Congratulations !

You have purchased the latest in Handheld Dissolved Oxygen-pH-ORP-Temperature instrumentation. We trust that your new **WP-91** will give you many years of reliable service.

The **WP-91** is a breeze to operate. This manual has been designed to help you get started, and also contains some handy application tips. If at any stage you require assistance, please contact either your local TPS representative or the TPS factory in Brisbane.

The manual is divided into the following sections:

1. **Table of Contents**
   Each major section of the handbook is clearly listed. Sub-sections have also been included to enable you to find the information you need at a glance.

2. **Introduction**
   The introduction has a diagram and explanation of the display and controls of the **WP-91**. It also contains a full listing of all of the items that you should have received with your **WP-91**. Please take the time to read this section, as it explains some of items that are mentioned in subsequent sections.

3. **Main Section**
   The main section of the handbook provides complete details of the **WP-91**, including operating modes, calibration, troubleshooting, specifications, and warranty terms.

4. **Appendices**
   Appendices containing background information and application notes are provided at the back of this manual.

Model WP-91
Dissolved Oxygen,
pH, ORP, Temp Meter
Version: 2.0
Date: 1-Jul-2012

TPS Pty Ltd

ABN 30 009 773 371

Unit 6 / 253 Leitchs Road
Brendale, QLD,
Australia, 4500

Phone : (07) 32 058 027
International : 61 7 32 058 027

Fax : (07) 3808 4871
International : 61 7 3808 4871

Email : tps@tps.com.au

Web : www.tps.com.au

Contents

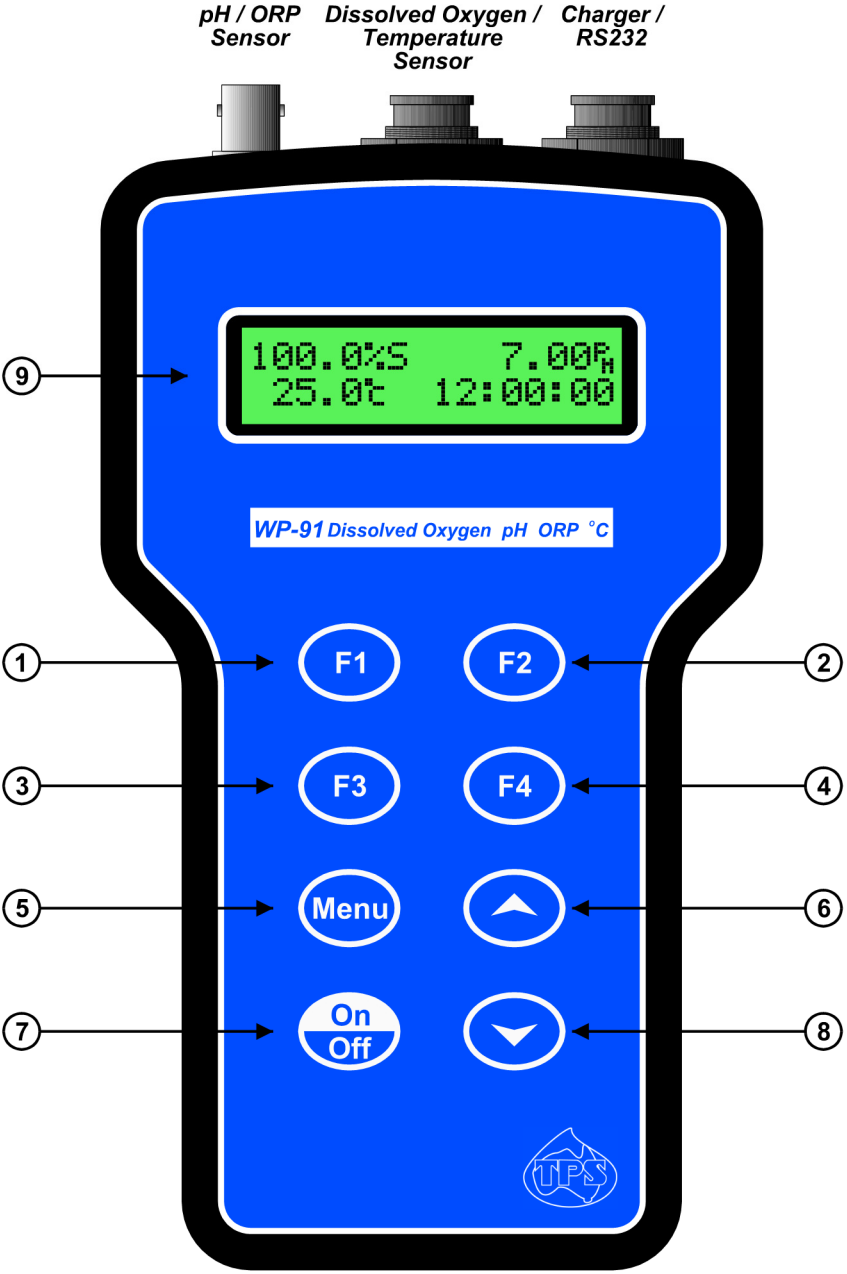
1. Introduction 5
1.1 WP-91 Display and Controls 5
1.2 Unpacking Information 7
1.3 Specifications 8
2. WP-91 Menu Structure 11
3. Oxygen Operating Modes 12
4. Dissolved Oxygen Calibration 13
4.1 Calibration Procedure 13
4.2 Measurement Notes: 14
4.3 Calibration Notes 14
4.4 Calibration Messages 15
5. pH Calibration 16
5.1 Calibration Procedure 16
5.2 Calibration Notes 18
6. mV/ORP Calibration 18
7. Temperature Calibration 19
7.1 Calibration Procedure 19
7.2 Calibration Notes 19
7.3 Calibration Messages 20
8. Salinity Correction 21
9. Altitude or Atmospheric Pressure Correction 22
9.1 Selecting Altitude or Pressure Correction 22
9.2 Changing the Altitude or Pressure Correction value 23
9.3 Notes 24
10. Good Laboratory Practices (GLP) 25
10.1 To recall GLP information on the display 25
10.2 Failed Calibration 27
10.3 Printing GLP Information to the RS232 Port 28
10.4 Instrument Serial Number 29
10.5 Additional GLP Features 29
11. Notepad Function 30
11.1 Recording Readings into the Notepad 30
11.2 Recalling Records from the Notepad 30
11.3 Erasing Records from the Notepad 31
11.4 Printing Records from the Notepad to the RS232 Port 32
12. Automatic Data logging 33
13. RS232 Port 35
13.1 Setting the Baud Rate 35
13.2 Sending Readings to the RS232 Port 35
13.3 RS232 Configuration 35
13.4 Communication and Statistical Software 35

