Materials for Making Disposable Protective Hoods

Conventional disposable protective hoods are commonly made of plastic film laminates, Tyvek sheets or nonwoven fabrics for their barrier functionality and low cost.

1. Plastic Films are the best material in shielding against corrosive chemicals and organic solvents with their chemical inertness and absolute imperviousness to liquids. The film laminates on textile are used for making heavy-duty hazmat suits. Laminates with nonwoven backing, having low strength against tearing and puncturing, are used for disposable protective apparel.


   The protective hoods made of film laminates are impervious to air, so they have to be equipped with an air-fed system. They are bulky, inconvenient and expensive for many daily jobs.

2. Tyvek Sheets, like plastic film laminates, are chemically inert and impervious to liquids. They are used to make disposable coveralls since they cost less than nonwoven laminates. Tyvek sheets have a moisture vapor transmission rate (MVTR) of less than 500 ml/m²/24 hours. However, the term “Breathable” used to describe their structure can be misleading. Such low volume of transmittable air is not adequate for human breathing since the average human respiratory rate requires at least 5 liters/minute.

   Tyvek hoods are unbearably hot to wear. Without being equipped with an air-fed system, it can cause uncomfortable anxiety, dizziness, and exhaustion from the buildup of heat and humidity. The design of exposing the wearer’s face is most likely to avoid suffocation accidents.

3. Spunmelt Nonwovens Fabrics are the best material for achieving a balance between “breathability” and “barrier functionality”. Their dense fiber-composite structures have ultrafine intertexture openings for air to flow through while providing particle filtration quality. Spunmelt nonwovens made of polypropylene (PP) fibers are commonly used for making face masks, surgical gowns, and disposable coverall suits.



   At room temperature, polypropylene fibers are stable and resistant to non-oxidizing acids and bases, fats and most organic solvents. Polypropylene nonwoven fabrics are recognized as a Class 1 flammability material which was determined by having a burn time of less than 3.5 seconds when subjected to a flame test. They do not catch fire and are acceptable for making disposable apparel. However, head coverings made of spunmelt nonwovens are too stiff to fit well even when incorporated with elastic components. Consequently, nonwoven hoods are not popular.

4. Cotton Knitted Fabrics: spray socks are used as an alternative in a few applications such as spray painting. However, their porous structure allows particles or drips to penetrate through them.

   Most spray socks are made from low-grade, un-scoured cotton, which some overseas manufacturers treat with formaldehyde to inhibit microbes. This makes them harmful for skin contact and highly flammable.

5. VitaFlex's Latex-free Elastic Nonwoven Fabrics are the breakthrough material that gives an elastic structure which enables the making of protective hoods that are soft and stretchy to fit comfortably and securely on the wearer's head. When stretched, the intertexture fibers of the elastic fabrics shift position, but do not create pin holes, maintaining the breathable barrier functionality of nonwovens.

   By combining different types of elastic nonwovens in a multi-layer structure, our soft-stretch hoods have been created with specific functionality such as blocking micron-sized particles (asbestos, silica, and glass fibers), bacteria, paint overspray, fluid or blood splashes, and UV rays. They also provide a physical barrier against scratches.

Latex-free Elastic Nonwovens

Revolutionary Materials for Making Soft-stretch Hoods

Spunmelt Polypropylene Nonwoven Fabrics are made by extruding polypropylene chips through a spinneret block to draw fine filaments of 1-50 um diameters and layering them on a collecting belt to form the nonwoven fabric. The ultrafine openings of their thin, yet dense fiber-composite structure allow for air to flow through while maintaining particle filtration quality.

Our Patented technology is a unique process that transforms regular, stiff nonwovens into soft and cross-stretch elastic fabrics without incorporating latex or other elastomers. By using our elastic fabrics, many protective apparels can be made form-fit without attaching elastic components. This allows the manufacturing process to be fully automated for mass production (low cost) and greatly reducing contamination (less human touches).

