A comparison between the static performances of two different families of composite dielectric fabrics used in ESD protective clothing

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Abstract: Two types of composite textiles for electrostatic protective clothing, here named ESD garments, have been investigated using a simple set-up and a manual procedure to obtain (and to measure) surface tribo-charge formation and decay. The obtained results formed an important input to build an automated system capable of precisely acquire data useful in the study of ESD garments performance indicators.

Introduction

Several types of electrostatic protective clothing, often named ESD garments, are in use, nowadays, within electronic industries and during certain apparatuses maintenance conditions.

The structure of such ESD garments is made by composite fabrics.

When the performance of a garment is described by the protection from ESD (direct or indirect) events that is given to an operator who wears such a clothing, then it can be difficult to achieve a satisfactory ranking of the protective clothing [1, 2].

Although non contact measurements on composite textile samples are not sufficient to characterise the behaviour of a whole system (ESD garment + operator + "ambient"), nevertheless they can suggest some problem-areas to be addressed, particularly when the charge is being "generated" via a tribo-electric way, i.e. via a way similar to the real conditions.

The latter approach involves the adoption of a rubbing procedure, so to arrive at monitoring the charge decay after a tribocharging period within a fully automated test system.

The design and the fine tuning of the latter system requires, as input:

– the results of from a preliminary test campaign, carried out by means of a manually operated test set-up, exploring the behaviour of two different types of composite textiles
– the output of an original charge generation and charge decay measuring system.

The here presented work deals with such a preliminary testing stage and offers an input to the final test set-up.

In fact it studies the charge decay behaviour of two different types of composite samples, fabrics hosting square grids of "surface conductive" threads or textiles hosting square grids of core conductive threads.

Different charge release experimental modes have been planned to gain some understanding of the consequences of tribo-charging as well as of the influence of the test parameters.

It is planned that the further experimental stage, making use of a purposely built automated test system should supply information, about the charge release/dissipation, useful as a basis for studying future measuring standards about the performance of ESD protective garments.

Test set up and specimens

As above noted, the first stage of the experimental investigation regarded a preliminary selection of two types of composite textiles and the preparation of a preliminary test set-up.

Circular ϕ = 110 mm samples of two textiles have been selected as representative of two large families: a cloth (50% polyester and 50% cotton) hosting a surface conductive 10 x 10 mm grid (named SC samples) and a cloth (100% polyester) hosting a core conductive "grid" made by 10 x 10 mm squares (named CC samples).

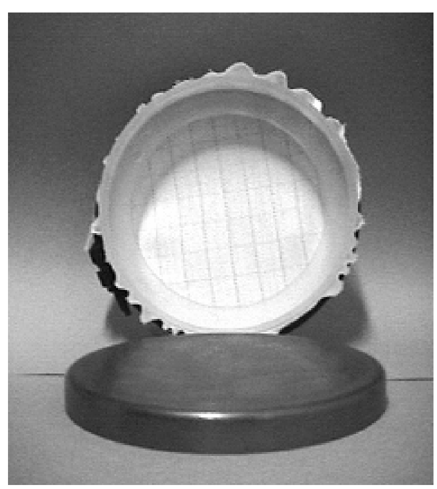

Figure 1: Cylindrical support

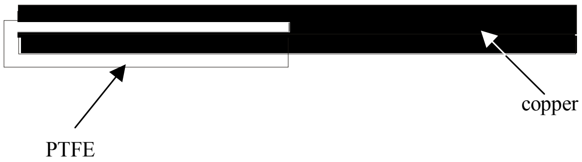

Figure 2: Flat rod section (sketch)

Then a cylindrical (ϕ = 100 mm) insulating support has been prepared and positioned over (at 10 mm distance) a grounded brass circular base, in order to offer a potential reference to the whole testing rig.

The picture in Fig. 1 illustrates the base and a sample mounted on the cylindrical support.

During this first stage of the activities an operator dependent procedure was accepted, while an environmental chamber was prepared.