13.5 Commands 36
13.6 Data Format 37
13.7 GLP Data Format 38
13.8 Importing Data into Microsoft Excel 39
14. Battery Saver Function 41
15. Recharging the Battery 42
16. Clock Function 43
16.1 Setting the Clock 43
16.2 Displaying or Hiding the Clock 43
17. Selecting Buffers for Auto Buffer Recognition 44
18. Initialising the WP-91 45
19. Instrument firmware version number. 45
20. Troubleshooting 46
20.1 General Errors 46
20.2 Dissolved Oxygen Troubleshooting 47
20.3 pH and mV/ORP Troubleshooting 48
20.4 Temperature Troubleshooting 49
21. Dissolved Oxygen Sensor Fundamentals 50
21.1 Operating Principle 50
21.2 Maintenance Of The Membrane 51
21.3 Sensor Storage 51
21.4 Notes On Units Of Dissolved Oxygen 52
21.5 Equilibrium Conditions 53
21.6 Velocity Past The Membrane 54
22. pH Sensor Fundamentals 55
22.1 Asymmetry of a pH Sensor 55
22.2 Slope of a pH Sensor 56
22.3 pH Temperature Compensation 57
23. Warranty 58

24. Sensor Manual

1. Introduction

1.1 WP-91 Display and Controls



① 

Press to record readings into memory. See section 11.1. Also used to switch the Altitude or Atmospheric Pressure Correction system on or off. See section 9.1.

② 

Press to alternate temperature, date/time, and manual Salinity/Altitude/ Pressure values on the display. See section 16.2. Also used to select pH buffers for automatic buffer recognition at pH calibration. See section 17.

③ 

Press to start or stop automatic logging. See section 12. Alternatively, press to transmit current reading plus date and time to the RS232 port. See section 13.2.

④ 

Only used within the menu system on the **WP-91**.

⑤ 

Press to access the user-friendly menu system which makes the **WP-91** easy to operate.

⑥  and ⑧ 

The ⌃ and ⌄ keys are used for calibrating temperature readout (section 7.1), setting the clock (section 16.1), setting the automatic logging period (section 12), and displaying GLP information (section 10.1). The ⌃ key is also used to initialise the **WP-91** at turn-on. See section 18.

⑦ 

Switches the **WP-91** on and off.

⑨ **Display**

32 character alpha-numeric display with user-friendly menu and prompting system. Shows Dissolved Oxygen, pH/ORP and Temperature simultaneously. Date, time, manual salinity value, altitude or pressure can also be displayed.

1.2 Unpacking Information

Before using your new **WP-91**, please check that the following accessories have been included:

		Part No
1.	**WP-91** Dissolved Oxygen-pH-ORP-Temp	123150/1 123150/3 123150/5
2.	Oxygen sensor	123204
3.	Oxygen sensor cable: *(see cable label for part No)*	1, 3 or 5m cable
4.	Membrane kit for oxygen sensor	123300
5.	pH Sensor: *(see cable label for part No)*	1, 3 or 5m cable
6.	pH7.00 Buffer, 200mL	121387
7.	pH4.01 Buffer, 200mL	121381
8.	Battery charger	130037
9.	Manual	

*Options that may have been ordered with your **WP-91**:*

1.	Extended cable	130040
2.	RS232 Serial Interface Cable	130041
3.	Communication software for Windows 95 and later	130086
4.	USB to Serial Adaptor (requires 130041 also)	130087
5.	Hard Carry Case	130059
6.	Battery charger lead for 12V cigarette lighter socket	130046
7.	Battery charger lead for 12V DC, with battery clips	130052
8.	Solar Panel	130012

1.3 Specifications

Dissolved Oxygen

ppM (mg/L)

Ranges *	0 to 20.00 ppM 20.0 to 40.0 ppM
Resolution	0.01 & 0.1 ppM
Accuracy	±0.2% of full scale of selected range

% Saturation

Ranges *	0 to 240.0 % Saturation 240 to 450 % Saturation
Resolution	0.1 & 1 % Saturation
Accuracy	±0.3 % Saturation

% Gaseous

Ranges *	0 to 45.0 % Gaseous 45 to 100 % Gaseous
Resolution	0.1 & 1 % Gaseous
Accuracy	±0.1 % Gaseous

