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USER MANUAL:
JCI 176 CHARGE MEASURING SAMPLE SUPPORT

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for easy mounting of flat layer material and fabric samples for corona charge decay measurements with opportunity to measure the corona charge received by the sample. From this can be calculated the 'capacitance loading' experienced by charge on the sample surface.

1. INTRODUCTION

The JCI 176 Charge Measuring Sample Support provides a convenient unit to support film and layer materials (and also powders and liquids) for corona charge decay measurements using JCI 155 Charge Decay Test Units. Measurement of the corona charge transferred enables measurements on different samples to be made under comparable test conditions and enables measurements to be made of the 'capacitance loading' performance of materials. Combination of capacitance loading with corona charge decay time provides an assessment can be made of the suitability of materials to avoid problems from static electricity [1-6].

The basic arrangement for measuring the corona charge transferred to the test surface during corona charge decay measurements is shown in Figures 1 and 2. Charge is measured as a combination of two components – 'conduction' charge and 'induction' charge. The 'conduction' component is that which couples directly (resistively or capacitively) to the sample mounting plates within the time of application of corona charging and the time for the plate carrying the corona discharge points to move away. The 'induction' component relates to the charge that has been deposited but has not coupled out directly to the mounting plates. The design of the 'induction' charge sensing electrode aims to match the physical form of the inside of the JCI 155 so that charge on the sample will couple close to 50% each to the sensing electrode and the inside of the JCI 155. The total charge transferred to the sample can then be measured as:

$$Q_{total} = Q_{(conduction)} + f * Q_{(induction)}$$

- where the factor f is actually close to 2.2. This factor can be determined experimentally (as described in Section 3 below).

The quantities of conduction and induction charge are measured using virtual earth charge sensitive amplifier circuits. These provide the capability to measure quantities of charge respectively up to $\pm$4000nC and $\pm$400nC.

Layer and fabric samples are easily mounted in the JCI 176 between the two hinged flat metal plates which have apertures to expose a rather larger area of the sample than the 45x54mm test aperture of the JCI 155. The apertures in the sample mounting plates, to which the conduction charge is measured, are 5mm larger all round than the 45x54mm test aperture of the JCI 155. Tests show that there is negligible direct coupling to these plates from the high voltage pulse applied to the corona discharge electrodes or by leakage corona current flow. Powder and liquid samples may be mounted in a JCI 173 Sample Support Plate. This is located into the aperture of the lower conduction charge measurement plate with the long limb back towards the hinge end of the JCI 176. Care needs to be taken to avoid spillage of powders and liquids and ingestion into the mechanics of the JCI 155.

2. OPERATION

The JCI 155 Charge Decay Test Unit sits on top of the JCI 176 Charge Measuring Sample Support into the recess between the boundary edges. The test aperture of the JCI 155 is positioned over the aperture in the top surface of the JCI 176. The arrangement is shown in Figure 1 and Figure 2.

The top plate of the JCI 176 can be swung up on its hinges at the back so samples can be placed between the plates over the aperture area. It is important to make sure that samples lie nice and flat and without wrinkles, etc. The top surface of the sample should be free of loose dust, particles and fibres and without projections that could get into the test aperture of the JCI 155. The top plate of the JCI 176 can usually be lifted sufficiently to enable samples to be positioned without removing the JCI 155 from on top.

Power for operating the JCI 176 may be provided by the two PP3 batteries in the battery compartments on the left side of the back of the unit. This supply is switched on by the slide switch on the right hand side of the back of the unit - the red led shows power is ON. If the JCI 176 is operated in conjunction with a JCI 155v5 Charge Decay Test Unit, with an 8w-8w mini DIN connection cable link between the units, then power is provided directly to the JCI 176 without need for batteries or for the JCI 176 unit to be switched on.

It is important that the earth bonding point of the JCI 176 mounting box is connected to the earth bonding point of the JCI 155 instrument. A combination 'Durable Dot'/4mm bayonet socket earth bonding point is provided to enable the casing of the unit to be bonded to the associated JCI 155. It is also desirable that the whole assembly is connected to earth to minimise risks of interference of fieldmeter observations by pick-up of 50Hz signals.

