Operation Manual

CM100-2 Conductivity Meter

Reid & Associates

TEL: +27 31 205 3329 FAX: +27 86 629 9747 www.reid.co.za

Warnings !

- ♦ Only lift and carry the CM100 with the fingers of each hand under the base, as indicated by the "CARRY HERE" labels on the front and back.

- ♦ Use the small silver handle on the front of the CM100 to open and close the unit. Keep holding this handle until the unit is fully open/ closed for smooth operation.

- ♦ Ensure the sample tray is correctly located in the tray supports before closing the lid.
- ♦ Only use the mains power adaptor supplied with the CM100 and ensure the mains plug has an earth connection.
- ♦ The mains power adaptor supplied with the CM100 is not splash-proof! Store and use it in an area well clear of any liquids!
- ♦ The CM100 Lid (blue) is not splash-proof!
- ♦ Only use the supplied stylus on the touch screen. Using finger nails or other hard objects will damage the touch screen.
- ♦ Only use a soft, dry cloth to clean the screen.
- ♦ Do not use solvents of any kind to clean the probes or wells as they will cause permanent damage!

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1. Checking your package

Take time now to check the contents of your package against the packing list and if your package is not complete please contact your supplier.

- Only lift and carry the CM100 with the fingers of each hand under the base as indicated by the "CARRY HERE" labels on the left and right.

2. Why use conductivity measurements?

Measuring conductivity of leachate from plant tissue is a long-standing method for estimating membrane permeability in relation to environmental stress, associated mycoflora, growth and development, and genotypic variation.

Measurement of electrolytes is also a well-established method of establishing seed quality.

Leakage measurements have been carried out on a range of other tissues such as fungal spores and pollen and on material such as lichen, moss, fern fronds and the leaves of higher plants.

Leakage measurements can be a useful tool for those involved in academic research as well in practical fields such as agriculture and horticulture.

3. Uses of conductivity measurements

Damage to cellular membranes is a virtually ubiquitous response to a wide variety of stresses. This damage leads to leakage of electrolytes from the cells of stressed tissues. Measurement of this stress is a reliable indicator of the severity of the stress.

- **Seed testing**

Measurement of electrolyte leakage after exposure to defined stress is a well-established, rapid and simple test of seed quality and viability. Conductivity measurements have also been used successfully to reveal the state of embryonic axes excised from both recalcitrant and orthodox seeds and subjected to various conditions. Similarly this technique can be used to assess the condition of pollen and fungal spores.

- **Stress injury**

Exposure to a range of environmental stresses often leads to injury of cellular membranes. This damage leads to leakage of solutes from the cell. Leakage of electrolytic solutes into the bathing solution has, for many years, been used as a simple and informative tool to measure damage caused by chilling, freezing, heat shock, dehydration, air pollutants and osmotic shock.

- **Screening for tolerance**

Differences in the ability to withstand a particular stress among different genotypes can be assessed by the amount of leakage after exposure to that stress. This has been used to test for drought- and cold resistance of many crop and forestry species.

4. Introducing the CM100-2

The CM100-2 Conductivity Meter was designed specifically for the measurement of electrolyte leakage from plant tissue and replaces the CM100 designed in 1994.

For brevity all references to CM100 are to be read as referencing the second generation CM100-2.

The advantages of the CM100 over single cell conductivity meters are that multiple, nearly simultaneous, measurements can be made on one hundred individual specimens. This allows the various leakage rates to be quickly and directly compared under the same conditions in a spreadsheet.

The CM100 is not intended to replace single cell conductivity meters for applications which require high accuracy measurements.

The CM100 can take single or multiple, automatic, measurements of the conductivity of 100 cells and the user has the flexibility to choose the measurement parameters.

The CM100 has a number of unique Features and Benefits:

- The CM100 has a large (5.7 inch) built in touch display and is stand alone, so it does not require a PC for operation, ensuring it will not become obsolete as new Windows ® operating systems are released.
- The probes are housed in a recess and so are protected from mechanical damage.
- The measurements are transferred to a PC using a USB memory stick, in a standard CSV format compatible with Exel ® and other software.
- The electrodes are enclosed in an epoxy housing so the stem of the electrodes are insulated, making the conductivity reading independent of the water level in each well (assuming there is sufficient water to fully immerse the electrode).
- A hinged lid with gas struts keeps the workspace required to a minimum.
- Only 1.5ml of water is required in the small tray enabling accurate measurements on small samples of plant material.
- Temperature compensation (conductivity changes by 2% / Degree °C) using a temperature sensor in the 101st well to measure the actual water temperature, makes measurements taken at different temperatures directly comparable. The measurements are referenced to 25 Degrees °C.
- The screen layout has been carefully designed with a clear and easy to use layout and functions are activated by pressing the screen with the supplied stylus.
- A robust housing made from Aluminium for a long service life.
- Two tray sizes: 1.5 and 3.5ml.
- The power supply is 12V DC so the unit can be powered from a 12V battery or solar panel for field use.