* Ranges subject to sensor performance.

pH

Range	0 to 14.00 pH
Resolution	0.01 pH
Accuracy	±0.01 pH

mV/ORP

Range	0 to ±500.0 and 0 to ±1500 mV (auto-ranging)
Resolution	0.15 and 1 mV
Accuracy	±0.3 and ±1 mV

Temperature (DO Sensor limit 45 °C)

Range	-10.0 to 120.0 °C (pH Sensor limit 60 °C)
Resolution	0.1 °C
Accuracy	±0.2 °C

Salinity Correction .....User-set, from 0 to 50.0 ppK NaCl

Barometric Pressure Correction ..User-set, from 500 to 1100 HPa

Altitude Correction.....User-set, from 0 to 5000m

General Specifications

Temperature Compensation:

pH (only – not for mV/ORP) .....Automatic 0 to 100 °C
Manual 0 to 100 °C

Dissolved oxygen.....Automatic -5 to 50 °C
Membrane permeability
Oxygen solubility in ppM mode

Calibration

pH.....Auto Standard Recognition in pH4.01, pH6.86,pH7.00, pH9.18 or pH10.01 buffers

pH Sensor Asymmetry Range.-1.00 to +1.00 pH

pH Sensor Slope Range .....85.0 to 105%

Input Impedance ..... >3 x 10^{12} Ω

mV/ORP .....Sensor calibration not available.

Oxygen .....Zero in Sodium Sulphite (Na_2SO_3) solution
Span in Air

Oxygen Sensor Span Range ..65 to 200%

Oxygen Sensor Zero Range ...0 to 7.5%

Temperature .....Use a reference thermometer.

Temperature Sensor Offset ....-10.0°C to +10.0°C

Memory .....3600 readings including date and time

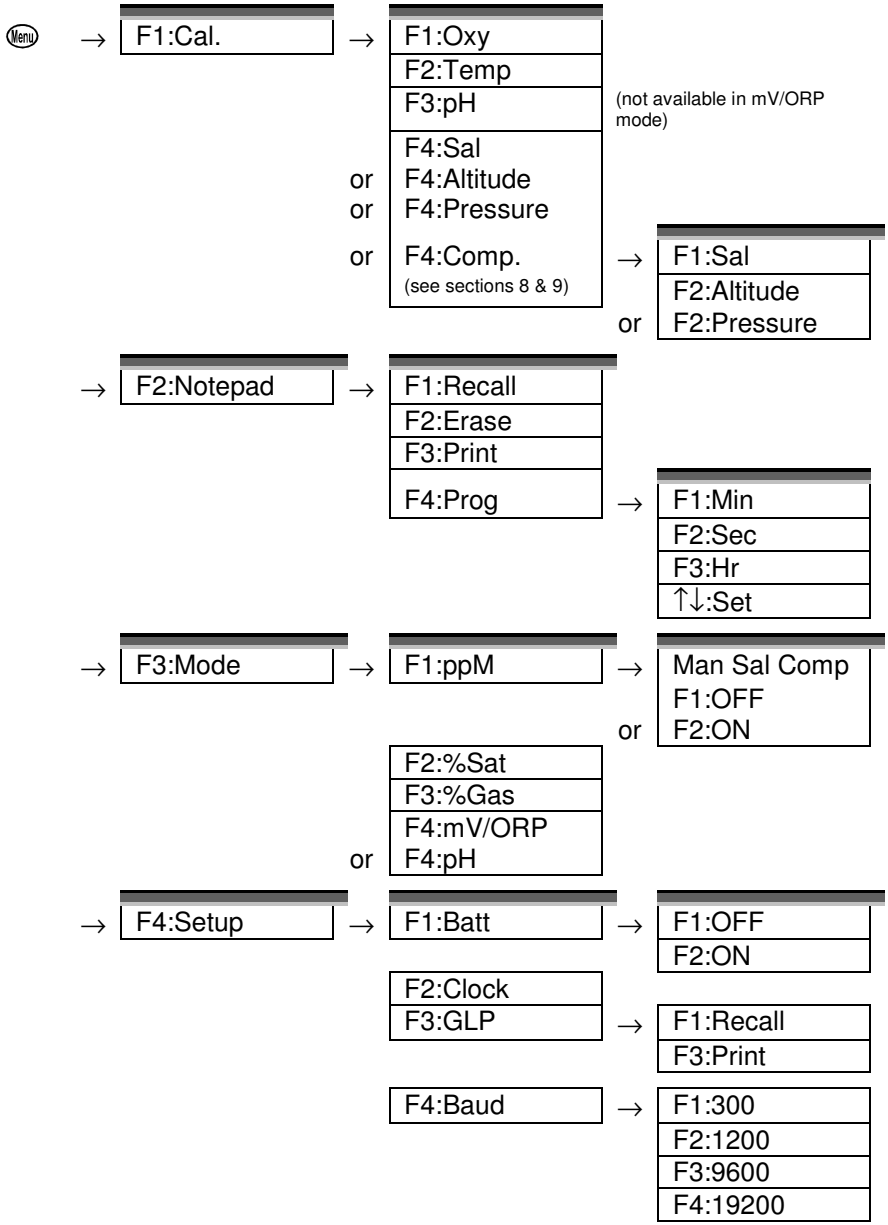
Automatic Logging.....User-set for one reading every 1 to 90 seconds, 1 to 90 minutes, or 1 to 24 hours.

RS232 Output .....300, 1200, 9600 & 19200 baud.
8 bits, no parity, 1 stop bit, XON/XOFF Protocol.

