

Managing foot comfort

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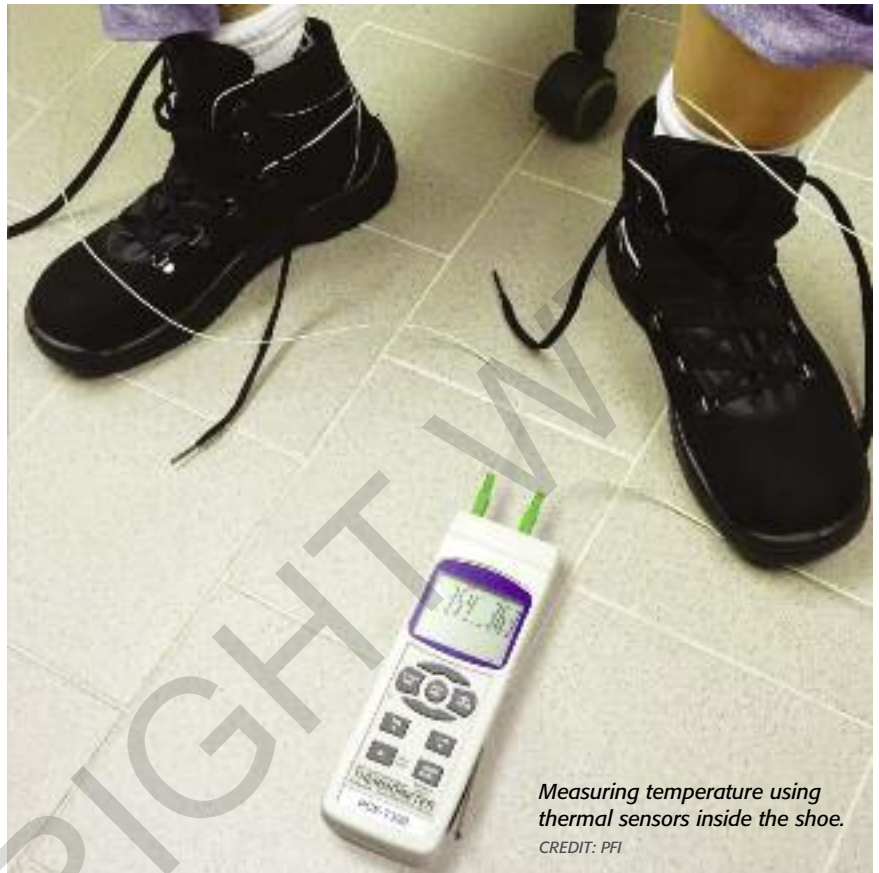
Comfort in wear of stockings and shoes depends to a considerable extent on the effectiveness of their thermal and moisture management systems. Indeed, shoe manufacturers actively promote properties such as water vapour absorption and permeability, promising dry feet and comfortable foot temperatures for the wearer. These properties are exceedingly important for shoes which are intended to be worn during intense physical activities as, for example, trekking shoes, safety shoes or those for the military and police.

Practical experience shows that frequently there are problems with this aspect of foot comfort and this is a reason why many safety shoes are not worn when they should be. In addition, the discomfort of wearing shoes with poor thermal and moisture management heightens the risk of accidents and the resultant injuries to feet.

Safety footwear standards take into account only water vapour absorption and permeability of the upper materials used. Soles, steel toecaps, steel insoles and steel heel caps—which are all impervious—have not been considered. There are only fairly basic technical works dealing with the overall relationship between foot, stocking and shoe. Most of these investigate only one component in isolation and not the interaction between all of them.

THE PROJECT

Test and Research Institute Pirmasens e.V. (PFI) and the Hohenstein Institute of Textile Innovation gGmbH (HIT) have recently completed a research project with the aim of investigating the influence of shoe and stocking construction on the climate found inside the shoe during everyday working situations. The overall foot/sock/shoe relationship in all types of safety shoes has been carefully analysed when worn during intense physical activity. Although the results obtained from this investigation concern safety shoes, they will be



Measuring temperature using thermal sensors inside the shoe.

CREDIT: PFI

equally applicable to other types of footwear.

It is the first time that a systematically varied sample selection has been used to analyse this complex relationship and has proved useful in resolving some previously unanswered questions. The scientific aim was to develop suitable actions to regulate moisture and thermal balance in the system. This can be best reached by well-directed use of materials in both stocking and shoe.

The spectrum of the most used materials was found to be very great, so five were selected from each type. Twenty-five combinations were then tested with the PFI Comfort Tester (Figure 1) and the Hohenstein Institute Sweating Foot device (Figure 2). These simulate different methods of sweating. The Comfort Tester uses water vapour, while the sweating foot device uses drops of water forced out of small holes in the 13 elements of its metal foot to simulate perspiratory glands. This

device can also allow a simulation of thermal management conditions.