The CM100-2 is a high quality instrument designed with the direct input of eminent Botanists which combines sophisticated features with ease of use.

5. Understanding CM100 terminology

This Operation Manual uses some terms which have special meaning in the context of the CM100. If you understand these terms, you can more easily understand the concepts and procedures contained in this Operation Manual.

Term	*Meaning*
Electrodes	A pair of electrically conductive plates immersed in a liquid
Probe	Electrodes and mechanical support
Well	A container holding liquid and a sample.
Cell	Electrode, mechanical support and well.
Tray	Perspex sheet with 101 wells.
Measurement interval	Time between measurements i.e. with a measurement interval of 60 seconds the conductivity of the cells would be measured once a minute.
Number of measurements	The number of times the selected cells are measured.
Number of cells	The number of cells, starting with cell number **one**, which will be measured i.e. if the number of cells to measure is set to 10 then cells 1 to 10 (inclusive) would be measured.
Temperature compensation (%/^{0}C)	The percent per degree Centigrade compensation, which is applied to the measured conductivity, to correct for the change in conductivity of liquids with temperature.
Reference temperature	The conductivity of a liquid changes with temperature. To compare conductivity's measured at different temperatures, it is necessary to first correct the conductivity measured, to the conductivity which would have been measured if both the liquids were at the same temperature. It is standard practise to use 25^{o}C as the reference temperature.
Test Number	The Test Number increments each time the measurements are started to a maximum of 999 when it will roll over to 1.

Temperature Compensation example:

Liquid A conductivity (Ka_{18}) = 45,1uS @ 18^{o}C

Liquid B conductivity (Kb_{21}) = 63,9uS @ 21^{o}C

Temperature compensation (T_c) = 2% / ^{o}C
Reference temperature (T_{ref}) = 25^{o}C

Liquid A conductivity @ 25^{o}C

$Ka_{25} = Ka_{18} / (1+((T_c / 100)*(18-T_{ref})))$

$Ka_{25} = 45,1 / (1+((2 / 100)*(18-25)))$

Ka_{25} = 52,4uS

Liquid B conductivity @ 25^{o}C

$Kb_{25} = Kb_{21} / (1+ ((T_c /100)*(21-T_{ref})))$

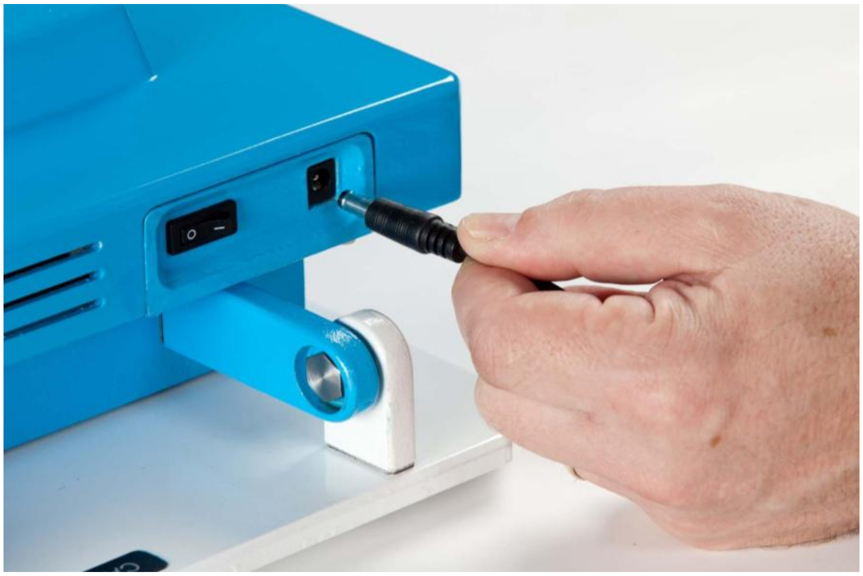
$Kb_{25} =63,9 / (1+ ((2 / 100)*(21-25)))$

Kb_{25} = 69,5uS

6. Connecting the Mains Power Supply

! Only use the mains power adaptor supplied with the CM100 and ensure the mains plug has an earth connection.

- Push the circular Aiwa connector into the socket on the right of the rocker switch, located on the right, rear side of the CM100-2.

