

New test equipment

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During the last five years the number of tests on shoes and components performed by PFI-Germany has more than quadrupled. One reason for the growing willingness of manufacturers and retailers to test shoes and components can be found in government regulations and laws which have led to restrictions in selling these products. Good examples are prohibited chemical substances or standards such as EN ISO 20344, which applies to occupational footwear.

Slip resistance

Another test standard that must be observed by occupational footwear manufacturers is DIN EN 13287. This standard describes a machine procedure (Figure 1) for measurement of slip resistance in which a shoe is worn on an artificial foot or a last and the ground reaction force is measured during the movement of the foot on a standard ground. The ratio of horizontal force generated by friction and the vertical force simulating body weight is called the coefficient of friction.

To measure the coefficient of friction, the horizontal and vertical forces are recorded (Figure 2) during the slip phase of the test and the calculated and averaged quotients of these values are displayed on the screen.

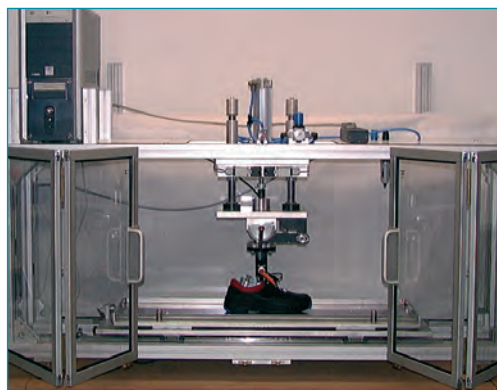


Figure 1: PFI slip resistance tester.

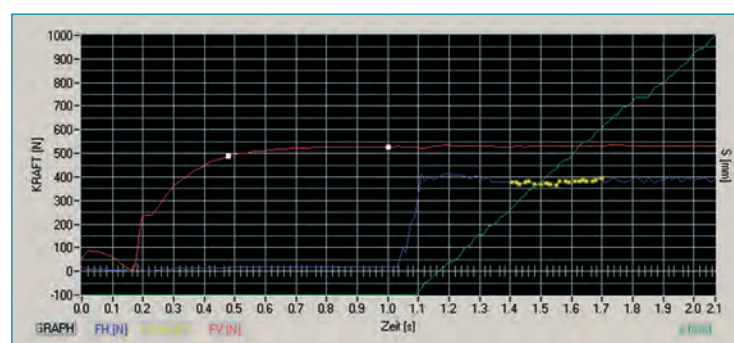


Figure 2: Recorded graph of vertical (red) and horizontal (blue) forces.

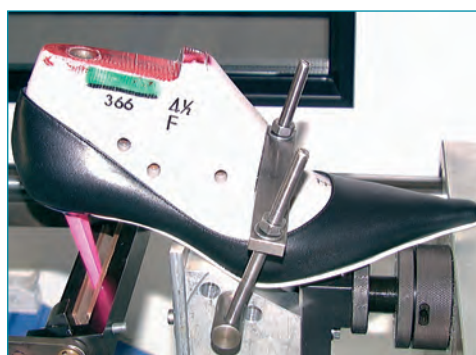


Figure 3: Heel test.

Another field of inspection concerns durability tests of shoes and components in which cyclical operating test devices apply a significant number of load cycles to the test specimen in an appropriate test time. With such devices the attenuation and cushioning properties of sole materials can be tested, for example, by applying 100.000 load cycles with a frequency of 2Hz and compression forces of 1.2 kN. This is roughly equivalent to

the force produced by an 80kg person when walking. Other tests are dynamic tensile tests of seam strength, toe cap and heel tests (Figure 3), and so on.

To make these kinds of durability tests, highly dynamic hydropulsers have been developed, available from several sources. An analysis of shoe and component

durability test requirements shows that in 90% of all cases, forces lower than 2kN and frequencies lower than 5Hz are sufficient. To meet these requirements the use of hydraulic systems is not needed and pneumatically driven devices can be used instead. These are much less expensive but still offer both force and displacement driven control of the test cycles with adequate accuracy. An example of a pneumatically driven durability test machine is the DBPM ➤

device from PFI (Figure 4), which can be used to perform PC-controlled dynamic tensile and compression tests.