Clock	Calendar clock displays date, month, hours, minutes & seconds. Year is recorded in memory and transmitted to the RS232 port, but is not displayed.
Battery Saver	On : Auto switch-off after 5 minutes Off : Continuous use Bar Graph display of battery charge level. Readout of battery voltage available for troubleshooting.
Good Laboratory Practices	Date, Time and Value of last Dissolved Oxygen, pH and Temperature calibration are stored, along with Altitude or Pressure setting at time of calibration. This information can be recalled or sent to the RS232 port at any time.
Power	6V NiCad Rechargeable Battery for approx 40 hours operation.
Dimensions	195 x 110 x 55 mm
Mass	Instrument only : Approx 520g Full Kit : Approx 2.5 kg
Environment	Temperature : 0 to 45 ºC Humidity : 0 to 95 % R.H.

2. WP-91 Menu Structure

A detailed breakdown of the menu system of the **WP-91** is shown below. This diagram provides a quick reference for the **WP-91** menu functions.

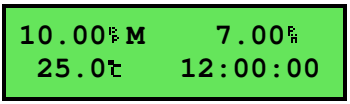


3. Oxygen Operating Modes

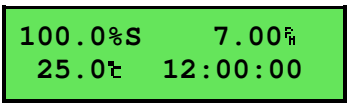
The **WP-91** has three Oxygen modes : ppM (mg/L), % Saturation, and % Gaseous.

To select an Oxygen mode, access the mode menu by pressing Menu, then **F3:Mode**.

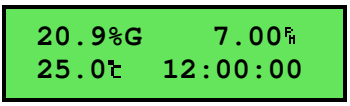
1. **F1:ppM** (ppM (mg/L) readout)
   Displays ppM Dissolved Oxygen, pH or mV/ORP and Temperature and the user-set Salinity value simultaneously. See section 8 for details on setting the Salinity correction value.
   See section 16.2 for details on how to alternate temperature and date.



2. **F2:%Sat** (% Saturation readout)
   Displays % Saturation Dissolved Oxygen, pH or mV/ORP and Temperature readings simultaneously.
   See section 16.2 for details on how to alternate temperature and date.



3. **F3:%Gas** (% Gaseous readout)
   Displays % Gaseous Oxygen, pH or mV/ORP and Temperature readings simultaneously.
   See section 16.2 for details on how to alternate temperature and date.



4. **Notes**
   1) If the temperature of the solution exceeds 120.0 °C, or the temperature sensor inside the dissolved oxygen sensor is faulty, the temperature reading is replaced by "**OVR°C**", to signify the over-range condition.
   2) The decimal point is replaced by a "**∗**" if a Dissolved Oxygen, pH or Temperature calibration has failed (sections 4, 5 & 7) or if the unit is initialised (section 18).

4. Dissolved Oxygen Calibration

4.1 Calibration Procedure

1. Plug the Dissolved Oxygen sensor into the **Dissolved Oxygen** socket.
2. Switch the meter on.
3. Select the mode of your choice. (Menu → **F3:Mode** → **F1 to F3**).
4. Ensure that temperature has already been calibrated (see section 7).
   NOTE: A "∗" in place of the decimal point in the temperature readout indicates that temperature is not calibrated.
5. Rinse the Dissolved Oxygen sensor in distilled water and blot dry.
6. **Zero Calibration**
   a) Place the sensor into an oxygen-free solution. This solution may be prepared by dissolving 2g of Sodium Sulphite in 100mL of distilled water. A 50g bottle of Sodium Sulphite powder is supplied with a new Dissolved Oxygen sensor for this purpose (part number 123302).
   b) Allow the reading to stabilise at or near zero. This may take 2-3 minutes.
   c) Select Oxygen Calibration. (Menu → **F1:Cal.** → **F1:Oxy**).
   d) Press the F1 key to calibrate.
   e) A "∗" will not be removed from the display after a Zero Calibration.
7. Rinse the Dissolved Oxygen sensor in distilled water and blot dry.
8. **Air Calibration**
   a) Hang the Dissolved Oxygen sensor in air. The tip of the sensor should be pointing downwards.
   b) Allow the reading to stabilise. After a zero calibration, this may take up to 5 minutes.
   c) Select Oxygen Calibration. (Menu → **F1:Cal.** → **F1:Oxy**).
   d) Press the F1 key to calibrate.
   e) A "∗" in the display will be replaced by a decimal point after a successful air calibration.
9. The **WP-91** is now calibrated ready for Dissolved Oxygen measurement.

4.2 Measurement Notes:

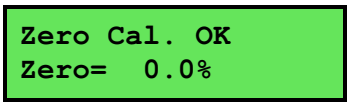
1. When taking sample measurements, always ensure that there is adequate flow of solution past the membrane for accurate, stable readings. See section 21.6.
2. If salinity-corrected ppM Dissolved Oxygen readings are required, set the salinity correction value before taking sample measurements. See section 8.
3. If Altitude or Atmospheric Pressure Correction is selected, set the correction value before calibrating and taking measurements. See section 9.

4.3 Calibration Notes

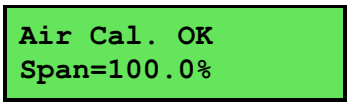
1. A zero calibration should be performed at least monthly, or when the membrane is replaced. In applications where there is a low level of dissolved oxygen, a zero calibration may have to be done weekly.
2. An air calibration should be performed at least weekly, or when the membrane is replaced. Of course, more frequent calibration will result in greater confidence in results.
3. The salinity correction value is ignored during zero and air calibration. There is therefore no need to re-set the salinity correction value when calibrating Dissolved Oxygen.
4. For optimum accuracy, set the altitude of atmospheric pressure before calibration.
5. All calibration information is retained in memory when the **WP-91** is switched off, even when the battery is removed. This information can be recalled or printed later using the GLP function (see section 10).