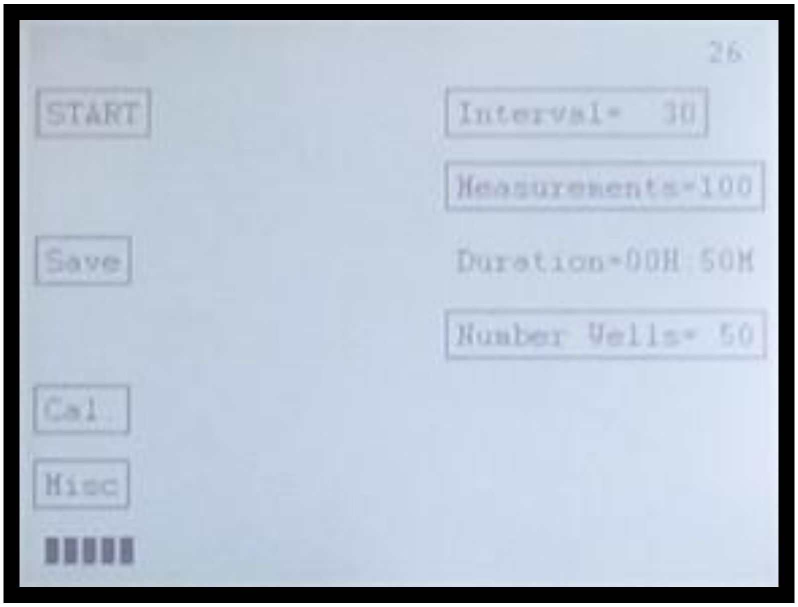


- Plug the mains cable into the Mains Power Adaptor.
- Plug the mains plug into a mains supply of 100 – 240VAC and turn the supply on.
- Turn the CM100-2 on by pressing the ‘1’ on the rocker switch.

The CM100 display backlight will turn on, a beep will be heard and after a few seconds the CM100 main screen will be displayed.

7. User Interface – Main Screen

CM100 main screen



Test Number

Progress indicator

- **Text within a rectangle is a 'button' which may be 'pressed' with the stylus.**

START – starts the measurements.

Save – saves measurements to a USB Flash Drive.

Cal. – User calibration using 0.001M KCl calibration solution.

Misc – lists the last User Calibration date/ time plus other information.

Interval – is the time between measurements in seconds (8 to 3599 seconds).

Measurements – the number of measurements the CM100 will take (1 to 100).

Duration – shows how long the test will take in hours and minutes and automatically updates when the measurement parameters are changed.

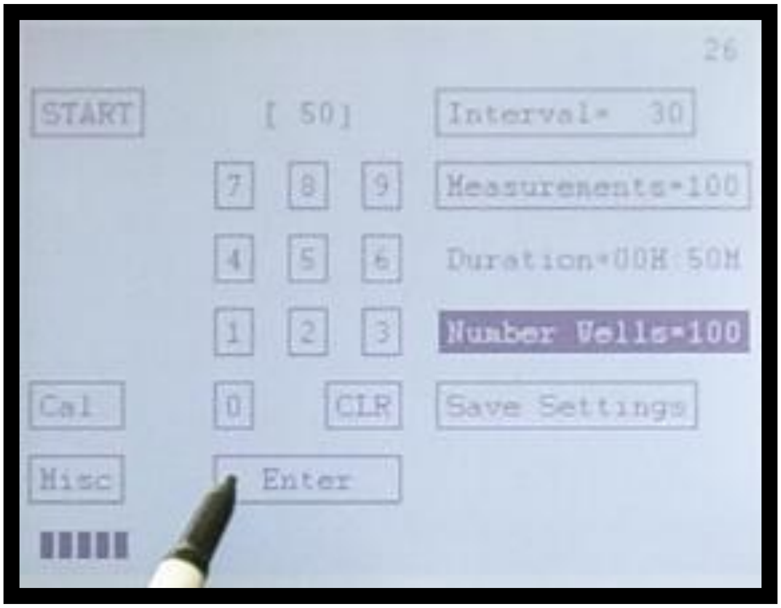
Number Wells – the number of wells the CM100 will measure (10 to 100 in increments of 10).

- Well number 1 is at the back left of the Tray and Well number 10 is at the back right of the Tray.

7.1 Changing measurement parameters

Changing a measurement parameter is a simple matter of pressing the parameter ‘button’ with the stylus.

- The selected parameter is highlighted and a numeric keypad is displayed.



- **CLR –** clears an incorrect entry.
- **Enter** – accepts the entry.
- **Save Settings –** saves the new setting to the CM100 non-volatile memory and erases the numeric keypad.

7.2 START measurements

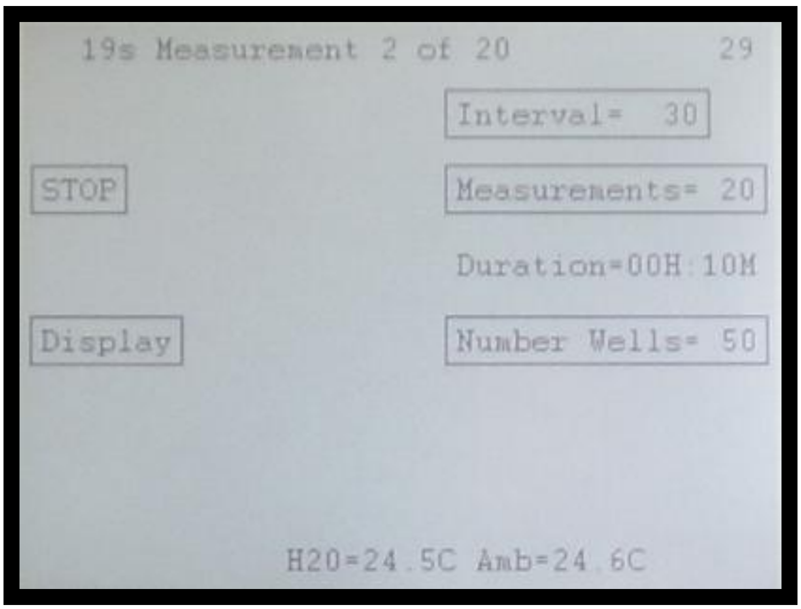
START – starts the measurements.

