COMMENTS ON APPROACHES FOR MEASUREMENT OF ‘CHARGE DECAY’

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There are several methods for measurement of ‘charge decay’ described in ‘standard’ documentation and in published literature. The methods of measurement are very different and many of the methods do not provide the information likely to be expected by uninitiated/unskilled users and are susceptible to the construction of the materials tested. For methods to be considered valid and generally applicable they should fulfill the following requirements:

- they should have demonstrated relevance to end user applications
- for non-tribocharging methods they should have demonstrated comparability to tribocharging
- there should be lack of dependence on particular constructions or features of materials
- there should be lack of modification of the material by the conduct of the test (and this should also apply to tribocharging methods).
- the method should be easy to use and interpret by non-specialist staff
- suitable equipment should be easy to construct or commercially available.
- approaches should also be backed by peer reviewed published papers describing the equipment and giving supporting experimental measurements. These papers should be referenced in the ‘standard’ document.

The following notes describe a number of methods of charge decay measurement in use with their strengths and limitations. The term ‘charge decay’ here covers the voltage created by rubbing a material or surface initially at earth potential and the time taken for this voltage to fall away as the charge migrates away.

Corona charge decay

The corona charging approach to charge decay measurement offers many practical advantages and has been implemented in compact easy to use commercial instrumentation. It is in use by non-specialist staff with many types of materials in a wide variety of industries around the world. It is included in formal standards documents [7,8]. The method can also be used to assist measurement of ‘capacitance loading’ [1,2]. An uncertainty of this approach is that charging is by a high voltage corona discharge rather than be tribocharging – so comparability needs to be demonstrated as does lack of modification of the surface by the action of corona ionisation. To enable short decay times to be measured, it is limited to modest size areas of charge and test area. Studies have been reported that show comparability between corona and tribocharged decay for a variety of materials [1,2,11] and lack of damage by the action of corona ionisation [11]. These factors should be checked more extensively as should the apparent independence to the area charged, the area of the sample and the level of the initial peak surface voltage achieved.

FTS 101C

Federal Test Standard 101C Method 4046 [9] has been around for many years and has been subject to a number of comments and refinements [12,13]. The basic approach involves mounting a 5” long 3” wide strip of material between supporting clamps in front of a fieldmeter. A voltage of 5000V is applied to the clamps and the build up of fieldmeter signal observed. The clamps are then earthed and the decay of the fieldmeter signal observed and timed. It is noted in the specification that the method should only be used for ‘homogeneous materials’ - but no guidance is given on how to recognise such materials! Comparative tests showed that many practical materials gave much shorter charge decay times by FTS 101C than are observed with corona charge decay measurements [10]. These tests confirmed that comparable results were indeed obtained with truly homogeneous materials. It was concluded that FTS 101C basically responded to the fastest route for charge movement in the layer of material, whereas corona charge decay showed how charge moved on the surface of materials. This equipment is available commercially from ETS.

ITV Denkendorf

ITV Denkendorf developed a tribocharging method (ITV-TEV) in which a nearly vertical strip of material is held between two earthed clamps and rubbed by polythene rollers on either side as these are moved down the strip under tension. The rubbed area is held stably in front of a fieldmeter to observe the initial peak voltage and the rate of charge decay. The principle of the method seems sound but is only applicable to flexible layer materials and to materials with decay times longer than several tenths of a second. With fabrics rather different behaviour is observed in the warp and in the weft directions. The equipment is not now available commercially.

NASA

A tribocharging method for testing layer materials has been developed at NASA by Gompf [4]. This uses a rotating Teflon brush to tribocharged the sample surface that is earthed around its edge. At cessation of charging the sample is quickly dropped in front of a fieldmeter and the initial peak surface voltage is measured and the rate of decay of this voltage. This seems a good, valid and useful approach. Results are reported to correlate well with safety experience at NASA. There also seems reasonable correlation with two other test methods [14]. As implemented the approach has been limited by using an induction probe type fieldmeter, rather than a field mill, and by the time taken to move the sample at the cessation of rubbing to the position of observation. Use of an induction probe limits the sensitivity for low surface voltages and the length of decay times that can usefully be measured. It is also, of course, limited to layer type materials that can be presented as cut samples and those not likely to be damaged by the tribocharged rubbing action. This equipment is not available commercially.

