# Fire Fighter Garment with Non Textile Insulation

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## Summary

A waterproof barrier combined with heat stable „spacers“ creates the thermal insulating air buffer.Fire fighting suits with the new insulation system fullfill thermal protection according EN 366 and EN 367 and are successfull in thermo-man test of DuPont. A controlled wear trial in a climatic chamber showed a higher physiological performance of the new system compared to traditional ones ( GORE-TEX® and leather with non woven insulation).

## Introduction

Fibers and yarns are not the real thermal insulater of a garment. It is the locked still standing air. Fibers conduct the heat 10 to 20 times better than still standing air. This was the idea to substitute the traditional textile insulation by an air cushion. GORE-TEX®Airlock® is a combination of moisture barrier and thermal protection: Heat stable „spacers“ of foamed silicone on the GORE-TEX® moisture barrier create the insulating air buffer.

Hot plate measurements showed that at similar heat resistance we gained a 40% lower water vapor resistance with the new system whereas the water vapor absorption was reduced by 60%.Transient measurements showed that the Airlock® system features a higher transportation rate but lower absorption rate for liquid water.Consequently a combination with Airlock® causes a significantly shorter drying time.

Conclusion out of this physical data : For wear situations with strong sweating,as experienced by fire fighters, a material combination with an Airlock® liner can be expected to show a better physiological performance than a material combination with a conventional textile insulation.In a controlled wear test on a treadmill in the climatic chamber we tried to proof this.

## Methods

Five professional fire fighters wore the following ensembles at 30°C / 50% R.H. for 95 min:

- Leather jacket with lining but without moisture barrier,Paris style,GORE-TEX® fire fighting trousers
- Textile jacket (Nomex, Aramid lining, GORE-TEX® barrier),Berlin style,GORE-TEX® fire fighting trousers
- Textile jacket (Nomex, Airlock®, lining),Paris style, modified Airlock® fire fighting trousers

Long-legged underpants and long-sleeved undershirt of a functional material (Ullfrotte:60%wool;25%PES;15%PA)
have been worn underneath.To be close to practice each test subject wore its boots, gloves, helmet, belt and breathing apparatus (without respirator mask).
The load regimen was based on former studies and consisted of work and rest cycles:

| | | |
|---|---|---|
| 10 min | 4 km/h | 0% |
| 10 min | rest | |
| 5 min | 5 km/h | 5% |
| 10 min | rest | |
| 5 min | 5 km/h | 10% |
| 10 min | rest | |
| 5 min | 5 km/h | 8% |
| 40 min | rest | |

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**Parameters measured:**

Core temperature (rectal),heart rate,skin temperatures, relative humidities between underwear and suit, weight loss of subject,weight gain of clothing.At the end of each cycle,the test subjects rated their heat and moisture perception as well as the wear comfort.

**Results and discussion**

- Core temperature: Up to the 25th test minute, the temperature increases of the body core lay within a relatively narrow temperature band and on a comparatively low level. From that time on, however,distinct increases were observed.In the Leather fire fighting jacket, the body core temperature rose by 0.9 K, in the Berlin GORE-TEX® jacket by 0.65 K, whereas an increase of only 0.45 K was measured in the jacket Airlock®-Paris.In the Leather jacket the body core temperature was continuously rising, even after the load phase had ended (55th test minute), and kept on rising until the end of the test in the 95th test minute.In the two other jackets, the body core temperature kept gradually falling from the 75th test minute on.
- Mean skin temperature: The temperature curves lie within a band of approximately 2 to 1.3 Kelvin;Leather on the top (more than 37 °C) and Airlock®-Paris the lowest skin tempeature (nearly 36°C).Berlin GORE-TEX® was in the middle.
- Heart rates: They rose in a way which was typical for the load regimen of the test and lay within a physiologically plausible bandwidth.The small differences between the mean value curves reveal that the individual jacket types have less influence on the heart rates.It was only in the fire fighting jacket Airlock®-Paris that the heart rates returned nearly to the starting levels from the 65th test minute on.
- Weight change: The weight losses of the test persons were, on an average, approximately 1 kg in the Airlock®-Paris jacket, 1.3 kg in the Berlin GORE-TEX® jacket and 1.7 kg in the Leather jacket. The water uptake of the garment ensembles coincided with the weight losses: 0.5 kg in the Airlock®-Paris jacket; 0.7 kg in the Berlin-GORE-TEX® jacket and 1 kg in the Leather jacket.
- Relative humidity:The humidities measured in the Leather jacket ranged about 5 to 10 % above the levels measured in the two other jackets, throughout the test. It was especially in the Airlock®-Paris jacket that the humidity reached a steady state slightly above 80% r.h.
- Heat perception: It was ranked on a scale from 0 to 7 (0=comfortable; 1=slightly warm; 2=warm;3=very warm; 4=hot; 5=very hot; 6=uncomfortable;7=intolerable).Up to the end of the last walking period (55th min) the Airlock®-Paris jacket was perceived as warm to very warm; Berlin GORE-TEX® as hot and Leather as very hot.This perception continued till the end of the test, whereas the two other jackets showed an improvement.
- Moisture perception: It was ranked on a scale from 0 to 7 (0=dry; 1=chest or back slightly moist; 2=chest or back moist; 3=body moist; 4=body moist with clothing partly sticking to the body; 5=perspiration is running down at some spots; 6=perspiration is pouring down the body in many areas; 7=intolerable).Up to the end of the last walking period (55th min) Airlock®-Paris ranked 3rd and Berlin-GORE-TEX® and Leather 5th.
- Wear comfort: It was ranked on a scale from 1 to 6 (1=excellent; 2= good; 3= satisfactory; 4= uncomfortable; 5=very uncomfortable; 6=extremely uncomfortable).Throughout the test period, Airlock®-Paris was perceived as excellent; Berlin GORE-TEX® as good and Leather as very uncomfortable.

The outcome of the study was that for all parameters, except for the heart rate, a clear rank can be assigned to each jacket type tested (rank 1 = best, rank 3 = worst performance):

1. Airlock®-Paris
2. Berlin GORE-TEX®
3. Leather

Conclusions

In the fire fighting suits with the new combination of thermal protection and liquid barrier very favourable thermophysiological conditions prevailed. Such suits can be expected to produce less heat stress at the wearer. Fire fighting suits with Airlock® fullfill EN 469 and had been successfull in thermo-man-tests.With the new concept the bulkiness of insulation could be reduced while maintaining the same level of heat

protection. Due to minimal moisture absorption and high moisture vapor transfer the risk of injuries by scalding should be reduced. High flexibility and reduced weight of such suits increases the wear comfort.

References

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