- If the previous measurements have not been saved the user will be prompted with a 'Measurements not Saved!' message and given the option to **Cancel** or **Continue**.

- Selecting **Continue** will permanently erase the previous measurements.

Count down timer showing the time remaining before the next measurement is taken.

Measurement progress



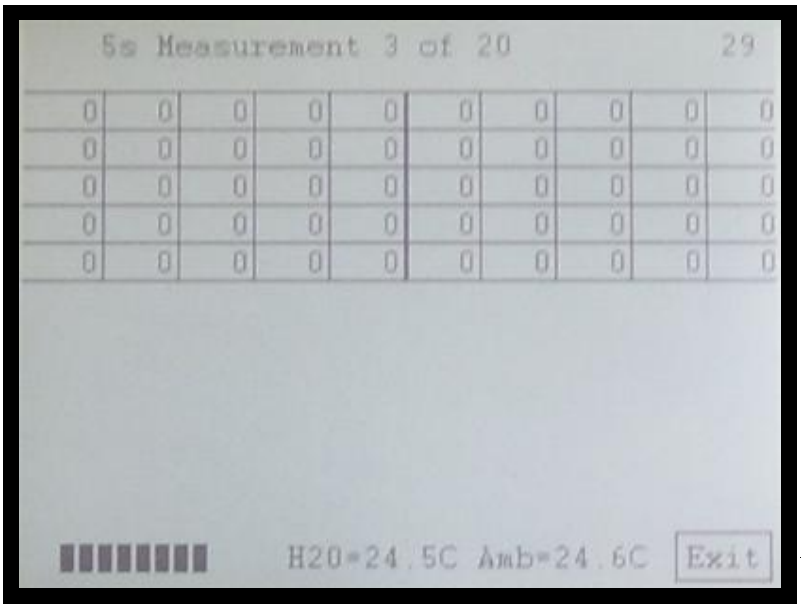
Water and ambient temperatures

- While the cells are being read (~ 3 seconds) the CM100-2 will not respond to the STOP or DISPLAY buttons. Press and **hold** the STOP or DISPLAY button until the command is actioned.

7.3 Display measurements

Display – shows the measurements in a table format.

- ➢ The measurement resolution is 0.1uS but measurements are displayed rounded up to the nearest 1uS.
- ➢ The measurements are saved to a USB Flash Drive with a resolution of 0.1uS.



Press Exit to return to the main screen

7.4 STOP measurements

STOP – stops the measurements.

- ➢ Warning – measurements that have been stopped cannot be re-started!

  When Start is pressed a new set of measurements will be started from measurement number 1.

- ➢ Warning – measurements that have been stopped cannot be saved!

7.5 Save measurements

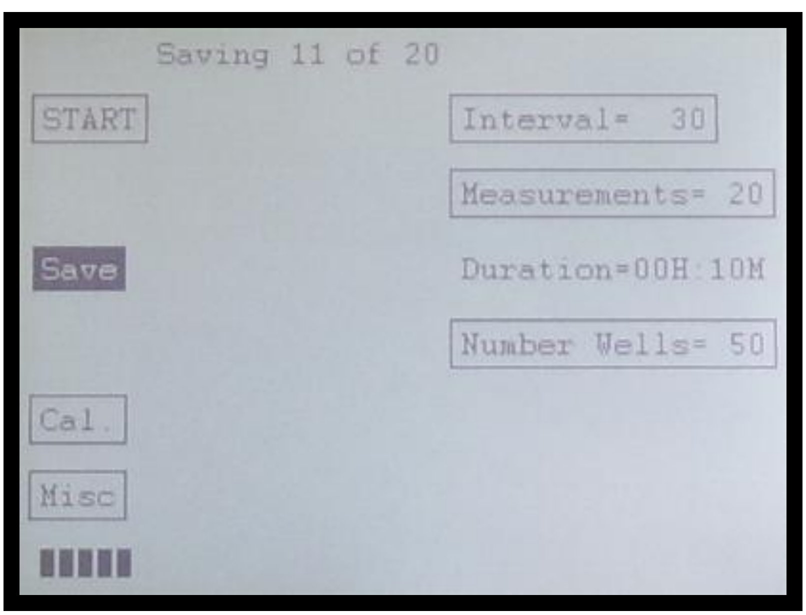
SAVE – saves the measurements to a USB Flash Drive.

