

The Lack of PPE for Primary Head Protection

The incidents of healthcare workers contracting the Ebola virus disease while caring for an infected patient have revealed the inadequacy of existing personal protective equipment (PPE) for primary head protection.

In fact, inadequate and improper primary head protection has been a problem in the work place as illustrated by the photos posted on numerous companies' websites and on the internet.

- Emergency responders wear only a face mask when conducting disaster site inspections.
- Some healthcare workers wear a face mask and goggles when treating patients with infectious diseases.
- Many workers wear a baseball cap and a mask in spraying paints, cutting concrete or materials recycling.



There is serious risk from harmful substances falling on a worker's head. Some can be absorbed through skin contact. Some are carried on the worker's hair and subsequently inhaled.

PPE should fit comfortably, encouraging worker use. However, the commonly used hooded nonwoven suit has been criticized by users for its stiffness and severely restricting the wearer's head movement and mobility. It also leaves the neck and face skin exposed. While working, the coverall hood easily pulls away from the wearer's face. Usually, duct tape was used to attach it to a respirator or face shield since there was no alternative.

Of greater concern is the removal of the coverall hood as the first step in the doffing procedure. After the hood is removed, the wearer's head is immediately exposed to the contaminants accumulated on the suit which defeats the intended protection purpose.



Materials for Making Disposable Protective Hoods

To comply with OSHA requirements, Personal Protective Equipment (PPE) is worn to minimize exposure to harmful substances and reduce workplace injuries and illnesses. Disposable protective hoods are a type of PPE. They are made from plastic film laminates, Tyvek sheets or nonwoven fabrics for their barrier functionality and low cost.

1. Plastic film laminates are used for making heavy-duty hazmat suits. Their absolute imperviousness to liquids and chemical inertness are effective in shielding against corrosive chemicals and organic solvents. The protective hoods are air-tightly connected with a face shield. Because plastic film laminates are impervious to air, the hoods have to be equipped with an air-fed system.
2. Tyvek sheets, like plastic film laminates, are impervious to liquids and chemically inert. They are used to make light-duty hazmat suits because their protection against puncture or abrasion is minimal.



Tyvek sheets are called “breathable material” by having a moisture vapor transmission rate (MVTR) of 5-10 liters/m²/24 hours tested at 100F°. 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 not designed to cover the wearer’s face, most likely to avoid suffocation accidents. 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.

3. Nonwovens are the best material for achieving a balance between “breathability” and “barrier functionality”. Their dense fiber-web structures have ultrafine intertexture openings for air to flow through while maintaining particle filtration quality.



Spunmelt nonwovens made of polypropylene (PP) fibers are popularly used for making protective articles including face masks, surgical gowns and coverall suits for shielding against airborne particles and droplets. At required filtration efficiency, the thinnest fabric is desirable for comfortable breathability. However, a common problem of spunmelt nonwovens is their poor uniformity 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). In making protective apparel, the uniformity defect is usually mitigated by increasing basis-weight (thickness). The adding thickness inhibits air flow which reduces breathability.

Nonwoven fabrics are stiff. When making nonwoven hoods barrier functional, the high basis weight material is too stiff to fit well even when incorporated with elastic components. Consequently, nonwoven hoods are not popular in industrial settings.

4. Cotton spray socks are used as an alternative in a few applications such as spray painting. However, they are **not qualified as protective equipment** because their **porous knitted structure allows particles or drips to penetrate through them**. Most of them are made from low-grade, un-scoured cotton which is also highly flammable.



VitaFlex Offers A Practical and Low-Cost Solution

5. Our latex-free elastic nonwoven fabrics are an innovative and unique material that gives a breathable, soft and stretchy structure. They allow the hoods to conform to the contours of the wearer’s face which provides a cool, comfortable form-fit.

Our patented nonwoven elastication technology creates a wide range of soft and cross-stretch elastic fabrics from these spunmelt nonwovens without adding latex or other elastomers. **They are non-allergenic and 100% recyclable.** The latex-free elastic nonwovens are the best material for primary protection except when dealing with organic organic solvents, corrosive chemicals or a large volume of pressurized fluids.



Latex-free Elastic Nonwovens

Materials for Making Soft-stretch Hoods

Polypropylene are versatile polymers used for making carpet fibers and food containers such as milk jugs. **Spunmelt Polypropylene Nonwoven Fabrics** are made by extruding polypropylene chips through a spinnerette block to draw fine filaments of 1-50 um diameters and layering them on a collecting belt to form the web structure. The ultrafine openings of their thin, yet dense fiber-web structure allow for air to flow through while maintaining particle filtration quality. They are a “breathable barrier” material irreplaceable in manufacturing disposable protective apparel, surgical gowns and face masks.

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. Their melting point and ignition point is 320 °F and 660 °F respectively.

