IoP Static Electrification Group meeting
'Electrostatic Measurements'
Institute of Energy, London 13 November 2001:

MEASURING THE ELECTROSTATIC SUITABILITY OF MATERIALS

John Chubb

John Chubb Instrumentation, Unit 30, Lansdown Industrial Estate,
Gloucester Road, Cheltenham, GL51 8PL, UK
(Tel: +44 (0)1242 573347 Fax: +44 (0)1242 251388
email: jchubb@jci.co.uk Website: www.jci.co.uk)

1. INTRODUCTION

Many of the useful opportunities presented by static electricity and many of the risks and problems it can cause relate to retention of electrostatic charge.

The 'suitability' of a material may be that:
- *it holds on to charge for an adequate time for its application*
- *that it dissipates the charge sufficiently quickly that no significant surface voltages arise and only briefly*

We recognise there are other electrostatic features relevant to suitability of materials:
- *opportunity for occurrence of shocks and spark discharges*
- *ability to shield items on one side from transient electrostatic events, such as sparks, on the other side*

An appreciation of charge retention is hence a major aspect of assessing if materials are suitable for particular purposes.

In practice, what is important is not, primarily, the <u>charge</u> created and retained on a surface - but the influence this exerts on things nearby.

This 'influence' is the electric field at the item – and that relates to the surface potential.

To assess the practical suitability of materials in respect of triboelectrically generated charge we want to know:

- *what surface potentials may arise*
- *how long does a high surface potential remain*

I want to describe work I have been doing over the last few years to justify confidence in particular approaches for assessing the suitability of materials.

I hope my presentation will show the more practically minded amongst us that there are fair and reliable ways to assess the electrostatic suitability of materials.

For the more academic, I hope to raise interest and enthusiasm to examine the variety of questions that arise from making and trying to understand practical measurements.

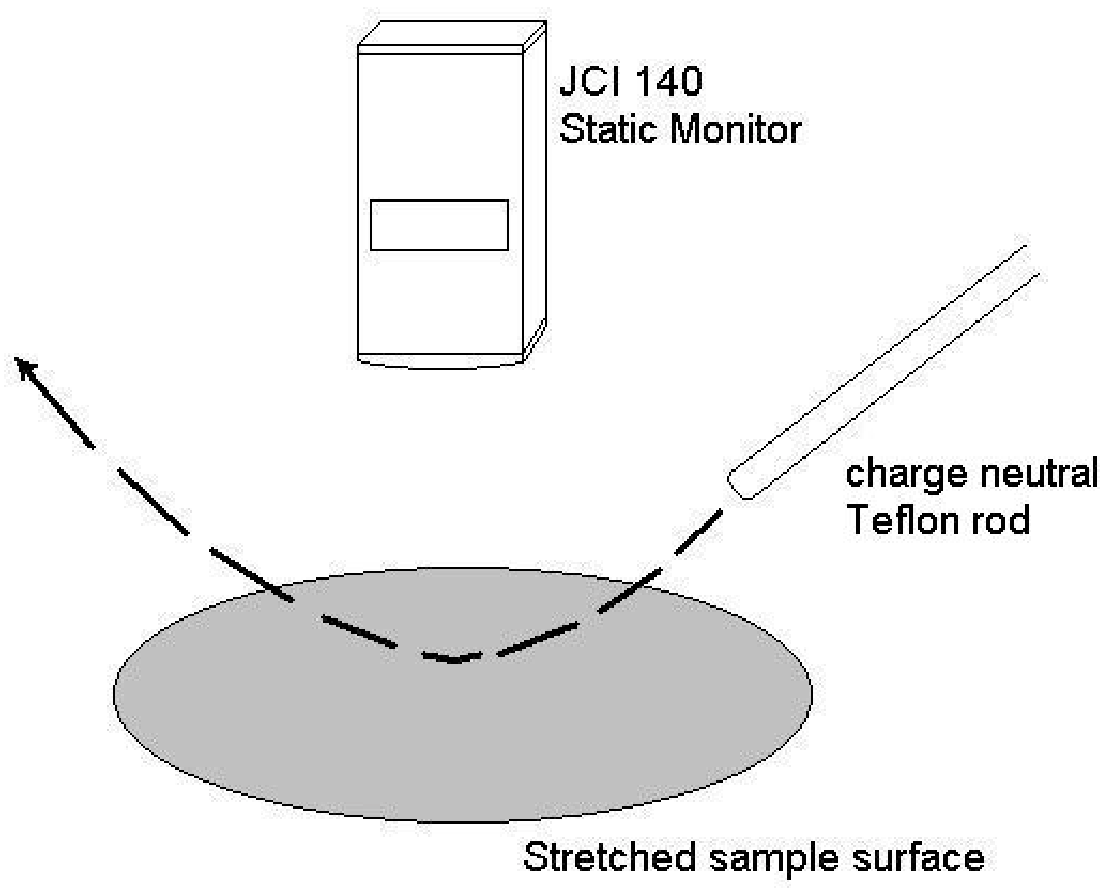
Some very basic experimental studies.