- The USB Flash Drive is plugged in on the left hand side of the screen.

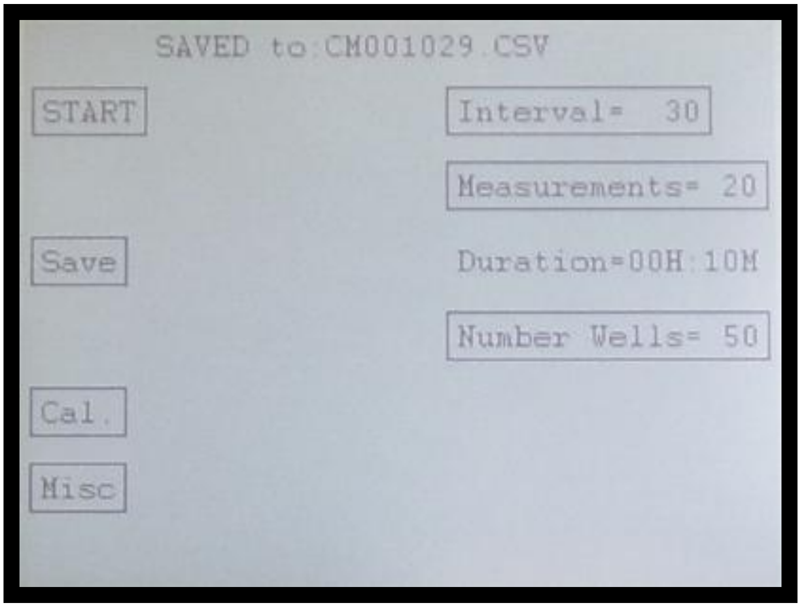
- The CM100 saves the measurements in a CSV file format for import into Excel or other programs for analysis.

- The 'USB Flash Drive' chapter 8 and 'Sample disk file' chapter 9 contain detailed information.

Progress indicator



Saving completed and filename used



- ✓ **Tip:** If you do not have samples in all the Wells, set the 'Number Wells' parameter to match the number of samples as this will result in a reduced time to save the measurements to the Flash Drive.

- ✓ **Tip:** If you do not need to make 100 measurements, set the 'Measurements parameter to match the number of measurements as this will result in a reduced time to save the measurements to the Flash Drive.

CAL. – starts the User Calibration procedure. **'**User calibration chapter' 10 contains detailed information.

MISC – lists the last User Calibration date/ time plus other information.

8. USB Flash Drive

- The CM100 is supplied with a Verbatim 2 GB USB Flash Drive and this is the recommended type.

- Limiting the **Number of measurements** and **Number of cells to measure** will reduce the time taken to save the measurements to the USB Flash Drive and the progress is indicated on the top of the LCD screen.

- The CM100 measurements are stored in non-volatile EEProm memory so if the CM100 is turned off, the measurements are not lost and can be transferred to a USB Flash Drive at any time in the future.

- The CM100 memory can store a single set of measurements and these must be transferred to USB Flash Drive before a new set of measurements are started or they will be over-written.

- The CM100 uses 'CM' plus the last three digits of the unit serial number, for example '001' and the test number, for example '128' as the file name - 'CM001128.TXT'.

- When the file is created the date/ time is set using the CM100 internal RTC which is set to GMT. While this is not always the same as local time, the intention is to assist the user by giving the exact date and approximate time when the measurements were saved.

- As the Test Number rolls over from 999 to 001 it is recommended that a 'Cut and Paste' is used to transfer the measurement file to a PC.

- Multiple saving of measurements from of the same test number, to the same USB Flash Drive, will append the measurements to the previously saved measurement file.

- The USB Flash Drive is plugged into the CM100 on the left hand side of the screen.

- Do not remove the USB Flash Drive while measurements are being saved.

- Unlike Windows the USB Flash Drive does not require a 'Safely Remove Hardware' action.

9. Sample disk file

The file format is **ASCII comma and quote**, which can be **imported** into most popular spreadsheet programs.

The header of the disk file contains all the details of the last calibration date/ time, the measurement start date/ time and various parameters relating to the measurements.

```
"Test Number: 012"
"Reid & Associates C.C. © 2010"
 "S/N 281101"
""
 "Last User calibration      :      ","Date: ","10/06/2010","Time: ","08:53:35"
""
"Start first measurement     :      ","Date: ","10/08/2010","Time: ","14:52:35"
""
"Temperature Compensation (Tc) = ",2,"%/oC"
"Reference Temperature (Rt)    = ",25," oC"
"Tamb = ",21.5," oC"  "Tliq    = ",22.1, " oC"
""
"Measurement interval(s)       = ",60"
"Measurement unit              = uS"
""
 "----------------------------------"
"Cell number: 1 to 100 (Columns)"
"Measurement  (Rows)"
001,   2.3,    2.4,    2.2,    2.3,    2.4,    2.5,    2.3,    2.4,    2.2,   2.5,
002, 15.1,  13.6,  12.6,  10.9,  10.5,  10.0,  10.8,  10.7,  10.7, 10.5,
003, 25.4,  23.3,  22.8,  20.6,  24.8,  24.5,  22.9,  24.3,  21.5, 20.2,
```

10. User Calibration

This menu allows the user to calibrate the CM100 for mechanical and electrical variations both initial (during the manufacturing process) and long term which affect the repeatability of the measurements in any equipment.

