

"A new textile construction offering higher levels of comfort during activities of varying intensity over a far greater range of climatic conditions than any other foul-weather garment alternative."

Totally spaced out

The small, but perfectly formed, annual 'Survival Conference' organised by the UK's Leeds University School of Textiles has always been able to guarantee at least one controversial topic. One can quote the 'Wool is comfortable next to the skin' discussion, long before Merino was re-engineered and re-marketed to do just that, or the 'Survival is sexy' theme of the early 1980s (it was).

From time to time there have been even more radical challenges to accepted thinking, and the 2002 programme produced one such in the form of Andrew Spink, a bicycling and backpacking physiotherapist, who was prepared to convince the assembled conferees that he had found 'a better mousetrap' in performance textiles.

The following paper is taken from his own words on the day, but, because the outcomes of his work are under active international consideration as we go to press - we have removed any references that would serve to identify the processes and possibly compromise the intellectual property rights in his development.

Figure 1: Water Vapour Permeability (g/m²/24h)

	RH (%)		
	40	65	90
Temp (C)			
15	6240	5422	4426
25	3955	3374	2752
35	3264	1923	1388
45	2358	798	-468

Performance Characteristics of Waterproof Breathable Fabrics, David A Holmes

"A new approach to cold and foul weather wear for sports and high intensity activity"

My paper introduces a design concept that has the potential to revolutionise the current approach to moisture management in outdoor garments. The design offers greatly improved moisture evaporation and removal from within the garment and a substantial decrease in condensation accumulation that far surpasses the alternatives. The garment is constructed in such a way that it is cooler to wear than any 'hi-tech' fabric shell because of its ability to maintain a manageable channel of air within and through it. In addition, because it is able to trap large quantities of still air, it is warmer and possesses better thermal properties than those of a standard waterproof/breathable shell garment. These apparently mutually exclusive characteristics are achieved by the presence of a 'technical layer' placed under the weatherproof shell fabric, and through which large volumes of air can flow, or in which large volumes of still air can be trapped, by the use of strategically-placed garment vents. These vents trap air when closed and allow the garment to 'flush' with cool air when open.

I suggest most strongly that the concept amounts to a massive leap forward in this field, NOT just another incremental step, yielding previously unimagined levels of garment performance and comfort. It encapsulates a form of garment construction that offers a whole new alternative to the '3 layer' system of outdoor clothing as well as being able to enhance the performance of any of the technical fabrics currently available.

The project

I have finally come to the conclusion that ambient humidity and the management of moisture within garments are more important factors affecting comfort than ambient temperature. High temperatures are easily tolerated if a body can dissipate heat by sweat evaporation. In hot climates if we can't evaporate sweat we feel disinclined to activity, feel lethargic and we can begin to overheat. Conversely, in cold climates our sweat can condense into our clothing, and we can lose heat rapidly by conduction as the air spaces in our clothes fill with liquid water, and the insulative capacity is lost. Breathable fabrics address this, but to a far lesser degree than the manufacturers would have us believe.

The charted results shown in this feature are derived from a series of tests undertaken by David Holmes of the Bolton Institute of Textile Technology in the UK. Figure 1 presents MVT (moisture vapour transmission) rates of ePTFE in 'realistic' conditions. It is unlikely that you would want to wear a waterproof at 45°C. and you would probably be grateful for rain at this temperature. We are likely to be wearing a waterproof at 15°C, especially in Western Europe where this is a common ambient temperature. Even at 40%RH (relative humidity) we can only expect a MVT of 6240g/m²/24h, significantly lower than the claims made on manufacturer's swing tickets. As RH rises MVT falls. You might think that 90% RH is unlikely but during rain it is normally between 85% and 100%.

Not only can we expect lower MVT from our waterproofs than the manufacturers claim but also moisture evaporation is compromised further by the presence of the ubiquitous thermal layer, the polyester fleece. This assembly we know and love as the 3-layer clothing set up. Base-layer, fleece and shell garment.