4.4 Calibration Messages

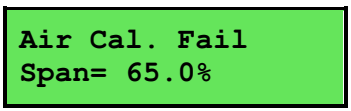
1. If a Zero calibration has been successfully performed, the **WP-91** will display the following message, and the zero value of the sensor.



2. If an Air calibration has been successfully performed, the **WP-91** will display the following message, and the span value of the sensor.



3. If an Air calibration has failed, the **WP-91** will display the following message, and the failed span value of the sensor.



5. pH Calibration

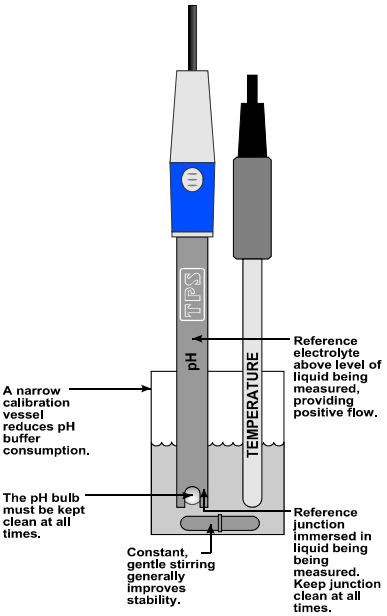
5.1 Calibration Procedure

1. Plug the pH sensor into the **pH/mV** socket. The Dissolved Oxygen sensor (or a Temperature sensor) should be plugged into the **Dissolved Oxygen** socket.
2. Switch the meter on.
3. Select pH Mode. (Menu → **F3:Mode** → **F4:pH**).
4. Ensure that temperature has already been calibrated (see section 7). **NOTE:** If the decimal point in the temperature reading is shown by a ∗, then the temperature readout is not calibrated.
5. Remove the wetting cap from the pH sensor.
6. Rinse the pH and Dissolved Oxygen/Temperature sensors in distilled water and blot them dry.
7. Ensure that you are using the primary buffer for which the **WP-91** has been set (see section **Error! Reference source not found.**).

   Place both sensors into a small sample of pH7.00 (or pH6.86) buffer, so that the bulb and reference junction are both covered, as per the diagram over the page.

   DO NOT place the sensors directly into the buffer bottle.

   To reduce the amount of pH buffer that is consumed, the Dissolved Oxygen sensor may be placed into a separate beaker of water that is **at the same temperature as the buffer**.

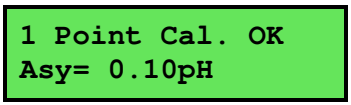


8. Select pH Calibration (Menu → **F1:Cal.** → **F3:pH**).
9. When the reading has stabilised, press the F1 key to calibrate. If a 1 point calibration has been performed, the "∗" will not be removed until a full 2 point calibration has been performed.
10. Rinse the sensors in distilled water and blot them dry.
11. Place both sensors into a small sample of pH4.01, pH9.18 or pH10.01 Buffer, so that the bulb and reference junction are both covered as per the diagram in step 8, above. **DO NOT** place the sensors directly into the buffer bottle.

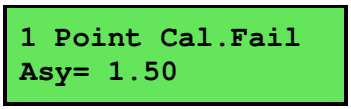
    pH9.18 and pH10.01 buffers are unstable once the bottles have been opened. Discard immediately after use.
12. Select pH Calibration (Menu → **F1:Cal.** → **F3:pH**).
13. When the reading has stabilised, press the F1 key to calibrate. The "∗" will now be replaced by a decimal point, if calibration was successful.
14. The **WP-91** is now calibrated for pH and is ready for use. Discard the used samples of buffer.

5.2 Calibration Notes

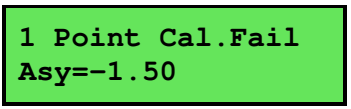
1. If a 1-point calibration has been successfully performed, the **WP-91** will display the following message, and the asymmetry of the sensor.



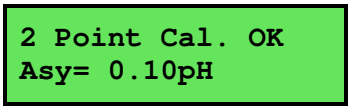
2. If a 1-point calibration has failed, the **WP-91** will display the following message, and the failed asymmetry value of the sensor.



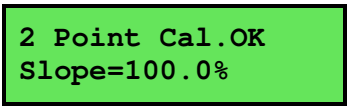
or



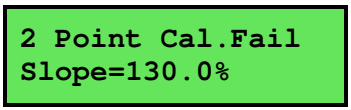
3. If a 2-point calibration has been successfully performed, the **WP-91** will display the following message, and the asymmetry and slope of the sensor.



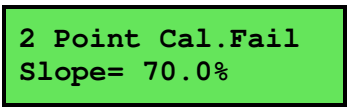
then



4. If a 2-point calibration has failed, the **WP-91** will display the following message, and the failed slope value of the sensor.



or



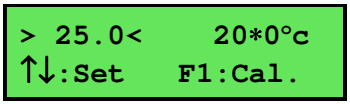
6. mV/ORP Calibration

The mV/ORP section is factory calibrated. There is no sensor calibration using a calibration standard for this mode.