The Development of Soft-stretch PPE-Hoods

The basis weight (gram per square meter or ounce per square yard) is a common measurement for nonwovens expressing the amount of fiber weight per unit area. At a specific basis weight, a fabric composed of finer fibers will have a higher fiber count per square meter, which results in a higher filtration rate with a thinner structure. At a required filtration rate, the thinnest fabric or the fabric having the highest breathability is the most desirable.

The uniformity of nonwovens is a common concern which can be visually observed by the many sparse spots on the fabric, especially for basis weight below 20 gram/m² (0.62 oz/yd²). We source our precursor nonwovens from advanced manufacturing lines having multiple spinning stations that can create a multiple layer composite structure. That plus our multi-layer quilted construction enhances our hoods' uniformity.

Nonwovens' Static Surface constantly attracts particles from the air. There is serious concern with conventional nonwoven apparel and drapes regarding contamination from many hours of exposure during a manufacturing process involving manual cut-and-saw and assembling. On the contrary, the manufacturing and packing of our hoods are done in the same room and completed within 5 minutes. Throughout these processes, our hoods remain on bench top 27" above the floor. The chance of contamination is greatly reduced.

Our hoods are designed to cover the entire head, face and neck. They have ample space and a breathable surface which allows for dissipation of exhaled air. This allows for comfortable breathing and also reduces goggle fogging. The design of our full-cover hood forms an air-pocket around the nose and mouth. If worn properly with goggles that fit the wearer's face (seals around the nose and presses firmly on the nose bridge), our hoods can serve as a facemask for respiratory protection.

Although there are no regulations or specifications from any agencies for head coverings certification, the **FDA guiding principles for surgical masks** were followed throughout the development process of our

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hoods. The three basic barrier properties, described below, are particle filtration efficiency (PFE), breathing resistance (ΔP), and blood penetration resistance.

The Particle Filtration Efficiency (PFE) is the percentage (%) of particles blocked by a filter media at a specified air-flow volume. Some of common particles are listed below.

Particle	Particle size
Corona Virus	0.08 - 0.12 µm
Respiratory Droplet	0.2 - 100 µm
Asbestos Fiber	0.7 - 100 µm
Paint Pigment	0.1 5 µm
Flower Pollen	6 - 20 µm
Respirable Silica Dust	0.3 - 15 µm
Glass Fiber	1 - 1000 µm
Bacterium	0.5 - 10 µm
Mold Spore	10 - 30 µm

Respirable particles of 1 to 15 µm are considered industrial health concerns. Generally, smaller particles have higher penetration rate through a filter. For example, a filter blocking 90% of 5- µm particles can only filter 70% of 1 µm. However, when the PFE is tested at a flow rate of 28.3 L/min (as per ASTM F2299), sub-micron particulates are charged and more easily trapped on mask fibers. Consequently, a surgical mask having PFE of 95% against 1-µm particulates can block 99% of 0.1 µm. Therefore, the PFE against 1-µm is an adequate filtration indicator for masks and head coverings. Since normal breathing is only 8 L/min and the PFE of surgical masks are tested at a three-time higher flow rate (28.3 L/min), any mask blocking 90% 1- µm should be able to block 99% of a particle mix of 1-15 µm in a work environment.

Regarding coronavirus, a nano-sized virus (0.05-0.12 micron) rarely floats in individual form. Even so, a few copies of an airborne virus are unlikely to trigger infection. It requires tens of copies of a virus to swamp a spot on a cell and enable penetration of the membrane and initiation of infection. Airborne transmission of Ebola and Covid-19 from infected passengers in air travel didn't happen. The facts seem to indicate that the long-distance air transmission rarely carries a critical mass capable of triggering an infection.

In fact, the most common threat from many communicable diseases is micron to mm-sized saliva droplets (expelled from talking, coughing, and sneezing) that often carry millions of virus and bacteria. Even though a facemask can block these airborne droplets from short-distance blasts, it only covers half the wearer's face. These infectious substances fall on the hair and skin as well as environmental surfaces and allow contact transmission to occur when people touch such contaminants and subsequently touch their nose or mouth.