2. SIMPLE TRIBOCHARGING STUDIES

Static charge arises on materials when these contact or are rubbed by other materials. If such charge can dissipate rapidly away to earth then little charge will be retained on the materials. There will then be little influence of retained charge on sensitive items nearby. 'Rapid' dissipation of charge means a timescale shorter than the timescale for separation of the surfaces – or for the charge to have a significant influence. This is a major way to 'control' static – and more appropriate than 'resitivity'

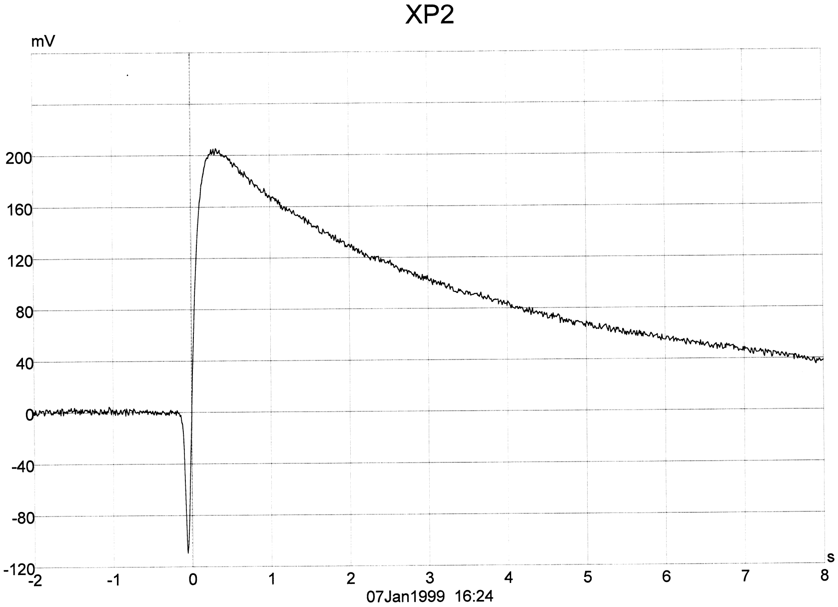
The logical way then to assess materials is to rub the surface and see what sort of surface voltages are generated and how quickly this goes away.

The following arrangement was set up for measurements:



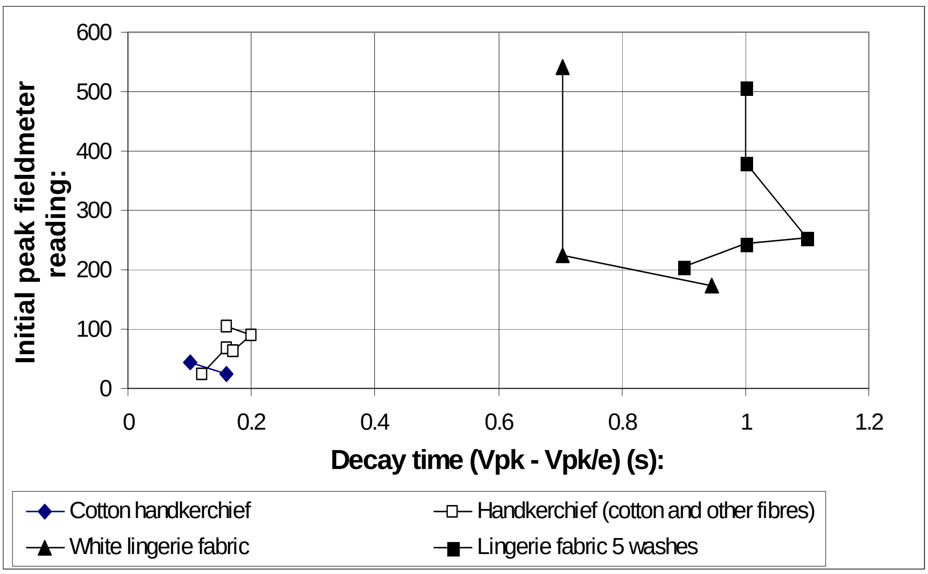
Charge on Teflon rod measured in Faraday Pail.

Example of fieldmeter signal



One problem is that the charge and initial peak signal are expected to depend on how hard material is struck. Hence, measurement made of quantity of charge so observations could be normalised.

If one looks at the variation of signal with decay time one sees the peak decreasing as decay time gets shorter – as expected.



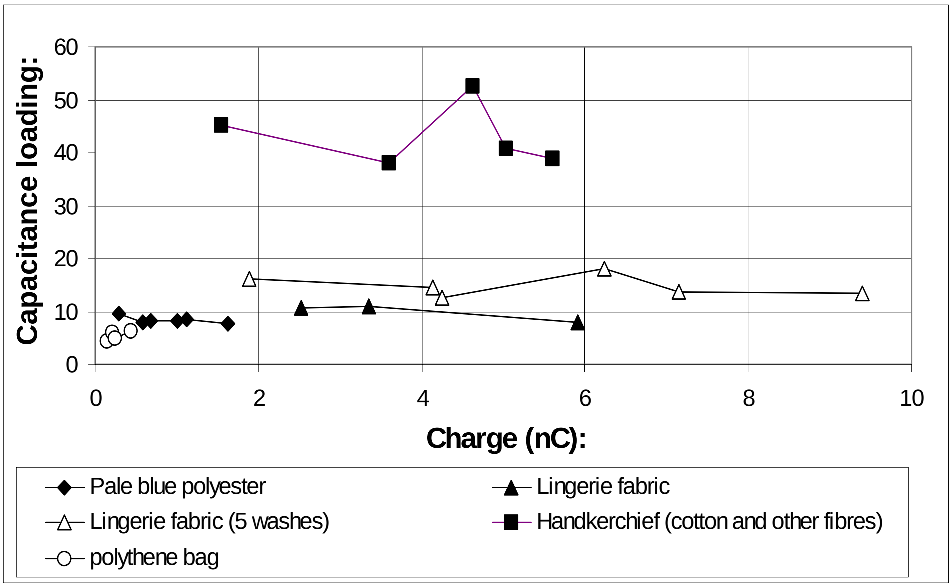
Note: Response times adequate relative to decay times

Noted that initial peak voltage per unit of charge varied greatly between materials.

