JCI 155v6 Charge Decay Time Analyser

The JCI 155v6 is a compact instrument for easy and direct measurement of the ability of materials to dissipate static electricity and to assess whether significant voltages will arise from practical amounts of charge transferred to the surface. The version 6 is the very latest in our highly successful and unique range of Charge Decay Time analysers and brings with it new features and benefits expected of modern day 21st century scientific measurement instruments.

INTRODUCTION

Many of the useful opportunities presented by static electricity and many of the risks and problems it can cause relate to the influence of retained electrostatic charge. This is manifest as the surface voltage created by the charge retained. The suitability of a material in a particular situation may therefore be judged in terms of the maximum surface voltage attained and/or the time for which this is maintained.

JCI 155v6 Charge Decay Test Unit

In the JCI 155 Charge Decay Test Unit a high voltage corona discharge is used to deposit a patch of charge on the surface of the material to be tested. A fast response electrostatic fieldmeter measures the voltage generated by this charge. It also measures how quickly this voltage falls as the charge migrates away [1]. Corona charging has been shown [2] to be a simple way to simulate practical charging events. It allows control of initial surface voltage and charge polarity and is applicable for all types of surfaces - whether uniform or with localised conducting features. It provides consistent, reproducible results that are not affected by corona exposure.

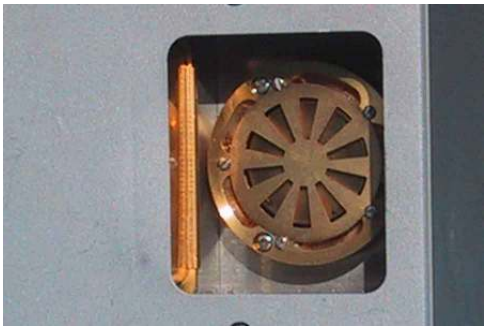
Operation of a JCI 155 in conjunction with measurement of the quantity of corona charge transferred to the test surface (by using a JCI 176 Charge Measuring Sample Support) allows calculation of the 'capacitance loading' experienced by charge on the surface. This 'capacitance loading' is related to the maximum surface voltage likely to be created by a given quantity of charge on a surface [4]. A high capacitance loading means that only low surface voltages arise per unit of charge.
The JCI 155v6 Charge Decay Test Analyser is a development of previous version JCI 155 instruments. It is the most intuitive and user friendly Charge Decay Analyser of the JCI 155 series and now includes a large LCD screen for both textual and graphical presentation of results using just 5 menu driven active operator keys.
Full versatility in setting instrument configuration and test parameters is provided by the instrument firmware and display. The analyser may be used independently or connected via USB link to our proprietary associated JCI Graph PC software.

INSTRUMENT OPERATIONAL FEATURES

Test Area: The JCI 155 has a 45x54mm test aperture in the instrument baseplate. This can rest directly on the test surface. Contact with the surface around the test aperture provides a return route for outwardly migrating charge and high local capacitance to trap such charge. With short duration corona charging (e.g.20ms) the presence and position of the outer earth boundary is not important. Measurements can be made on surfaces smaller than the test aperture area although you must understand how, in doing so, this may affect readings.

Charging: The surface is charged by a high voltage corona discharge (3-approx 10kV) from the tips of a small conical cluster of fine wires mounted on the underside of a light moveable plate. This plate is moved between the fieldmeter sensing aperture and the material surface exposed through the instrument baseplate. Corona is usually generated as a brief pulse (20ms) immediately before the plate is moved away. The plate moves fully away in approximately 20ms.
The moving plate and instrument construction shield the fieldmeter from high voltage connections so reliable measurements can be made down to even quite low surface voltages. An 'air dam' is included on the trailing edge of the moving plate. This sweeps away residual air ionisation at the end of the corona period so there is little influence on surface voltage measurements.

Fieldmeter: A proprietary fast response 'field mill' electrostatic fieldmeter [5,6] gives fast, sensitive and stable measurement of surface potential. The response time is below 10ms and charge decay times can be measured from below 50ms to many days.