Figure 5 illustrates the force/way curve of one cycle during a permanent load test of a typical PUR-sole component with a test frequency of 0.5Hz. The area between the upper and the lower part of the curve is equivalent to the energy absorbed by the test specimen during the load cycle. This energy causes the test specimen to warm and this limits the maximum test frequency.

A special feature of the device displayed in Figure 4 is that beside permanent load tests, impact tests can also be carried out. In these, a mass of 7.5kg is allowed to free-fall from a defined height above the test specimen and hits the surface of the test sample with an impact velocity that corresponds to the height. The force and distance is then recorded during the compression phase while the impact head (Figure 6) is in contact with the test item. The energy is calculated and the percentage of absorbed energy displayed. Some materials achieve a shock absorption coefficient of more than 90%, while most sole materials are in the area of 50% to 60%.

The next diagram (Figure 7) shows the force/distance comparison of the same test item shown in Figure 5. One can clearly see the much higher energy absorption of the material in the impact

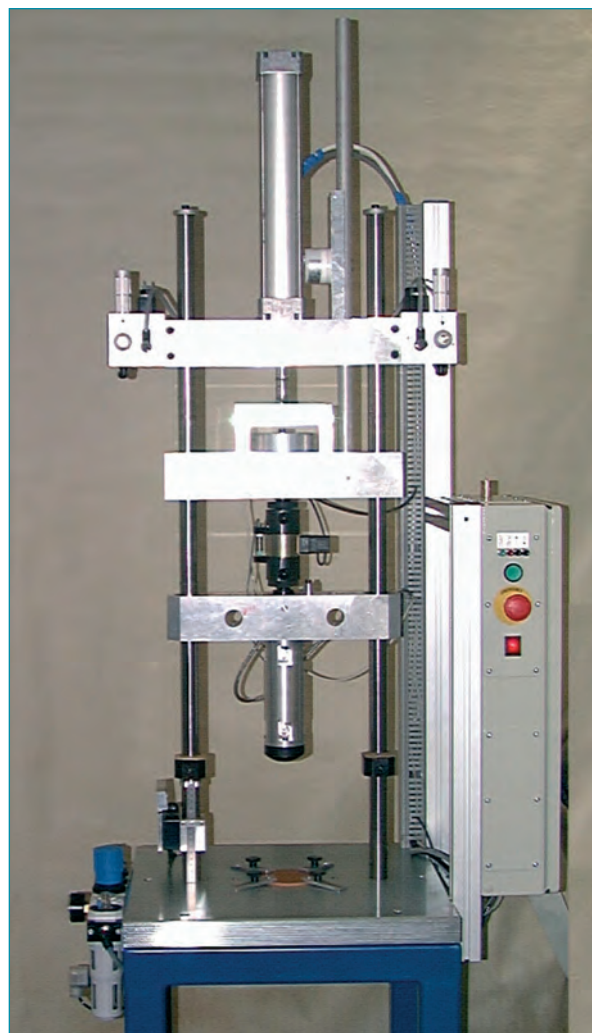


Figure 4: PFI combined permanent load and impact tester.

test compared to the relatively slow cyclical test. The reason for this is the visco-elastic behaviour of the material. The red curve shows the intrusion of the impact head into the material, the green shows the rebound of the first peak and



Figure 6: Impact head.

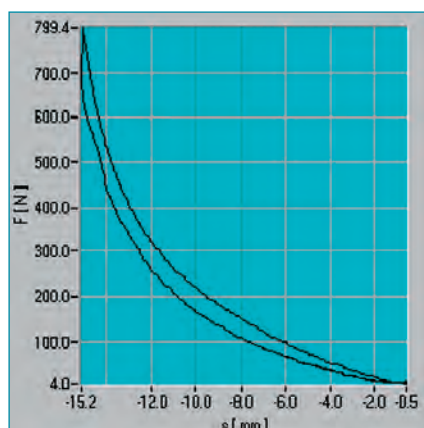


Figure 5: Force/distance diagram of a PUR sole at 0.5Hz.

the black the succeeding peaks of the impact test.