Response of fieldmeter was to quantity of charge – not to local surface voltage.

Hence different materials were exhibiting different effective ***capacitance loading*** *to charge at the surface to suppress electric fields on nearby items.*

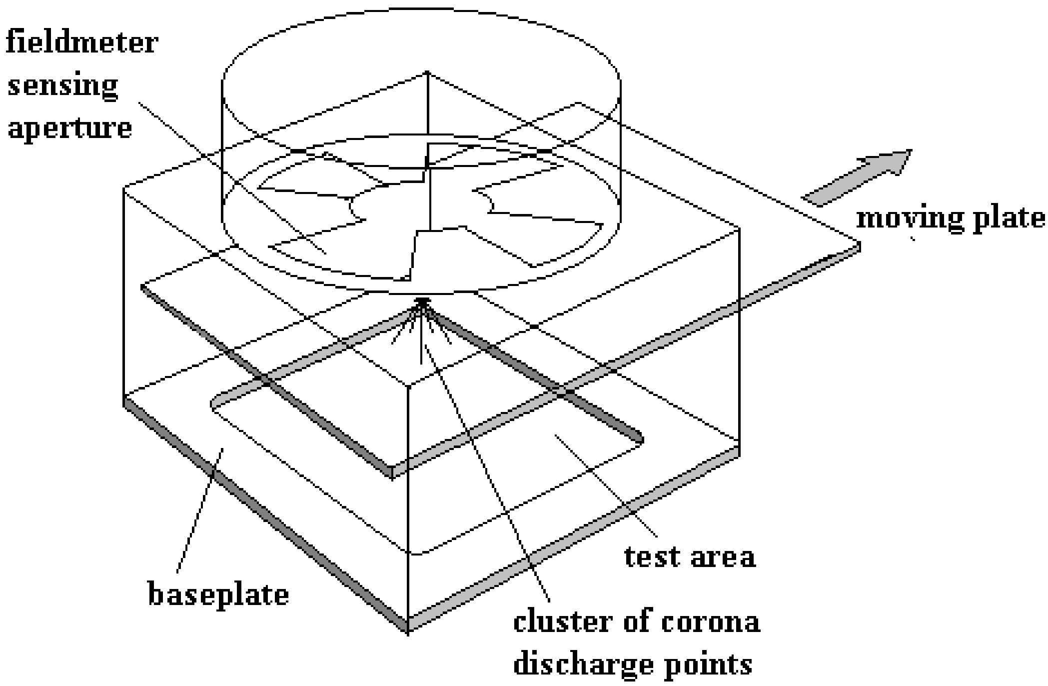
> *The term* ***'Capacitance loading'*** *used as results are compared to results for thin film of good dielectric. This avoids needing to know the charge pattern – but an assumption of similarity.*



Note that 'capacitance loading' means you cannot simply use fieldmeter readings near a web to judge 'charge density'.

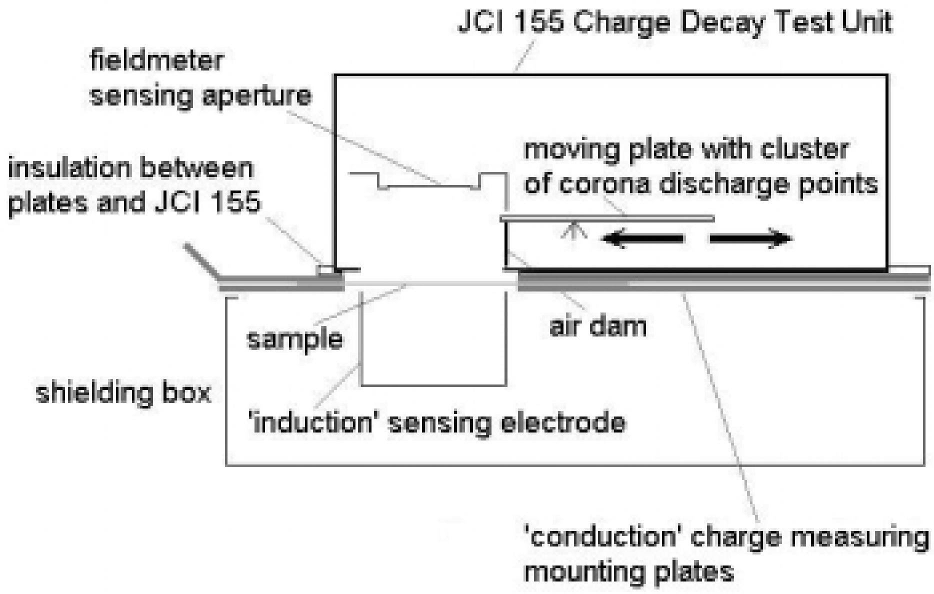
The physics of capacitance loading seems worthy of fuller examination. Meanwhile the practical significance needs to be recognised.

