STANDARDIZED AND PRACTICE ORIENTED TESTS; COMFORT AND PROTECTION OF CLOTHING: TWO CONTRADICTIONS IN ONE ?

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INTRODUCTION

Test methods and apparatus which are supposed to be standardized have to fulfil strict requirements concerning reproducibility and repeatability. In order to achieve these requirements the test parameters have to be fixed in a way which in most cases makes it very difficult to correlate the results to the practical use of the product tested. On the other hand, if test methods and equipment are developed for research purposes, care has to be taken that they are as much practice oriented as possible in order to make predictions which correlate with reality. EMPA as a laboratory which carries out standardized material tests as well as research work has to cope with these contradicting requirements.

Protective clothing is intended to protect the wearer against external hazards. This means that the clothing has to have a very low permeability for hazardous influences (heat, chemicals etc.). Clothing comfort, on the other hand, aims at the thermo-physiological balance of the human body. This means that the body should have the possibility to get rid if the metabolic heat produced even at a high workload. This is done by thermal conduction and convection as well as by evaporation of sweat. This means that the clothing has to be permeable to heat and to water vapour. So, we have another contradiction between the demands of protection and comfort..

EMPA has developed in the last years, based on standardized methods, a range of new test equipment (sweating arm, sweating torso etc.) which allows measurements under conditions near to practice. Several research projects (breathable rainwear, comfort and protection etc.) have been carried out or are still in progress in the two fields comfort and protection. In the following it is shown how EMPA tries to overcome the contradictory and competing requirements and to come to a synthesis between research and standardization as well as between comfort and protection.

STANDARDIZED TESTS

Two representatives of the standardized test methods, one in the field of protection and one related to comfort, shall be described shortly:

- The protective property of clothing materials against radiant heat can be measured according to ISO 6942 / EN 366. The test device consists of a radiation source able to produce a heat flux density up to 80 kW/m^2 and a calorimeter which allows the measurement of the heat flux. The results of this test are the transmission factor

and two threshold times. The threshold times correspond approximately to the time spaces until pain sensation and second degree burn respectively occur.

The comfort properties of clothing materials, i.e. thermal and water vapour resistance, can be assessed with a sweating guarded hot plate according to ISO 11092 / EN 31092. The thermal resistance of the material is determined by measuring the heating power of the plate which is needed to keep a given temperature difference between the plate and the air. For the measurement of the water vapour resistance the porous plate is fed with destilled water which evaporates at the surface and simulates the sweating. The heating power of the plate is only used for the evaporation of the water - the measurement is done under isothermal conditions - and is therefore a measure for the water vapour permeability of the material under test.

These two test methods are qualified as standardized material tests because they provide reasonably repeatable and reproducible results. On the other hand they have several drawbacks compared with real life conditions:

1. The geometrical conditions do not correspond at all to reality. Normally the different layers of the clothing are not lying flat on each other; there are air gaps between them which constitute additional thermal and water vapour resistances.
2. When measuring the protection against radiative heat the humidity in the materials play an important role on the heat transmission [1, 2].
3. Another very important effect, the so called pumping effect, cannot be assessed by the skin model. It is the transport of air containing heat and humidity through the openings of the clothing, caused by the movement of the wearer.
4. **A** simultaneous assessment of protective and comfort properties, which is necessary because they are dependent of each other, is not possible.

EQUIPMENT DEVELOPED BY EMPA

There is quite a variety of test equipment developed during the last years by which **EMPA** tried to overcome the above mentioned drawbacks of the standardized test methods [3, 4, 5]. **As** one representative of these the sweating torso will be described in short (for more details see [4]).