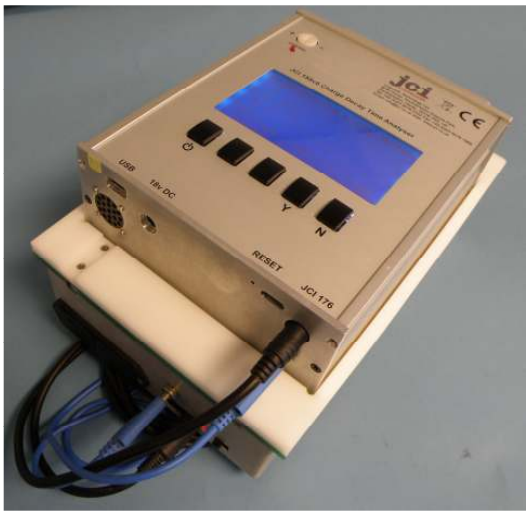
Fieldmeter seen through test aperture

Instrument software provides for automatic zero setting of the fieldmeter just before each test. In very long charge decay studies arrangements are made to check the fieldmeter zero from time to time.

It is not easy to measure decay times with signals where noise is significant in comparison to the signals or the signal differences to be measured. This may apply for materials that dissipate charge either so quickly that the initial peak voltage is very low, only 10-50V, or with materials that dissipate charge very slowly, so that small differences in signal levels need to be measured to get results within modest periods of observation. A special feature of the JCI 155v6 is that it uses a ‘stutter timing’ approach for decay timing. This provides an excellent way to identify average values of a noisy signal without slowing down time response.

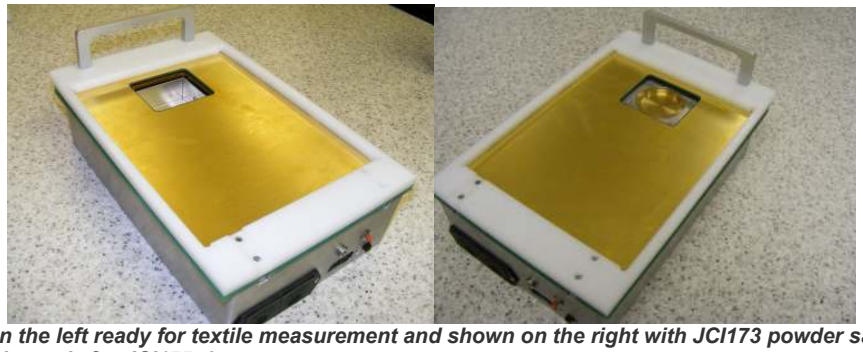
Sample support: Measurements are normally made both with the material freely supported with an open backing and also resting against an earthed backing surface. These two arrangements represent the extremes of constraints of practical application. The longer of the two decay times is used for assessment of the suitability of the material. The JCI 166 Sample Support provides a simple arrangement for such measurements.

Simultaneous measurement of the quantity of charge received by the sample surface and the initial peak surface voltage achieved enables calculation of the ‘capacitance loading’ experienced by charge on the sample surface [3,4,7,8]. The JCI 176 Charge Measuring Sample support provides the ability to measure the corona charge received by the sample. This unit can be directly connected to the JCI 155v6 (by an 8w-8w DIN cable) so that charge measurements are stored alongside the relevant charge decay observations. Measurements using the JCI 176 can be with both open and earthed backing, though capacitance loading measurements are easily achievable with “open” backed testing, taking these measurements using “earthed” backing will require a more considered approach.



JCI 155v6 on JCI 176 Charge Measuring Sample Support

Powder samples may be presented using the JCI 170 Powder Sample Support with the JCI 155v6 supported by a JCI 172 Support Plate so the JCI 170 can be easily put in place an removed and so that the base plate of the JCI 155v6 stands off a few millimeters to reduce risk of powder dispersal into the air by action of the air dam. Powder, and liquid, samples can alternatively be presented for simple testing using a JCI 173 Powder Sample Support Plate mounted between the plates of a JCI 176 sample support, Capacitance loading measurements are possible with a more considered approach.



JCI176 shown on the left ready for textile measurement and shown on the right with JCI173 powder sample support mounted within it, ready for JCI155v6 measurements.

Optional JCI170 powder sample support shown sitting within a JCI172 support for use with the JCI155v6 unit.. Reversal of the JCI170 disc presents a larger or smaller sample test area to the JCI155.