7. Temperature Calibration

7.1 Calibration Procedure

1. Plug the Dissolved Oxygen/Temperature sensor into the **Dissolved Oxygen** socket.
2. Switch the meter on.
3. Place the sensor into a beaker of room temperature water, alongside a good quality mercury thermometer. Stir the sensor and the thermometer gently to ensure an even temperature throughout the beaker.
4. Select Temperature Calibration.(Menu → **F1:Cal.** → **F2:Temp**).
5. The reading from the sensor is now displayed on the right of the display, and the value you are going to set is shown on the left.



6. When the reading on the right has stabilised, press the ⌃ and ⌄ keys until the reading on the left shows the same temperature as the mercury thermometer.
7. Press the F1 key to calibrate the temperature readout.

   The "*" will now be replaced by a decimal point, if calibration was successful.

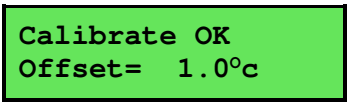
   Alternatively, press the Menu key to abort temperature calibration.

7.2 Calibration Notes

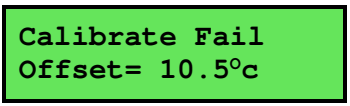
1. Temperature calibration information is retained in memory when the **WP-91** is switched off, even when the battery is removed. This information can be recalled or printed later using the GLP function (see section 10).
2. Temperature does not need to be recalibrated unless the sensor is replaced or the meter is initialised.

7.3 Calibration Messages

1. If a temperature calibration has been successfully performed, the **WP-91** will display the following message and the offset value of the sensor.



2. If a temperature calibration has failed, the **WP-91** will display the following message, and the failed offset value of the sensor.



8. Salinity Correction

Manual salinity correction for ppM Dissolved Oxygen readings is available on the **WP-91**.

1. Select Salinity-corrected ppM mode.

   (Menu → **F3:Mode** → **F1:ppM** → **F2:ON**).

2. Set the Salinity correction value. (Menu → **F1:Cal** → **F4:Sal**).

   If Altitude of Pressure Compensation is currently selected, then the above key sequence becomes Menu → **F1:Cal** → **F4:Comp.** → **F1:Sal**

3. The current salinity correction value is now displayed…

   ```
   > 36.0< ppK Sal.
   ↑↓:Set   F1:Save
   ```

4. Press the ▲ and ▼ keys until the display shows the desired salinity correction value.

5. Press the F1 key to save the salinity correction value.

   Alternatively, press the Menu key to quit and retain the current setting.

6. When manual Salinity correction is selected, an "**s**" is shown after the "**ppM**" units description in the Dissolved Oxygen readout.

9. Altitude or Atmospheric Pressure Correction

Manual altitude or atmospheric pressure correction are available on the **WP-91**. Either one or the other may be selected at any one time or the system can be switched off.

9.1 Selecting Altitude or Pressure Correction

1. Switch the **WP-91** OFF.
2. Press and hold the F1 key while switching the **WP-91** back ON.
3. The Altitude or Pressure mode menu is now displayed.

   ```
   F1:Altitude
   F3:Pressure>F4:OFF
   ```

   The arrow indicates the current selection.
4. Press F1 to select Altitude correction.

   Press F3 to select Atmospheric Pressure correction.

   Press F4 to switch the Altitude or Pressure correction system OFF.
5. If F1 or F3 was selected, then the **WP-91** now asks for the altitude or pressure.

   ```
   >   0< m Alt
   12:Set   F1:Save
   ```

   or

   ```
   >1013< HPa
   ↑↓:Set   F1:Save
   ```

   Press the ▲ and ▼ keys to set the desired Altitude or Pressure.
6. Press the F1 key to save the Altitude or Pressure value.

   Alternatively, press the Menu key to quit and retain the current setting.

9.2 Changing the Altitude or Pressure Correction value

To change the altitude or atmospheric pressure correction value when one or the other is switched on:

1. Switch the **WP-91** on.
2. Select Altitude or Pressure calibration, depending upon which is switched on:

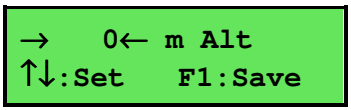
   i.e.: Menu → **F1:Cal.** → **F4:Altitude**

   or Menu → **F1:Cal.** → **F4:Pressure**

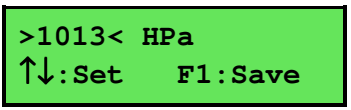
   If Manual Salinity Correction is currently selected, then the above key sequence becomes :

   Menu → **F1:Cal** → **F4:Comp** → **F2:Altitude**

   or Menu → **F1:Cal** → **F4:Comp** → **F2:Pressure**
3. The **WP-91** now asks for the altitude or pressure.

   or

   Press the ⌃ and ⌄ keys to set the desired Altitude or Pressure.
4. Press the F1 key to save the Altitude or Pressure value.
5. Alternatively, press the Menu key to quit and retain the current setting.

9.3 Notes

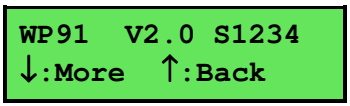
1. For optimum accuracy, the altitude or pressure should be set before calibrating or taking measurements.
2. When the altitude or atmospheric pressure correction system is switched off, the **WP-91** assumes sea level (0m) and 1013 HPa conditions. These values are satisfactory for the precision required for most Dissolved Oxygen measurements.
3. If Altitude correction is switched on, an "**A**" is added to the **WP-91** display in normal measurement mode.
4. If Atmospheric Pressure correction is switched on, a "**P**" is added to the
5. **WP-91** display in normal measurement mode.
6. % Saturation and % Gaseous readings are normalised to sea level (0m) and 1013HPa, when altitude or atmospheric pressure compensation is in use.
7. ppM and salinity-corrected ppM modes show the actual oxygen present at the user-set altitude or atmospheric pressure.

