

ADVANCED MOISTURE MANAGEMENT TEST

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SATRA's Advanced Moisture Management Test (AMMT) assesses the sweat management and thermo-regulatory characteristics of the whole shoe, both properties being crucial to overall footwear comfort. In combination with SATRA's guidelines on performance, AMMT results can be used to judge the product's fitness for purpose for its intended end use.

MOISTURE MANAGEMENT IS IMPORTANT

Given well-fitted footwear, dry feet are generally comfortable feet, so keeping socks dry is important. Effective moisture management requires that the shoe's materials and construction transport water in liquid and vapour form away from the foot. The rate of moisture (sweat) production will vary from individual to individual and also between areas of the foot (the top of the foot sweats more than the sole) but 5g/hour per foot is a good average for temperate conditions. In very hot conditions or during high physical exertion it can be much higher, so the dispersion of this moisture is extremely important for both comfort and health.

As well as affecting foot comfort, moisture levels within the shoe have a bearing on foot and shoe hygiene. Bacteria, fungi and yeasts are omnipresent and wherever they find warmth, moisture and nutrients they flourish. As shoes will inevitably be warm and contain skin flakes and other detritus, the presence of moisture will trigger some undesirable microbiological growth, causing odours, staining and deterioration of components.

EFFECTIVE MOISTURE MANAGEMENT

Effective moisture management within the whole shoe is achieved in actual wear from a combination of transport mechanisms including wicking, absorption and subsequent desorption and water vapour permeability. The sock will absorb a certain amount of perspiration from the foot while allowing vapour to pass through to the shoe's lining. The lining must therefore have good wicking and absorption properties to draw moisture from the sock and keep it relatively dry. While moisture management is an important property in the majority of footwear, it is particularly important in high performance outdoor styles such as walking boots and safety footwear.



Test foot with skin in place.

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When moisture evaporates from the shoe it cools the foot down due to the latent heat of vaporisation and is therefore advantageous in hot arid conditions. In footwear designed specifically for very cold conditions this evaporation cooling can be a distinct disadvantage. Here, the thermal insulation properties of the footwear become paramount. Sweat (water) has a high thermal conductivity, so in order for a thermal barrier to be effective the shoe needs to be kept dry and moisture transported by mechanisms that do not rely on air movement or evaporation from the surface of the shoe. Wicking is one such mechanism. Most good insulators rely on trapping air because dry air is a poor conductor of heat. Each component within a shoe will have its own moisture management and thermal insulation characteristics and these, together with the construction and quality of manufacture, will contribute to the overall comfort performance of the shoe.

TESTING FOR MOISTURE MANAGEMENT

The AMMT equipment employs a specially designed aluminium-loaded, polyurethane moulded test foot containing an electrical heating element capable of maintaining a surface temperature similar to that of a human foot. The test foot also has eight microbore pipes which deliver water at known, uniform rates to eight sweat zones on the foot surface and in such a way that the top of the foot 'sweats' differently to the underneath. Surface temperature is closely regulated at 34°C to be comparable to a typical foot temperature and the water flow rate adjusted to suit required test conditions. To carry out a test a thin, close-fitting standard material with high moisture wicking properties is placed over the foot. Referred to as a 'skin', this provides a mechanism for distributing water from the

eight sweat zones.

The test foot has a leg extension which is clamped vertically inside a test chamber that has one end open and unobstructed. At the toe end a fan maintains a constant air flow over the foot. Four thermocouples placed at specific positions on the test foot surface are wired so as to measure the average surface temperature of the foot. A data acquisition module records electrical power consumed by the foot heater element throughout the test.

Effective assessment of the moisture management and thermoregulatory properties of complete footwear requires a test method that reflects in-shoe conditions encountered during wear without the expense and delay inherent in wear trials with human subjects. The AMMT allows the thermal and moisture management properties of footwear as a finished product to be considered, taking into consideration the combination of sole, upper, lining, seams, footbed and socks.

In order to replicate the conditions of real wear the footwear is tested with a sock. The type of sock used in a test will affect the water take-up of the shoe and is chosen as one likely to be worn with the type of shoe being tested. For everyday footwear a thin cotton-rich sock is used, whereas thicker socks are more suitable for heavier footwear.

The pre-conditioned weight of the skin, sock and shoe is measured at the start of a test run and before each item is put on to the test foot. Once all the items have reached 34°C, the water pump and data acquisition module are started. When the test cycle is complete, the pump, heater and fan are turned off and the shoe, sock and skin are removed and reweighed as quickly as possible to minimise water evaporation. The total electrical power used to heat the foot

*Test in progress showing fan in motion.*

during the test is recorded together with the amount of water pumped into the foot. The change in weight of the skin, sock and shoe, and the total water evaporated from the system are then calculated.

INTERPRETATION

The total water evaporated from the system provides an indication of the water vapour permeability of the complete shoe construction. If a sizeable proportion of 'sweat' pumped into the system is found to have evaporated, one can be assured that the individual shoe components are complementing each other to provide effective moisture disposal.

From the moisture uptake of the skin, sock and shoe, the approximate distribution of sweat within the system as a whole can be ascertained. If a significant proportion of the added moisture is retained by the skin and sock, this points to poor wicking and absorption properties. As a result, this may have a negative impact on the wearer's perception of comfort since much of the sweat remains close to the wearer's skin.

The total electrical power consumption of the test foot heater element indicates how well the complete shoe would insulate against foot temperature extremes. A high value corresponds to a shoe with low thermal insulation properties because the heater is operating for longer

periods in order to maintain test foot surface temperature. Low power consumption, on the other hand, indicates a shoe with high thermal insulation properties which might be used to protect the foot against extremes in outside temperature.

The AMMT test can also be run without the simulated perspiration in order to measure whole shoe thermal insulation. In this instance, the electrical energy or power used by the heater to maintain a foot surface temperature of 34°C is recorded. This is particularly important both for cold environment footwear such as outdoor winter or cold store boots and hot environment footwear where a degree of protection from the ambient conditions is necessary.

While the test machine has UK size 9/Eur 43 foot form as standard, other sizes are now available to enable it to accommodate testing of women's and children's footwear. This is an important development as it will allow testing and analysis of children's cold weather boots and shoes which cannot be performed with the traditional method of using a subject in an environmental chamber.

SATRA has provided members with advanced moisture management testing for a number of years and is now making the AMMT (STM 567) plus full training and calibration available on an exclusive basis to members wishing to carry out these tests as part of their product development programme. 