I suggest that the presence of the fleece reduces the rate at which water vapour reaches the breathable shell garment fabric, because the space between the body and the fleece reaches lOO%RH long before the breathable fabric has begun to function at the optimum. This prevents further evaporation of sweat causing the wearer to feel damp and uncomfortable.

The practicality in riding my cycle in the rain showed me that without a waterproof I would get cold and wet, and if I wore a waterproof I would get hot and wet; different temperatures but always wet. What I needed to do was to reduce the resistance encountered by my body moisture in reaching the breathable garment. With necessity being the mother of invention, I introduced an ultra-low-density spacer material between my base layer and my shell garment. With the addition of a system of openings in the shell garment I found that I could also improve the movement of moisture by channelling a manageable current of air into the spacer material, picking up evaporated vapour and carrying it to the outer atmosphere.

Figure 2: Shell garment, fleece & base layer

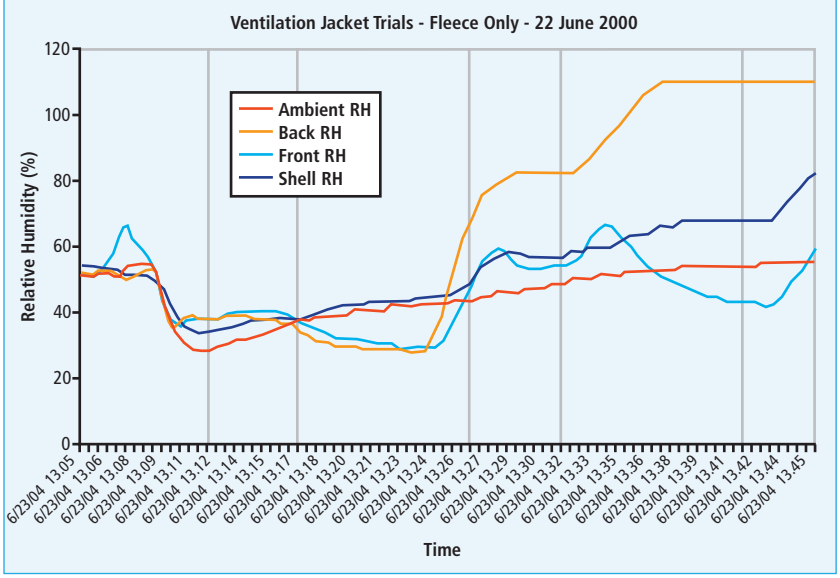
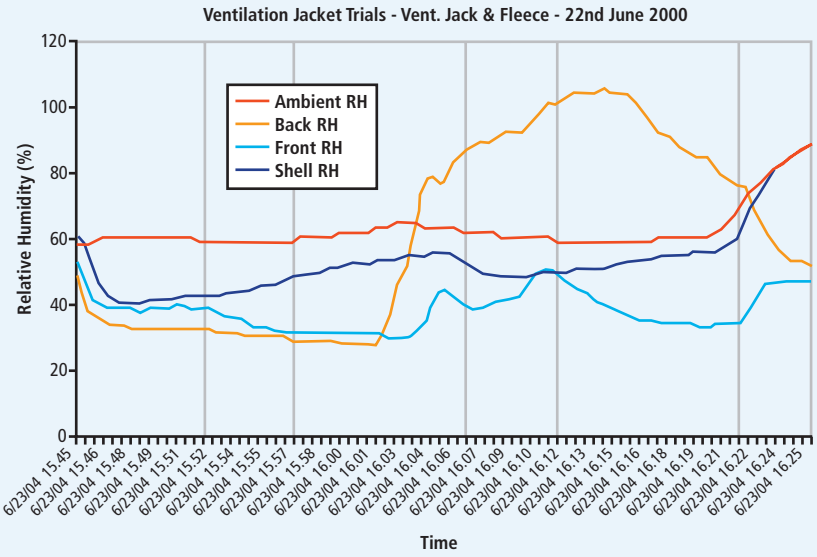


Figure 3: Shell, Vent. Garment, fleece & base layer



Proof testing

Having conceived and made the garments, I needed to test my theories. With the help of Leeds University School of Textiles I carried out a series of comparative tests as follows:

- **Performance comparison:** 'traditional' three layer system v new design
- **Water retention:** fleece v ventilation material
- **Thermal insulation:** Dry, Wet and 'shaken' fleece and ventilation. garment
- **Performance comparison:** High Intensity activity two layer set-up v ventilation garment.

