Manufacturing trials for anti-static ladies' shoes

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As far as people are concerned, electrostatic fields have until recently been seen largely as irrelevant to human health and well-being. This has changed over the last five years or so, and such installations as high-voltage overland electrical cables and microwave transmitter aerials have come under suspicion as being possibly detrimental to health.

A new niche market?

Although electrostatic fields are generally associated in the public eye with electro-technical installations,they are also present in the clothes and shoes we wear. In the case of shoes which are fabricated from a strong insulating material, a strong electrostatic charge can be built up when the wearer walks over a carpet which is likewise made from a good insulating material. The wearer of the shoes remains unaware of the charge build-up until he or she reaches out for a metal handle and receives an unpleasant but minor electric shock. But even if no shock is experienced, it is quite possible that the charge buildup in shoes has negative side-effects upon the wearer.

In a recent test report published in the German „Öko-Test-Magazin", the authors looked at the electrostatic qualities of ladies' shoes. Generally, the material used in the shoes had very high electrical resistance and this can lead to a build-up of an electrostatic charge. For this reason, the authors marked the shoes down in their evaluation.

Electrostatic charge

Even though there is as yet no clear scientific evidence that electrostatic fields have a negative effect upon human health, the proposition cannot be dismissed out of hand. In any case, the electric shock which is received as a result of static discharge is quite unpleasant and should be avoided.

An electrostatic field builds up when synthetic materials which are also good insulators, are rubbed against each other. This phenomenon becomes particularly apparent for people when they are surrounded by air of low humidity, as this is a poor electrical conductor. Enormous voltages may be generated by the build-up of electrostatic charges. Examples are given in Table 1.

In principle, when two different materials come into contact – here disregarding metals – the build-up of an electrostatic charge is simply unavoidable and is a natural physical phenomenon and must be accepted as such. However, the removal or leaching of the charge can be controlled. Many types of plastic can build up and retain an electrostatic charge over a period of weeks or months, unless a discharge is effected.

	Electrostatic charge in Volts V		
Relative humidity	10%	40%	55%
On carpet	35 000	15 000	75 000
On PVC floor covering	12 000	5 000	3 000

Table 1: What Voltages can be created by electrostatic charges due to walking?

Shoes as electrical conductors

Ideally, there should be a continual adjustment of the potential electrical difference between the human body and the ground. When electrically conductive shoes are worn, the human is subjected either to no or very little electrostatic charge, even when walking on a carpet which is a very good electrical insulator. The evidence can be found in the soles of safety shoes worn in an industrial environment.

The electrically conductive qualities of shoes are determined primarily by their soles, the only possible exception being leather soles. The second factor is the shoe insole and the adhesive holding it in place.

Shoe type	Sole	Upper	Lining	Insole	Glue	Electrical resistance normal/dry	Classification (EN 345)
2	PUR 2	Leather	Leather	Leather	C	330 MOhm/900 MOhm	antistatitc
2	PUR 2	Leather	Leather	Fleece fibre, black	C	240 MOhm/650 MOhm	antistatitc
2	PUR 2	Leather	Leather	Fleece fibre, black	D	360 MOhm/800 Ohm	antistatitc
3	Rubber 2	Leather	Leather	Leather	D	>360 Mohm/ >890 MOhm	antistatitc
3	Rubber 2	Leather	Leather	Fleece fibre, black	C	400 MOhm/230 MOhm	antistatitc
3	Rubber 2	Leather	Leather	Fleece fibre, black	D	190 MOhm/380 MOhm	antistatitc
3	Leather	Synthetics	Synthetics	Leather	B	110 MOhm/870 MOhm	antistatitc
3	PUR 2	Synthetics	Synthetics	Fleece fibre, black	D	80 MOhm/210 MOhm	antistatitc
3	Rubber 2	Synthetics	Synthetics	Fleece fibre, black	D	65 MOhm/90 MOhm	antistatitc
3	Rubber 2	Leather	Leather	Fleece fibre light + copper rivet	C	30 MOhm/25 MOhm	antistatitc
2	PUR 2	Leather	Leather	Fleece fibre light + copper rivet	C	18 MOhm/10 MOhm	antistatitc
3	Rubber 2	Leather	Leather	Fleece fibre light + metal seam	C	15 MOhm/8 MOhm	antistatitc

Table 2: This table presents the possible combinations of materials which could be used to fabricate an 'antistatic' shoe within the definition of industrial standard EN 345.