10. Good Laboratory Practices (GLP)

The **WP-91** keeps a record of the date and time of the last Dissolved Oxygen, pH and Temperature calibrations as part of GLP guidelines.

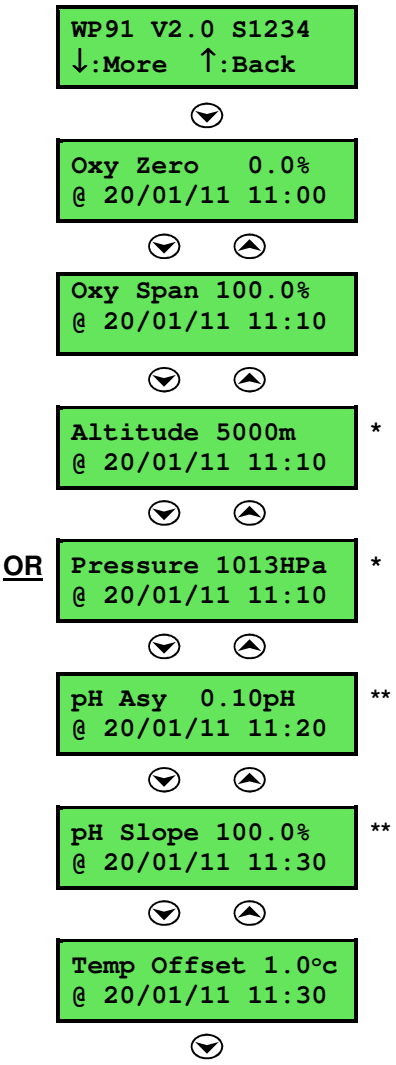
10.1 To recall GLP information on the display

1. Switch the meter on.
2. Select the GLP menu. (Menu → **F4:Setup** → **F3:GLP**).
3. Select **F1:Recall** from the menu.
4. The instrument model, firmware version number, and instrument serial number are displayed, along with a prompt describing how to scroll through the GLP information.



5. Press the ⌄ key to sequentially scroll through the GLP information for all parameters. Press the ⌃ key to scroll back to previous data. The sequence of information displayed is shown below. Press Menu to abort at any time.

GLP Display sequence…

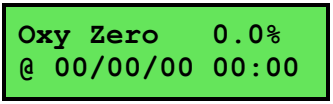


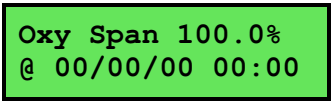
* Altitude **OR** Pressure are displayed only if either one was switched on at the time of the last calibration.

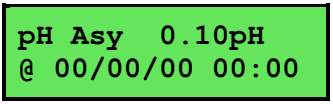
** pH Asymmetry and pH Slope calibration data is displayed only when the pH mode is switched on.

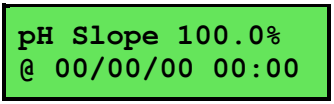
10.2 Failed Calibration

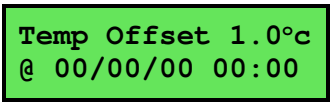
If calibration has failed, the GLP function will reset the date and time to zero. The **WP-91** still shows the results of the last successful calibration. These calibration values are still used if further measurements are taken without recalibrating. The following are examples of failed calibrations…











10.3 Printing GLP Information to the RS232 Port

The GLP information stored in the instrument's memory can be sent to a printer or PC via the RS232 port.

1. Switch the meter on.
2. Ensure that the **WP-91** RS232 cable is connected to the instrument and to the printer or PC.
3. Send the GLP information to the RS232 port…

   Menu → **F4:Setup** → **F3:GLP** → **F3:Print**

4. The GLP information is sent to the RS232 port in formatted ASCII text, for example…

```
WP91    V2.0 S1234 @ 20/01/11 12:00
Oxygen       Zero=       0.0%     @ 20/01/11 11:00
Oxygen       Span=     100.0%     @ 20/01/11 11:10
Oxygen       Altitude=  5000m     @ 20/01/11 11:10
Oxygen       Pressure=  1013HPa   @ 20/01/11 11:10
pH           Asy=       0.10pH    @ 20/01/11 11:20
pH           Slope=    100.0%     @ 20/01/11 11:30
Temperature  Offset=     1.0oC    @ 20/01/11 11:40
ENDS
```

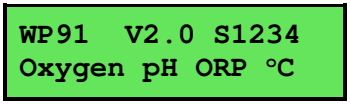
Notes

1. Either Altitude **OR** Pressure is sent, depending upon which was selected the last time the instrument was calibrated.
2. pH calibration data is displayed only if the pH mode is switched on.

10.4 Instrument Serial Number

In case the serial number that is fitted to the rear of the **WP-91** is removed or becomes illegible, it is also available on the **WP-91** display.

- The serial number is displayed at turn-on,



  where **S1234** is the serial number.

- The serial number is display when recalling the GLP information (section 10.1).
- The serial number is included on the printout of GLP information (section 10.3).

10.5 Additional GLP Features

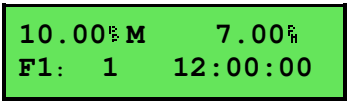
Another GLP requirement is to record the date and time of every reading. The **WP-91** does this for you when readings are recorded either with the Notepad function (section 11) or the Automatic Logging function (section 12).