The test profile was:

- Chamber temp. 0°C (-10°C & +15°C)
- Closure of garments appropriate to conditions
- 5 min. acclimatisation at rest (seated) and in still air
- 10 min. 'work' period with shell garment closed
- 5 min.'work' following prescribed garment opening
- 10 min. cool down, seated in still air.
- 'Work' = Stepping on and off 20cm step at 30 steps/min
- All of 'work' performed in 6kph of air flow from front.

RH and temperature were recorded at four points: front and back on the outside of the base layer; on the inside of the shell garment; the ambient conditions of the environment chamber.

The chart in Figure 2 indicates that at 7-8 minutes, and wearing an accepted 3-layer system of base-layer, fleece and breathable waterproof shell, there was a rapid rise in RH both front and back at the base layer and to a lesser degree at the inner surface of the shell. Note also the level of the ambient RH of the chamber.

Bringing the new ventilated garment into the system, Figure 3 indicates that there was a similar rise at the back sensor, while RH at the front rose to a lesser degree - slightly later. During the cooling off period the RH at the back began to fall, unlike the standard 3-layer set-up. This in my opinion was due to the natural convection currents that occurred within the spacer material where warm, moist air could rise and vent at the top openings of the garment to be replaced by cooler, drier air drawn in at the bottom.

NB. Natural convection currents need a minimum space in which to exist. This is usually about 10mm, although forced convection currents can exist in much smaller spaces depending on the pressure differences at either side of that space.

The front and back sensors show very low RH readings throughout the duration of the work period in Figure 4 suggesting significantly improved rates of moisture removal. Remember the work is the same and the breathable shell is the same. Following the cessation of work, there can be seen a sudden rise in RH on the back. This is the point at which the subject moves out of the airflow and the as yet undissipated heat created by the work is lost by increasing the output of sweat on the skin. This peak RH is less than 70% and falls back within 2-3 minutes and once again I believe this to be the effects of natural convection currents within the spacer material.

NB. Compare the ambient RH to that of Figure 2. The RH is significantly higher, which under normal circumstances would decrease breathability, but we are not depending on MVT for the removal of moisture in this system.

Figure 5 shows TOG rating of the spacer material compared to the fleece dry, wet and then shaken. The wet spacer material is almost as warm as the dry fleece and, following one shake, returns to within 92% of its original thermal insulation.

We then reviewed the RH values recorded when comparing the ventilation garment with a clothing set up which an athlete may have chosen for training in cold or wet conditions. I took this to be a base-layer and shell garment.

The track athlete's viewpoint

At 15°C both tests showed a fairly high RH reading particularly at the back sensor during the closed work period but the reading was lower when wearing the ventilation garment (remember the Tog value of the spacer material). The RH in the ventilation garment dropped significantly following the opening of the garment both front and back. There was a profound rise after the subject moved away from the wind source but it would be unusual for an athlete to continue to wear his waterproof after his training in that he would be likely to return to a place of shelter.

At 5°C, Figure 5, there was less difference in the readings of the front sensors throughout the work period and both back sensor readings fall following opening, so there was little difference by the end of the work period. Once again there was a rapid rise front and back in the ventilation garment set-up after moving away from the wind source.

Having got used to getting significantly better results with my system I was concerned about this result, and I checked the corresponding temperature readings for the first 5°C test to see if I could find a performance difference. My conclusions about the results from this section of the tests was that, despite the workload, the subject was not producing body moisture because he was actually beginning to get cold.

