Installation

Instrument

After unpacking the instrument check the mains voltage selector switch, it should match the mains voltage in your country.

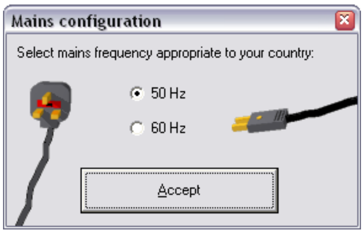
Although the instrument is heavily shielded it is advisable to keep the instrument, cables and test cell clear of any strong electromagnetic sources. Mains noise can affect test results especially when using high impedance cells, in such cases, better results can be obtained by shielding the test cell using a Faraday cage connected to green instrument earth connector on the back of your instrument.

Connect the instrument to any free serial port with the supplied serial cable, using the 9 to 25-way adapter should it be required.

Software

If ACM supplied a computer with your instrumentation, the software will already be installed.

Before installation, quit any open programs and insert the installation CD-ROM, after a few seconds the install program should self activate (if not run setup.exe found in the root of the CD drive). Follow the on screen instructions to install the software. Straight after installation has completed **Mains Configuration** will appear:



Select the mains frequency that matches your country, this setting is required by the instrument analogue to digital converters (ADC), so they are able to digitally reject mains noise.

Software

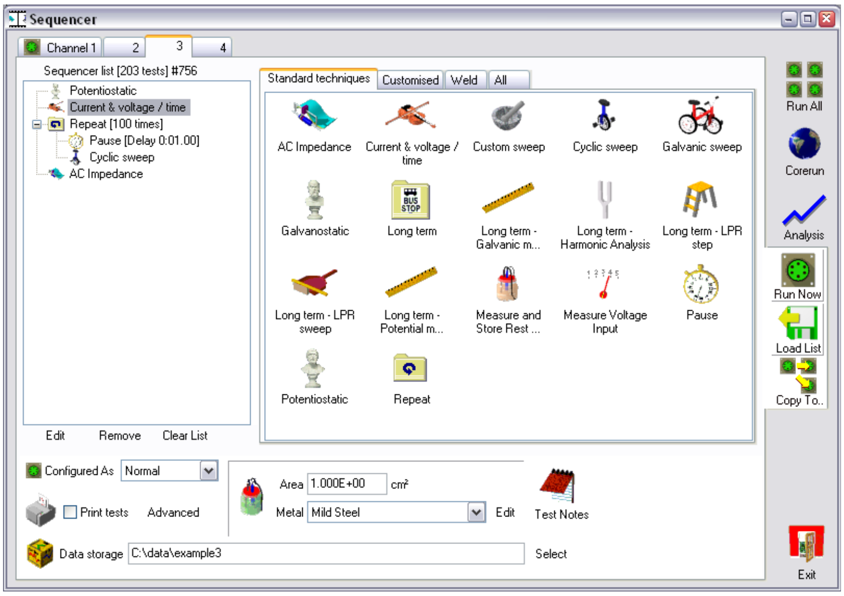
Overview

It is worth mentioning at this early stage - any potential shown or entered always with **respect to the reference electrode**.

All programs installed can be found in the **Start** menu, under **Programs >> ACM Instruments Version 5**.

Two programs make up the logging software, **Sequencer** and **Core running**. The Sequencer does the work of setting up a list of tests (a sequence) to be passed to the Core running for collection.

Sequencer



Shown above is the sequencer (above there are four channels, channel 3 is selected), to switch between channels click on the **Channel** number required. Each channel is treated independently, a sequence of tests can be created on one channel and then copied to other channels.
Down the left side is the **Sequence list**, a list of tests is built here, then passed to the **Core running** which works through these tests from top to bottom, in sequential order.

Data Storage sets which file will be used to store data, all data is automatically stored on to the hard disk and whilst a sequence list is being collected data can be viewed in the analysis.

Available techniques are shown to the right of the sequence list, to add a technique to the sequence list click once on the required technique, it is added and instantly the technique parameter page appears. Each technique is described in detail later in this manual. Techniques in the sequence list can have their parameters altered by double clicking, or select and click **Edit**.

The Sequencer follows these rules when adding a technique to the sequence list:

- If the last technique of a sequence list is selected, any new technique added will be placed at the end of the list:

ie adding Potentiostatic →

- If the selected technique is not the last technique, adding a new one to the list will insert it before the selected technique:

ie adding Cyclic Sweep →

Techniques in the sequence list can be dragged to a new position if they are not in the desired order, whilst dragging a black arrow displays where the sequence will be dropped.

Folders

Folders are used to group techniques together, the following folders are available:

Repeat Folder

Repeat Folder can be found in **Standard Techniques**, after clicking once to add to the sequence list, a settings page allows the number of repeats to be set:

A technique to be repeated can be added into the repeat:

Additional techniques can be added the same way. To add tests after a repeat and not into the repeat, click on the [-] symbol next to the repeat folder to close it, any new tests will now be added after the repeat.

Long Term Folder

A **Long Term** folder acts in a similar way to a repeat folder, except that only certain types of 'Long Term' techniques can be placed into it, such as **Long Term - LPR Sweep**. In addition Long Term sets up how many readings should be taken at scheduled intervals. For example *Long Term - LPR Sweep* could be placed in the sequence list as a normal test, but only one LPR sweep would be taken, creating only one LPR result. If it was placed within a Long term folder set to record 24 readings, one every hour, then 24 LPR results would be created linked together under one long term graph.

Core Running & Sequencer List

The core running and sequencer each have their own separate sequence lists, this allows the core running to be collecting a sequence of tests, whilst a new list of tests is constructed in the sequencer. A new sequence list can be sent to the core running in one of three ways:

The sequence list for the **selected channel only** is sent to the core running, logging is started on said channel straight away.

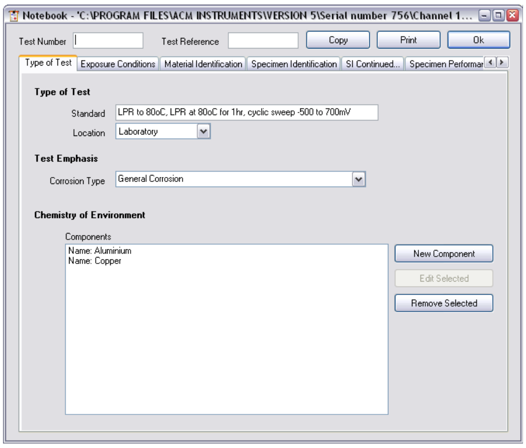
Every channel will be updated to the core running, logging will then commence on all channels.

Gives the option 

to update selected channels, channels have to be manually started from the core running.

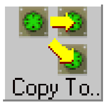
Database Notebook

Included within the Sequencer is a full ASTM G107 standard notebook (click **Test Notes**), providing a way of storing detailed information to go along with test data:

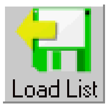


Each time a sequence of tests is collected, notebook information is saved to a database, which can be searched to find matching data, see later on in this manual for details on how to search. Also when data is loaded into the analysis, the notebook can be viewed.

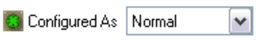
Advanced Sequencer Features



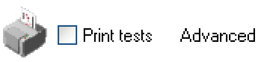
Copy To is used to copy all settings from one channel to another.



The settings (sequence list, and note book settings) from a previously gathered data sequence can be loaded into the selected channel.



If your instrument has a paint buffer, it will be listed within **Configured As**. Select **Paint Buffer** if the paint buffer is being used, otherwise **Normal** should be selected.



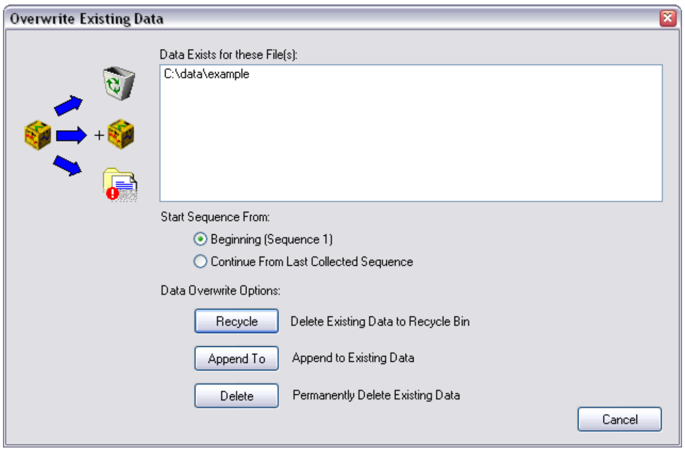
Advanced printing options include printer font and orientation, graph titles and a finer control over exact graph types to print (such as long term, short term, voltage inputs, etc).

Core running

Each channel is controlled from **Channel Control** within Core running, to start data collection click Enabled for a channel, it will become Enabled showing logging is taking place for that channel. Similarly clicking **Disabled** ends logging for a channel. Each data graph has a green bar in the corner this lights up to indicate a channel is actively communicating with an instrument, on sequential channel instruments only one channel can be active at once.

<u>Updating - Overwriting Existing Data</u>

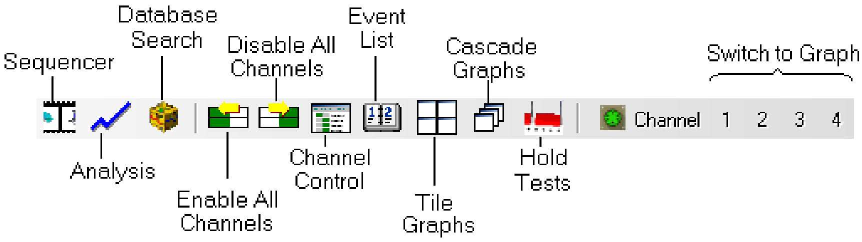
When starting logging, this page is shown if existing data will be overwritten:



There are two main options on this page – the first **Start Sequence From** designates which sequence the core should start from, either the beginning of the sequence list, or the last collected sequence.

Existing data can be treated in one of three ways – **Recycled**, **Appended To** or permanently **Deleted**.

Main Control Buttons



Shortcut buttons on the core running tool bar include:

Hold Tests acts as a toggle button, whilst this button is toggled down no new techniques will be started until the button is released.

Event List serves two purposes – allowing user events to be stored with data and informing of any problems whilst logging. User events can be added from the Event list page:

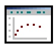
All events are drawn to any Long Term graph and shown in the Analysis, an event could be anything, such as *'Stirred Test Cell'* a date and time automatically prefix all events.