Test conditions: Charge decay characteristics are usually susceptible to absorption of surface moisture from the atmosphere, so measurements are very likely to depend on humidity. It is hence desirable to carry out testing under defined, or at least known, conditions of temperature and humidity. This can be achieved by carrying out measurements in a controlled environment – as is provided, for example, in the JCI 191/C Controlled Humidity Test Chamber, with adequate time allowed for acclimatisation. The JCI 155v6 comes fitted with sensors to measure both temperature and humidity within the test region of the instrument. These measurements are stored along with all the other information on test conditions.

JCI-Graph: All test conditions and observations are stored to the on-board memory of the JCI 155v6. This data can be transferred to a PC using proprietary Windows software JCI-Graph. This provides opportunity to display up to 4 graphs at a time of observations and to transfer these together with associated numerical test and result information into word-processed documents. A summary table of test and result information is also created. Opportunity for on-line operation.

Test criterion: A simple acceptance test criterion is that the decay time (initial peak voltage to 1/e (ca 37%) of this) should be less than half a second.

Experience is that the form of charge decay curves is usually not an exponential. The form of the curve however does not usually depend on the level of the initial peak voltage or, hence, on the level of charging. Thus a ‘decay time’ measured as a set percentage of the initial peak voltage is an appropriate basis by which to rate materials.

A point immediately after the initial peak voltage is used as a starting point for the analysis (t=0). Timing from t=0 includes as much information as possible about transient initial voltage drops. The t=0 point (which is operator adjustable up to ca 100ms) is chosen to allow for the plate to retract following operation and also to allow for a period equivalent to material separation times.

It is also useful to record how the rate of charge decay varies during decay to see whether significant levels of charge may be retained for long durations. It is observed that charge decay curves may 'plateau out' after an initial perhaps fairly rapid fall of surface voltage. In this situation it may be argued that a better acceptance test criterion would be the time to 10% of the initial peak voltage – as this would better ensure that residual surface voltages were low. Measurements to both 1/e and to 10% are recommended when practicable.

Measurement of the quantity of charge transferred to the sample and the initial peak voltage enables materials to also be assessed in terms of 'capacitance loading'.

Decay timing: Decay times are measured using a proprietary technique called 'stutter timing'. This approach very effectively overcomes problems with signal noise at low signal levels. It is helpful a) with very slow charge decay rates, and b) with very low initial peak voltages (for example 10-50V). Stutter timing works by running and stopping the timing clock according to whether the instantaneous fieldmeter signal is above or below the voltage level of interest. This approach is used both in the algorithm for finding an initial peak surface voltage, from which timing will start, and for determining the end of timing. It is also used in calculation of local charge decay time constants during the progress of charge decay.

Operation: The JCI 155v6 operates via mains adapter or from its own NimH batteries. When the instrument is connected to a mains power supply via an external 18V switch mode mains powers supply unit (115V/230V) the batteries are Smart recharged according to need. Mains power supply connection and fast battery recharging are indicated by on screen LCD indication. For measurements under defined environmental conditions it is best to use the instrument on batteries, without external power supply input, to minimise heat dissipation within the instrument.

To save battery power the instrument has a selectable low power mode if required.

The instrument operation is set up and controlled using the top panel keys. Operation may alternatively be controlled from JCI-Graph via the USB port with quasi-real time display of observations and results.
Results displayed by JCI-Graph can be easily transferred into word processing and Spreadsheet operations.

Calibration: Where the results of measurements may be used with contractual or legal implications then it is necessary for the JCI 155v6 to be formally calibrated and for measurements to be made using appropriate test procedures. Instrument performance can be formally calibrated at JCI to British Standard BS 7506: Part 2: 1996 [9] using measurements whose accuracy is traceable to National Standards. The JCI 255 Calibrator Unit provides a convenient basis for such formal calibration.

