CORROSION ELECTRONICS PTY. LTD.

Model T11

Digital

AUTORANGE+

Conductivity Meter

SOLD AND SERVICED BY:

TABLE OF CONTENTS

1.0 General description

1.1 Features

The model T11 meter is an advanced micro-controller based instrument. It is designed to provide a portable means of displaying various attributes of water systems relating to conductivity.

The model T11 provides the following features:

- displays Total Dissolved Solids (ppm TDS).
- permits user adjustment of TDS factor.
- displays Dissolved Salt (ppm NaCl) for measuring saltwater pools and spas.
- permits user calibration to a standard salt solution.
- displays conductivity as µS / cm or mS / m.
- permits user calibration to a conductivity standard.
- displays solution temperature.
- permits user adjustment of temperature co-efficient.
- displays resistivity in Ω.cm compensated to 25°C
- displays resistivity in Ω.cm at solution temperature.
- my be used as a hand held instrument or wall mounted.
- sealed to a rating of IP65.
- fitted with a measuring probe with integral temperature sensor on a flexible lead.
- operated with a replaceable internal alkaline 9V battery.
- includes “vapour phase inhibitor” corrosion control.
- automatic scaling of measurement range.
- displays battery condition at each use.

1.2 Benefits

The advanced dynamic probe driver, user preferences memory and use of a digital display eliminate the need for range change switches, trimming potentiometers and other electro-mechanical devices which cause decreased reliability.

Additionally, the T11 may be easily calibrated by the user to suit individual demands without referring to the factory or having to open the instrument to make critical adjustments.

2.0 Operation and Display Modes

A label similar to the following is fixed to the back of the instrument. The user should be familiar with these procedures to maintain the T11 in first class operating condition.

Operation

1. Rinse probe with test water sample. Immerse probe until the two holes are covered.
2. Press “ON”. After initialising, the display will default to last mode used.
3. Press “MODE” switch to select measurement required.
4. Move probe up & down until reading is steady.
   Reading is temperature compensated - referred to 25°C
   Pressing UP or DOWN button displays water temperature.

Calibration Refer to manual for instructions.

Probe Care

Avoid probe fouling. Rinse cell with distilled water after use. **Check probe regularly with a known solution.** Clean the two carbon electrodes by wiping lightly with P360-600 wet paper. Always clean probe before calibrating.

Note: Probe fouling will cause low readings.

IMPORTANT:

The moving of the probe up and down in the water sample is so that the temperature sensor, which is in a “blind” hole, is contacting the water effectively. As the reading begins to stabilise, stop moving the probe.

The display modes are presented in the following order.
At switch ON, the instrument will default to the last measurement mode used. This is convenient for users making the same measurement each time. Alternately, press the MODE button until the desired measurement is displayed.

2.1 Power ON initialisation

When the ON switch is pressed and held, the following information will be displayed for one (1) second. The battery condition and voltage is displayed (GOOD or FAIL). A GOOD battery should measure greater than 7 V

```
Digital  T11  Vx.x
Batt.  Good  9.09V
```

After pressing the ON button, the display initialises which takes 1 second, then displays the measurement mode last used. Pressing the MODE button toggles through the various measuring modes as described.

2.2 Dissolved Salt (NaCl) (parts per million) ppm

The instrument will default to the last display mode used. For example, if the previous test measurement was Dissolved Salt, the default at start-up will be Dissolved Salt.
This measurement is intended for swimming pools, to which salt (NaCl) is added.

```
Dissolved Salt
(NaCl)   5500  PPM
```

2.3 Resistivity Ω. cm @ 25°C (compensated)

```
Resistivity
@25c   20000  Ω.cm
```

2.4 Resistivity Ω. cm actual (uncompensated)

R e s i s t i v i t y	
A c t .	**2 0 0 0 0 Ω . c m**

2.5 Conductivity @ 25^{o}C

µS/cm or mS/m, Refer to section 4.6

C o n d u c t i v i t y	
@ 2 5 C	**1 0 0 0 0 µ S / c m**

2.6 Total Dissolved Solids PPM

T o t a l D i s s o l v e d	
S o l i d s	**1 5 0 0 P P M**

2.7 Water temperature ^{o}C

Toggle ⇑ or ⇓ buttons in any mode to read solution temperature.