The sample mounting plates are part of the active charge measurement circuits. It is hence important that these plates do not contact anything grounded or anything that may have charge induced on it. This means that when working with samples which include high conductivity components that samples are cut which do not extend much beyond the mounting plates or that these samples are isolated or carefully supported on insulation and left undisturbed during the duration of testing. It is also wise when making charge decay studies involving small quantities of charge that the overall assembly is not affected by external alternating fields. This may be checked by looking at the 'conduction' signal displayed on an oscilloscope.

The charge sensing circuits are designed to hold observed charge signals for long times to make measurement of charge values easy using, for example, digital multimeters on the analogue output channels. Typical charge leakage rates at both conduction and induction inputs are around 0.1pC s^{-1} (10^{-13}A). It is usual to zero the charge measurement circuits before each measurement. However if the circuits are not zeroed then observations will be additive within the dynamic range of the measurement circuits – to outputs around $\pm$4.5V.

For high sensitivity measurements, it is best to hold the circuits in the zeroed state until measurements are to be made. When used in conjunction with a JCI 155v5 Charge Decay Test Unit the charge measuring circuits are held in the zeroed state until just before measurements are to be made and then released by the software program within the JCI 155v5. When used with other instruments, for example a JCI 155v4, the charge measuring circuits need to be zeroed either by connecting pin 5 of one of the mini DIN connector leads (a violet lead) to earth or manually pressing the push button provided on the back of the unit for a second or two. This should be held in the zero state until just before the moving plate carrying the cluster of corona discharge points is advanced. When operated in conjunction with a JCI 191 Controlled Humidity Test Chamber the zeroing can be accomplished with a zeroing button outside the JCI 191 chamber.

The feedback capacitors in the virtual earth charge amplifiers are 1000nF and 100nF for the conduction and induction signal channels. These give basic charge sensitivities respectively of 1mV per nC of conduction charge and 10mV per nC of induction charge. As the coupling of induction charge to the induction sensing electrode is about 0.5 the effective sensitivity for induced charge is about 5mV per nC. The relative sensitivities of 'induction' and 'conduction' observations can conveniently be checked using by making corona charge decay measurements with a sample such as paper or cling film. The initial induction charging signal falls away while the conduction charge signal increases due to outward migration of deposited corona charge. The sum of the two will be the total quantity of charge transferred. Hence the relative sensitivity can be found as the factor by which the 'induction' signal needs to be multiplied to give a total charge, when added to the conduction signal, which does not vary with time over a few seconds. This relative sensitivity factor is needed for measurements with samples that show little conduction charge.

Two levels of sensitivity, x1 and x8, are provided for both conduction and induction signal channels and these are selected by choice of lead connection.

A simple test on operation of operation with the signal outputs connected to multimeters is to scuff one's shoes on the floor and briefly touch either the metal of the top plate of the JCI 176 or the induction signal sensing box through the test aperture. A change in the corresponding charge reading will be seen with this signal being held steady.

When the JCI 176 is used with samples and surfaces that have very fast charge decay times it needs to be recognised that the ultimate performance may be limited by effects due to residual air ionisation. The air dam on the moving plate very effectively removes residual air ionisation when JCI 155 instruments are used with the baseplate resting directly on the sample surface. When used with the JCI 176 there is a slightly increased opportunity for ionised air to leak back to the region in front of the fieldmeter. Typically this will give apparent initial peak surface voltages of 10-20V for maximum charge transfers around 3000nC, and show decay times around 100ms. If charge decay performances of such levels are observed, it will be wise to check instrument operation with a fully conducting surface mounted in the sample position of the JCI 176.

