



Controlling Static Electricity in Modern Buildings

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The problem of static electricity in commercial offices and stores is a relatively modern phenomenon. It represents an annoying source of painful electric shocks to both occupants and visitors and contributes to low morale amongst staff and workers. In department stores for example it often generates complaints from customers, sometimes resulting in litigation. In a recent incident a cup of hot coffee was spilt on a child after the parent received a shock from a hand rail in a department store café. Uncontrolled static electricity can also cause chaos by interfering with computer systems and electronic point of sales (EPOS) equipment. In the most extreme cases it can even constitute a fire or explosion risk.

Graham Hearn is the Director of Wolfson Electrostatics and Visiting Fellow at the University of Southampton in the UK. He specialises in the control of unwanted static electricity and has investigated and advised on static problems in buildings throughout Europe. In this short article he considers the causes of electrostatic problems and how they might be avoided.

Shocks

Modern buildings are inherent static generators and dry, fine weather often brings complaints of electric shocks from people touching metal objects such as radiators, door handles, filing cabinets and hand rails. Whether it is a new apartment, office or the interior of a department store, the question is often asked, can repeated shocks from static electricity constitute a health hazard?

On the face of it one might expect static electricity to pose a lethal threat. The voltages encountered may be as high as 15,000 or even 20,000 volts, whereas mains supply voltages of only 240 volts are known to be fatal. Furthermore, the destructive nature of static electricity is vividly demonstrated in nature by a lightning strike, itself an extreme form of static discharge. Within buildings, however, we do not encounter lightning-like discharges and what determines the severity of the electrostatic shock, in virtually all cases, is the amount of electrical charge that is generated and stored on the human body. When a person reaches for a door handle and experiences an electric shock it is the release of electrical energy developed on their body by actions or movement prior to touching the handle. The charge may be generated by a simple action such as walking across a carpeted or tiled floor. The electrical shock that is experienced occurs when the body loses its stored energy very rapidly in the form of a spark.



Figure 1. Captured on film! An electrostatic spark from a person's finger to a filing cabinet. The effects of electrical current passing through the human body are covered at length in the International Standard IEC 479-2:1987. It indicates that the energy content of a spark from the human body is too low to produce a direct serious risk to health. However case histories have shown a number of accidents due to shock reaction or recoil. Such accidents include falling down stairs and dropping or releasing loads.

There is no doubt that static electricity is an insidious danger. It is by nature unpredictable and difficult to detect. With the correct approach however the risks presented by static can be quantified and controlled. For a hazard to occur, the following three elements must be present

- Generation of electrostatic charge
- Accumulation of charge
- Electrostatic discharge (ESD)

Charge generation

It is possible for a person to generate electrostatic charge on his or her body by movement particularly walking. The contact and separation of the sole of the shoe with the floor creates a small imbalance of charge with every step. Increased friction due to shuffling the feet when walking exacerbates the charge separation process and factors such as the flooring material, the type of footwear and the humidity in the building can have a major effect. Human skin is very conductive in electrostatic terms and if a person is electrically isolated or insulated from earth by synthetic soles the electrostatic charge can accumulate on the body like a capacitor and their voltage may rise to several kilovolts. The person involved may be blissfully unaware of this condition until they reach a grounded object such as a hand rail, radiator or lift button whereupon a spark jumps from their finger. In this spark the body releases all of its accumulated charge at once giving the resultant sensation of shock.

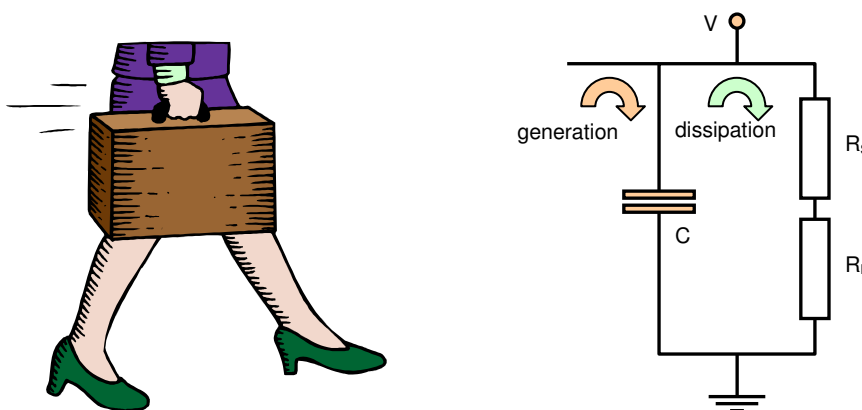


Figure 2: Electrostatic model of the human body. The charge generation mechanism could be walking, handling of charged materials, movement in a chair etc.