Therefore, the best practice in infection-risk situations or highly dusty work environments is to wear a hood covering the entire head, face, and neck all the time.

Keeping Heads Cool was a major criterion when we developed the soft-stretch hoods to be worn for extended periods of time. Otherwise, a high PFE can be easily achieved by simply making the hood thick enough. **An indicator of breathability** is to measure the differential pressure (ΔP, mm H_2O/cm^2) across the hood structure at an air flow rate of 8 liters per minute (L/min) according to test method MIL-M-36954C. The 8 L/min was selected because it is close to the air flow rate of normal breathing. FDA guidance on surgical masks states that the wearer will feel hot when wearing a mask having a ΔP of more than 5. As a matter of fact, the wearer would also experience breathing difficulty at any higher ΔP. Therefore, our soft-stretch hoods are constructed with a ΔP less than 5.

For the first few seconds of wearing our hoods, the face might feel warm since it is shielded from ambient airflow. However, the wearer should feel cool and comfortable in extended wearing due to the low ΔP of the hood's structures allowing perspiration vapor to escape through it. There is no unbearable heat or humidity build up inside the hood. Please note: People would feel hot with or without a hood when working in a confined space, without air circulation, or the ambient temperature higher than body temperature (96.8 °F).

The disposable coveralls have been popular in shielding against contaminants in workplaces. Workers' bodies often come in contact with or are held tightly against work objects. To isolate contaminants in liquid or viscous forms, the disposable coveralls need to be made of Tyvek or membrane-laminated or coated nonwoven fabrics to create impermeability. These materials are not breathable and make the wearers hot. **On the contrary**, healthcare workers' heads and faces rarely ever contact work objects; rather, their heads always stay at a higher position and at a distance. Since heads are more sensitive to heat and humidity, the materials used for making the hoods should be different from that of the body covering. It should have good breathability and need less liquid impermeability.

Synthetic Blood Penetration Test ASTM F1862 was used to qualify our Biosafety hoods as level 1 and 2 barriers against blood splashes (at a distance of one foot and velocities corresponding to a human blood pressure of 80 and 120 mm Hg). Please note**:** nonwoven fiber-web structures are not water-proof and can be wetted through by detergents, pressurized liquids, high viscosity solutions and alcohol or other organic solvents.

By combining different types of elastic nonwoven fabrics into multi-layer structures, a series of innovative soft-stretch PPE Hoods have been developed with various combinations of functionalities.

	Sot-stretch Hairnet	General Safety Dust Hood/Spray Hood	UV-Shield Black Hood/Silver Hood	Biosafety Hood
Structure	1-layer: SMS 24 gsm	3-layer: S/SMS/S 55 gsm	3-layer: S/S/S 60 gsm	3-layer: SMS/SS/SMS 70 gsm
Intended Use	Contamination Control	Primary Head Protection	Outdoor Primary Head Protection	Biohazard Prevention
Thickness	0.12 mm	0.30 mm	0.35 mm	0.45 mm
ΔP (mm H^2O/cm^2) MIL-M-36954C	< 1.5	< 2.5	< 3	3.5
Breathability/Perception	Normal/ Very Cool	Normal/ Very Cool	Normal/Cool	Normal/Cool
Hydrostatic (cm H^2O) AATCC Test Method 127	14	20/26	22/28	32
Particle Filtration Efficiency @ 1 µm ASTM F2299	-	75	80	> 90
UVA/UVB Block % AATCC TM 183	-	-	> 98.1/98.5	-
Particle Shed Analysis Helmke Drum Particle Counts	585 of ≥0.3 µm	2,240 of ≥0.3 µm	-	1,850 of ≥0.3 µm
Synthetic Blood Penetration Resistance ASTM F1862	-	-	-	Pass at 80 mmHg (10.7 kPa)

*The physical properties and test results mentioned above represent typical values of **the fabric structure of soft-stretch hoods**. These values should not be considered as specification or certificate of material and or specification values.*

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