Legend:

Basic shoe type 2 and 3: Ladies' pumps with semi-high heels

PUR 2: Polyurethane soles with anti-static elements

Rubber 2: Rubber soles of the usual type, with antistatic elements

Glues A, C: Glues without antistatic properties

Glues B, D: Glues with antistatic properties

Fibre fleece, light: shoe insole material, not antitstatic-modified

Fibre fleece, black: antitstatic-modified shoe insole material

A number of materials which would normally be regarded as electrically insulating including polyurethane, PVC, TR and rubber, can be endowed to a degree with electrical conducting properties. This likewise holds true for the adhesives. Similarly, modifications can be made to the shoe which create an electrical bridge between the wearer and the ground. Personal protective clothing is manufactured to industrial standards (DIN 4843, EN 345 to 347) using constructional techniques which prevent a build-up of an electrostatic charge by incorporating a discharge conductor. Industrial standard EN 345, for example, requires that antistatic shoes incorporate a sesistor in the range of 100 kOhm to 1000 MOhm.

There are plenty of glues, plastics and leather which have adequate electrical conductivity to meet these requirements. The conductivity can also be attained by the incorporation of metal pins, conductor strips or conductive rubber lugs. There are special high-conductivity shoes for those who work with sensitive electronic components. However, the materials and the processing technologies employed have so far only been tested on heavier shoes, special sandals and the so-called "bio-shoes".

Anti-static ladies' shoes

To date, anti-static materials and working methods have not been employed, tried or tested on ladies' fashion shoes. But fashion shoes are worn by relatively large numbers of women working in offices where they are exposed to electrostatic charges and require commensurate footwear.

Fabrication of samples

For this reason, the PFI has looked at the means by which ladies' fashion shoes can be modified to deal with the problem of static without excessive sacrifice of the fashion and design aspects. The study looked first at the existing 'antistatic' materials and processes used for the manufacture of industrial safety shoes, and the possibility of their further use for ladies' fashion shoes. This embraced adhesives, sole material, shoe insoles and other materials. So far, it has not been possible to determine what problems might occur given the different manufacturing methods used for ladies' shoes, or what effect there might be on appearance and price.

The PFI arranged for a range of samples to be made by shoe manufacturers using materials obtained by the PFI. These shoes were subsequently tested for conductivity and antistatic properties at different humidity levels by the PFI in line with DIN 4843.

In contrast with industrial safety shoes and shoes and sandals made for 'rustic' wear, ladies' fashion shoes used in the office, shopping or for recreation should have smooth soles made from flat rubber, leather or possibly PVC. The range of materials currently in general use apparently incorporate a high level of electrical insulation. This is likewise true for the shoe insoles and adhesives in current use. Possibly, the bottom filler is too well insulated.

The aim of the trials was to make shoes with an electrical resistance of 10^6 Ohms, which might then be fairly described as 'antistatic'. The materials used were to be restricted to those currently available and unmodified. Materials which were deemed unsuitable for use in the manufacture of ladies' shoes were to be assessed for possible adaptation by chemical means to current production methods. Three different types of shoe design were made using different types of materials and tested against the requirements (Table 2).

Results

When making shoes with the standard existing materials, it is not possible to achieve any improvement in the antistatic properties without modifying the construction. In other words, the shoes can be regarded as 'electrically insulating'. The results confirmed the reports mentioned earlier and published by the consumer press.

Market niche: antistatic ladies' shoes

As would be expected, the use of electrically-conducting materials greatly enhances the antistatic properties by lowering electrical resistance. However, it became clear that the use of these materials placed considerable limitations on the range of materials which could be employed in the manufacturing process. In view of the fast-changing requirements of fashion and model changes, this is simply unacceptable throughout the entire range.

The only realistic option would be to use such materials in a limited number of models which would continue in production relatively over a number of years. However, it is quite possible that a new market could be created by appropriate promotion and product marking.

The most certain way of achieving a low level of electrical resistance is by modification of the construction, and in terms of the material only the sole need be antistatic. There is no difficulty in reaching the desired electrical conductivity even in conjunction with standard insoles and adhesives: the options range from the insertion of a copper clamp, a fine metal wire, or a conductive metal ribbon in the forefoot. Air humidity has little effect upon the conductivity. In the achievement of the desired antistatic properties only the material used for the sole must be specially selected. However, at present the range of antistatic sole materials is small and the prices are relatively high.

Demand is there

As explained above, the tests described here were originally triggered by the reports published in „Öko-Test-Magazin". Irrespective of whether or not the static properties of the shoes tested have any effect upon human health or well-being, the fact is that these reports triggered an increase in demand for 'antistatic shoes'. At present, German shoe manufacturers are unable to meet this demand, and leave the impression of being somewhat helpless when asked the question. If they responded quickly to this new departure, they might well be able to steal a march on the competition.

Fashionable or elegant ladies' shoes which can be described as genuinely 'antistatic' are not presently available on the German market. Perhaps consideration should be given to the development of an antistatic trade or brand mark for such shoes in order to encourage their development and introduction.