Should there be a problem with the instrument it will be listed in the Event List, such as:

11/12/98 14:29:43 Sequence 4 - Unable to find instrument serial number 437 on any serial port [Cyclic sweep]
11/12/98 14:29:39 Sequence 3 - Unable to find instrument serial number 437 on any serial port [Current & voltage / time]
11/12/98 14:29:34 Sequence 2 - Unable to find instrument serial number 437 on any serial port [AC Impedance]
11/12/98 14:29:30 Sequence 1 - Unable to find instrument serial number 437 on any serial port [Custom sweep]

In addition both **Channel Control** and the data graph will indicate the event list should be viewed.

Advanced Features

Each data graph remembers the last 10 tests, clicking  allows these stored graphs to be viewed, viewing an older graph 'locks' the view to that older graph, select the newest graph (at the top of the list) to unlock the view. **Long Term** and **Voltage Input** graphs can also be viewed here.

To facilitate navigating around the core running a number of key presses and mouse clicks speed up selection of different windows:

To switch to **Channel Control** press **insert** key, pressing **insert** again when **Channel Control** is active hides it. **Channel Control** can also be switching to by right clicking the mouse on the grey tool bar on any of the data graphs.

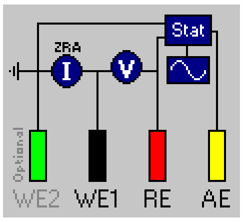
Locking your Computer

To stop unauthorised access to the core running during testing, Windows 2000/NT/XP can be locked, by pressing **CTRL** + **ALT** + **DELETE** together and select **Lock Computer**, the core running will carry on logging unaffected.

Techniques

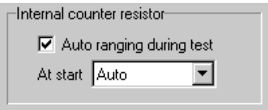
Common Elements

Various areas on set-up pages are common to most techniques, these are:



Each set-up page has a diagram of the required cell connections, optional connections are shown in light grey.

All potentials measured or inputted are displayed with respect to the reference electrode.



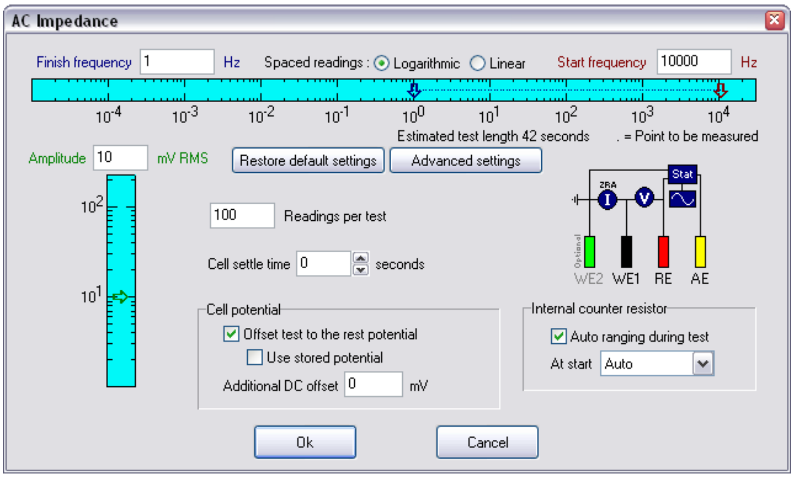
This section allows the precise control of internal count resistors at the beginning and during a test. **Auto ranging during test** if checked, allows the instrument to change to the best-suited count resistor whilst the test is running. At the start of the test the count resistor can be fixed on a certain resistor, or be automatically found before a test is started. These two options can be combined in any order, for example it is possible to automatically find the best count resistor at the start of the test, and then to fix on this resistor during the test (*Auto ranging during test* unchecked, and *At Start* to *Auto*).

Cell Settle Time allows the cell to settle before a test begins, during a settle delay the instrument is coupled to the cell, at the test start potential (if applicable).
This option should not be confused with a **Pause** technique (waits a pre-set time between tests, the cell is isolated).

The option for offsetting to the rest potential is available when a technique applies a potential. For normal use this option should be on (checked), even if testing dummy resistor test cells. An example of *Offset test to rest potential* and a Cyclic test –

> Assuming a Cyclic technique was set to sweep from -100mV to +100mV and there was a rest potential of -53mV (**All potentials are with respect to reference electrode)** the actual potential of the sweep would be -153mv to +47mV.

AC Impedance



AC Impedance does a series of sine waves from **Start Frequency** to **Finish Frequency**. For normal testing **Spaced readings** should be set to **Logarithmic** and the **Start Frequency** should be higher than the **Finish Frequency**, so the initial count resistor will be found more quickly.

Amplitude used for the AC signal plays an important role in obtaining the best possible results, always use the highest amplitude possible, a test at 30mV AC will yield better results than a test at 4mV AC.
The cell potential applied to the cell is affected by two options, firstly is the option **Offset test to the rest potential** that biases the test around the rest potential, an **Additional DC Offset** can also be applied (with respect to RE), for eample a cell has a 133mV rest potential, *Offset test to the rest potential* is checked and there is an *Additional DC Offset* of 200mV - the final test potential would be 333mV.

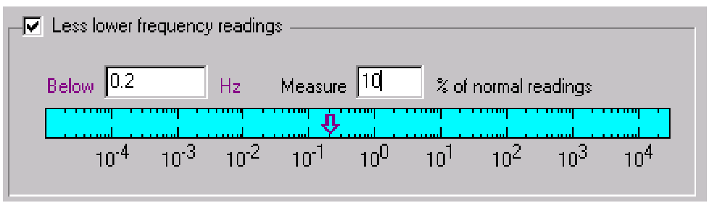
<u>Advanced Settings</u>

Each instrument undergoes a very extensive calibration procedure over a series of 8 decades of cell load, 10 amplitudes and the full range of frequencies to produce a calibration matrix we call the **P.A.I.R.** table (Phase and Impedance Reduction). This is then applied to the raw data to reduce cable and instrument induced errors.

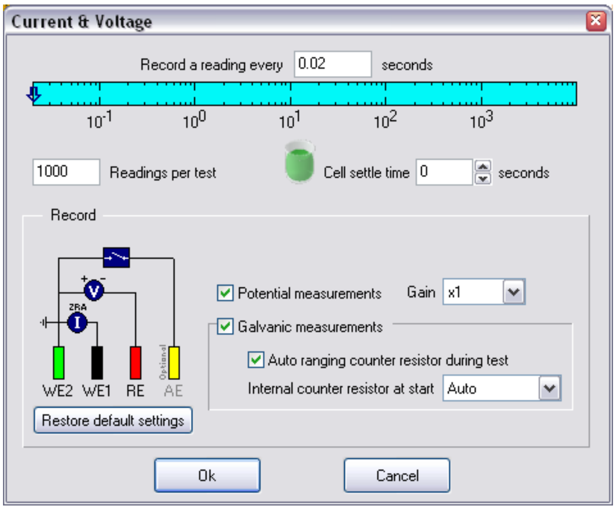
Averaging over a number of points can improve AC Impedance results, there are two averaging options which complement each other - **Integration factor** and **Maximum Integration Cycles**. Starting with *Maximum Integration Cycles* this controls the maximum number of averages allowed. The other option *Integration factor* specifies the percentage error until the result can be passed. For example with a 8% error setting the averaging will continue until the averaged result drift from averaging drift is less than 8%. *Low, Medium and High* translate into 8%, 0.75% and 0.25% respectively.

Low frequency points can take a long time to collect, at high frequencies many averages are done in the blink of an eye. To speed up a test at these lower frequencies **Single Integration Factor below 1 Hz** can be checked, it effectively turns off averaging below 1 Hz.

Less lower frequency readings can also speed up a test, by collecting less points below a certain frequency, a percentage of the normal number of points can be set:



Current & Voltage / time

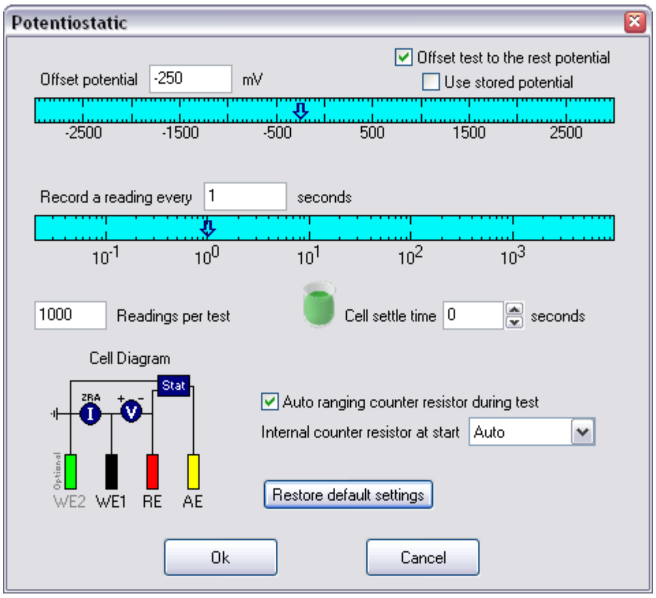


Current & Voltage permits the continuous measurement of potential and galvanic readings. The maximum read rate for Current & Voltage is limited by the mains frequency, 0.02 for 50Hz and .0166667 for 60Hz. Should the read rate be very infrequent (one point every 15 minutes or more) consider using a **Long Term** test with **Potential Measurement** and **Galvanic Measurement** tests, this would have the advantage of freeing up the instrument during measurements, where as using Current & Voltage would not.

If count resisters are permitted to auto range during a test and a count resistor change happens, a small delay in galvanic measurement will occur whilst the cell 'settles down', whilst delaying no data is stored. When this data is viewed in the analysis a straight line will be presented for the resistor change delay.

Potential **Gain:** internal gain can be applied to the potential measurement to increase resolution, maximum recordable potentials for each gain are: 10x ±750mV 100x ±75mV 1000x ±7.5mV
At the start of a test with Gain applied, the initial potential is subtracted, this offsets the range of measurement, but the drift in potential (for the length of time of the test) can only be a maximum of the values presented here.