3.0 General Discussion

3.1 Measurement principles

Specific conductance is a term applied to indicate the capacity of a liquid to conduct electric current. This property is related to total concentration of the ionised substances in the water and the temperature at which the measurement is made. The nature of the dissolved substances, that is, their ionic mobility and concentrations, both actual and relative, vitally affects the specific conductance.

This instrument measures electrical conductivity. A low voltage AC signal is applied across two electrodes in the measuring probe. The solution between these two electrodes acts as a resistance to the AC signal. A low conductance solution, eg, distilled water, will have a high resistance to the AC signal and so it will have a low conductivity reading but a high resistivity reading. Conversely, a high conductance water, eg salt water, will easily conduct AC between the two electrodes hence the conductivity or TDS reading will be high and the resistivity will be low.

The model T11 can display the conductance in either of two units. These are: micro-Siemens per centimetre (µS/cm), or milli-Siemens per meter (mS / m). The user can select which of these two units is preferred.

Conversion calculation mS / m = $\frac{\mu S/cm}{10}$

For example, 500 mS / m = 5000 µS/cm

The internationally recognized conductivity calibration standard is Potassium Chloride (KCl) dissolved in distilled water in the following molar concentrations.

Molar KCl		**Conductivity in micro-Siemens / cm at 25^{o}C (µS/cm)**
0.1	=	12890
0.05	=	6668
0.02	=	2767
0.01	=	1413
0.005	=	717
0.0017	=	250
0.001	=	147
0.0002	=	30
0.0001	=	15

3.2 Temperature Coefficient

As an example, the following table shows the change of conductivity versus temperature of 0.01 M KCl.

Temp.	**Conductivity (micro-Siemens/cm)**
15°C	1140
20°C	1273
25°C	1413
30°C	1546

The above table shows clearly, that for conductance to be a measure of dissolved solids, it needs to be expressed relative to a standard temperature, usually 25°C.

Different dissolved salts in a solution will exhibit different changes in conductivity with temperature. The coefficient is expressed as **%change per degree Celsius.** What this means is that at lower temperatures, the conductivity of a given solution will be lower than it is at a higher temperature. The standard temperature at which conductivity readings are expressed is 25° Celsius. Ideally, calibrations should be performed at this temperature. The temperature coefficient in % / °C can be set by the user in the calibrate mode of operation. This would be based on tests at different temperatures. (Refer section 4.2)
Temperature gradients in the order of +1.5% to +2.5% cumulative per degree Celsius are typical.

3.3 TDS (Total Dissolved Solids)

This mode is intended for measuring the dissolved solids in water systems such as, fresh water pools, cooling towers, boilers, hydroponics, etc.

3.3.1 TDS Discussion

It is important to remember that the model T11 can only measure electrical conductance. For a given dissolved substance in water, the ppm (parts by weight of the substance per million parts by weight of solution), will be directly related to the conductivity. The ppm value can also be expressed as: mg/l (milligrams per litre).

The dissolved salts in water systems may include a wide variety of chemicals with widely varying electrical conductances. Some salts are weak electrolytes, particularly Calcium salts whereas Sodium and Potassium salts are much stronger electrolytes. The ratio of ppm (mg/l) to Conductivity (µS/cm) will vary depending on the mixture and concentrations of dissolved salts.

3.3.2 TDS to Conductivity Factor

This meter is not "ion" specific. It cannot analyse the types of dissolved salts.
A factor, F=0.65 is factory preset in the memory of the model T11. This means that the ppm value is calculated by the T11 to be 0.65 x the µS / cm conductivity value. This factor is conservative in that it may overstate the dissolved solids by up to 10-20%, particularly if the dissolved salts are predominantly saline.
This means, that for a factor of 0.65 the following conversion applies:
10,000 µS / cm = 6,500 ppm TDS

It is recommended that this factor be used for all situations except where it is known that a lesser or greater factor should apply.

