcuate concave rear vest neckline, the rear vest forward facing outer surface includes a pair of opposing upper rear vest fastening sections defined along the rear vest upper portion and orientated in a mirrored relationship along the vertical axis, each upper rear vest fastening section including hook & loop fabric material extending across a corresponding rear vest shoulder portion and including a bottom edge extending from the rear vest neckline to a corresponding rear vest side edge at a downward oblique angle.

**7.** The personal protective vest assembly of claim 6, wherein the rear vest panel assembly includes a rear vest central portion having a smooth surface extending between the lower rear vest fastening section and each of the upper rear vest fastening sections.

**8.** The personal protective vest assembly of claim 6, wherein the plurality of attachment straps includes a pair of upper attachment straps removably coupled to a corresponding upper front vest fastening section and a corresponding upper rear vest fastening section.

**9.** The personal protective vest assembly of claim 8, wherein the plurality of attachment straps includes two pairs of side attachment straps, each pair of side attachment straps removably coupled to the lower rear vest fastening section and a corresponding lower front vest fastening section.

**10.** The personal protective vest assembly of claim 9, wherein each pair of side attachment straps includes an upper side attachment strap and a lower side attachment strap, the lower side attachment strap positioned closer to a bottom of the carrier vest than the upper side attachment strap and including a length that is longer than a length of the upper side attachment strap.

**11.** The personal protective vest assembly of claim 1, wherein each attachment strap includes a pair of opposing fastening tabs each including hook & loop fabric material defined along an outer surface and a flexible section including an elastic material extending between the opposing fastening tabs.

**12.** A carrier vest comprising: a front vest panel assembly adapted to overlay a chest of the wearer; a rear vest panel assembly adapted to overlay a back of the wearer; and a plurality of attachment straps removably coupled to the front vest panel assembly and the rear vest panel assembly; the front vest panel assembly including a front vest panel body extending between a front vest upper portion and a front vest lower portion along a vertical axis and between opposing front vest side

edges along a horizontal axis; the front vest panel body including a forward facing outer surface and an interior facing outer surface; the forward facing outer surface including a pair of lower front vest fastening sections defined along the front vest lower portion orientated in a mirrored relationship along the vertical axis; each lower front vest fastening section including hook & loop fabric material extending from a corresponding front vest side edge towards a center of the front vest lower portion and including an interior edge spaced a distance from the corresponding front vest side edge and having a concave arcuate shape extending from an upper end of the front vest lower portion to a bottom edge of the forward facing outer surface.

**13.** The carrier vest of claim 12, wherein the front vest upper portion includes opposing shoulder portions defining an arcuate concave neckline, the forward facing outer surface includes a pair of opposing upper front vest fastening sections defined along the front vest upper portion and orientated in a mirrored relationship along the vertical axis, each upper front vest fastening section including hook & loop fabric material extending across a corresponding shoulder portion and including a bottom edge extending from the neckline to a corresponding front vest side edge at a downward oblique angle.

**14.** The carrier vest of claim 13, wherein the front vest panel assembly includes a front vest central portion having a smooth surface extending between each lower front vest fastening section and each upper front vest fastening section.

**15.** The carrier vest of claim 13, wherein the rear vest panel assembly includes: a rear vest panel body extending between a rear vest upper portion and a rear vest lower portion along the vertical axis and between a first rear vest side edge and an opposing second rear vest side edge along the horizontal axis; the rear vest panel body including a rear vest forward facing outer surface and a rear vest interior facing outer surface; and the rear vest forward facing outer surface including a lower rear vest fastening section defined along the rear vest lower portion including hook & loop fabric material extending from a top end of the rear vest lower portion to a bottom edge of the rear vest forward facing outer surface and from the first rear vest side edge to the opposing second rear vest side edge.

**16.** The carrier vest of claim 15, wherein the rear vest upper portion includes opposing rear vest shoulder portions defining an arcuate concave rear vest neckline, the rear vest forward facing outer surface includes a pair of opposing upper rear vest fastening sections defined along the rear vest upper portion and orientated in a mirrored relationship along the vertical axis, each upper rear vest fastening section including hook & loop fabric material extending across a corresponding rear vest shoulder portion and including a bottom edge extending from the rear vest neckline to a corresponding rear vest side edge at a downward oblique angle.

**17.** The carrier vest of claim 16, wherein the rear vest panel assembly includes a rear vest central portion having a smooth surface extending between the lower rear vest fastening section and each of the upper rear vest fastening sections.

**18.** The carrier vest of claim 16, wherein the plurality of attachment straps includes a pair of upper attachment straps removably coupled to a corresponding upper front vest fastening section and a corresponding upper rear vest fastening section.

**19.** The carrier vest of claim 18, wherein the plurality of attachment straps includes two pairs of side attachment straps, each pair of side attachment straps removably coupled to the lower rear vest fastening section and a corresponding lower front vest fastening section.

**20.** The carrier vest of claim 19, wherein each pair of side attachment straps includes an upper side attachment strap and a lower side attachment strap, the lower side attachment strap positioned closer to a bottom of the carrier vest than the upper side attachment strap and including a length that is longer than a length of the upper side attachment strap.

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