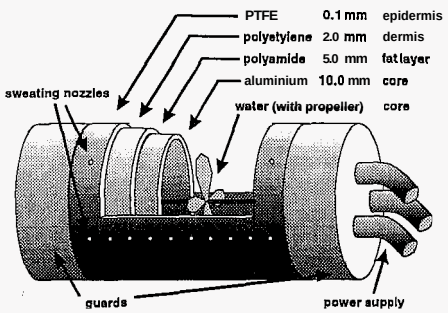

Figure 1 : Cut view of the sweating torso

The torso, which is shown schematically in figure 1, is a cylinder with the dimensions of a human trunk. It consists of three parts, the measuring part (cylinder) in the middle and two guards at the ends. The cylinder is constructed with different material layers which have been chosen to correspond in thickness and thermal properties to the layers of the human body. The cylinder is heated electrically by heating foils. The tempera-

ture of every layer can be measured at any time. The guards at both ends are kept at the same temperature as the cylinder in order to avoid any heat loss of the cylinder through conduction towards the ends. The sweating of the torso is achieved by sweating nozzles evenly distributed on the cylinder surface. During the measurements the cylinder is covered with a cotton fabric which distributes the water fed through the nozzles evenly over the surface of the cylinder. On top of this fabric a foil or membrane is mounted to prevent liquid water from passing to the outside while letting water vapour pass through.

For the measurements the torso is covered by the test object (piece of clothing, sleeping bag, material sample etc.). There are two possible ways how the torso can be operated. It can be run at a constant temperature of cylinder and guards. In this case the heating power of the cylinder is measured and the thermal and water vapour resistances of the test object are calculated thereof. The second way of operation is at constant heating power corresponding to the metabolic heat production of a human body. For this way of operation it is essential that the thermal and geometric properties of the cylinder are similar to those of a human body. Only then it is possible to analyse transient processes. It is then possible to follow, at a constant rate of sweating, the decay or increase of the core temperature.

With the torso already some measurements have been made. An evaluation of sleeping bags showed a good correlation to practice tests with test subjects and allowed to determine the lower limiting temperature of use of the sleeping bags [4]. At the moment a radiative heat source is under construction with which it will be possible to assess simultaneously the comfort and the heat protective properties of clothing. So, when looking at the drawbacks of the standardized test methods listed above, one may see that the points No 1, 2 and 4 could be eliminated with the torso. For the assessment of the pumping effect according to point No 3, EMPA has constructed a sweating and moving arm which has been described elsewhere [3]. On the other hand, the sweating torso is, at least for the time being, not qualified to be standardized. Too many parameters are free and therefore too many different types of results may be obtained with this apparatus. But this, on the other side, is very advantageous for research work

RESEARCH PROJECTS

Two years ago EMPA has finished the ARES research project [6] in which the comfort and rain protective properties of breathable rainwear were studied. In order to have a representative survey on the products on the market, 36 different rain jackets have been tested according to 18 different test methods. Based on the results the tested products could be classed with different fields of application: leisure, sport, work and outdoor. Another research project which is still in progress, FOKUS, deals quite generally with comfort and protection, but focusing mainly on heat protection (industrial, fire-fighter etc.). A part of this work, dealing with the influence of ageing on comfort and protection, has recently been presented at a symposium [7]. A third

project which is in progress, a continuation of the ARES project, is looking specially at the products from the outdoor sector. In all these research projects, of course, the new pieces of equipment developed by EMPA are used.

CONCLUSION

The development of test equipment and methods for research projects which are closer to reality, leads from the well defined and reproducible standardized test methods to more complex concepts of testing. These have more degrees of freedom in order to adapt the test to the situation to be simulated. The outcome of the research work done with this equipment will lead to a knowledge which parameters are essential for the classification of products. Only then it will be possible to standardize these, primarily research oriented test methods. So, the contradiction between standardized and practice oriented tests still stays, but it is clear that both have to coexist and that they do influence and improve each other.

The other contradiction between protection and comfort, too, cannot be resolved. But the research work done with practice related test methods and equipment will, together with a very careful risk assessment at the workplace'of the users, help to collect the knowledge necessary for the development of protective clothing with sufficient protection combined with the maximum achievable comfort.

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