Charge accumulation

A person standing can be modelled as a capacitor in parallel with two resistors (Figure 2). The capacitance (C) of the human body determines how much electrical charge can be stored. It is somewhat dependant on the body's physical size but generally varies little from person to person. As the capacitor becomes charged eg by walking, a simultaneous charge decay occurs governed by the resistance path to ground. R_S and R_F respectively represent the resistances of the footwear sole and flooring. The time taken for charge on the body to decay is given by the product $(R_S+R_F).C$.

If either the footwear or flooring resistance is high, rate of generation will exceed decay and charge will accumulate on the body. Standards recommend a maximum resistance for footwear and flooring of 10^9 ohms (1000 million ohms) to minimise human body charging in non-flammable atmospheres. This gives a charge relaxation time of a fraction of a second. It should be noted that since R_S and R_F are in series, both must be low to avoid charge accumulation.

Electrostatic discharge

If electrical charge on the body reaches a voltage in excess of about 3,000 Volts (3 kilovolts) it is likely that the person will experience a shock when touching an earthed metal object such as a radiator. At 10,000V or greater most people would consider the shock to be painful and experience involuntary recoil. 20,000V usually represents a maximum since at this level charge starts to leak away into the air from 'sharp' parts of the body such as fingernails and hair.

The high voltages and relatively high currents produced during spark discharges not only cause discomfort, they also represent a risk to sensitive electronics and microprocessor systems.

Materials

In virtually every case that has been investigated the prime causes of repeated electrostatic problems in buildings are the material of construction of the floors and the floor coverings. Traditional materials such as wood, natural-fibre carpets, concrete and Antistatic-grade vinyl are electrically dissipative. Modern synthetic materials, although generally more hard wearing, are often highly electrically insulating. Quartz tiles, ceramics, epoxy resin, plain vinyl and synthetic carpets fall into this latter category.

Figure 3 on the following page shows the electrostatic voltage recorded on a test subject walking around a five story department store. The basement (B) and 3rd floors have antistatic grade vinyl tiles and the intermediate floors (ground, 1 and 2) are suspended quartz tiles.

The graph in this figure shows the influence of both the flooring material and the footwear on the level of electrostatic charge generated. The antistatic vinyl tiles on floors B and 3 produced a small positive voltage with no perceivable static discharges. The quartz floor on the other hand produced significantly higher negative body voltages up to 5500V and subsequent uncomfortable shocks. In this particular store, the incorporation of polished steel hand rails exacerbated the problem by providing a convenient grounded metal object for the person to discharge to.

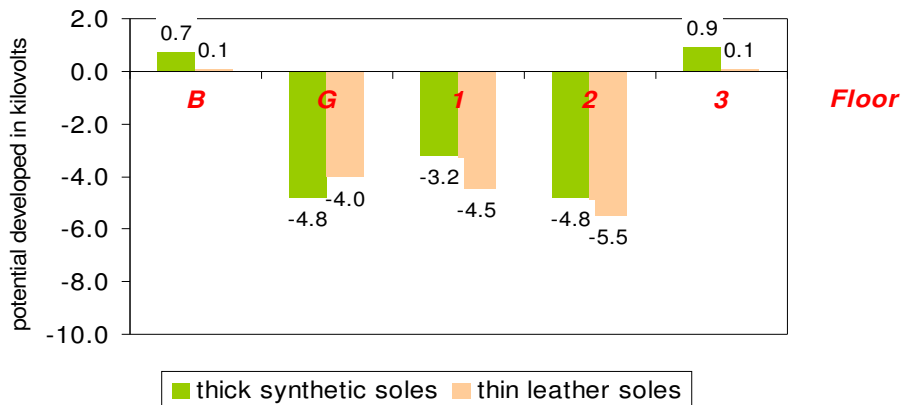


Figure 3. Voltages (in kilovolts) generated on a person walking around a department store. Data collected at 21-26% relative humidity and 18-21°C.