A tribo-electric charging was adopted. The reason for this choice regards the situation of a ESD garment when worn. The textile would experience a sort of rubbing versus the common clothing worn by an operator: the relevant charge is certainly a tribo-charge.

Actually the sample had been manually rubbed by means of a special "flat rod", covered by PTFE material.

Figure 2 shows a lateral section of this 2 mm thick "flat rod", made by copper and PTFE; it was covered by a copper strip and it was permanently connected to ground.

The surface of the sample was then charged by rubbing this flat rod a few times over the sample surface. Further a fine and grounded stick was used to touch the centre or the side of another square, so to create a suitable ground path for the charge release.

The relevant surface charge was obtained by measuring the surface voltage over the centre of one of the squares, using the non-contact probe of an electrostatic voltmeter (the probe support had the same potential of the measured surface), positioned at 1 mm distance from the textile, as illustrated in Fig. 3.

This probe and voltmeter output were sent to a PC card (sampling rate = 4000 samples/s) and recorded by means of a dedicated PC.

This way curves of surface voltage vs. time were obtained in different conditions, for both textile families, for different relative humidity (r.h.) values and for different modes of charge decrease after tribo-charging

As regards the charge shown by the surface of a rubbed textile sample, three different "decreasing modes" were taken into account:

a) ground path *gsc*: obtained when touching a square *centre* by means of a grounded fine stick

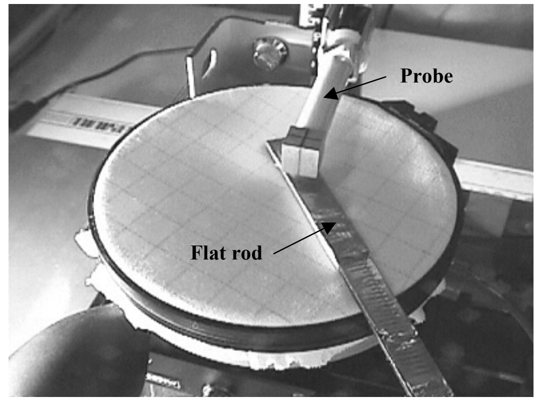

Figure 3: Experimental set up

b) ground path *gsc*: obtained when touching a square *centre* by means of a grounded fine stick
c) ground path *gth*: obtained when touching the *side* of a square by means of a grounded fine stick
d) self-decay *self*: obtained without introducing any further ground-path

Besides, a preliminary test campaign was performed keeping the rubbing pressure and the rubbing speed almost constant from test to test; the relevant outcome did show that the obtained curves "surface-voltage vs. time" could be considered reasonably well reproducible, even if the output was due to data obtained by triboelectric phenomena.

This situation was common to all performed tests, so that the outcome illustrated by the examples reported in Figs. 4 and 5 was found to be representative of the two extreme situations in all the tests, that is of the most of the least spread out outcome. For this reason the introduction in the test protocol of a normalisation stage was deemed suitable.

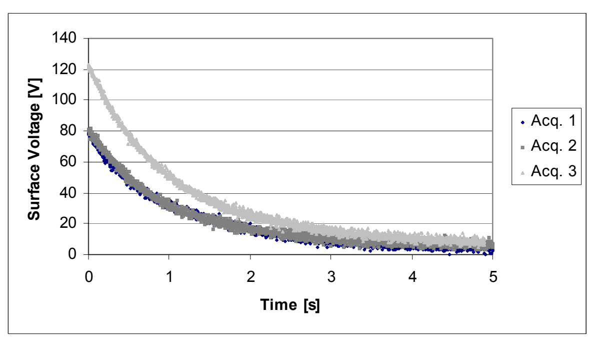

Figure 4: Surface voltage curves (SC textile, *gsc* mode, 60% r.h.) obtained for three different single tests