Conclusion

Despite their enormous technical superiority over the fabrics they replaced, the waterproof/breathable fabrics available today are frequently frustrated in their attempts to match the expectations of the consumers. Climatic conditions prevalent in so many European and US states deny the humidity and temperature gradients essential for the optimal performance of these otherwise superb products. Active outdoor sports participants constantly struggle for comfort, torn between the choices of either wearing waterproof clothing leading to overheating, or becoming wet and cold from not doing so. Two 'givens' currently exist in the sports and foul weather wear sector. They are: 'hi-tech' fabric waterproof clothing is no guarantee that an active participant will remain dry and comfortable; rain is not the only reason why an active participant becomes wet and uncomfortable.

In summary, this new design for high-intensity activity, cold/foul weather clothing would claim to be: cooler (when open) than its competitors, warmer (when closed) than its competitors, drier than its competitors, and operates over a greater climatic range than its competitors.

Andrew Spink

Figure 4: Shell, ventilation garment & base layer

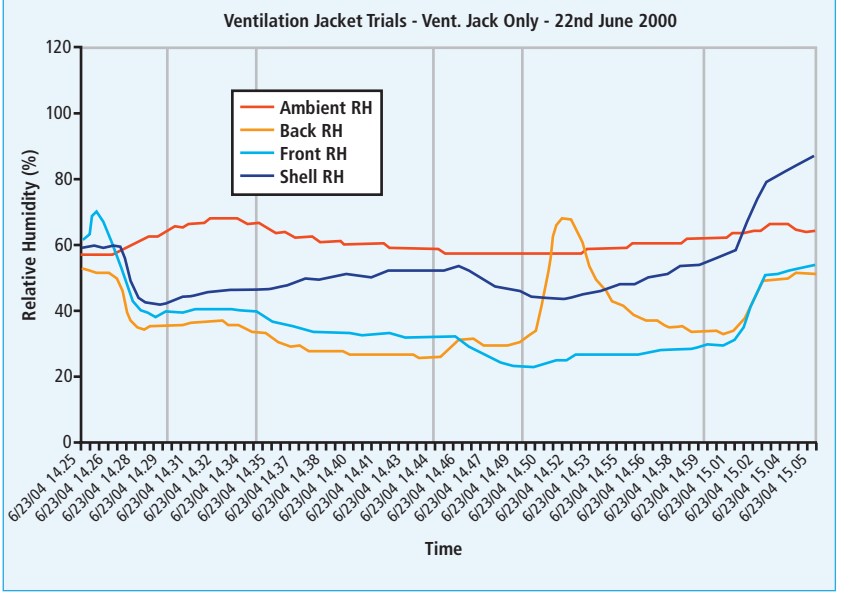


Figure 5a: Relative Humidity Trial at 5°C with jacket

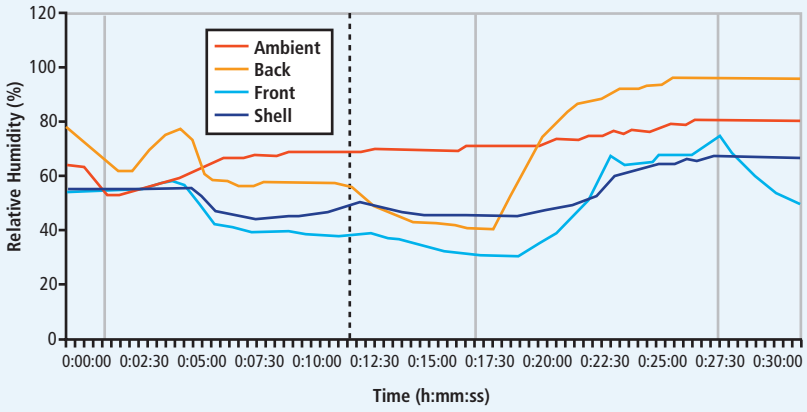


Figure 5b: Relative Humidity Trial at 5°C without jacket