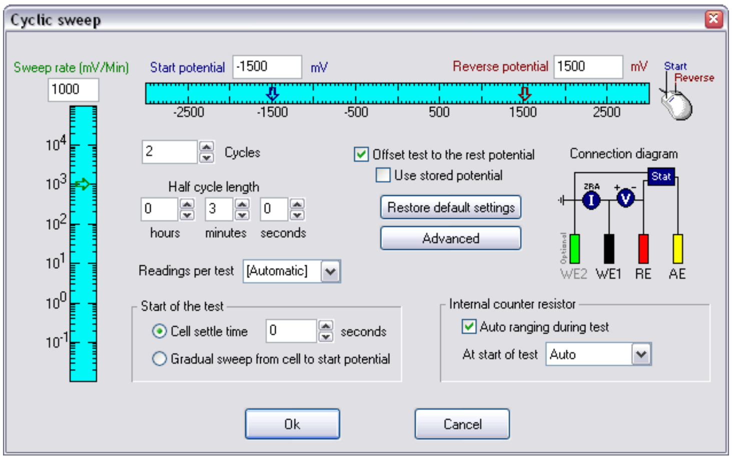
Potentiostatic



Potentiostatic applies a constant DC offset potential whilst measuring galvanic readings at up to 50 / 60 measurements per second. The maximum read rate is governed by the mains frequency, 0.02 for 50Hz and .0166667 for 60Hz. Normally **Offset test to the rest potential** is checked to apply the offset potential around the cell rest potential.

As with *Current & Voltage / time*, if count resisters are permitted to auto range during the test and a count resistor change happens, a delay will occur from when the new count resistor was set. The delay allows the cell to settle a set length of time, dependant upon the resistor set. Whilst a delay is taking place the test continues, but no data is stored during the delay, later in the analysis a straight line will be present from the change point to the point after the delay has finished.

Cyclic Sweep



Cyclic sweep performs a sweep from **Start potential** to **Reverse potential** over a set number of **Cycles**. One complete cycle goes from the start to reverse back to the start potential, half cycles can be specified to finish on a reverse potential.

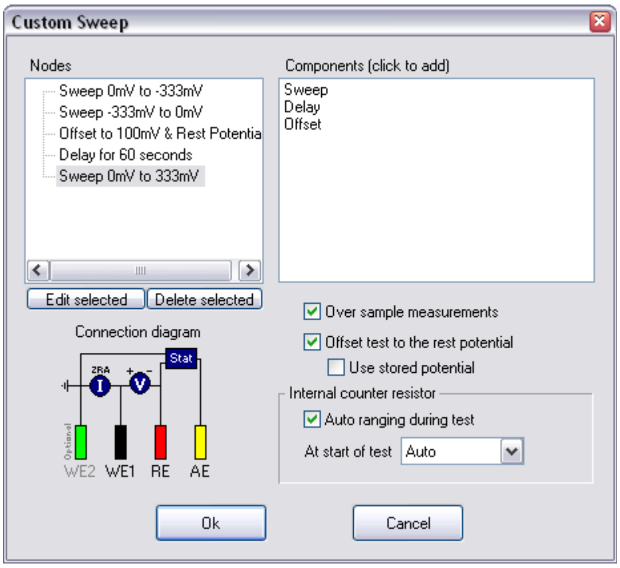
The rate at which the sweep progresses is controlled by either **Sweep rate** or **Half cycle length**, these two are linked together, so altering one affects the other one.

At the start of the test one of two delays can be performed - **Cell settle time** delays at the test start potential (including rest potential if applicable) for the length of time specified, if the internal counter resistor option **At Start of test** is set to *Auto* the correct internal count resistor will be found during the delay. **Gradual sweep from cell to start potential** stops the cell from being jolted, instead of jumping to the start potential, a gradual sweep from the cell rest potential to the start potential at a rate determined by *Sweep rate* is performed.

<u>Advanced Settings</u>

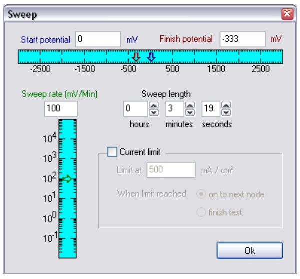
A positive current limit can be set on the advanced page, once the limit has been reached there are options to either end the test, or to reverse the sweep.

Custom Sweep (part of Cyclic Sweeps)



Custom sweep is quite similar to cyclic sweep, except that user defined sweeps can be constructed with delays and re-offsets. **Over sample measurements** greatly improves the smoothness of recorded data, many readings are averaged for each point. A custom sweep is constructed from **Nodes**, to add a *Node* click one of the available Components:

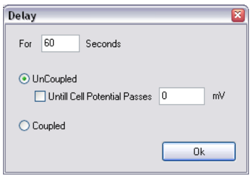
Sweep



A sweep from a **start** to a **finish** potential at a defined **sweep rate** or **sweep length**.

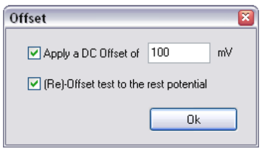
A positive **current limit** can be imposed, when reached the test can either move onto the next node or the test can be finished.

Delay



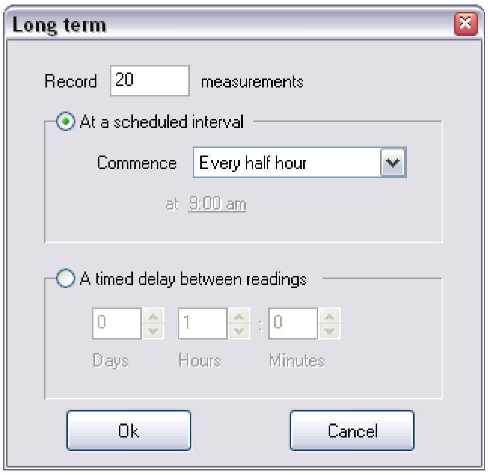
Delay for a predefined length of time, either **coupled** or **isolated** from the cell. For a coupled delay the cell potential is held at the last set potential - normally the finish potential of the previous sweep node, or an offset potential (see below). If the cell is isolated, there is an option to end a delay if the cell potential passes a set potential.

Offset



Offset can be used to set a potential before a delay, or to re-measure and re-offset to the rest potential before a sweep node.

Long Term



A long term technique is a folder, into which techniques inserted, techniques with names prefixed by **Long Term -**, these tests include:

Long Term - Potential Measurement
Long Term - Galvanic Measurement
Long Term - LPR Sweep
Long Term - LPR Step

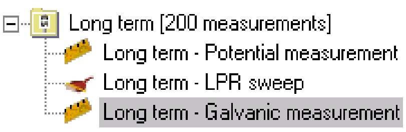
Options

Record xxx Measurements set how many times the tests within the long term folder should be repeated. The interval between each long term measurement is set by either **At a scheduled interval**, or **A timed delay between readings**. To ensure long term readings are evenly spaced, subsequent long term reads are scheduled from when a long term reading begins, not from when the tests within the long term finish. For example if a long term test is scheduled to measure every 5 minutes and contained within the long term test is an LPR sweep that will last approximately 2 minutes, then an LPR sweep will be recorded every 5 minutes regardless of the time taken for the LPR sweep.

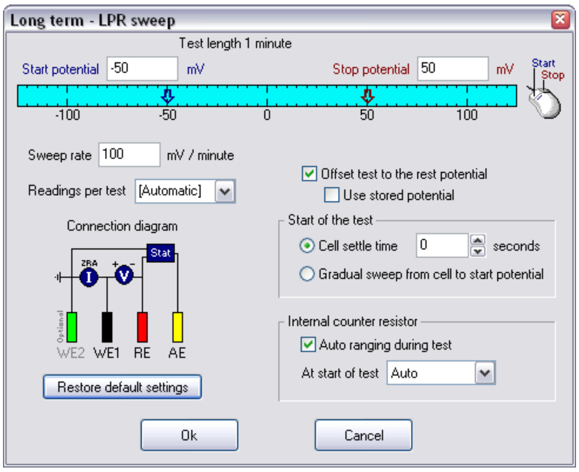
Why use a Long term test?

Apart from providing scheduled times, the main benefit from using a long term folder is that all results generated by techniques contained within are presented on a result vs time graph in both the logging and the analysis program.

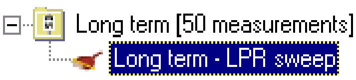
Example use of long term :



Long Term - LPR Sweep



LPR Sweep calculates an LPR result from a polarisation sweep. The LPR Sweep technique can be placed inside a **Long Term folder** to be repeated at scheduled intervals, all results will be shown using a LPR result vs time graph, or can be placed on its own anywhere in a sequence list:



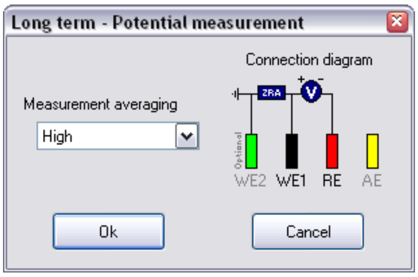
within a Long term folder

single LPR test

Cell settle time delays at the start potential, which includes the rest potential if *Include rest potential* is checked, if the internal counter resistor option *At Start of test* is set to *Auto* the best internal count resistor during the delay will be found.

Gradual sweep from cell to start potential stops the cell from being jolted when the start potential is applied. Instead of setting the start potential, a gradual sweep from the cell rest potential to the start potential at a rate determined by *Sweep rate* is performed.

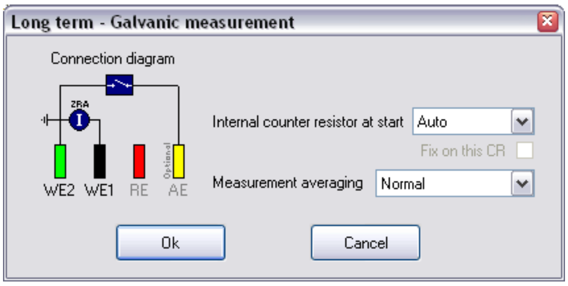
Long Term - Potential Measurement



Potential Measurement should always be placed within a long term folder, so that it can be plotted on a Potential vs Time graph both in the logging and analysis. There is only one setting for potential measurement - **Measurement averaging**, the actual averages taken for each setting are as follows:

Measurement Averaging	Number of Averages
Normal	20
High	40
Very High	60

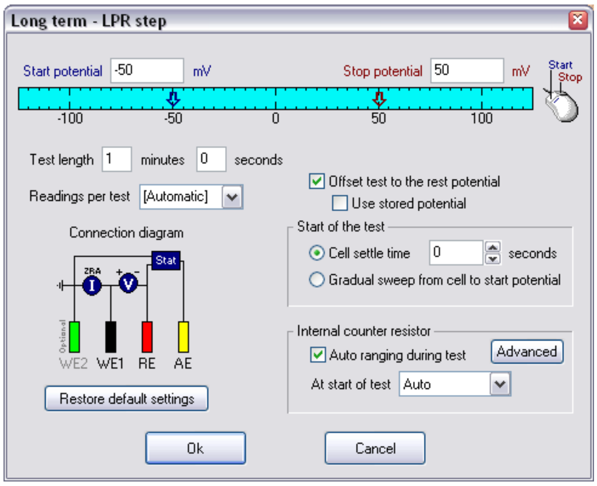
Long Term - Galvanic Measurement



As with a Potential Measurement, **Galvanic Measurement** should only be placed within a long term folder, so the results can be viewed. **Measurement averaging**, the actual averages taken for each setting are as follows:

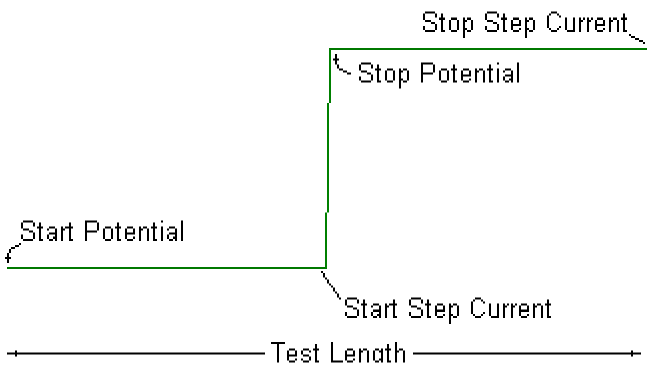
Measurement Averaging	Number of Averages
Normal	20
High	40
Very High	60

Long Term - LPR Step

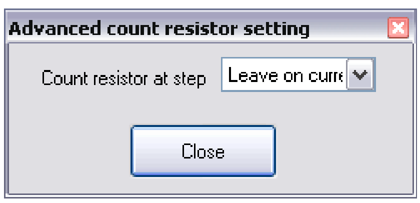


LPR Step begins the first half of the test at a start potential, exactly half way through the test a step is applied to the stop potential. An LPR result is calculated from two currents each recorded at the end of each half step.

<u>Step Diagram</u>

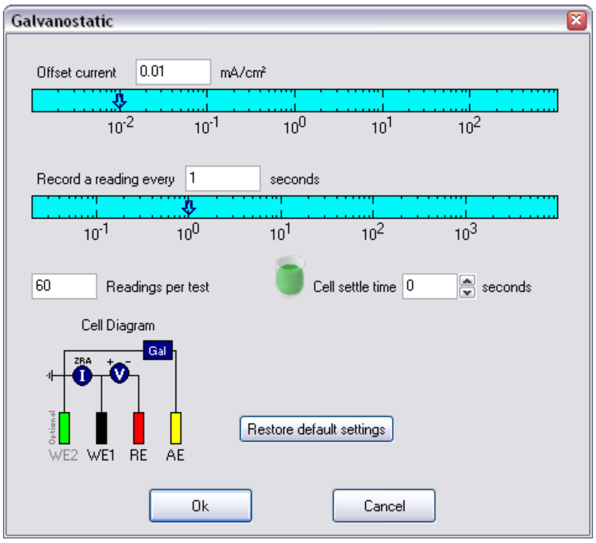


<u>Advanced Settings</u>



Half way through the test various count resistor options can be applied when the stop potential is set. ***Auto*** option reduces the internal count resistor to 10 ohms, after which it will auto range. If ***Leave on current*** is chosen, the internal CR will not change unless it needs to (assuming ***Auto ranging during test*** is selected).

Galvanostatic

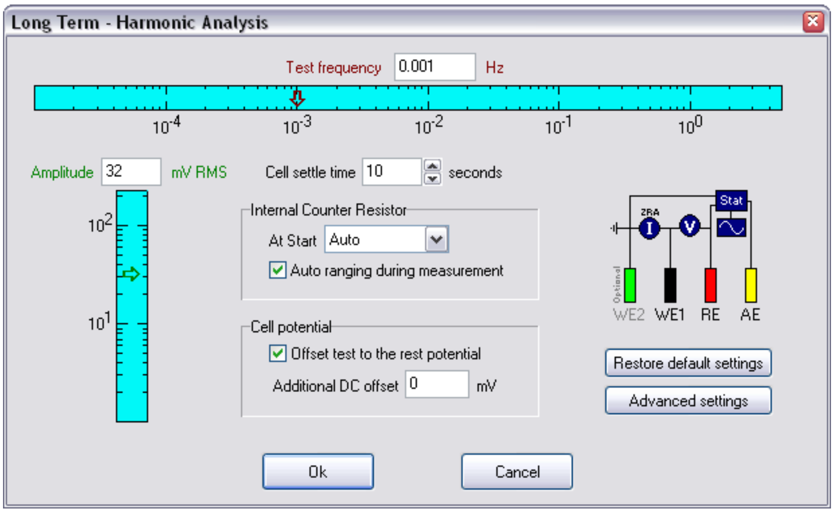


Galvanostatic sets a specified static offset current (area corrected) whilst monitoring the potential response. Care must be taken when choosing the offset current, a current should be picked the instrument is able to supply, for example:

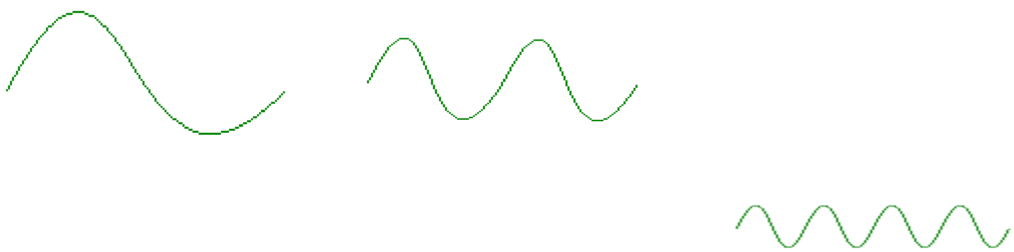
> Assuming the cell impedance is 1000 ohms the maximum offset current is 15mA, this is calculated from:
>
> <u>15000 mV (maximum compliance potential)</u>
> 1000 ohms (cell impedance)

A **Cell settle time** delays at the test offset current, it can be used to give the cell a chance to settle down after the offset current has been applied.

Harmonic Analysis



Harmonic analysis applies a sine wave at a predefined frequency, first, second and third harmonics are extrapolated. A corrosion current and Tafel slope are then calculated from the three harmonic results.



First Harmonic Second Harmonic Third Harmonic

The **Amplitude** used for the AC signal plays an important role in obtaining the best possible results, always use the highest amplitude possible, a test at 30mV AC will yield better results than a test at 4mV AC.

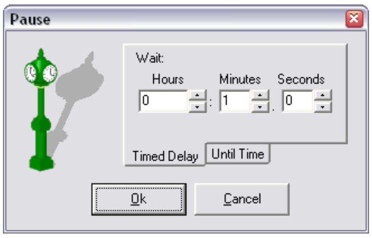
The cell potential applied to the cell is affected by two options, firstly is the option **Offset test to the rest potential** that biases the test around the rest potential if checked, the second option allows a DC Offset to be applied (with respect to RE). An example of both options, a cell has a rest potential of 133mV, if *Offset test to the rest potential* is checked and there is a DC Offset of 200mV to be applied then the test would be done at 333mV.

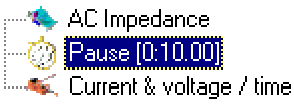
Advanced Settings

Each instrument undergoes a very extensive calibration procedure over a series of 8 decades of cell load, 10 amplitudes and the full range of frequencies to produce a calibration matrix we call the P.A.I.R. table (Phase and Impedance Reduction). This is then applied to the raw data to reduce cable and instrument induced errors. The PAIR option is on by default, it can be accessed on the Advanced options page.

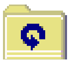
Pause

The pause technique can used to place a delay between two techniques, whilst a pause is taking place the channel is isolated from the cell.



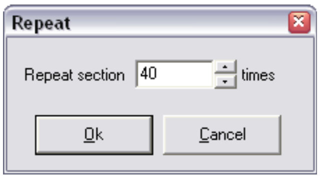


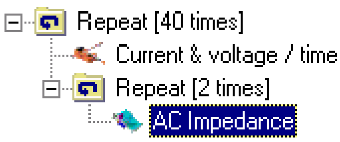
A pause length is either entered as a **Timed Delay** (ie wait 1 hour), or **Until Time** (ie 3 pm)



Repeat

Techniques to be repeated are placed within a repeat, tests are added into a selected Repeat folder until the [-] sign next to the folder is used to close it.





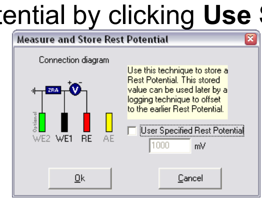
In the above illustration the core running would collect:

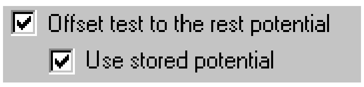
Current & voltage / time
AC Impedance
AC Impedance

Repeated 40 times.

Measure and Store Rest Potential

With this technique the Rest potential can be measured and stored, or specify fixed offset potential (normally at the beginning of a sequence of tests), to be used by later techniques. Subsequent logging technique can use this stored potential by clicking **Use Stored Potential** on its relevant parameters page.