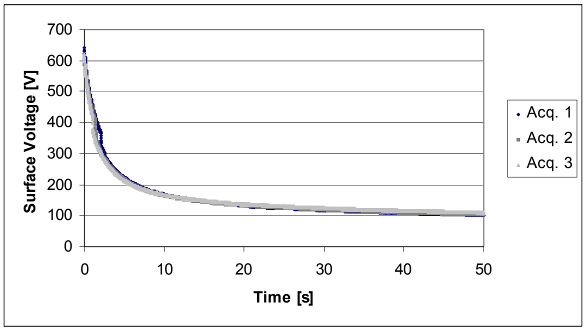

Figure 5: Surface voltage curves (CC textile, *gth* mode, 60% r.h.) obtained for three different single tests

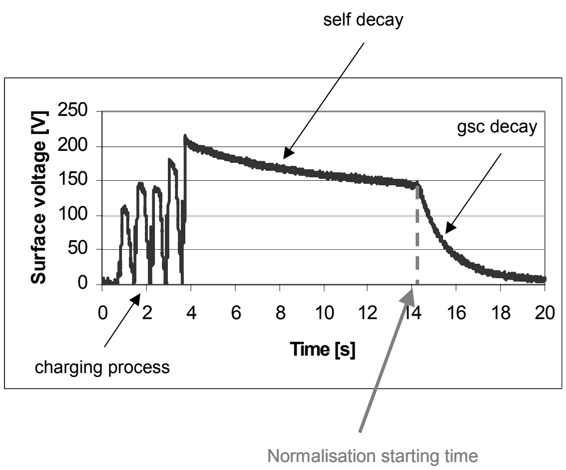

Figure 6: Example of surface voltage vs. time plot (SC textile)

Results

First plots of the surface voltage vs. time were obtained at 60% r.h. in *gsc* mode; one example is reported in Fig. 6.

It is to be noted how the reference starting time and surface voltage for normalisation were selected: for *gsc* and *gth* modes, they corresponded to the respective values at the instant when the grounded stick touched the cloth.

Besides, for *self* mode, they corresponded to the instant and voltage when the charging period was stopped.

Then a selection from the several data available about further acquisitions, is here reported in Figs. 7 and 8: some relevant normalised surface voltage curves vs. time, obtained at 25% r.h. for the SC and for the CC textiles, where the output for the 3 modes of charge decrease is shown.

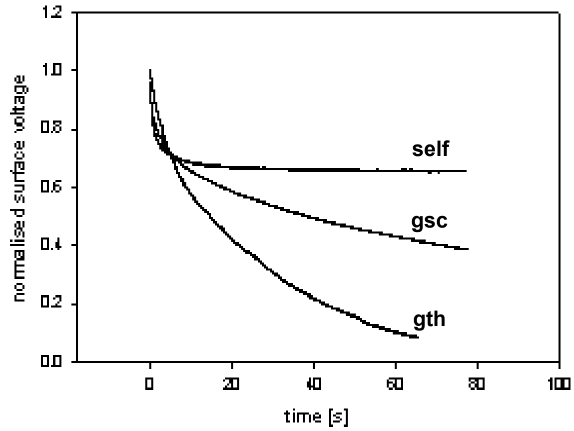

Figure 7: Example of surface voltage vs. time (SC textile, 25% r.h.)

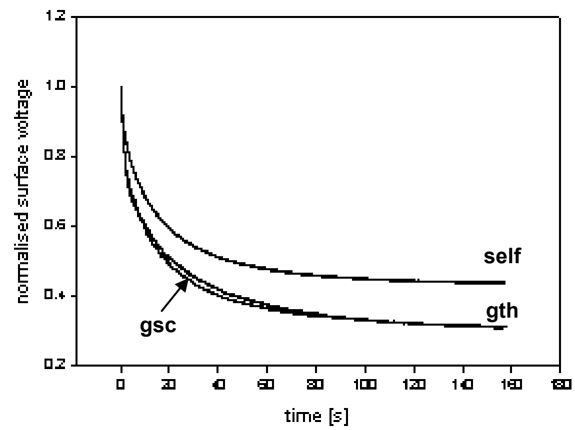

Figure 8: Example of surface voltage vs. time plot (CC textile, 25% r.h.)