3. CALIBRATION

The sensitivity of conduction and induction charge measurements may be calibrated by charging a calibrated quality capacitor to a calibrated voltage and discharging this to the instrument input. Because the input is to a virtual earth preamplifier all the charge (Q = C V) will be transferred and used as a basis for instrument calibration. For example, a 10nF 1% polystyrene capacitor charged to 1.0V is a convenient arrangement for providing 10nC of charge. (See also Calibration section on JCI Website [7]).

Since the JCI 176 used virtual earth charge measurement circuits an alternative approach is to provide calibrated quantities of charge on the basis of switching a defined current into the output connection for a defined period of time [7]. The current is defined by a stable and known reference voltage and a precision resistor. The period of current flow is defined by selected number counting of cycles from a crystal controlled clock. The JCI 256 Charge Calibrator provides this calibration capability for quantities of charge from 1-999nC with an accuracy better than 1%. Provision is included to enable the unit itself to be formally calibrated with measurements whose accuracies are traceable to National Standards.

The sensitivities of the conduction and induction charge sensing amplifiers have been chosen to allow measurements over the range of quantities of charge transfer likely to occur in tribocharging events – from around 1nC up to about 4000nC. This allows direct comparison of the characteristics of materials using corona charging with those obtained in tribocharging work [1,2,4,5].

The 'induction' signal sensing surface is a fairly symmetrical geometric match below the sample surface to the sensing region of the JCI 155 above. In prospect, the quantity of charge on the induction electrode structure will be about 0.5 of the total charge retained on the sample where it is deposited. The actual value can be established using, for example, paper as a test sample. An oscilloscope recording of induction and conduction signals during corona charge transfer will show that the charge is initially sensed by the induction circuit, and that within a second or so the induction signal falls to zero as the conduction signal builds to a plateau value. (A ‘Picoscope’ is a convenient and low cost way to turn a PC into a digital storage ‘scope). The quantity of charge measured by the induction circuit transfers to become the conduction signal, so the relationship between the two can be checked by looking for the factor that matches the two to a constant total quantity of charge.

The sensitivity of the JCI 155 to the voltage of the surface area likely to be charged by corona in the plane of measurement is about 0.95 of the normal JCI 155 calibration - based on a voltage applied to a conducting plate across the full area of the sample aperture [3].

4. CONNECTIONS

Connections at each of the two 8w miniature DIN sockets on the rear of the sample support unit, and colours for the plug lead, are listed below. The 8w DIN sockets are connected in parallel so two types of observations at the same time.

1	Conduction charge signal x1	Black
2	Induction charge signal x1	White
3	Conduction charge signal x8	Red
4	Induction charge signal x8	Yellow
5	Initial zeroing to earth	Violet
6	Ground	Blue
7	+5V supply input	green
8	-5V supply input	brown

The x1 and x8 signals are available together. The conduction and induction charge signals may be displayed and recorded on a digital storage oscilloscope and/or displayed on digital multimeters. It is important to either pre-select or record the sensitivity ranges at the same time. In addition the JCI 176 may be directly connected to a JCI 155v5 Charge Decay Test Unit. This both provides power supplies for operation of the JCI 176, records observations of induction and conduction charge components at x12 and x8 sensitivity levels and controls zeroing of the JCI 176 in appropriate relation to deposition of corona charge.

A combination Durable Dot/4mm bayonet socket earth bonding point is provided to enable the casing of the unit to be bonded to the associated JCI 155 and to local earth.

5. RoHS and WEEE Directives

JCI electrostatic measuring instruments are not required to conform to the RoHS Directive because they come within Category 9 exemption.

To comply with the requirements of the EC WEEE (Waste Electrical & Electronic Equipment) Directive all JCI instruments at the end of their useful life should be returned to JCI so they can be disposed of or recycled in an environmentally appropriate manner. JCI WEEE registration number is: WEE/GA0697TX.