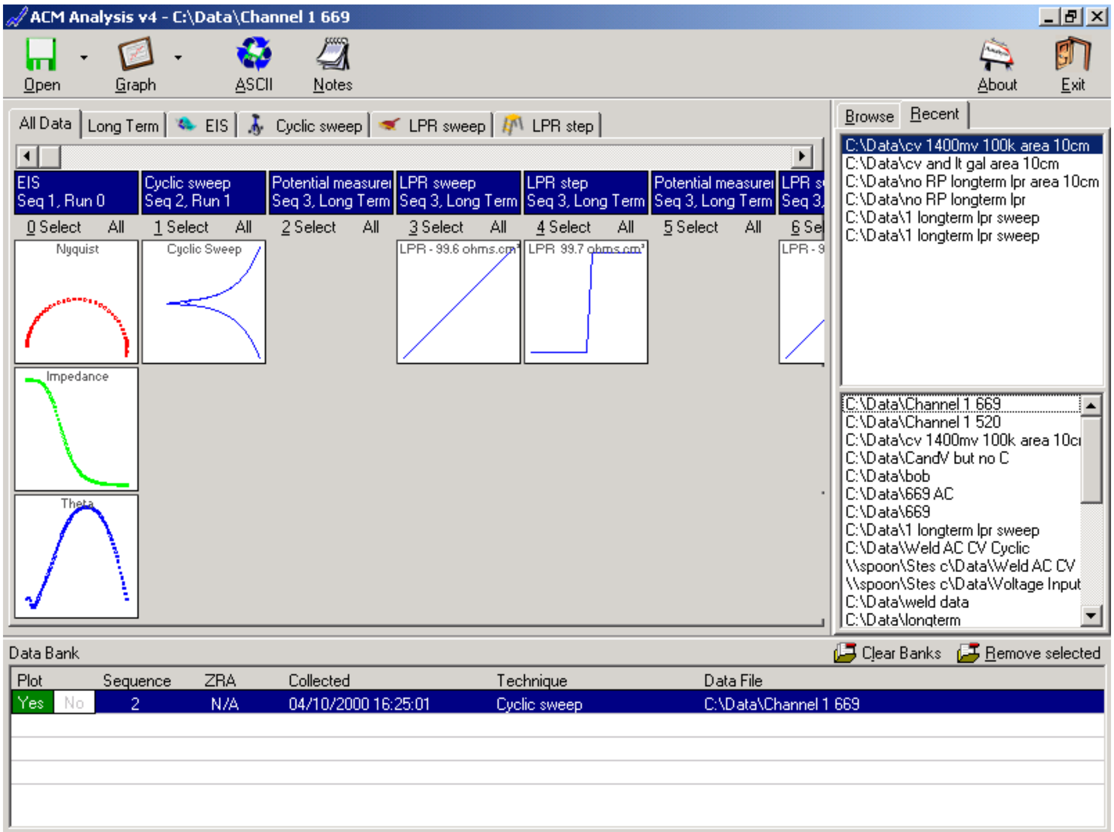




Typically this technique can be used remove the effects of Rest potential drift caused by polarising techniques.

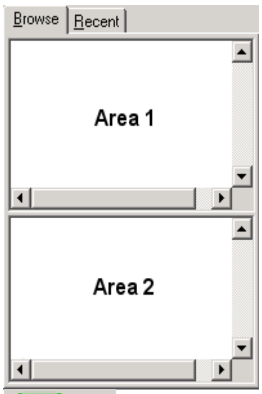
Please note if **Use stored potential** is enabled in any techniques, a **Measure and Store Rest Potential** technique MUST be placed earlier in the sequence list.

Analysis



Above is the analysis data explorer window; it is split into 4 sections. At the top is a Tool bar, right side is the data file selection area, centre of screen is where the contents of a data file are displayed and at the bottom are data banks where individual tests are placed ready for analysis.

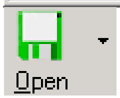
First we will look at the data file selection (right side). This is partially hidden until the mouse cursor is moved over it:



Here you will see two tabs, Browse and Recent, and two Areas.

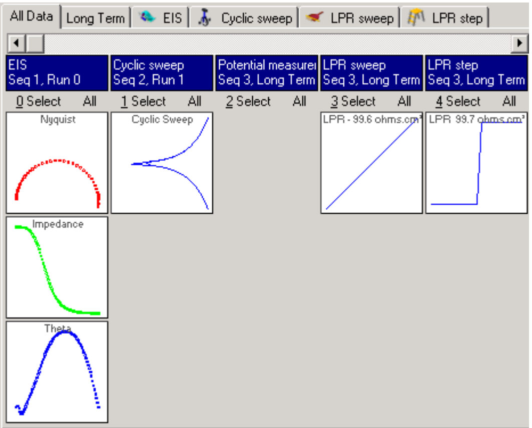
The Browse tab will display a tree view of available Drives and Folders in Area 1, Area 2 shows the contents for the presently selected folder in Area 1. To open a data file select a folder in Area 1 and click on the required file in Area 2

The Recent tab displays the last files stored by the Core running in Area 1 and a history of files previously opened in Area 2. To open a file displayed in Area 1 or 2 simply click it.



The 'Open' button on the tool bar can also be used to select a file. Unlike the Browse option above, network drives do not need to be mapped for data to be accessed. Next to the open button is a drop down arrow that produces a list of the last data files recorded.

Once a data file is opened its contents are displayed:



At the top there are several tabs showing different types of data contained within the file.

Data from individual tabs can be viewed all together by using 'All Data' Tab or a specific technique can be displayed by selecting the required Tab.

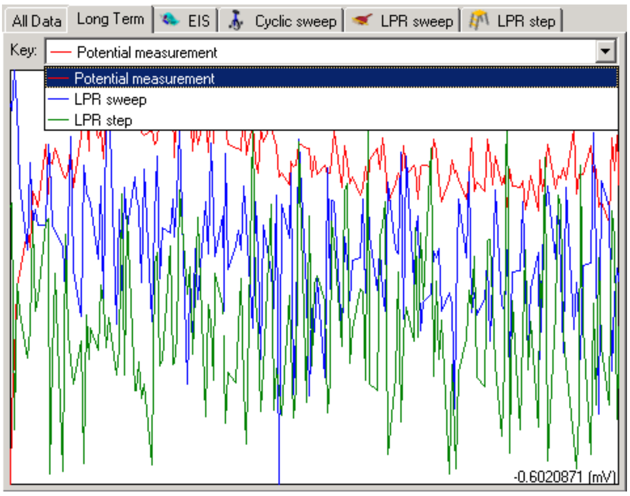
Below these Tabs is a scroll bar for when the number of tests within a data file exceeds the displayable number.

Individual tests are displayed in columns. At the top of the column is a text area showing information about the test. Each test can contain up to three thumbnail graphs previewing data stored. Each column also contains selection buttons, 'Select' which enters the data from the column into data bank and 'All' which places all data from the same technique into data banks. However, some techniques are treated differently with the 'All' option, techniques that contain data which can not produce a graph individually (Harmonic or a single potential or current measurement, etc.) will produce a measurement Vs time graph for any values stored. For Current and Voltage data the 'All' option adds all individual tests end to end and also allows trend graphs to be drawn (e.g., Delta I Vs time, Delta V Vs time, etc).

Data may also be entered into data banks by dragging one of the thumbnail graphs down to one data bank.

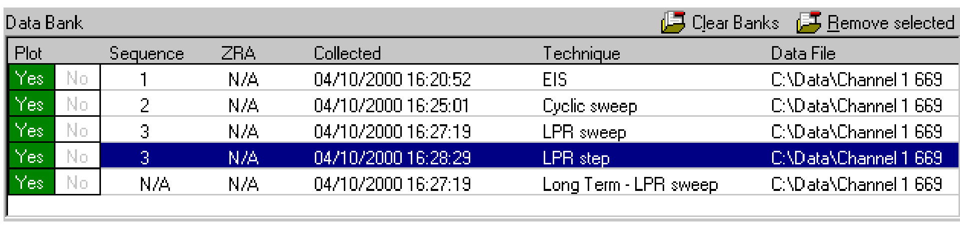
Some Custom techniques have their own analysis software; in these cases double clicking one of the thumbnail graphs will launch the Custom analysis software. Normally double clicking a thumbnail graph will place it into the data banks.

Long term and Voltage input data are treated differently:



Selecting long term or voltage input tabs displays a graph containing all the relevant data. A drop down list containing a colour key is used to identify each type of data and also decides which data type is added to the data bank. To select data, first select the type of data from the Key and then drag the graph into the data bank area.

Data banks contain the data to be displayed:


Data Bank — Clear Banks — Remove selected

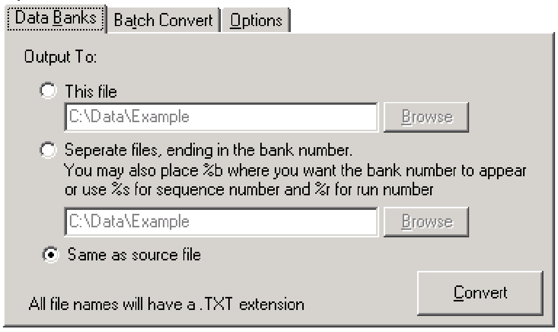
Plot		Sequence	ZRA	Collected	Technique	Data File
Yes	No	1	N/A	04/10/2000 16:20:52	EIS	C:\Data\Channel 1 669
Yes	No	2	N/A	04/10/2000 16:25:01	Cyclic sweep	C:\Data\Channel 1 669
Yes	No	3	N/A	04/10/2000 16:27:19	LPR sweep	C:\Data\Channel 1 669
Yes	No	3	N/A	04/10/2000 16:28:29	LPR step	C:\Data\Channel 1 669
Yes	No	N/A	N/A	04/10/2000 16:27:19	Long Term - LPR sweep	C:\Data\Channel 1 669

To remove a single test, select it and click 'Remove Selected'.

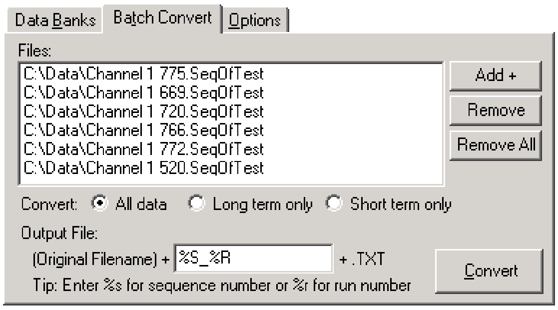
To remove all tests from the data bank select 'Clear Banks' option.

The tool bar contains the available options:

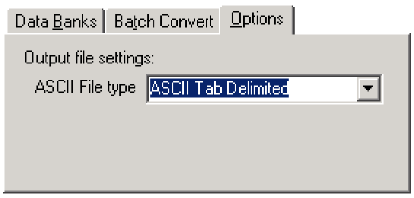
allows data to be converted to a file suitable for spread sheets and other analysis software. This option has three sections:



Data Banks convert tests currently in the data banks. All files created will have the file extension of .TXT. There are three options which decide the filename. **This File** where all data is stored in the same file, **Separate files** where the filename ends in the bank number or bank number (%b), sequence number (%s) or run number (%r) can be placed anywhere in the file name. Same as source file uses the source filename (but with the .TXT extension). Select **Convert** to start conversion.



Batch convert enables large amounts of data to be converted to ASCII. Use **Add** to add files to the list, select unwanted files and click on **Remove** or **Remove all** to clear the list of files. There is the ability to convert just Long term or just Short term or all types of data. Output file is the original filename with the file extension of .TXT and the ability to include sequence number (%s), run number (%r) and additional text.



Options contains settings for the output file. ASCII file types are Tab delimited (used by most packages) and Comma delimited (sometimes known as CSV).

NB, More data conversion options are available from the File and Edit menus once the data graph has been drawn.