TESTS

Both short time and long time tests were made using the Comfort Tester. The former simulates the high demand caused by intense physical activity and drying of the foot. The latter simulates a complete working day with all the variable demands that implies. Figure 3 shows the course of the short time test. The combined components of the foot/stocking/shoe system were weighed at the beginning of the test and at a further two points in the cycle (weight) as shown. The differences in weight of all the components were then compared and analysed.

The tests carried out using the sweating foot device consisted of three phases of 60 minutes each (Figure 4). The thermal transmittance and water consumption of the sweating foot were recorded and analysed for each phase and element.



Figure 1 – PFI Comfort Tester.

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Figure 2 – HIT Sweating Foot.

CREDIT: HIT

RESULTS

The results of both types of test showed that it is very important to view all components as a system. Stockings have an immense influence on its overall properties. They can block or support the transport of moisture from the foot into the shoe. The materials of the shoe determine the quantity of moisture absorption from the stocking and the evaporation to the environment. Different materials achieve different evaporation rates.

Textile shoe and stocking materials containing cotton and polyamide provide best moisture transport. Leather materials absorb a high quantity of moisture but need a long time to transmit it. The tests delivered further details regarding water vapour permeability resistance. The different combinations showed different values, with a shoe having a leather upper and lining having the highest resistance. The lowest values were achieved by shoes with a textile lining and one incorporating a membrane. As regards stockings, the lowest resistance was achieved by one made using a blend based on polypropylene. Stockings of wool and a mixture of wool and polyamide showed the highest resistance.

the test. The two young men involved were asked to rate their perceptions concerning temperature and moisture.

The results showed that the combination of stocking and safety shoe under test was unable to transport moisture from the foot during high physical activities. The test persons felt their feet as being uncomfortably wet after only a short period. *(Any temperature over 33°C has to be regarded as too warm)*. Even so, they were unable to clearly differentiate between thermal and moisture sensations. They did however rate the leather shoes as being more comfortable than the textile ones.

The tests carried out by HIT favoured textile shoes or those with a textile lining, where the measured data showed a tendency to lower moisture. The leather shoes and shoes

with a lining of wool showed a higher level of moisture. The test subjects rated the temperature at the foot as too warm due to the combination of stocking and shoe. The most uncomfortable was the leather shoe with a wool stocking worn during the complete test duration time.

These tests have indicated a wide range of individual ratings and deviations in the simulation tests. The results make clear that further research activities in this field are necessary. Stockings and shoes must be considered as a combined system and it should be possible to improve the properties of the system and achieve noticeably better comfort for the wearer.

Full results of these tests can be obtained from PFI. 📞

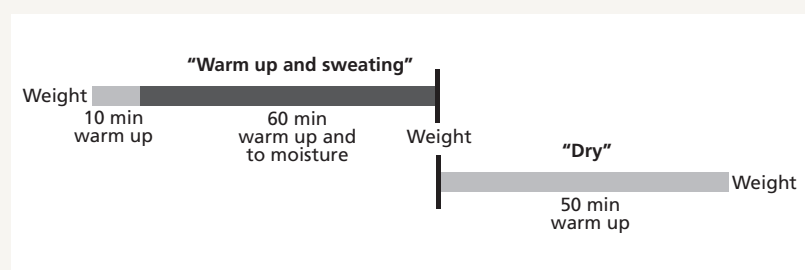


Figure 3 – Course of short time test.

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WEAR TESTS

It was also thought necessary to complete the project with subjective assessments by real people, so tests were carried out under different physical activities. PFI combined the subjective assessments with the measurement of the temperature in the shoe (see title image) and the weight of stockings and shoes before and after

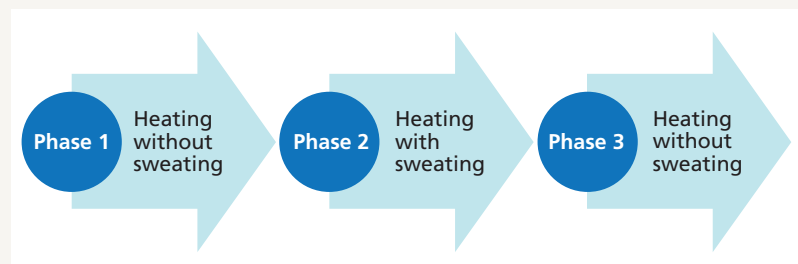


Figure 4 – Course of HIT test.

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