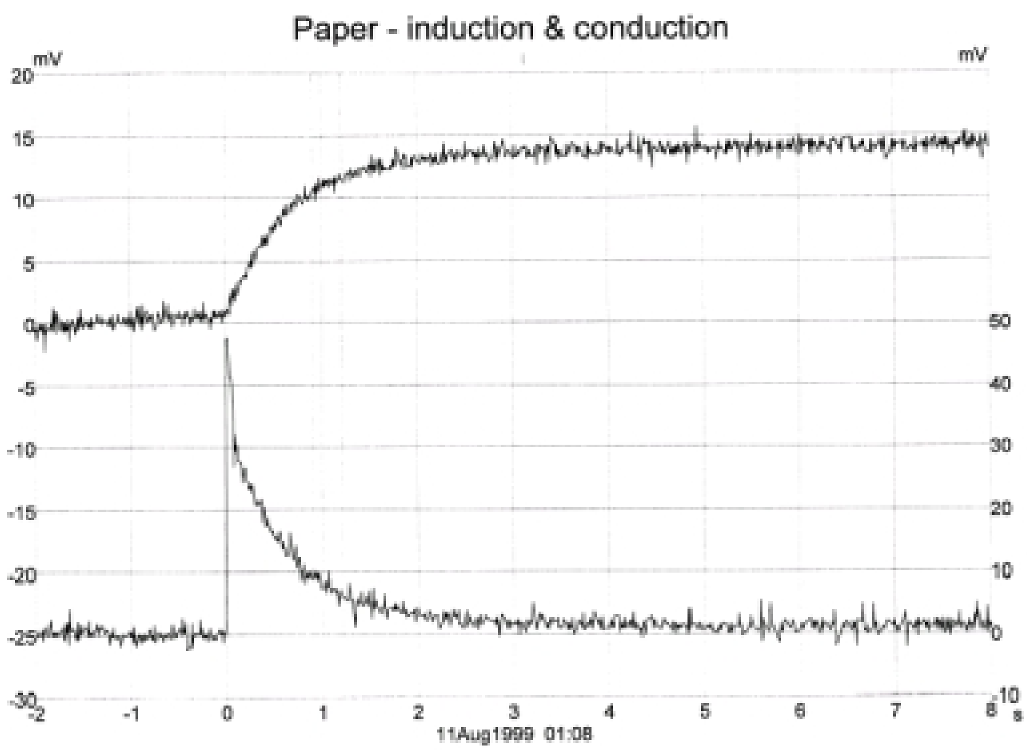
Corona charging *for easier and fuller studies.*



Great advantage of using corona charging is ease of measurement on a wide variety of materials

Measurement of charge received as sum of ‘induction’ and ‘conduction’ components.





Comparison between tribo and corona performance

PPC 8 — *100% polyester - surface conductor 20mm stripe*
PPC 11 — *65/34% poly/cot 1% core conductor 8x10mm grid*
PPC 12 — *65/34% poly/cotton 1% St St conductor blended*
PPC 17 — *100% cotton flame retardant (FR) finish*
PPC 20 — *100% aramid*
PPC 24 — *97/3% aramid/core condutor*
PPC 27 — *polyester with flame retardant and antistat finish*
XP1 — *black conductive plastic bag*
XP2 — *A4 transparent plastic document wallet*

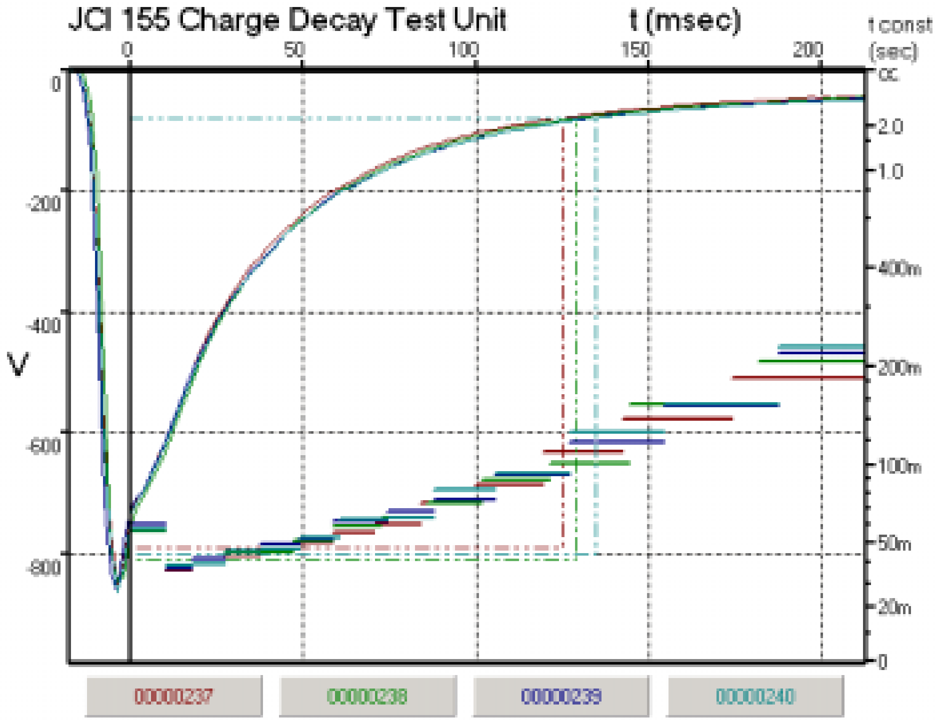
Sample:	**Tribocharging performance features:**				**Corona performance features:**	
	Initial Peak reading:	***Decay time (s):***	***Cap loading***		***Decay time (s):***	***Cap loading***
PPC8	**10**	**3-4**	**25-84**		**2**	**112**
PPC11	**12**	**7-8**	**25-37**		**4.5**	**37**
PPC12	**14**	**3-5.5**	**25-35**		**2.7**	**97-345**
PPC17	**350**	**0.65**	**3-3.5**		**0.3-0.35**	**4-11**
PPC20	**300**	**300-600**	**12-16**		**270-320**	
PPC24	**12**	**7-13**	**42-50**		**3.4-3.8**	**75**
PPC27	**2**		**115**		**0.64**	**2600-3000**
XP1	**3**		**220**			
XP2	**200**	**0.7-4**	**2.7-2.9**		**0.5**	**5-7**
	Lowest peak volts:	**Shortest time:**	**Loading**		**Shortest time:**	**Loading**
Best:	**PPC27, XP1**	**PPC17**	**PPC27, XP1**		**PPC17**	**PPC27**
	PPC8	**XP2**	**PPC24**		**XP2, PPC27**	**PPC12**
	PPC11, PPC24	**PPC8, PPC12**	**PPC8**		**PPC8**	**PPC8**
	PPC12	**PPC11**	**PPC11, PPC12**		**PPC12**	**PPC24**
	XP2	**PPC24**	**PPC17, XP2**		**PPC24**	**PPC11**
Worst:	**PPC20, PPC17**	**PPC20**	**PPC20**		**PPC11 PPC20**	**PPC17, XP2**