On the other hand, if sufficient quantities of weak electrolytes are present, the factor of 0.65 may be too low. Remember, a weak electrolyte will give a lower reading therefore the dissolved solids may be higher than indicated.
The factor can be user set in the calibrate mode. The set range is 0.5 to 0.99.

For those who wish to calibrate the TDS factor more accurately for a particular situation, Appendix 1 details a simple gravimetric analysis.

SWIMMING POOL APPLICATIONS NOTE: It is important to understand that pools containing salt for chlorine generation will display a high reading when measured with the ppm TDS range. The ppm TDS range should only be used for measuring pools containing fresh water.

3.4 Dissolved Salt ppm (NaCl)

This mode is principally for measuring the salt level in swimming pools to which salt has been added for the purpose of generating chlorine. The dissolved salt measurement is based on a calibration using a 5500 ppm salt (NaCl) solution. **Refer to calibration procedure.** A 5500 ppm salt standard optimises the accuracy of the instrument at the area of interest for salt-water pools.

The relationship of this reading to conductivity is:

5,500 ppm NaCl = 10,000 µS / cm

NOTE: For best accuracy, use a **standard salt solution** with a nominated value that measures between 5000 and 6000 ppm.

3.5 Resistivity Ohm.cm (Ω.cm)

Resistivity is related to conductivity. Increasing salt in water increases the electrical conductivity. Inversely, as the amount of salt decreases, the resistance increases.

$$\text{Conductance (Siemens)} = \frac{1}{\text{Resistance (ohms)}}$$

The model T11 calculates the resistivity in ohm.cm from the conductivity. An example of this calculation is as follows:

<u>Example 1 City drinking water</u>

250 µS/cm = 0.00025 S/cm

$$\text{Resistivity} = \frac{1}{0.00025} = 4000\ \Omega\text{.cm}$$

Example 2 Seawater

57000 µS/cm = 0.057 S/cm

$$\text{Resistivity} = \frac{1}{0.057}$$

= 17.5 Ω.cm

3.6 Conductivity (µS / cm) or (mS / m)

This mode measures “specific conductance”, which is an international standard of measurement. The reading is temperature compensated relative to 25°C. This means that if the sample tested is between 5 and 60°C, the reading will be displayed as if the measurement is made at 25°C.

If it is required to measure the specific conductance of a solution without temperature compensation at any given temperature between 5 and 60°C, this can be calculated from the “resistivity actual (act.)” mode reading.

$$\text{Conductivity } (\mu S/cm) \text{ at actual temp. } ^{o}C = \frac{10^6}{\text{Resistivity } (\Omega.cm) \text{ at temp. } ^{o}C}$$

$$\text{Using the above Example 1} = \frac{1{,}000{,}000}{4000}$$

= 250 µS / cm

4.0 Calibration

4.1 Cleaning the probe

It is essential to clean the probe carbon electrodes before calibrating against a standard solution. In act, they should be cleaned on a regular basis as indicated by a test against a standard solution.
The carbon electrodes are easily fouled. Fouling will affect the operation of the instrument. At the end of the probe, there are two carbon electrodes which are ground flush with the grey PVC body and a third hole about 3mm deep with a temperature sensor bead exposed in it's centre.

Caution: Do not disturb the temperature sensor - it is easily damaged.

The two carbon electrodes are cleaned as follows:
(a) Obtain a small piece of P360-600 grit "wet & dry" paper.
(b) Wet the probe with water.
(c) Lightly wipe the "wet & dry" paper across the two carbon electrodes until a new surface is obvious.
(d) Rinse the probe thoroughly in clean water. Prior to testing, rinse the probe with the sample or standard solution.