A modification has been proposed to the above approach [15] to try to simulate the risk from the charging of an unearthed person’s body while wearing personnel protective clothing. An isolated pick up disc has been mounted as a backing support for the sample with 220pF capacitance to earth. The idea is that the electrostatic energy picked up by this disc will represent the energy available to create risks of ignition. However, if the sample is mounted on an earthy support then the presence of conductive threads in the test fabric could diminish the quantities of charge observed because of shielding effects. It needs to be recognised that risk may also arise if there are local areas of high voltage on garment fabric surfaces relative to the body – although the incendivity of such discharges will be affected by characteristics of the fabric.

BTTG

A tribocharging method for testing materials is used at British Textile Technology Group (BTTG) [16]. A 300mm diameter disc of material is held under radial tension in a circular conducting frame. The material is charged by hand rubbing with chosen materials. The total quantity of charge separated on the surface is measured in a Faraday Pail unit. A fieldmeter then observes how the surface potential of the middle of the disc varies when the mounting frame is earthed. As with the ITV and NASA approaches this measures the chargeability of the material. Charge decay behaviour needs to be assessed with care because this will comprise components associated with capacitive coupling via relatively high conductivity components of the fabric as well as possible slow components of the basic material surface. The approach seems fair in terms of charging the material, but charge decay observations will not be the same as those of observations from the spreading of charge from a local area that is charged by rubbing an initially charge neutral material. It is only applicable for layer type materials that can be presented as cut samples and those not likely to be damaged by the tribocharged rubbing action. This equipment is not available commercially.

BTTG has also developed a corona charging method (Shirley Method for Charge Decay Time Measurement on a Full Garment) for testing whole garments. This involves using a corona discharge to charge an area of the garment, while the garment is hung up vertically from insulated supports. The variation of the potential at the charged area is observed from the time the corona charging electrode system is removed. Charge decay behaviour is observed with four test procedures: charging with the garment unearthed and then earthed via the cuff and ankle area and then charged while continuously earthed via the cuff and via the ankle area. This equipment is not available commercially.

STFI

A method for assessing materials has been developed by STFI [17]. This involves observation of the form of components of the signal observed on the far side of a sample in response to a step function potential applied to an electrode on the near side. With careful interpretation these observations seem to relate to the risks of incendive electrostatic discharges from charged surfaces. The method is not, however, very useful for measuring the charge decay capabilities of the layer. The material is ‘charged’ by induction so a material will only be charged to a low level if the decay time is long. This means that only small surface voltages will be available for decay time measurements. A field mill type fieldmeter is needed, rather than an induction type, to monitor charging and charge decay. If conductive threads are included in the material tested then their influence will depend on the resistive and capacitance coupling to the earthed mounting. This will affect charge decay observations. The response time of observations to the fast rising applied electric field gives indication of the effective conductivity within the material providing shielding performance. It seems very reasonable that this has a relation to the opportunity for drawing incendive electrostatic discharges from the material surface [18,19]. Again, however, observations could be affected by the resistive and capacitance coupling at the earthed mounting of the sample boundary. This equipment will be made commercially available during 2002.

Charge plate monitor

Observations are often made using a metal electrode in contact with the test material connected to an electrostatic voltmeter [8,20]. A popular approach is to use a ‘charge plate monitor’. This approach may be useful for assessing how quickly charge may be removed from a conducting item in contact with a material. This is relevant for such situations as a person standing on flooring. It needs to be appreciated that this method does NOT, however, measure the ability of a material to dissipate charge on its own surface. Again, as with FTS

101C etc, the reason is the problem that observations are influenced by linkage to fast routes for charge migration and lack of fair representation of the influence of retained charge. There is also the uncertain influence from the capacitance loading of the contacting electrode. Equipment is available commercially from several sources.

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