- Thoroughly clean the probes and tray with de-ionised water.

- Leave the lid in the open position to allow the probes to dry. This will eliminate any possible dilution of the calibration solution by traces of de-ionised water on the probes.

- Shake the small tray (upside down) over a sink to remove excess water from the wells.

- Place the tray upside down on a drying rack to dry. This will eliminate any possible dilution of the calibration solution by traces of de-ionised water in the wells.

- Only use 0.001M KCL calibration solution specifically for the calibration of conductivity meters. Do NOT reuse the calibration solution.

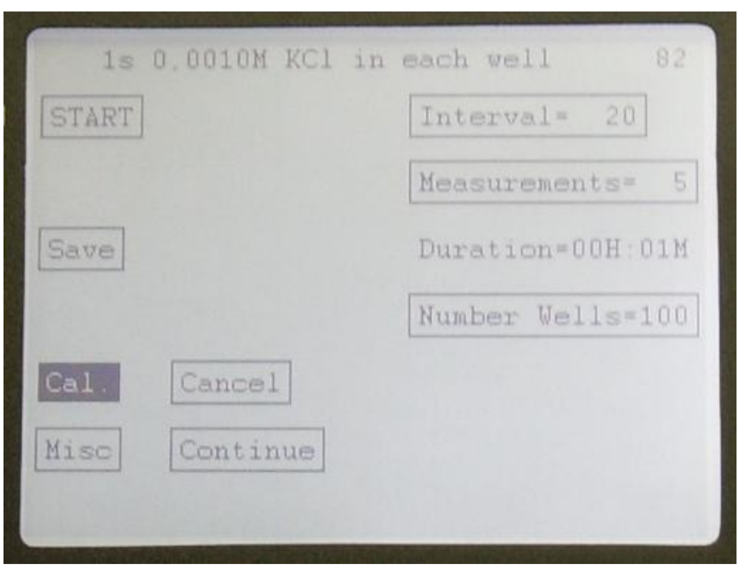
- For consistent calibration, the calibration solution must be between 18-25^{o}C and at room temperature.

- For consistent calibration, the calibration solution must be well stirred before and during the filling of the wells.

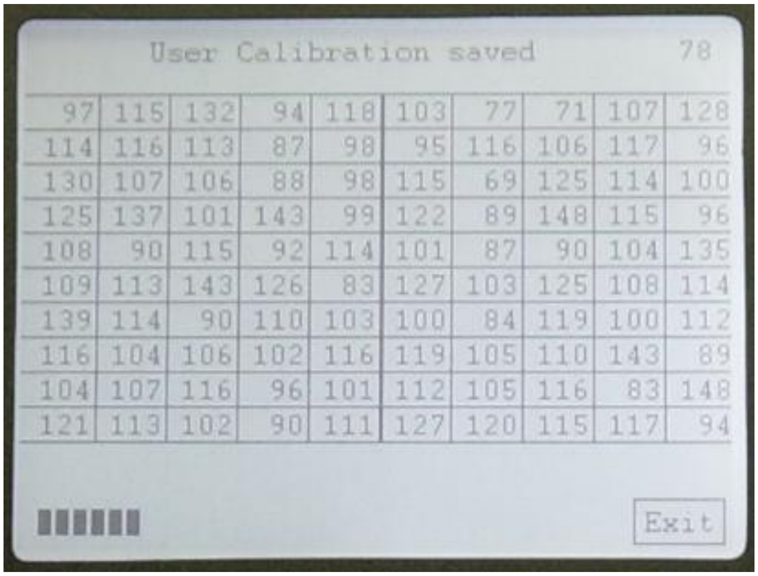
- Fill each well, of the small tray, with exactly 1.25ml of the calibration solution.

- Allow the CM100 probes to soak in the calibration solution for five minutes. Periodically raise and lower the CM100 lid to ensure complete wetting of the probes and mixing of any residual water on the probes with the calibration solution.

- Start the calibration procedure by pressing the **CAL.** Button, then the Continue button.



- When the calibration is complete the User Calibration is saved.



- The displayed values are the User Calibration values for each cell and NOT the conductivity.

- To confirm the User Calibration is correct, set the Measurement Interval to 20 seconds and the Number of Measurements to 2 then press Start and Display.