Calibration will commence by pressing the [MODE] **button followed by the** [ON] **button. The** [MODE] **button may be released as soon as the display energises.**

4.2 Calibrate temperature coefficient

The instrument will default to the last measurement mode used. Press the [MODE] button repeatedly until the following display is accessed.
This display mode is the first of six (6) consecutive displays with user adjustments.

```
T/Coeff  2.0  %/°C
Adjust now
```

This temperature coefficient has a factory default value of 2.0% / ^{o}C, which is based on a salt (NaCl) solution. All test modes will operate with this figure. **For swimming pool water testing, the 2.0% coefficient will be adequate.**

For other water systems, it is suggested that samples of water be tested at two (2) temperatures within the expected temperature range. For example, a sample at 20^{o} C and one at 35^{o} C. If the higher temp sample reads greater than the lower, a higher coefficient is indicated and vice-versa. Press the ⇑ or ⇓ buttons as required to modify the coefficient. **Press the** MODE **button once after adjusting, this saves the change. <u>CAUTION: Allow time for the temperature sensor to stabilise at each level</u>.** Continue to test and adjust until the two readings are the same. **NOTE: <u>The instrument MUST be re-calibrated with a standard solution after adjusting the temperature coefficient.</u>**

4.3 Calibrate conductivity

Use either a salt (NaCl) **5500 ppm** standard or preferably, a Potassium Chloride (KCl) standard in the range of interest, refer listing under section 2.1
If the salt 5500 ppm standard is used, this equates to 10,000 µS / cm or 1000 mS / m

Clean the probe first as described in section 4.1

The user adjustable display is as follows:

µ	**S**		**@**	**2**	**5**	**o**	**C**		**=**		**1**	**0**	**0**	**0**	**0**
A	**d**	**j**	**u**	**s**	**t**		**n**	**o**	**w**		**k**	**=**	**1**	**6**	**0**

It is advised that the calibration be done with a solution temperature as close as possible to 25^{o} C. This minimises any errors associated with temperature compensation gradients.
Adjust the k factor using the ⇑ or ⇓ arrows until the display reads the required value. **Press the** MODE **button once after adjusting - this saves the change.**

4.4 Calibrate TDS PPM

The factory default preset is a factor of 0.65. Refer to section 3.3.2 for discussion on applicable factors.

The 0.65 factor will produce a reading of 6500 ppm from a solution measuring 10,000 µS/cm. A 5500 ppm salt (NaCl) standard should display 6500 ppm TDS

The user adjustable display is as follows:

T . D . S . R e a d	6 5 0 0
A d j u s t N o w	k = . 6 5

It is advised that the calibration be done with a solution temperature as close as possible to 25^o C. This minimises any errors associated with temperature compensation gradients.
Adjust the k factor using the ⇑ or ⇓ until the display reads the required value (6500 ppm). **Press the** MODE **button once after adjusting - this saves the change.**

4.5 Calibrate Dissolved Salt PPM

This calibration is done with a standard salt (NaCl) solution. Use the recommended 5500 ppm standard.

Clean the probe first as described in section 4.1

The user adjustable display is as follows:

p p M S a l t	5 5 0 0
A d j u s t N o w	k = 1 6 0

It is advised that the calibration be done with a solution temperature as close as possible to 25^o C. This minimizes any errors associated with temperature compensation gradients.

Adjust the k factor using the [⇑] or [⇓] buttons until the display reads the required value (5500 ppm). **Press the [MODE] button once after adjusting - this saves the change.**

4.6 Set conductivity units, µS / cm or mS / m

The user adjustable display is as follows:
The factory default is µS/cm

or mS / m

```
D i s p l a y   µ S / c m
A d j u s t   N o w
```

Select the required units by pressing one of the arrow buttons to toggle the display. **Press the [MODE] button once after adjusting - this saves the change.**
Note: **these two options will only affect conductivity mode.**

4.7 Calibrate temperature reading

This facility is provided to allow user calibration of the displayed water temperature V's a known temperature standard. The temperature range of the instrument is from 5 to 60°C.
The display resolution is in 0.5°C steps. It is recommended that if adjustment is made, it should at a temperature range of interest.