Tackling the problem

Uncontrolled static electricity is a serious issue which has long been recognised in many sectors of industry such as petrochemicals where the consequences of ESD ignition are often catastrophic. A lesser but significant problem is now also being encountered in offices, stores and other commercial premises in terms of electrical interference to computers, personal accidents and general nuisance. More often than not the fault lies with the materials used in construction, in particular flooring, and unfortunately some of the most attractive floors produce the most severe static problems

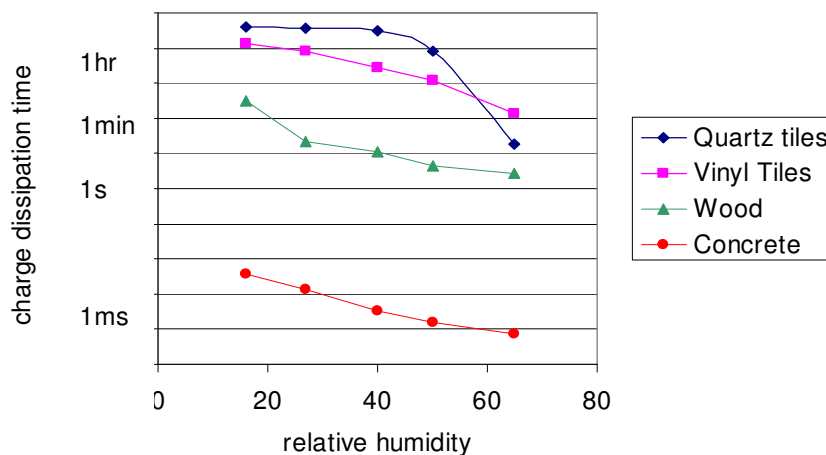


Figure 4. Charge dissipation time versus relative humidity for some common flooring materials (1ms = 1 millisecond).

The electrostatic properties of some typical flooring materials are shown in Figure 4. Here the time taken for static charge to dissipate from a person standing on the floor is plotted against relative humidity. The graph in Figure 4 illustrates the large difference between the flooring types which give dissipation times ranging from milliseconds (concrete) to hours (quartz). The

effect of humidity is also highlighted. In the case of the quartz tiles a significant improvement in charge dissipation is only observed at relative humidity levels above about 50%.

The following steps are recommended prior to design & installation:

- Determine the electrostatic properties of the proposed materials well in advance. This can be performed at a specialist laboratory. A specialist will be able to predict whether there will be a static problem once the building is completed.
- Do not rule out any generic flooring material (for example ceramic tiles) as there can be a great variation in the electrostatic performance of different varieties. Materials used for the base or underlay may also have a significant effect.
- Do not rely on claims that a particular product is 'Antistatic'. Experience has shown that this term is often applied without foundation. Polypropylene carpets are often claimed to be antistatic because they generate less charge than nylon. Static problems will still occur at low humidity levels.
- Air conditioning can generate an extremely dry atmosphere which exacerbates static problems. Consider humidity control and aim for 45%RH or greater. In small offices, well-watered pot plants will often raise humidity and reduce static.
- Fixtures and fittings such as door handles, hand rails etc are less likely to cause shocks and accidents if made of partially conductive or dissipative materials rather than metal. A natural 'dissipative' material is wood although partially conductive plastics are also available. These have the advantage of removing the charge from your body without experiencing a shock!

If static electricity only becomes an issue after the building is completed, the approach becomes one of 'damage limitation' rather than a full solution. An electrostatic audit will determine the source of the problem, quantify the properties of the materials and levels of static and recommend the most practical and cost-effective solution. Measures may include humidity control, antistatic sprays or coatings, floor coverings, antistatic mats, air-ionisers, carpet treatments and replacement or modification of fixtures and fittings.



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