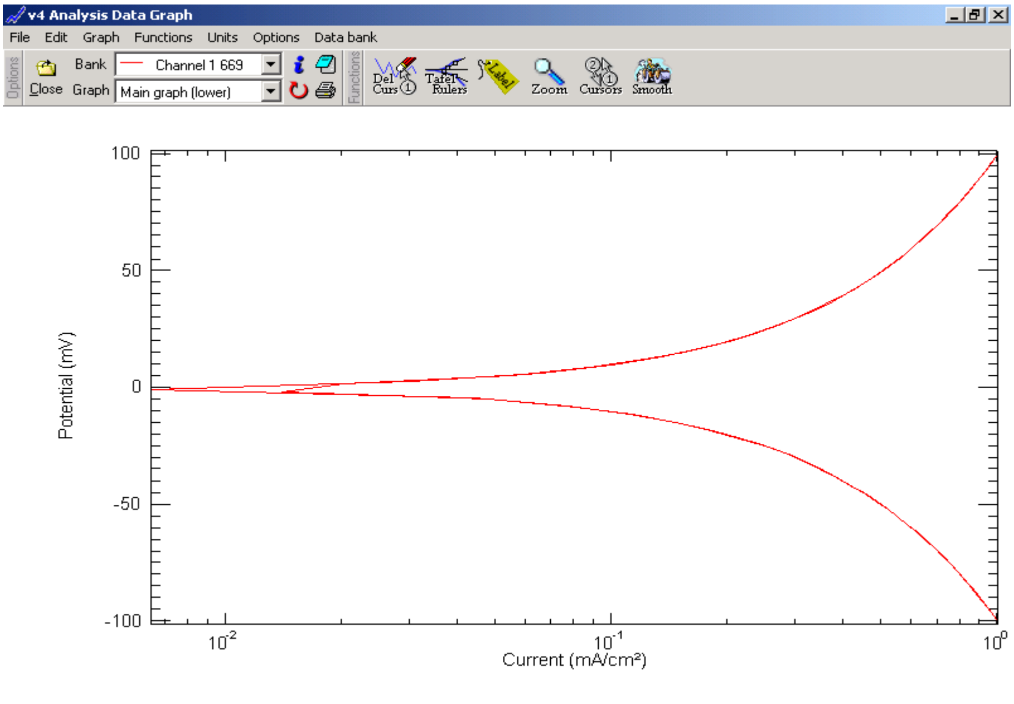
displays the note book for the open data file (see the notebook section of the manual).

draws the default graph data in the data banks. Selecting the down arrow next to graph displays a list of all possible graphs.

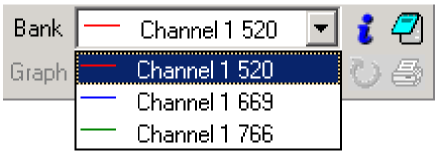
shows the analysis version info.

quits the analysis software

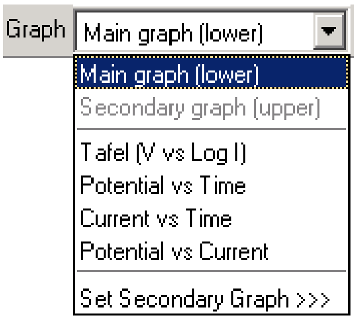
Data Graph



A data graph is made up of three sections, a menu where functions and options can be selected, info bar where functions, information and results are shown, and the graph itself.



On the info bar is a Bank key, this can be used to select an active data bank and to identify a data set by it's colour. Clicking on the word 'Bank' allows banks settings to be edited (i.e., title, colours and markers). Clicking on displays all information associated with the selected data bank. Selecting will display the note book for the active data bank.



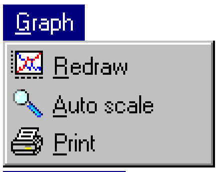
Graph contains a list of standard graphs that may be drawn. Certain standard graphs types will include two separate graphs, however on graphs which don't, a second graph may be added via the **Set Secondary Graph >>>** option. Clicking on the word **Graph** allows graph settings to be edited (i.e., axis types, colours, fonts, etc.).

Clicking on the button re-draws the graph. prints the present graph.

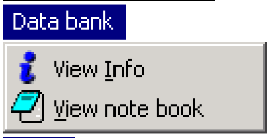
Menus:

Save As allows data or graph information to be saved to various formats, e.g., text, bit map, HTML, etc.
Close graph returns to the data file explorer page.
About displays the about form.
Exit quits the analysis software

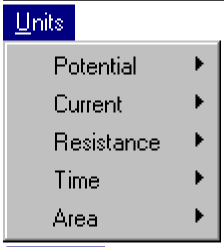
Copy As copies data to the clipboard to be pasted into other programs such as MS Word or Excel.
Revert reloads data from disk, therefore removing any modifications to the data such as smoothing.



Log X axis and **Log Y axis** allow the axis to be displayed in linear or logarithmic.
Redraw refreshes the graph after any changes.
Auto scale re-scales the graph to the maximum scaling.
Print prints the graph to the default printer. If a special function, such as tafel rulers, is selected they will also be printed.



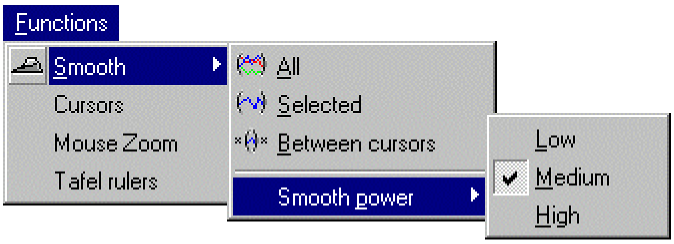
View Data info displays all relevant information on the selected data bank including analysis results such as Icorr and Corrosion rates.
View Note book displays the note book for the selected data bank.



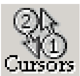
Units menu can be used to change displayed units. For example potential may be set to V, mV, µV or pV. Certain data types such as voltage inputs are unaffected by the units.

Bank Settings allows the selected banks settings to be edited (i.e., title, colours and markers).
Graph Settings edits graphs settings such as axis, colours, fonts, etc.
Join gaps in data when checked draws lines between gaps in the data. Gaps appear when data points are deleted, cyclic sweeps are reversed or long term data is appended to.
Zero plot time axis when checked starts all data banks from Zero on the time axis. When un-checked zero plot start each bank from its relative start time to all other data graphs start times.

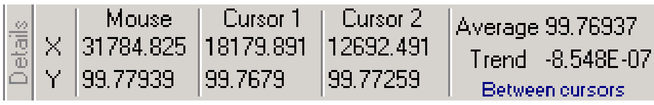
Functions menu:



The Smooth function can be applied to **All** data on a graph, just the **Selected** data bank or **Between** the cursors for the selected data bank.

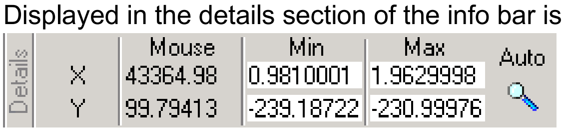


Cursors function places two cursors onto the selected data bank. When **Cursors** is selected, X



and Y positions of both cursors and the mouse pointer are displayed on the info bar. Also shown is information relative to the present graph, usually average and trend between the cursors.
Cursor 1 is be moved by clicking the left mouse button when the mouse pointer is over the required point or by using the left and right cursor keys. Cursor 2 is moved by clicking the right mouse or using the up and down cursor keys.

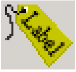
Mouse Zoom function is used to re-scale the graph. Simply click the mouse pointer at the top left corner of the required area and drag the mouse pointer to draw a box around the selected area. Displayed in the details section of the info bar is current X, Y, Max & Min positions of the mouse



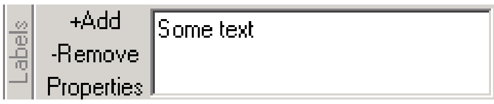
pointer. Values for the max and min X and Y axis may be typed directly into these boxes.  re-scales the graph to the new values. To scale the graph around the data select 

followed by .

Del Curs (1) deletes the data point at cursor 1. To recover deleted data points select Revert under the Edit menu. Only data in memory is deleted and not data in the data file.



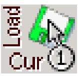
Label enables labels to be placed onto the graph. Click on the graph where the label is required and type some text. A yellow background highlights the selected label. Labels may be ‘dragged’ anywhere on the graph.



On the info bar a labels section is shown. Here text can be edited, label removed or new labels added. Select the **Properties** option to change the font, size and colour of the selected label.

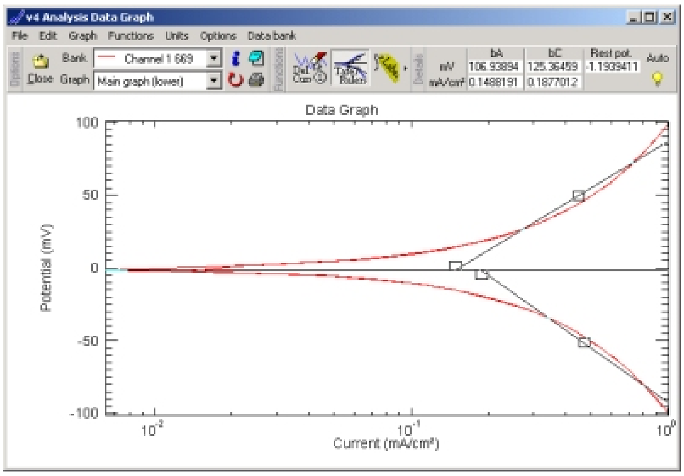
Other functions are available which are data/graph type specific. These include:

Point to point is available with current and voltage data only. Selecting point to point calculates the difference between one point and the next and displays the result. To revert back to the original data select Revert under the Edit menu.



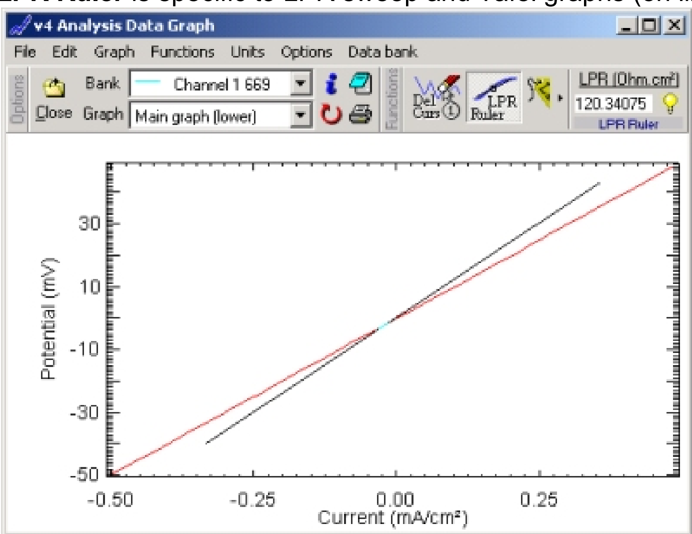
Load Cur(1) is available for Long term LPR/Corrosion rate graphs recorded with the Long term LPR Sweep or Step techniques. When selected the LPR Sweep or Step for the data point at cursor 1 is loaded and displayed.