REFERENCES

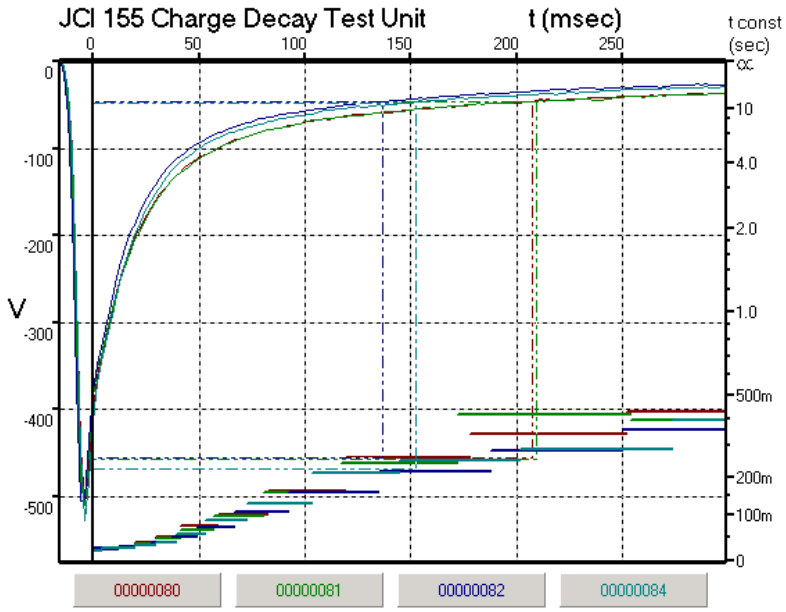
[1] J. N. Chubb "*Instrumentation and standards for testing static control materials*" IEEE Trans. Ind. Appl. 26 (6) Nov/Dec 1990, p 1182.
[2] J. N. Chubb *"The assessment of materials by tribo and corona charging and charge decay measurements"* Proc Inst Phys Confr 'Electrostatics 1999', Univ Cambridge, Mar 1999. Inst Phys Confr Series 163 p329
[3] 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
[4] J. N. Chubb *"New approaches for electrostatic testing of materials"* J. Electrostatics 54 (3/4) March 2002 p233 (ESA 2000 meeting, Brock University, Niagara Falls, June 2000).
[5] J. N. Chubb *"Two new designs of 'field mill' type fieldmeters not requiring earthing of rotating chopper."* IEEE Trans. Ind. Appl. 26 (6) Nov/Dec 1990, p 1178.
[6] J. N. Chubb *"Experience with electrostatic fieldmeter instruments with no earthing of the rotating chopper"* Proc Inst Phys Confr 'Electrostatics 1999' Univ Cambridge, Mar 1999. Inst Phys Confr Series 163 p443
[7] J. N. Chubb, P. Holdstock, M. Dyer *"Predicting the maximum voltages expected on inhabited cleanroom garments in practical use"* Inst Phys Confr 'Electrostatics 2003' Heriot-Watt Univ 23-28 March 2003
[8] J. N. Chubb, P. Holdstock, M. Dyer *"Predicting maximum surface voltages on inhabited cleanroom garments in practical*

use" Paper presented at ESTECH 2003, Contamination Control Division, Phoenix, Arizona.18-21 May, 2003 (To be published) [9] British Standard *'Methods for measurements in electrostatics'* BS 7506: Part 2: 1996.

SPECIFICATION FEATURES – JCI 155v6

Controls:	- Power ON key at lower left hand corner of top panel. - 5 keys under liquid crystal display. Active Key assignment showing buttons available for use. Key functions cover initiation of charge decay test runs, inspecting data from the most recent as well as earlier runs, graphical display of results with zoom/unzoom functions, selecting and editing test conditions and aborting operations, test description viewing for test run comparison of data. - corona voltage polarity change-over rotary switch
Displays:	- Large Interactive LCD Display (112x60mm) - LED indication of connection to external mains power supply - LED indication that corona charging is active - On screen LCD indication that batteries are in 'fast charge' mode (unless fully charged)
Test area:	- 45x54mm aperture in instrument baseplate
Sample:	- the unit may be placed directly on a surface or area of sample. - the JCI 166 Sample Support Unit provides a simple support for open and earthed backing tests - the JCI 176 Charge Measuring Sample Support provides open and earthed backing support for film and layer samples up to 5mm thick with measurement of the corona charge received by the sample - powders and liquids may be studied using a JCI 173 in the JCI 176
Fieldmeter:	- fast response 'field mill' fieldmeter measures surface voltage with response time less than 10ms. - automatic zero setting by software with plate advanced at start of each test. Zero stable within $\pm$5V over long duration runs. Noise on displayed and stored values within $\pm$1V.
Operating times:	- about 2 seconds to 'set for charging', 20ms opening. 'Slow opening' operation, about 2s, for measurements on light powders.
HV supply:	- internal feedback stabilised high voltage supply providing positive and negative potentials to ca 10kV and 6ms to 50msec duration (with delimited configuration setting accessible to JCI 255 users). - 10 Megohm personnel safety resistor is used in the link to the corona discharge points. - direct measurement by software of corona voltage and current
Surface voltage:	- from about 50V to about 3kV Max, depending on rate of charge dissipation
Timing range:	- charge decay times from below 50ms to over 100,000 seconds.
Operation:	- direct operation by integral NiMH rechargeable batteries providing about 8 hours continuous operation. Automatic progressive shut down by software with advice on LO BATT condition. Low Power mode is selectable by the operator if required. - operation by mains supply (115V/ 240V 6VA 60/50Hz) via 18V switched mode power supply unit. Mains supply connection indicated by red LED.