6. SPECIFICATION FEATURES

Sample size:	100x100mm or larger
Charge sensitivities:	1mV per nC conducted charge (1 Black) 10mV per nC induction from retained charge (2 White) 8mV per nC conducted charge (3 Red) 80mV per nC induction from retained charge (4 Yellow)
Power supply:	Two PP3 batteries or external supplies ±5V to ±7V Red led indicator when operating
Controls:	On/Off switch Pushbutton to zero charge amplifiers
Connections:	Two 8w miniature DIN sockets in parallel Combination Durable Dot/4mm bayonet earthing connection
Dimensions:	190x206mm 65mm high
Sample size:	100x100mm or larger

References:

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[2] 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

[3] British Standard BS 7506: Part 2: 1996 *"Methods for measurements in electrostatics"*

[4] J. N. Chubb *"New approaches for electrostatic testing of materials"* J. Electrostatics 54 2002 p233

[5] J. N. Chubb, P. Holdstock, M. Dyer *"Can surface voltages on inhabited garments be predicted"* Institute of Physics 'Electrostatics 2003' Conference, Heriot-Watt University, 23-27 March, 2003.

[6] *"Test method to assess the electrostatic suitability of materials for retained electrostatic charge"* www.jci.co.uk/cache/JCITestMethod.pdf

[7] J N Chubb *"Methods for the Calibration of Electrostatic Measuring Instruments"* http://www.jci.co.uk/Calibration/Calibration.pdf

Figure 1: Arrangement of JCI 155 on JCI 176 Charge Measuring Sample Support

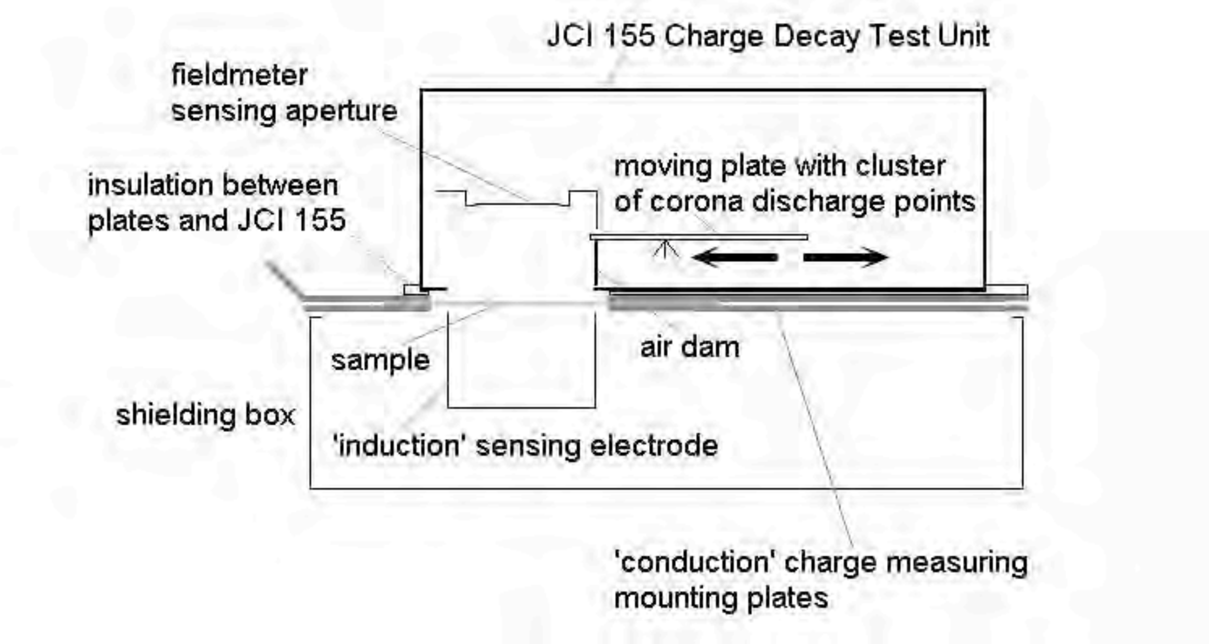

Figure 2: JCI 155v5 Charge Decay Test Unit mounted on JCI 176 Charge Measuring Sample Support

Figure 3: JCI 173 Powder Sample Support mounted in JCI 176