These results (and others reported) show comparability between performance of a variety of materials with tribo and corona charging.

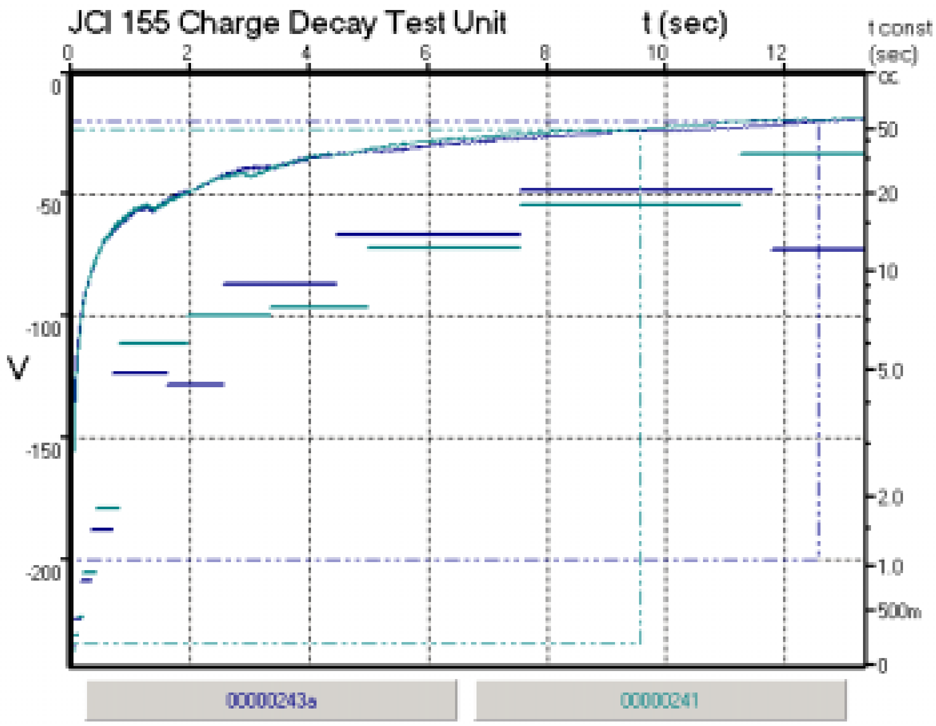
(It would be helpful if other methods of measurement promoted for assessing materials provided similar correlation to tribocharging observations).

