3M Science. Applied to Life.™

Technical Data Bulletin

The Science of Comfort:

Breathability in Protective Apparel

What is breathability in Protective Apparel?

Breathability in Protective Apparel, such as coveralls, is a key factor in determining the wearer's ability to maintain thermal comfort. The human body, particularly when working hard, generates heat. If this heat and moisture is trapped inside the garment then the wearer is likely to get hotter faster and experience more and more discomfort, increasing the possibility of stress on the body due to increased heat load.

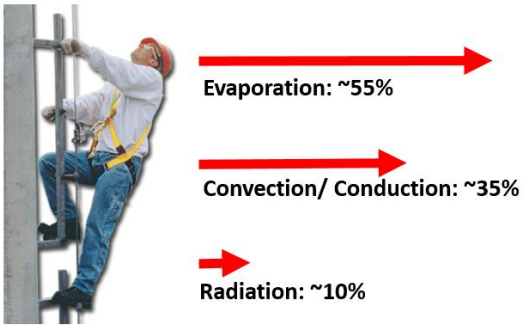
How humans dissipate heat

Humans shed excess heat through three primary mechanisms:

Evaporative cooling is the absorption of energy as water (sweat) changes phase form liquid to vapor, also known as "heat of vaporization". This heat is drawn away from the body with the vapor, leaving the skin surface cooler.

Convection and conduction is the heat lost to air or other materials that are in contact with the skin. Heat loss by these mechanisms are proportional to the difference between the skin surface and the material contacting the skin. When air is warmer than the skin, these mechanisms will add heat to the body.

Radiation is the heat given off by infra-red (IR) radiation. Radiant heat loss is off-set by IR radiation absorbed by the body from other heat sources, such as the sun, and may be a net gain in some situations.



Source: Molly Smith, Weber State University, Utah.

Evaporative cooling is the dominant cooling mechanism for humans under normal ambient conditions. Therefore, a coverall's ability to allow water vapor to escape, or breathability, is the most important factor impacting heat stress, and perceived comfort.

Chemical Protection vs Breathability

The need for breathability is often in conflict with the need for protection from chemical exposures. Coveralls offering maximum protection from liquid chemicals are typically non-breathable or minimally breathable. This results in the need for different designs and different fabrics designed to meet the unique aspects of each work environment, job tasks and chemical hazards. The range of 3M™ Protective Apparel has been designed and manufactured to help address these needs.

Testing Breathability

There are a number of tests designed to quantify the breathability of fabrics. One test is to measure the water vapor resistance of a fabric under steady-state conditions. This is often referred to as the "sweating guarded hotplate test" or "skin model" because in many ways it tries to replicate the way the human body sweats in order to cool down and maintain a steady temperature.

In this test, samples of fabric are placed over a porous plate. Water is heated and passes through the fabric sample as a vapor. Air flows over the top of the fabric at a rate of 1 meter per second. The rate of heat flux required to maintain a constant temperature is a measure of the rate of water evaporation. From this the water vapor resistance is calculated. This is known as the Ret:

$$\text{Water vapour resistance (Ret)} = m^2.Pa/W$$

Using the resulting Ret, it is possible to suggest a comparison between fabrics with different Ret values. The following table suggests how the Ret values could be described in terms of their breathability and how this might affect the comfort for the wearer, depending on the type of work being carried out. However, please note that these are subjective descriptions and what one worker may consider comfortable and breathable even when carrying out physically demanding work, may not be considered comfortable by another worker doing the same work activity.

Ret Value	Suggested Performance
0 - 6	Very good or extremely breathable, even when working at high activity rates
6 - 13	Good or very breathable, suitable for working at moderate activity levels
13 -20	Satisfactory or breathable, but may be uncomfortable working at higher activity rates
20 - 30	Slightly breathable but, but may be uncomfortable even when working at low activity rates
30+	Not breathable, evaporative cooling of the skin is eliminated leading to higher potential for thermal discomfort.

Table 1: Suggested Performance Levels based on Ret values using test method ISO 11092

Coverall Fabric Options

The breathability of fabrics depends very much on the type of fabric used. Many Type 5/6 (or Level C) coveralls which are designed to help protect against hazardous dusts and light liquid splashes are manufactured from fabric made from non-woven Polypropylene fibers. These fabrics are often known by the acronym "SMS" for Spunbond Meltblown Spunbond and can come in a variety of compositions, SMS, SMMS, etc.

Laminate fabrics are generally less breathable than garments made with SMS polypropylene. Laminate fabrics in the 3M range are made from a substrate layer of either polypropylene, or a layer of bi-component fibers which have a polyester core and a polyethylene sheath. A protective layer of polyethylene is laminated on top of the substrate layer.

The breathability of laminates can vary. This is caused by changes in the size of the micro pores of the polyethylene film. The larger the micro pores, the more breathable will be the fabric, although this may also mean than such a fabric may be less protective than a laminate with very small micro pores.

The breathability of the SMS fabrics used in 3M protective apparel has been tested and the water vapor resistance has been found to be below 6. This suggests these coveralls are extremely breathable even when working at physically demanding work rates. 3M garments made with a fabric laminated with polyethylene have also been tested.

3M™ Protective Coverall	Fabric Weight (gsm = grams per square meter) & Type (SMS = spunbond meltblown spunbond)	Typical Ret & suggested work rate
4515	50 gsm SMS	Typical Ret 0 - 6
4520	43 gsm SMMMS	
4530	54 gsm SMMS	
4510	47 gsm laminate	Typical Ret 6 -13
4535	60 gsm laminate	Typical Ret 20 -30
	43gsm SMMMS back panel	Typical Ret 0 - 6
4540+	49gsm laminate	Typical Ret 6 - 13
	43gsm SMMMS back panel	Typical Ret 0 - 6
4545	49gsm laminate	Typical Ret 6 - 13
4565	49gsm laminate	Typical Ret >30
4570	92 gsm laminate	Typical Ret >30

Table 2: 3M™ Protective Coverall range

3M uses this understanding of breathability to design coveralls which aim to provide the right level of protection, with high user comfort. Instead of using just one fabric 3M has different fabrics for different levels of protection. For example, the 3M™ Protective Coverall 4545 is a Type 6 (and Type 5) coverall for protection against light splashes (and particulates), and is made using a fabric which is more breathable than the 3M™ Protective Coverall 4565 which is a Type 4 coverall for protection against sprays. This coverall is made from a fabric which is lighter than the 3M™ Protective Coverall 4570 which meets the requirements of Type 3 for protection against jet sprays.

3M™ Protective Coverall 4545

3M™ Protective Coverall 4570

Another option when full laminates are not required is to use a combination design of splash resistant laminate and breathable SMS fabrics. For example the 3M™ Protective Coverall 4535 is a coverall with a large laminate panel at the front of the body where the risk of splash may be higher, with the back made from an SMS fabric to help make the coverall more comfortable to wear.

3M™ Protective Coverall 4535

3M™ Protective Coverall 4520CS

To find out more about the range of 3M™ Protective Apparel, or which solution best meets your needs visit **3M.com/protectiveapparel** or speak with your local 3M representative.

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