Tafel Rulers function is specific to Custom, Cyclic, Galvanic and LPR Sweeps. Tafel rulers can

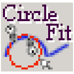


only be used on potential Vs current graphs where the current axis is Logarithmic. Three rulers are placed on the graph, a horizontal ruler (vertical if the X axis is potential) which identifies the rest potential. This can be moved by placing the mouse pointer over the line until it changes to a ⇕ cursor (⇔ if the X axis is potential), press and hold the left mouse button down and drag the line to its new position. The other rulers indicate tafel slopes. These can be adjusted by moving the mouse pointer over a square until the mouse pointer changes to ⇔(⇕ if the X axis is potential), then press and hold the left mouse button and drag the line to its new position. Use the  option to remember these tafel slopes. Corrosion rate will be calculated and displayed in the Data Info section (see **Data bank** menu, **View Info**). Auto automatically fits rulers to the slopes.

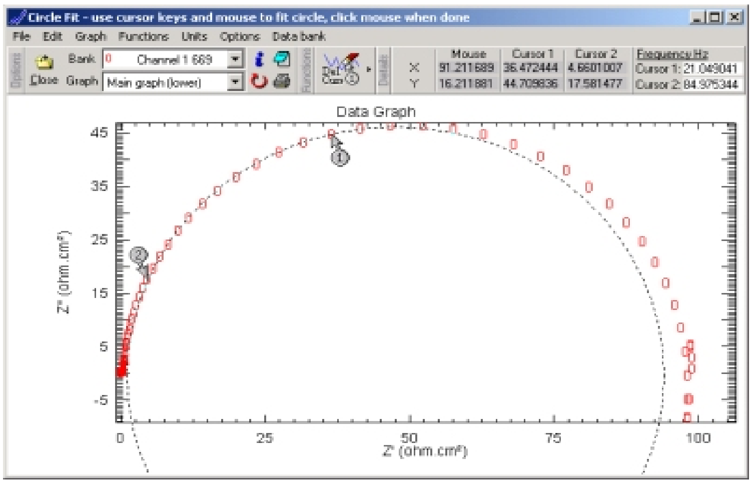
LPR Ruler is specific to LPR sweep and Tafel graphs (on linear axis only). A Ruler is drawn that

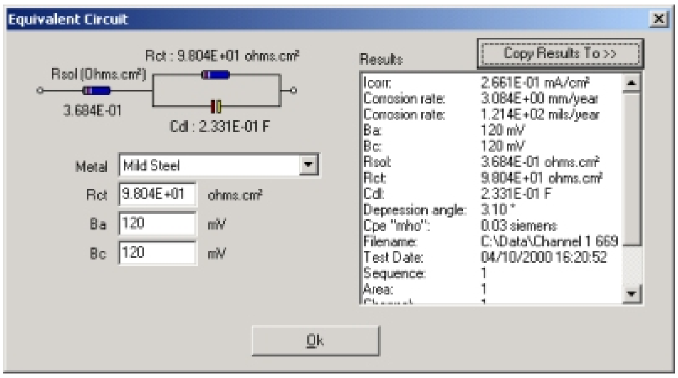


can be positioned by use of the mouse pointer and the left & right mouse buttons. The result is displayed in real time. Use  to remember the LPR result (for the selected data bank). Corrosion rate will be calculated and displayed in the Data Info section (see **Data bank** menu, **View Info**).



Circle fit is specific to Nyquist graphs. First select **Cursor** and place two cursors on the arc, then select **Circle fit**, use the mouse pointer as the third point of the circle adjusting it until the circle best fits the data and click the mouse button to calculate the result. While fitting you may reposition cursor 1 and 2 by using the cursor keys.



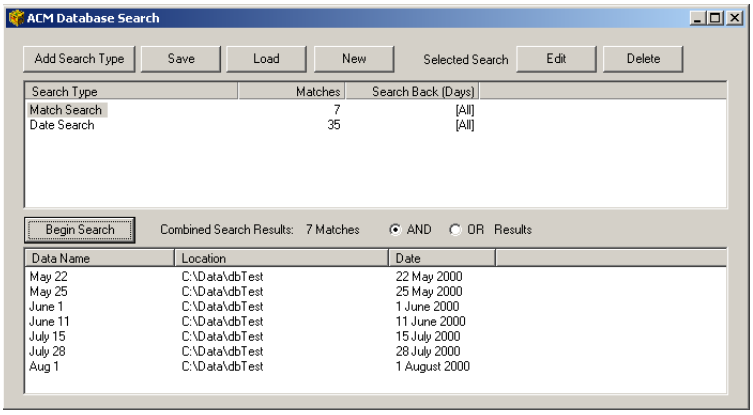


Once calculated, **Equivalent circuit** is displayed. The results can then be copied to Printer, Excel file, Text file or to the Clipboard.

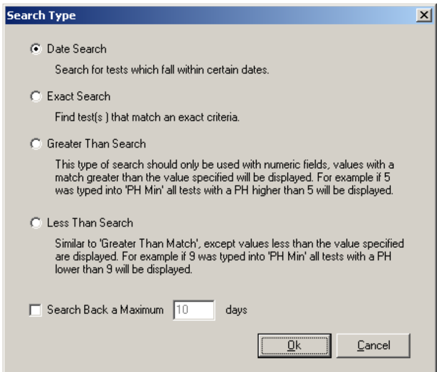
Nyquist functions are specific to Nyquist Graphs. **Isotropic Scale X and Y** uses the X or Y axis to keep the aspect correct. Isotropic scaling is useful if the nyquist plot has been zoomed and the aspect of the X and Y axis are incorrect. **Zero Plot XY** sets the minimum values for the X and Y axis to Zero (Isotropic should be used after Zero plot).

Notebook Database Search

Database searches can be performed across notebooks using previously collected data. Each time a sequence is started, the notebook for the test is stored in a database. The *ACM Database Search* program is able to search the database, making finding data easier:



Searches can be built up from more than one search type, and the results combined across searches. A new search is added with the *Add Search Type* button:



There are 4 different search types:

Date Search - data collected between a specified start and end date is be found.

Exact Search - After selection an empty 'Notebook' will appear, edit the field(s) in this notebook that will be sought in the database (leave the rest blank). When searching for text, short key words can be used.

Greater & Less Than Search – Numeric fields can be searched on a greater than, or less than basis. Using 2 searches (a Greater Than and a Less Than search) enables records that fall in a certain range to be found, for example: doing a Greater Than search on a Temperature of 16, and a Less Than search on a Temperature of 26 will find records with a temperature greater than 16, but less than 26.

Once the search type(s) have been selected the search can be carried out by selecting *Begin Search*, results from the search are be displayed in the lower list. Double clicking on a search result loads that data into the Analysis. Right clicking on a result gives the option of displaying / editing the Notebook. Results from each search type can be combined in two ways *And / Or*, when *And*ing results, only records present in each search are displayed, whereas *Or*ing will display each unique result.

Calculating corrosion rates

Corrosion rates are calculated from icorr (corrosion current) multiplied by a Metal factor. The following formulas are used :

$$\text{mm / year corrosion rate} = \frac{\text{Metal factor} \times \text{icorr}}{1000}$$

$$\text{mils / year corrosion rate} = \frac{\text{Metal factor} \times \text{icorr}}{25.4}$$

where Icorr is calculated from:

$$\text{icorr}\ (A/m^2) = \frac{ba \times bc}{2.3 \times Rp \times (ba + bc)}$$

ba is anodic Tafel slope in Volts
bc is the cathodic Tafel slope in Volts
Rp is the polarisation resistance in Ω/m^2

Metal factor is calculated from:

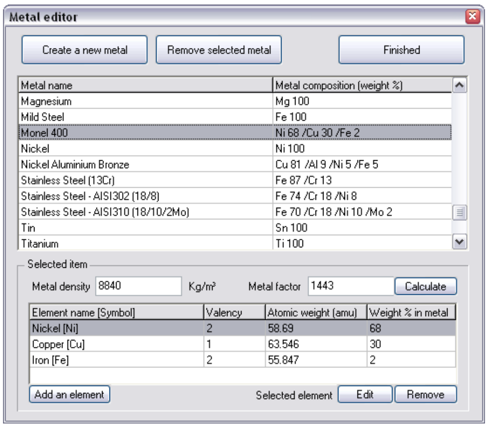
$$\text{Metal factor} = \frac{t \times K}{\rho}$$

t (seconds in year) = 365.2422454 * 24 * 60 * 60 = 31556930 seconds
ρ is the metal density in g/cm^2
K is the electrochemical equivalent in g / coulombs, K is obtained from

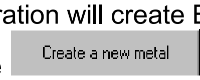
$$K = \sum \frac{\text{atomic \% of element} \times \text{atomic weight of element}}{96487 \times \text{Valency of element}}$$

Metal editor

The metal editor enables metal factors to be created from known compositions of metals or alloys, properties of the most popular metals and alloys are already included:

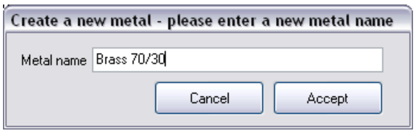


Creating a new metal

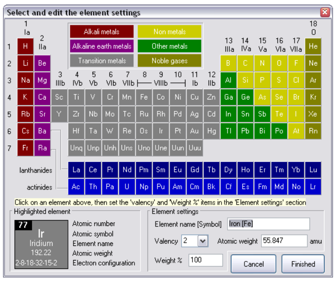
If a metal is not listed it can be created, the following illustration will create Brass 70/30. Firstly a new blank metal must be created, this can be done by clicking on the 

button.