3. RESULTS OF SOME STUDIES

Examples of decay curves - for paper

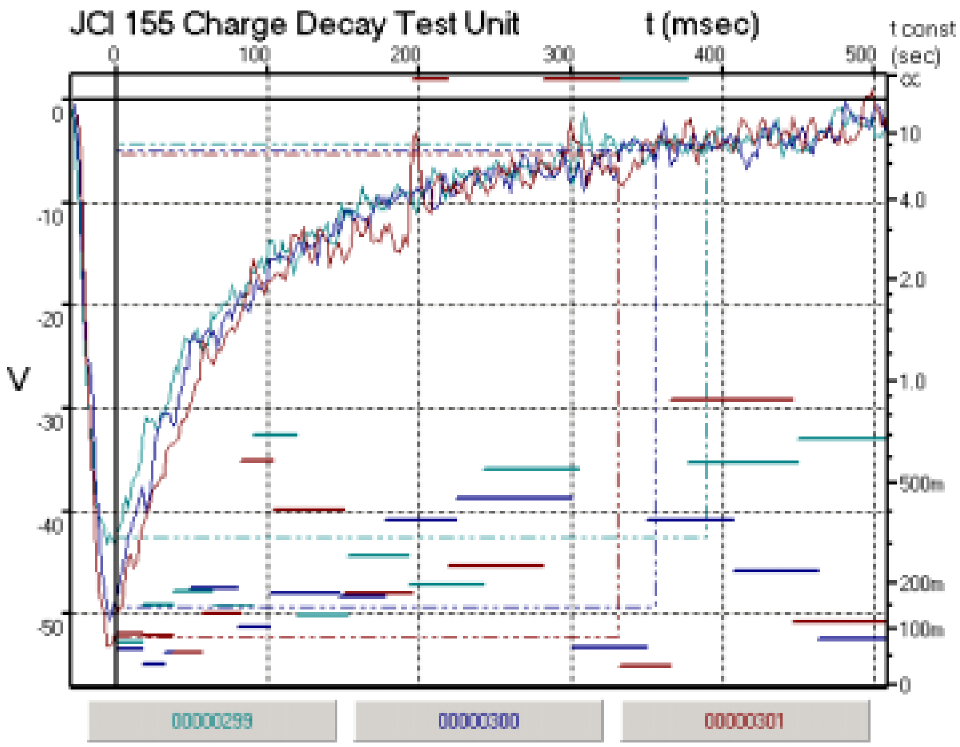


Open backing – paper sample
Note: consistency from 2 locations, 2 repeats

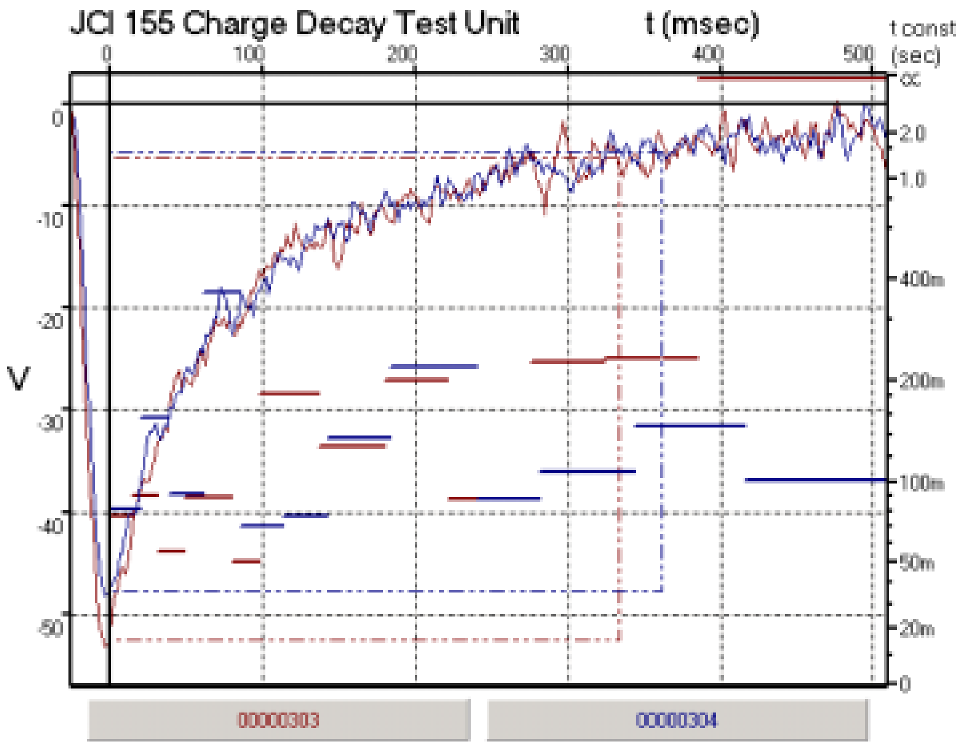


Earthed backing – same sample as above

Residual air ionisation – air dam to reduce influence

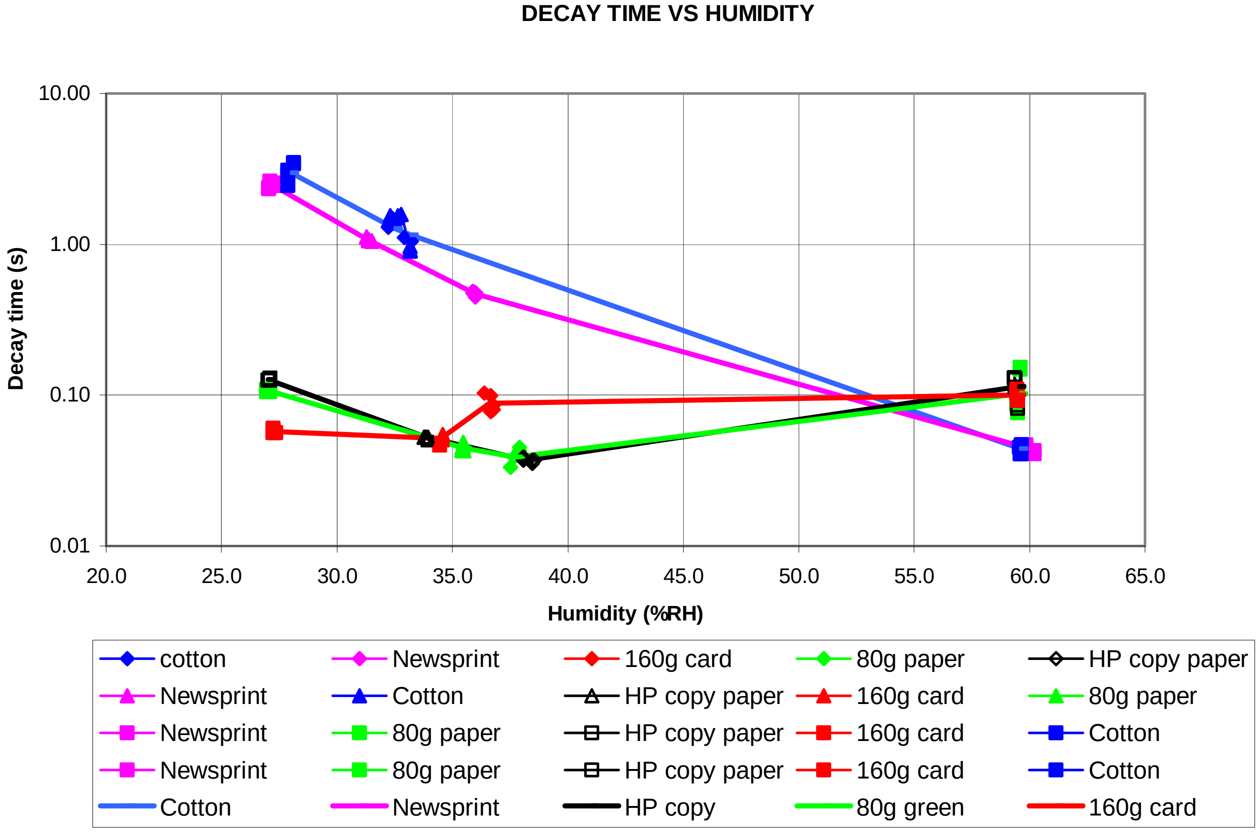


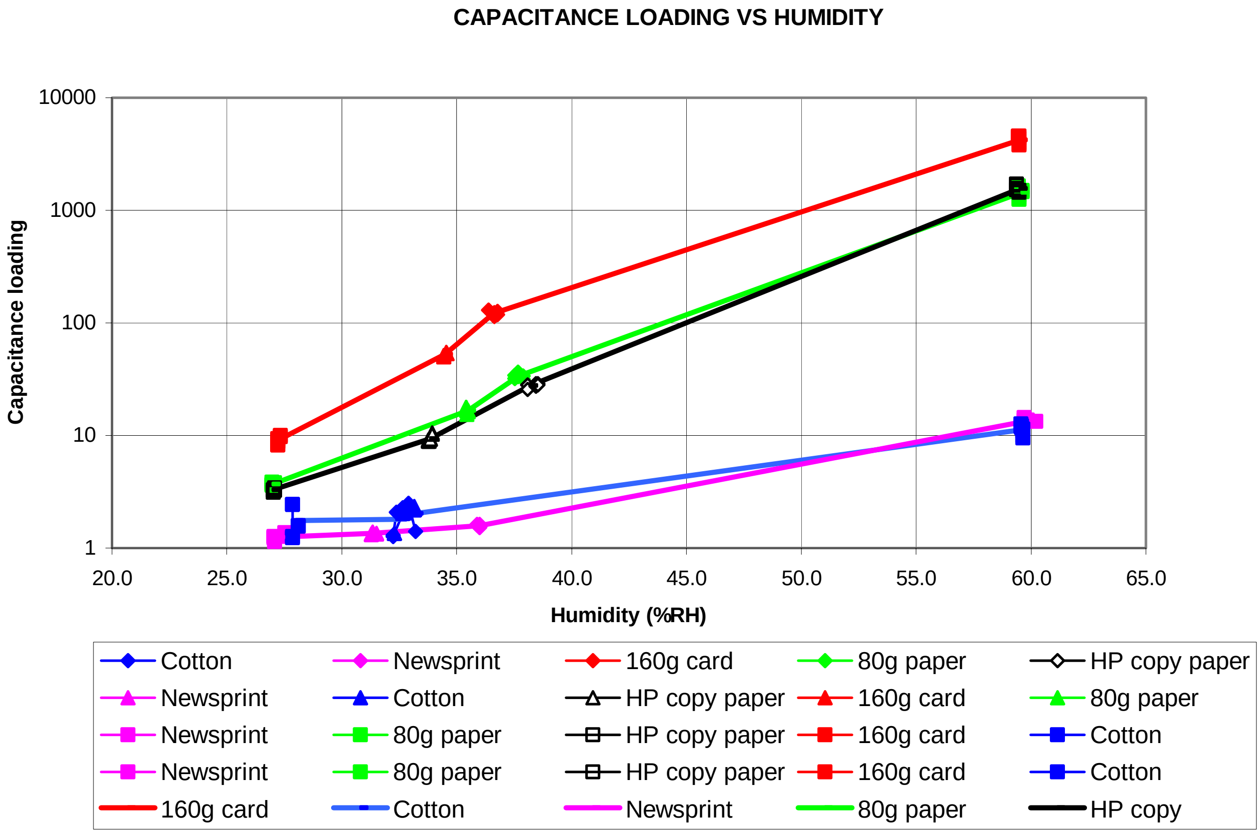
Test sample



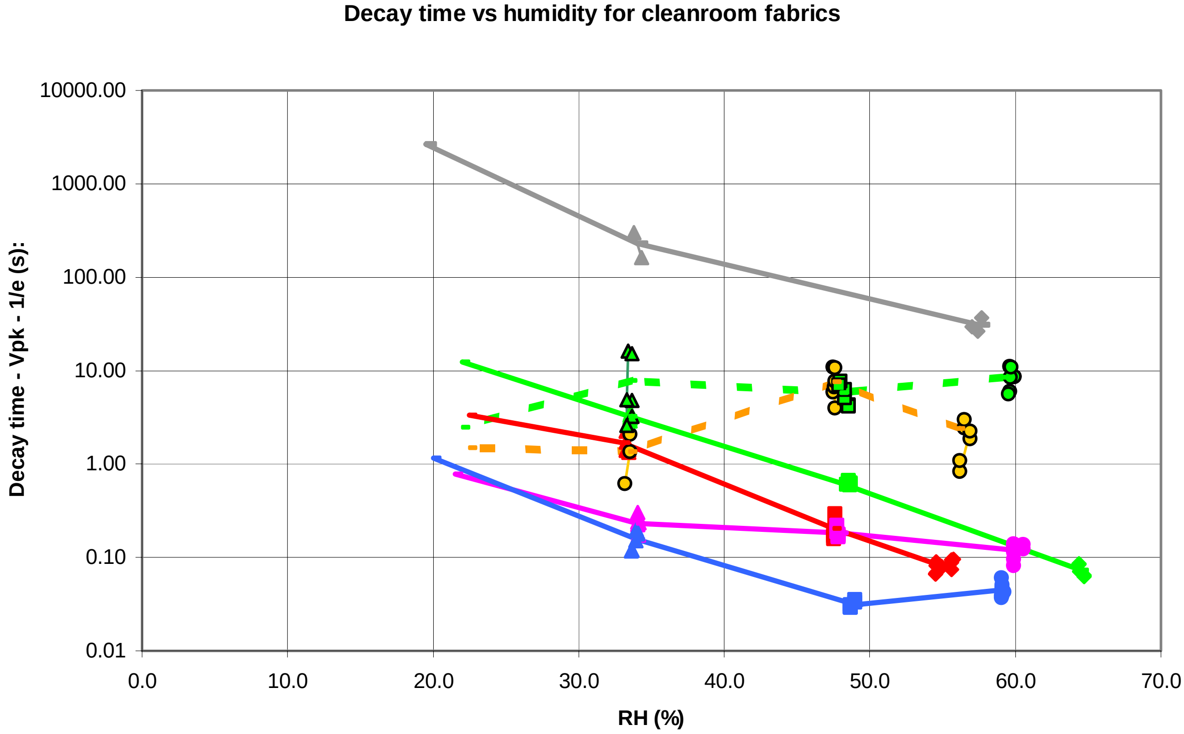
Metal surface

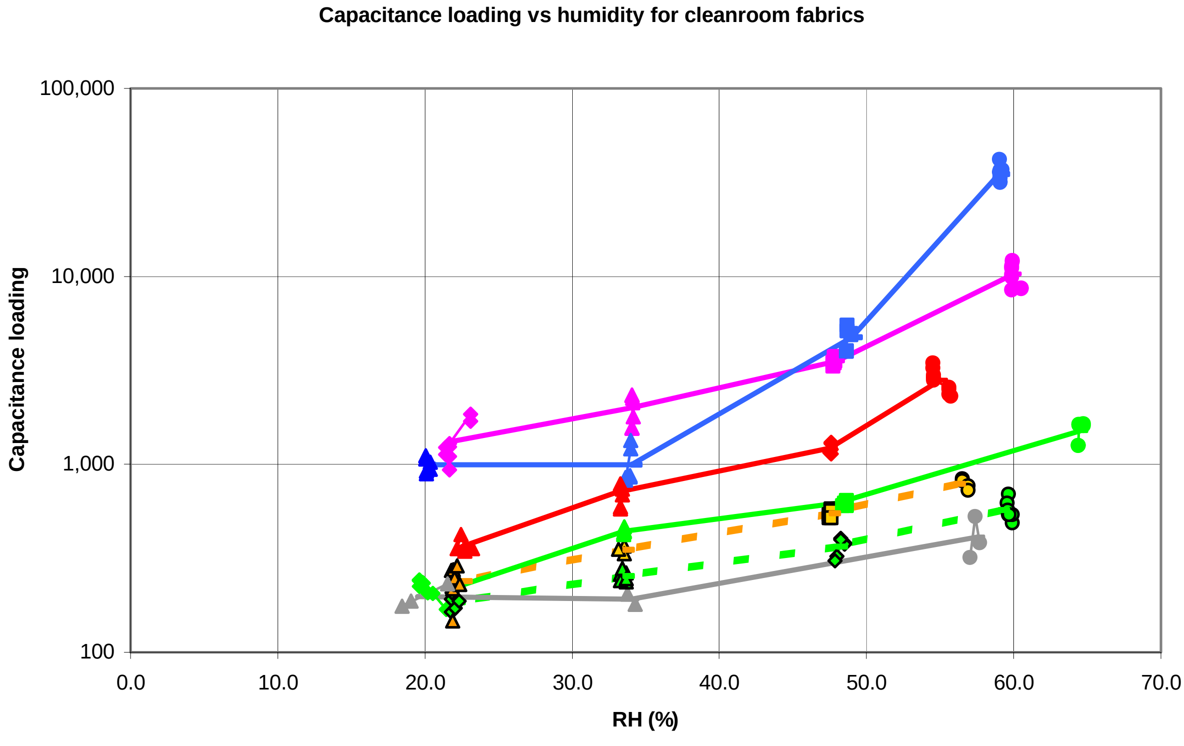
Variations with RH for papers





Fabrics including conductive threads





4. CONCLUSIONS:

1) Have shown comparability of results between tribo and corona charging.

> *This gives confidence that practical measurements using corona charging are valid.*

2) Have introduced concept of 'capacitance loading'.

> *This is a new approach for assessing materials*

3) The suitability of materials can be assessed by measuring the rate of charge dissipation and by measuring the capacitance loading.

> *Suggested:*
>
> ***decay times** need to be below ¼ s*
>
> *and/or*
>
> ***capacitance loading** greater than 100.*

References:

[1] J. N. Chubb ***"Measurement of tribo and corona charging features of materials for assessment of risks from static electricity"***
Trans IEEE Ind Appl 36 (6) Nov/Dec 2000 p1515-1522

[2] J. N. Chubb ***"New approaches for electrostatic testing of materials"***
Paper presented at ESA meeting, Brock University, Niagara Falls, May 2000. To be published in J. Electrostatics

[3] J. N. Chubb ***"Test method to assess the suitability of materials and surfaces to avoid problems from static electricity by measurement of the ability to dissipate corona charge"***
JCI Website: www.jci.co.uk/Measurements/ChargeDecay.pdf

[4] J. N. Chubb ***"Test method to assess the suitability of materials and surfaces to avoid problems from static electricity by measurement of capacitance loading"***
JCI Website: www.jci.co.uk/Measurements/CapacitanceLoading.pdf