Besides testing according to laws and regulations, the determination and measurement of comfort is another area in which manufacturers and distributors invest in order to prove that their products are better than those of their competitors. One aspect of this concerns biomechanics and the impact tests mentioned earlier belong to this category. Another important area is foot and shoe climate, which leads to tests such as water vapour permeability (EN ISO 20344). In recent years, whole shoe comfort testers have appeared that will not only analyse individual components but also the construction and manufacturing process of a complete shoe (Figure 8).

An artificial foot that emits heat and humidity is placed into the shoe to be measured. A measurement sock with distributed temperature and humidity sensors acts as artificial skin and sends the sensor information to the PC controlling the test procedure. Several load settings can be chosen with different heat and humidity being emitted. So, for example, a working day with phases of heavy work and breaks with low heat and humidity emission can be simulated. The humidity and temperature curves can be displayed on the screen or exported and analysed in spreadsheet programs like Excel.

This device enables manufacturers ➤

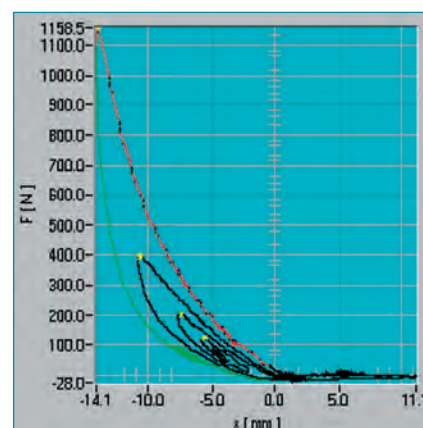


Figure 7: Impact diagram of a PUR sole.



Figure 8: PFI foot comfort tester.

and component suppliers to systematically optimise their products (Figure 9). This illustrates the humidity curve versus time of two shoes from the

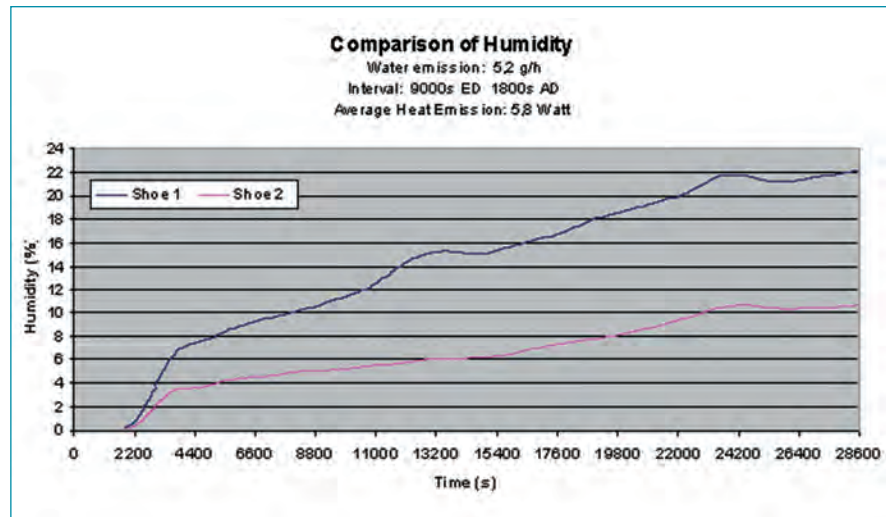


Figure 9: Humidity measured with PFI comfort tester.

same manufacturer. The upper (blue) curve is recorded before and the lower (red) curve after optimisation.

Because of the increased significance of whole shoe tests compared to

components tests, PFI is continuing to develop test methods to determine whole shoe behaviour not only in the field of comfort but also in everyday wear and tear.

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