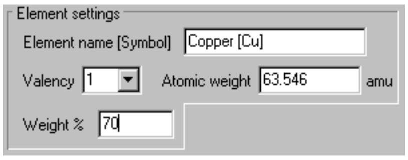
Type the name of the metal, and click *Accept*:



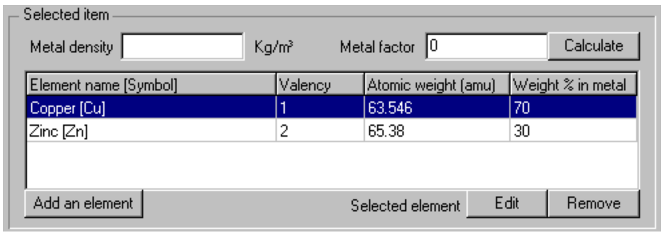
The new metal is then transferred onto the main page, in amongst all the existing metals and is automatically highlighted. The *Selected item* will have no entries, yet. From this point there are two ways of setting a metal factor, the first and easiest way is to just type the metal factor if it is known into the metal factor box. The second way is to build the metal up from its elements, and then let the program calculate the metal factor. Brass 70/30 is composed of 70% Copper and 30% Zinc, to add elements firstly start with the largest Cu. Click the Add an element button and the *Element selection* page will appear:



Move the mouse over to element Cu (29). The *Highlighted element* section in the bottom left of the page will change to show the element parameters for Cu. Click the left mouse button, to transfer all the element parameters to the *Element settings* section in the bottom right. There are two items which have to be checked, first is *Weight %*. Initially when an element is selected, the program calculates the remaining % needed to fill the metal. For the first element, the weight % is set to 100, this value should be reduced to 70. The other item which requires attention is the *Valency* box. The most popular valencies for the selected element are shown in the *Valency* box. Copper has two typical valencies of 1 and 2. For the example of Brass a Valency of 1 is normally used. If a Valency is not listed, then just type the number required into the Valency box. Before *Finish* is selected, the settings for copper should resemble:



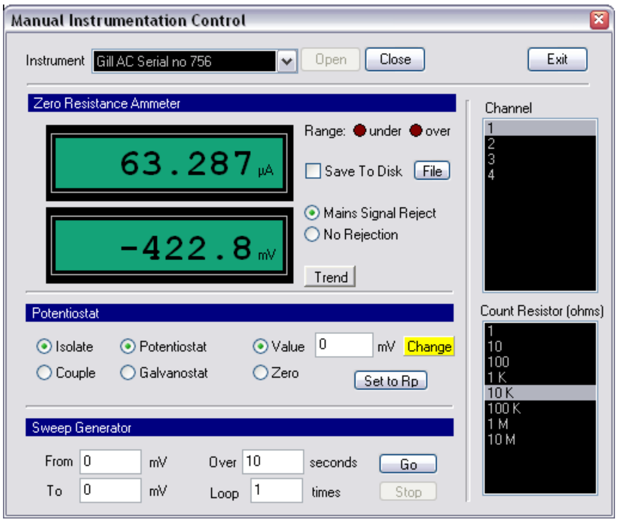
Next 30% Zinc has to be added, this is done in exactly the same way as for copper, the Valency for Zinc is normally 2. The *Selected item* section on the main page should now resemble:



Finally the metal density for Brass is set to 8550Kg/m³ and when in the above example the Calculate button is pressed, a Metal factor of 2083 is calculated. Interestingly for selective corrosion such as dezincification, the Valency of Cu should be set to 0.The program is able to automatically suggest a density if there is only one element which is set to 100% composition.

<u>Editing an existing metal</u>
Existing metals can be edited by first choosing the metal. The element to be edited is selected, and the *Edit* button clicked. On the *Element* page the settings can then be changed, remember to re-click the *Calculate* button to get the new metal factor.

Manual Instrumentation Control



Having precise manual control over instrumentation, as possible with a manual instrument such as a ZRA, or Potentiostat can be a useful tool in an educational environment. Manual Instrumentation Control **enables a computer-controlled instrument to be controlled 'manually'.**

Begin by selecting the correct instrument serial number and click Open, **this will open communications with the instrument (NB other programs will not be able to access the instrument at the same time).**

Zero Resistance Ammeter

The Zero Resistance Ammeter **section begins operating as soon as communication is opened to the instrument,** Over **&** Under **range LED's are provided as a guide for selecting the correct count resistor.** Trend **can be pressed to switch the two meter displays to a trend graph of potential and current.**

Potentiostat

Potential offsets can be applied by changing Value **text (**Couple **has to be selected for the potential to be applied to the cell), or click on** Change **and hold the mouse button down and move the mouse up and down. The mouse gives an analogue movement that is similar in many ways to a turn-pot found on manual Potentiostats.** Set to Rp **offsets** Value **to the rest potential, it will only function correctly when the instrument is** Isolated **from the cell.**

Sweep Generator

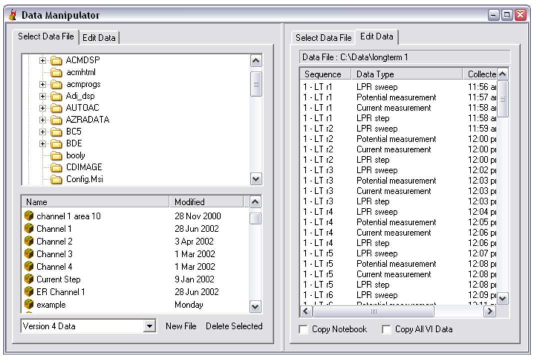
The Sweep Generator section allows very simple sweeps to be constructed. Enter From **and** To **potentials and the length of time the sweep will take (**Over**). A** Loop **can be specified, for example if** Loop **were set at 3 the sweep would go From-To-From-To. To start a sweep press** Go, **the current value of the sweep is shown in** Value **(Potentiostat section).**

Advanced Options

Save To Disk **– when checked, potential and current readings will be saved to disk (a filename will be requested) in an Excel compatible text file, click** File **to change the filename. Data will be continually saved until the box is unchecked.**

Mains Signal Rejection **– Ordinarily the instrument will automatically remove any mains signal interference from the collected data, with** No Rejection **the mains rejection can be switched off.**

Data Manipulator



Data Manipulator **has many uses:**

- **Look inside data files and show test information,**
- **Copy individual sequence data from one data file to another,**
- **Convert *Version 3.xx data to V4* data format,**
- **Copy a complete data set to another folder, or floppy,**

The main screen is split into two halves, each half is identical to the other half with one exception, only the left side can convert Version 3.x data to Version 4.

Look inside data files and show test information

Information such as Test parameters and Test Environment (i.e. Rest Potential) can be viewed with Data Manipulator. To view sequence information, use the explorer display to select a folder where your data resides. Data files contained within the selected the folder view are listed at the bottom, right click on a data file and select Edit Data. **The page will change to show individual tests within the data file, right clicking on any one of these tests and select** Show Sequence Information **reveals detailed information about the test. To return to select another data file click the** Select Data File **tab at the top.**

Copy individual sequence data from one data file to another

It will become apparent why the data viewer is split into to halves in this short tutorial, copying one test from one file into another:

> **Using the left half of *Data Manipulator,* right click on a data file, and select** Edit Data. **Now move your attention over to the right hand pane, select a folder and click the** New File **button at the bottom, give this empty data file a name. Next, right click on the new data file and select** Edit Data **also. A piece of data can be copied to this new data file by dragging it from the left pane and dropping it in the right pane.**

Convert *Version 3.xx data to V4* data format

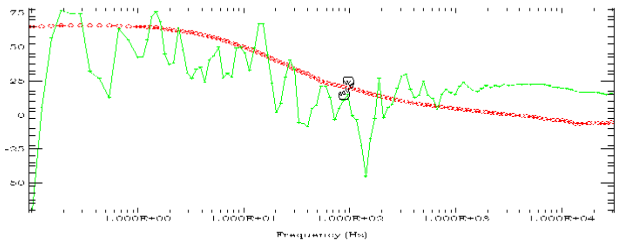
Data file conversion can only be done using the left pane. Select a folder in which V3 data exists, the select Version 3.x Data **in the combo box at the bottom of the screen (next to** New File **button), all version 3 data will be shown below the folder view. Right click on the file to convert and select** Convert Selected to Version 4**. The existing V3 data is left untouched, Version 4 data files are placed along side in the same folder. Multiple files can be converted by holding CTRL down whilst selecting.**

Copying a complete data set

This is achieved by selecting a folder containing data and right clicking on a data file, select Copy**. Next select a different folder where the data is to be copied to, and right click in the pane where the files are normally displayed and select** Paste**.**

Reduction of noise during AC Impedance

Modifications have been made to the GillAC to dramatically reduce noise in AC impedance curves. Systems using remote reference electrodes, salt bridges and lugin probes are prone to very high levels of mains pick up, causing large random scatter of data points. ACM sell a unique noise reducing electrode for this job, contact our sales department for details. This does not change the rest potential as the NR electrode is purely AC coupled with no DC component.



For example the bode plot showing phase v frequency above shows the result using a SCE and lugin only in green, and in red the SCE, lugin and a Pt electrode connected to a noise reducing electrode. All run parameters were the same. In many cases the Noise Reducing electrode will not be needed, but if the data looks like the green curve above it is strongly recommended.

Field Machine Transportation

The following information relates to the internal battery inside a field machine:

Air Transport

Under IATA Dangerous Goods Regulations 38th Edition effective 1st January 1997, the above battery is classified as – "Class 8, Group III UN No. 2800 Batteries, wet, non-spillable, electric storage, special provision A67"
This battery is classified as non-spillable because it has been shown to meet the requirements of the above regulations as stated in Packing Instruction 806 on page 406.
According to the "Technical Instructions for the Safe Transport of Dangerous Goods by Air" 1995-1996 Edition of the International Civil Aviation Organisation (ICAO), special provision states "Non-spillable batteries are not subject to these Instructions (Packing Instruction 806) if, at temperature of 55 deg C, the electrolyte will not flow from a ruptured or cracked case and there is no free liquid to flow, and if, when packaged for transport the terminals are protected from short circuit."
This battery is classified as meeting the A67 requirement after testing by PIRA in 1985, who stated that the batteries may be regarded as non-dangerous. Several other independent internationally recognised laboratories are also in agreement that these batteries are non-dangerous.

Transport by Road and Sea Freight

The IMDG code states that to be classified as non-spillable, "The battery must be able to satisfactorily withstand without leakage the vibration and attitude tests described…" Ref IMDG Code page 8121. These battery types have satisfactorily completed these tests as certified be Giltspur Packaging Ltd. Certificated of Test Serial No RTD3330/45/2 Job No 4000/0775 issued under Ministry of Technology Authority Ref No 30260. Packaging and labelling are as in 1.

TREM cards are not required.

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