  The measured conductivity should be within 147uS +/- 2uS. If any of the measured values are outside this range repeat the User calibration.

- If a Calibration ERROR occurs, the User Calibration values for each cell are NOT saved. Turn unit off and then on to restore previous User Calibration values

11. Cleaning of the trays and probes

Contamination of the measured liquids can lead to significant errors. The primary source of these errors are residues remaining on the probes or in the trays from previous measurements of high conductivity liquids, calibration solution and the detergent used to wash the tray.

The probes and trays are best washed by:

- ♦ Prepare a well mixed, rinsing solution of 2-5% CONTRAD CONCENTRATE® (manufactured by DECON LABORATORIES LTD., BRIGHTON, ENGLAND) and de-ionised or tap water.
- ♦ Fill the trays, to the top of the wells, with the Contrad rinsing solution. Special care with the volume in each cell is not necessary.
- ♦ Place the tray in the CM100-2 and lower the lid to rinse the probes.
- ♦ Leave to soak for 15 minutes to 2 hours.
- ♦ Fill the trays, to the top of the wells, with deionised water. Special care with the volume in each cell is not necessary.
- ♦ Place the tray in the CM100-2 and lower the lid to rinse the probes.
- ♦ Leave to soak for 5 minutes.
- ♦ Repeat the rinsing with deionised water until consistent measurements across all 100 wells are obtained.

Measurements of less than 2uS are usually adequate for most measurements of the conductivity of liquids or the electrolyte leakage from plant tissues.

DO NOT USE SOLVENTS OF ANY KIND TO CLEAN THE PROBES! SOLVENTS WILL DAMAGE THE EPOXY BODY OF THE PROBE CAUSING PERMINANT DAMAGE.

12. Factors influencing conductivity

The measured values of conductivity are affected by numerous factors, which the user must bear in mind at all times.

- **Contamination**

  Contamination of the measured liquids can lead to significant errors. The primary source of these errors are residues remaining on the probes or in the trays from previous measurements of high conductivity liquids, calibration solution and the detergent used to wash the tray.

  The trays and probes must always be rinsed thoroughly before a new measurement is started and a few measurements of the conductivity of de-ionised water taken, to confirm the tray and probes are clean. Consistent readings of less than 2uS across all 100 wells are usually adequate for most measurements.

  Once the tray and probes have been rinsed, all finger contact with the inside of the wells, tip of the pipette/automatic syringe or the probes must be avoided.

  Significant contamination of the liquids being measured, can result from the use of containers which leach ions. Polyethylene plastic bottles are recommended and soda glass should be avoided.

- **Temperature**

  The conductivity is affected significantly by temperature with an increase in the order of 1.5 to 3.5 %, per degree centigrade increase in temperature.

  The CM100-2 applies a temperature compensation of 2% / ^{o}C (a typical value for aqueous solutions).

- **Temperature differential**

  The CM100-2 provides temperature compensation using a single, low thermal mass, temperature sensor using a well in the centre of the tray. To avoid compensation errors, ensure that the liquids used are at the same temperature and preferably room temperature.

- **Absorption of carbon dioxide and ammonia**

  Distilled and de-ionised water absorb carbon dioxide and ammonia from the air resulting in an increase in measured conductivity. This increase in conductivity is rapid initially and then slows down as the water becomes saturated and is significant for conductivity's less than 10uS.

  This phenomena can only be avoided by using flow through conductivity cells or by taking measurements in the absence of air (a chamber filled with dry nitrogen).

  There are two possible methods to work with this phenomena: 1) Allow the water to stand for 24 hours before use and 2) expect a increase in conductivity to approximately 2.5uS depending on the duration of the measurement.

- **Concentration**

  The increase in conductivity with increasing concentration is non-linear. For example a 0,001M KCL solution has a conductivity of 147uS and a 0,01M KCL solution has a conductivity of 1410uS (at 25 ^{o}C).

- **Electrodes not completely immersed**

  It is essential that the electrodes are fully immersed to avoid significant under-reading of the conductivity.

  The trays with the large wells, provide the most tolerance maintaining complete immersion of the electrodes for volumes of 3.1 to 3.5ml. The large trays are preferred for most measurements.

  The small trays have a fairly small tolerance of 1.1 to 1.5ml. These trays are supplied to reduce the amount of calibration solution used and for small plant material specimens with low electrolyte leakages.

  Ensure that the CM100 is placed on a flat, level surface to ensure uniform immersion depth across the tray.

- **Evaporation**

  Evaporation of water from the trays results in increases in the concentration of the remaining liquid and a corresponding increase in the conductivity. In extreme cases, the level of the liquid in the wells could fall significantly, resulting in the electrodes not being completely immersed and a corresponding decrease in the measured conductivity.

  The effects of evaporation become significant if the duration of the measurements is long or if the tray is left standing for long periods before the measurements are started.

  The CM100-2 has been designed to enclose the tray and so reduce the evaporation due to air flow.