Battery charging:	- the NiMH batteries are Smart recharged whenever the JCI 155 is connected to the mains supply (115V or 240V). Charging time is about 2 hour. LCD indication of fast recharge operation.
Connections:	- mains input via 2.1mm d.c. power connector. Red LED indication of mains power supply active - 8w mini DIN connector for linking to JCI 176 for sample charge measurements - New USB Connector link to PC (also useful for future firmware update download via the internet over USB) - combined Durable Dot and 4mm bayonet earth bonding point.
Software:	- proprietary firmware in ROM for operation of integral microcomputer for control of instrument operation , for setting operational parameters and for recording and analysis of charge decay curve data. Data stored to on board memory card. - New version of JCI-Graph. Windows XP and Windows 7 compatible software for transfer of data and display and analysis of instrument observations.
Data storage:	Internal memory. Downloadable to PC via USB link or directly to USB stick (useful if PC not directly linked during measurements)
Dimensions:	- 173x216x67 mm
Packaging:	- in carrying case with mains AC adapter, USB port connecting cable, 8w - 8w mini DIN cable for linking to JCI 176, earth bonding lead.



Example of charge decay graphs – Figure 1

1 : C:\JCIx\01091949\2001-09-27\00000080.jc6
Light paper (40g) open repeat
Serial: 01091949, run: 00000080
Date: 27.09.2001 at 09:23:03
Corona (Voltage): 7000
Corona (Time): 0.02
Surface (Temp. °C): 20.4
Surface (% R.H.): 51.08
Peak at -455.83 volts
1/e reached after 0.027344 sec
10% reached after 0.20703 sec
Received charge = -19.1395 nC
Capacitance loading = 18.0303

2 : C:\JCIx\01091949\2001-09-27\00000081.jc6
Light paper (40g) open repeat
Serial: 01091949, run: 00000081
Date: 27.09.2001 at 09:23:24
Corona (Voltage): 7000
Corona (Time): 0.02
Surface (Temp. °C): 20.4
Surface (% R.H.): 51.08
Peak at -456.24 volts
1/e reached after 0.029297 sec
10% reached after 0.20898 sec
Received charge = -19.8749 nC
Capacitance loading = 18.7063

3 : C:\JCIx\01091949\2001-09-27\00000082.jc6
Light paper (40g) open new
Serial: 01091949, run: 00000082
Date: 27.09.2001 at 09:56:10
Corona (Voltage): 7000
Corona (Time): 0.02
Surface (Temp. °C): 20.81
Surface (% R.H.): 50.31
Peak at -454.99 volts
1/e reached after 0.023438 sec
10% reached after 0.13672 sec
Received charge = -19.6917 nC
Capacitance loading = 18.5846

4 : C:\JCIx\01091949\2001-09-27\00000084.jc6
Light paper (40g) open repeat
Serial: 01091949, run: 00000083
Date: 27.09.2001 at 09:56:29
Corona (Voltage): 7000
Corona (Time): 0.02
Surface (Temp. °C): 20.81
Surface (% R.H.): 50.31
Peak at -468.32 volts
1/e reached after 0.025391 sec
10% reached after 0.15234 sec
Received charge = -21.3544 nC
Capacitance loading = 19.5804

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