The user adjustable display is as follows:
The factory default is K = 0 for V2.0 and up software.

```
W a t e r T e m p . 2 1 . 5 ° C
A d j u s t   n o w   k = + 1
```

By pressing the [⇑] or [⇓] the temperature display will increase or decrease by 0.5°C each time the button is pressed.
Press the [MODE] button once after adjusting - this saves the change.

4.8 Oops command (Restore factory defaults)

Restore factory defaults by pressing the following sequence of buttons. Hold the two ARROW buttons down then press the ON button. The display will briefly indicate the word ====RECOVERING====.
Re-calibrate using the appropriate standard solutions. **Use this as a last resort only – it may not always recover the default settings.**

5.0 Maintenance

There are no user adjustments inside the instrument.

To access the battery for replacement, remove the four (4) corner inserts and screws in the bottom of the instrument.
Use only alkaline 9V batteries

Do not over–tighten the screws as the screw inserts in the top half may pull out and the case will be permanently damaged.

A “vapour phase inhibitor” patch is attached inside the bottom of the case. This material is straw coloured to light brown. This inhibitor will coat the surface of all the internal components and inhibit corrosion for approximately 18 months. Replacement patches are available for replacement each 18 month period. The long-term reliability of the instrument will depend on this inhibitor working efficiently.

Replacement labels are available should they be worn out or damaged

It is recommended that any other servicing be done at the following location.

Corrosion Electronics Pty Ltd
30 Lady Penrhyn Drive,
UNANDERRA NSW 2526
AUSTRALIA Ph: (02) 4272 5509 Fax: (02) 4272 5209

6.0 Warranty

The T11 Conductivity meter is warranted against faulty parts and manufacture for a period of twelve (12) months from the date of purchase. Proof of purchase will be required for all warranty claims.

All delivery charges in respect of replacement or repair shall be the responsibility of the owner. We shall not be responsible for freight charges, damage or loss in transit howsoever caused. Items should be suitably packed to avoid transit damage.

Any sign of water or salt residue internally voids the warranty. This can only result from improper handling. It is recommended that the T11 case is not placed in contact with damp tools or objects.

7.0 Disclaimer

Every effort has been made to present all information accurately, however no liability is accepted for any inclusions or advice given or for omissions from the publication.

Corrosion Electronics Pty. Ltd. will not accept liability for any deficiency in the design of the product described herein whether physical or intellectual. Any deficiency in the application of the product that may from time to time cause inconvenience or damage to persons or property, being immediate or consequential, whether or not such application forms an intentional component of the design, must remain the responsibility of the user.

Manufactured by:

Corrosion Electronics Pty Ltd
30 Lady Penrhyn Drive
UNANDERRA NSW 2526
AUSTRALIA
Ph: (02) 4272 5509 Fax: (02) 4272 5209

E-mail: info@corrosionelectronics.com.au

8.0 APPENDICES

Depending on the user application, the TDS factor can be accurately determined for a given water system, with a given typical level of dissolved solids, by noting the conductivity in µS / cm of a sample, weigh the sample of solution then weigh the oven dried residue after evaporation. The dry residue can be calculated as ppm. This would normally be done in a suitably equipped laboratory.

Example:

Solution conductivity	=	1500 µS / cm
Solution weight	=	100 gm
Dry residue weight	=	0.102 gm

Therefore by calculation:

$$\text{Dry residue ppm} = \frac{\text{Residue weight (gms)} \times 10^6}{\text{Solution weight (gms)}}$$

$$= \frac{0.102 \times 10^6}{100}$$

$$= 1020 \text{ ppm}$$

$$\text{Therefore the factor (F)} = \frac{\text{Residue (ppm)}}{\text{Solution Conductivity (} \mu\text{S / cm)}}$$

$$= \frac{1020}{1500}$$

$$F = 0.68$$