Accurate measurements below 10uS are difficult to achieve due to the factors outlined above. Measurements below 10uS are useful to confirm the probes and wells are clean and also the quality of the water used in the cleaning process.

13. Techniques to minimise the factors affecting Conductivity

The key to minimising the affect of the factors described above is consistency.

1) Ensure that the probes and tray are thoroughly rinsed before measurements are started. Verify this by starting a measurement and selecting DISPLAY to view the measurements.

- A decreasing conductivity indicates residue on the probe which is being diluted by the water in the cell.

- An increasing conductivity indicates residue in the well which is mixing with the water in the cell.

- A steady high conductivity in all the cells indicates a problem with the water placed in the cells.

2) Ensure the liquid(s) and plant material(s) added to the wells are at a uniform temperature – preferably room temperature.

3) Always fill the wells in the same order 1-50, temperature compensation (Tc) well and then 51-100. The effects of absorption of carbon dioxide and ammonia from the air will be similar, for each set of measurements.

The same order should be used when filling the wells with calibration solution.

4) Use a pipette or automatic syringe to fill the wells. If measuring the leakage from plant material, of differing sizes, use the depth gauge to confirm that all the electrodes will be fully immersed.

5) If long measurement cycles are being used, keep the effects of evaporation from the wells in mind – particularly if the relative humidity is low.

Summary

If the CM100-2 user has s good understanding of the factors influencing conductivity and the techniques to minimise these factors, consistent results will be obtained.

This will allow the user direct comparison of conductivities or liquids or the electrolyte leakage from plant material.

14. Caring for the CM100

The CM100 has been designed as a robust instrument which requires minimal maintenance.

The following guidelines should be followed:

- The CM100-2 should be used on a smooth, level surface to ensure the correct immersion depth of the probes.

- The CM100-2 must **not** be positioned close to equipment which generate strong electrical or magnetic fields (e.g. mains step-down transformers).

- The CM100-2 probes must **not** be force air dried using a fan – this could result in a residue on the probes. This residue could be salt, in coastal areas with high relative humdity, or airborne pollution.

- **To avoid damage to the probes / tray when taking measurements of the leakage of plant material, always lower the lid slowly and check that it rests evenly on the base.**

- The probes should be inspected periodically to confirm that there is no plant material wedged between the electrodes.

  Plant material must be removed using plastic tweezers, a plastic spatula or a short bristle brush. Do not use metallic tools, as these may scratch the electrodes.

- Use a soft, dry cloth to wipe up any liquid which spills from the tray after a measurement is complete.

- **The CM100-2 Lid and the mains power supply are not splashproof, always store and use it in an area clear of any liquids!**

- **If the CM100-2 is to be stored for any length of time, use a soft, dry cloth to wipe up any liquid on the base. Remove the tray and allow the probes to air dry with the lid in the open position before the unit is put into storage.**

15. Specifications

Number of cells	101 (10*10 matrix) + one for temperature compensation
Free volume of wells	1.5ml/ 3.5ml (both sizes are supplied)
Electrodes	Polished Stainless steel
Measurement voltage	AUTO ranging
Measurement current	AUTO ranging
Conductivity	1uS – 999uS
Measurement frequency	1kHz
Temperature compensation	ambient temperature 15-35^{o}C
Reference temperature	25 ^{o}C
Measurement interval	1 minute to 60 minutes (1 second increments.)
Number of measurements/ cell	1 - 100
Time to measure 100 Cells	< 30 seconds
Display	5.7" 320x240 pixel Graphic LCD with backlighting
Internal storage	10 000 measurements (100*100)
Dimensions	330*342*135mm (W*D*H)
Weight	7.5kg
Finish	Epoxy paint
PC interface	USB Memory Stick
Power supply	12V @ 250mA

Specifications subject to change without prior notice.

16. WARRANTY

Reid & Associates CC warrants each new product manufactured and sold to be free from defects in material, workmanship and construction and that when used in accordance with this Operation Manual will perform to applicable specifications for a period of one year after original delivery.

If examination by Reid & Associates CC discloses that the product has been defective, then our obligation is limited to repair or replacement, at our option, of the defective unit or its components.

Reid & Associates CC is not responsible for products which have been subject to misuse, alteration, accident or repairs not performed by Reid & Associates CC.

Products must be returned to Reid & Associates CC properly packed with transport charges prepaid to Reid & Associates CC, return transport charges will be F.O.B. Reid & Associates CC.

The foregoing warranty constitutes Reid & Associates CC sole liability, and is in lieu of any other warranty, of merchantability or fitness. Reid & Associates CC shall not be responsible for any incidental or consequential damages arising from any breach of warranty.

Reid & Associates CC

P.O. Box 17291	PH:	+27 31 205 3329
Congella	Fax:	+27 86 629 9747
Durban, 4013	E-mail:	info@ reid.co.za
SOUTH AFRICA	Web site:	http://www.reid.co.za