The Basis Weight (gram per square meter or ounce per square yard) is a common measurement for expressing the amount of fiber weight per unit area. At a higher basis weight, the fabric is heavier and usually thicker with a higher filtration rate but also a higher resistance to air flow (lower breathability). At a required filtration rate, the thinnest fabric or the fabric having the highest breathability is the most desirable. 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 for easier breathability.

The uniformity of web formation is most critical for the end-product quality assurance. The uniformity defect can be visually observed for having many sparse spots on the fabric especially the basis weight below 15 gram/m² (0.47 oz/yd²). In the US, only several advanced spunmelt production lines equipped with a multi-row spinnerette can produce high uniformity fabrics at a low basis-weight.

Our Patented Technology provides a process for creating soft and stretchy fabrics from regular nonwovens. They are latex-free (non-allergenic), soft, and highly stretchable with low retraction power. This enables finished products to be form-fitting and stress-less to the wearer while maintaining their breathable barrier quality. **VitaFlex LLC** is the exclusive manufacturer of latex-free elastic nonwovens. Our nonwovens are sourced from the most advanced lines in the southeastern states. The conversion and manufacturing processes are done in Burlington, North Carolina. The latex-free elastic nonwoven technologies and the materials have been globally co-patented by **DuPont®** and **Dr. De-Sheng Tsai**. For more information, please visit www.VitaflexUSA.com.

VitaFlex’s Soft-stretch Hoods are made from latex-free elastic nonwoven fabrics. They are the only soft head covering to provide coverage of the entire head and neck. By combining fiber engineering and converting technologies, the hoods are diversified with specific barrier functionalities to meet the requirements of Contamination Control, Primary Head Protection, and Infection Prevention.

The quality objective for our soft-stretch hoods is to achieve barrier functionality with cool, soft and comfortable form-fit. The following basic measurements are used in developing the hood structures.

The hydrostatic pressure test is used to measure the hood structure’s resistance to water penetration. Our single layer hairnet can block airborne droplets and the triple-layer structure of general safety hoods is effective in blocking some liquid splashes. However, the structure of the Biosafety hood is the one qualified as a level 1 fluid barrier (resistance to synthetic blood penetration under 80 mm Hg sprayed from a distance of 12”). **Please note: nonwoven fiber-web structures are not water-proof and can be wetted through by detergents, alcohol or other organic solvents, pressurized liquids or high viscosity solutions.**

An indicator of breathability is to measure the differential pressure (ΔP , mm H₂O/cm²) across the web structure. A surgical mask is preferred to have a ΔP of less than 5.0. N95 respirators have a ΔP under 35 and 25 for inhalation and exhalation resistance, respectively. The wearer will feel hot when wearing a mask having a ΔP of more than 5. And, a N95 respirator with ΔP of more than 20 requires great effort to breathe through.

In contrast, the ΔP of VitaFlex’s soft-stretch hoods is under 3.0, so breathing remains normal. There will be no unbearable heat or humidity build up inside the hood. **For the first few seconds of wearing our soft-stretch hoods, the face might feel warm** since it is shielded from ambient airflow. However, in most circumstances, the wearer should feel cool and comfortable in extended wearing due to the low ΔP of the hood’s structure allowing perspiration vapor to escape through it. **In a confined space, without air circulation, and the ambient temperature higher than body temperature (96.8 °F), people would feel hot with or without a hood.**

The filtration efficiency is the percentage (%) of particular size particles blocked by the hood structure at a specified air-flow volume. Most of the sub-micron particulates are charged and many are aggregated into micron-size granules. The charged particles can be trapped on a static surface. **Respirable particles of 3 to 15 μm in size are generally considered industrial safety and health concerns.** Some particles that are commonly of concern are listed below.

Particles	Particle size
Flu Virus	0.08-0.12 μm
Respiratory Droplets	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
Bacteria	0.5-10 μm
Mold Spores	10-30 μm

Our Particle Filtration Efficiency (PFE) test is conducted at an air flow of 28.3 liters/minute to evaluate particle retention of latex particle of 1 μm size. However, **our hoods are not respiratory protective devices.** They are designed for covering the scalp, face and neck. **Since they fit tightly against the wearer’s hair and skin, no air flows through them, so the barrier effectiveness is higher than the tested PFE.** For proper protection, we suggest wearing our hood in conjunction with a respirator.

	Sot-stretch Hairnet	General Safety Hood	UV-Shield Hood	Biosafety Hood
Structure	SMS	S/S/S	S/S/S	SMMS/S/SMMS
Basis Weight	25 gsm	50 gsm	55 gsm	65 gsm
Thickness	0.12 mm	0.30 mm	0.32 mm	0.35 mm
Hydrostatic (cm H ₂ O) AATCC Test Method 127	15	20	22	32
ΔP (mm H ₂ O/cm ²) MIL-M-36954C	1.2	1	1.4	2.7
Breathability/Perception	Normal/ Very Cool	Normal/ Very Cool	Normal/ Very Cool	Normal/Cool
Particle Filtration Efficiency @ 1 μm ASTM F2299	-	>75	>75	95