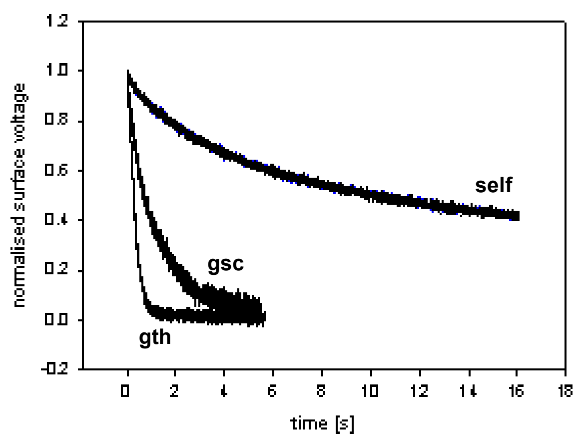

Figure 9: Example of surface voltage vs. time plot (SC textile, 60% r.h.)

In a similar way also the data, suitably normalised, concerning surface voltage curves vs. time, obtained at

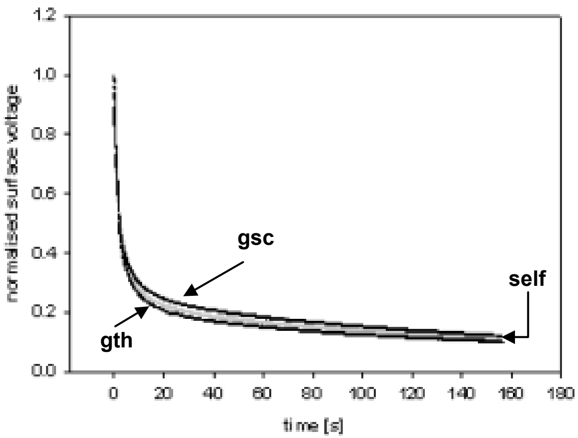

Figure 10: Example of surface voltage vs. time plot (CC textile, 60% r.h.)

60% r.h. for the SC and for the CC textiles - as regards the output for the 3 modes of charge decrease - are reported in Figs. 9 and 10.

Comments

The Fig. 6 data output evidenced that the adopted set up offered information about the behaviour of a composite textile, used for ESD garments, even if the manual operation implied difficulties in the repeatability of data.

A similar difficulty was experienced also in [3]: in our case the rubbing could be successfully standardized.

The latter problem had been approached, still at this preliminary stage, adopting normalisation techniques (as the charge decay curves appeared dependent on time in similar ways) and controlling the pressure on the "flat-rod" as much as possible.

The repeatability aspect deserved attention also because of the measured non-linearity in the conduction mechanisms and because of the variation of surface voltage with the pressure of the "flat-rod" over the sample.

Furthermore, it is worth to recall that, even for CC samples, the plots generally evidenced a different behaviour between the output of 25% r.h. tests and the output 60% r.h. tests: the latter ones showed initially a faster charge decrease than the "dry ones"; besides, for the same cloths, the "dry" tests evidenced always a faster charge decay for *gsc* and *gth* modes.

So the r.h. effect appeared to influence, although slightly, also the CC cloth samples, 100% polyester made.

Conclusions

The whole obtained data-output (here partially reported) of these experiments did offer a useful basis for the design of an automated set up to perform tests on samples of composite textiles following an optimal procedure (in an environmental chamber) and monitoring the test via a PC control and through data acquisition processes.

It is considered that the latter results are be a starting point for the modelling of the charge dynamics on several samples obtained from ESD garments, after suitable tribo-charging.

Acknowledgements

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References

[1] EU Project "*ESTAT Garments*" (G6RD-CT-2001-00615).

[2] J. Paasi et al " ESD-protective clothing for electronics industry – A new European research project ESTAT-Garments" *6th Dresden Textile Conference, June 19-20, 2002*

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