11. Notepad Function

11.1 Recording Readings into the Notepad

To record readings into the Notepad memory:

1. Press (F1) in normal display mode. The display should now look like this…



2. If you now press (F1), the Dissolved Oxygen, pH or mV/ORP, Temperature, Date and Time will be recorded into the notepad, and labelled as reading number 1.

   If manual salinity, altitude or pressure correction are in use, they are also recorded with the reading.

3. Repeat steps 1 & 2 as often as required. The maximum number of readings that can be stored in the Notepad is 3600.

11.2 Recalling Records from the Notepad

To recall records from the Notepad onto the **WP-91** display:

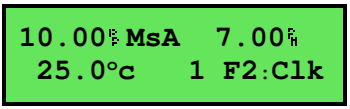
1. Select the Notepad menu ((Menu) → **F2:Notepad**).
2. Select **F1: Recall** from the menu.
3. Record number 1 is now displayed.

   An "**s**" is displayed if manual Salinity correction was switched on when the reading was recorded.

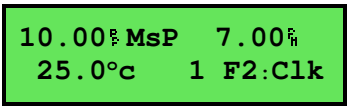
   An "**A**" is displayed if Altitude correction was switched on when the reading was recorded.

   A "**P**" is displayed if Pressure correction was switched on when the reading was recorded.

   For example…

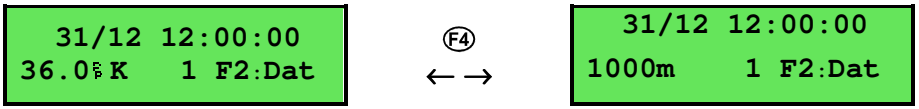


or



4. Press F2 to alternate between the data and the date / time / compensation for this record. For example…

5. When date/time/compensation is displayed, press F4 to alternatively display the manual salinity value and the Altitude or Pressure value for this record. The F4 key is only available when BOTH Salinity AND Altitude/Pressure were switched on when the reading was taken. For example…



6. Press ▲ to move forward through the records.

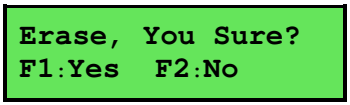
   Press ▼ to move backward through the records.

   Press and hold the ▲ or ▼ keys to roll rapidly through the readings.

11.3 Erasing Records from the Notepad

To erase all records from the Notepad:

1. Select the Notepad menu (Menu → **F2:Notepad**).
2. Select **F2:Erase** from the menu.
3. The **WP-91** now asks if you are sure that you wish to erase all records…



4. Press F1 to erase all records from the Notepad

   Press F2 to quit without erasing the records from the Notepad.

11.4 Printing Records from the Notepad to the RS232 Port

1. Connect one end of the RS232 cable to the **Charger**/**RS232** socket of the **WP-91**. The charger, optional solar panel, or optional car battery lead can be connected into the spare socket on the cable for long term use, if required.
2. Connect the other end of the RS232 cable to an RS232 Printer, or to COM1 or COM2 of a PC.
3. Ensure that the baud rate for the printer or PC and the **WP-91** are the same.

   If necessary, alter the baud rate of the **WP-91** (see section 13.1).

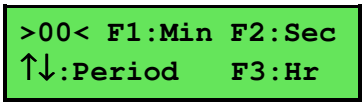
   The **WP-91** uses XON/XOFF protocol. Ensure that the printer is set accordingly.
4. Select the Notepad menu (Menu → **F2:Notepad**).
5. Select **F3:Print** from the menu.

   Printing starts as soon as F3 is pressed. The display shows the word "**Printing**" until printing is completed.

12. Automatic Data logging

The **WP-91** can automatically log readings. First the logging period must be programmed, then automatic logging can be started and stopped as required.

1. Select the Program menu (Menu → **F2:Notepad** → **F4:Prog.**).
2. The display should now look like this:



3. Use the ⌃ and ⌄ keys to set the period at which the **WP-91** will automatically log records.
4. When the logging period has been correctly set, select whether this period is in minutes, seconds or hours.

   Press F1 to save the period as minutes.

   Press F2 to save the period as seconds.

   Press F3 to save the period as hours.

   eg: If the period was set to **05**, followed by F2, then the **WP-91** will automatically log a record every 5 seconds.
5. The **WP-91** will ask if the records are to be logged into the Notepad, or sent directly to the RS232 port.

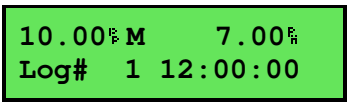
   Press F1 to log records into the Notepad (maximum of 3600 readings).

   Press F3 to send records directly to the RS232 port.
6. The automatic logging function is now programmed, and can be started and stopped as required.

Continued over the page…

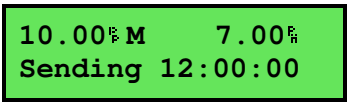
7. To start automatic logging, press F3 in normal display mode.

If the **WP-91** is logging into the Notepad, the display will look like this…



The log number will increment and the **WP-91** will beep each time a reading is recorded.

If the **WP-91** is sending records directly to the RS232 port, the display will look like this…



The **WP-91** will beep each time a record is sent to the RS232 port.

8. Press F3 to stop automatic logging.

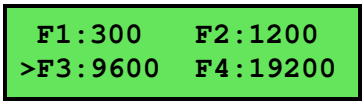
Notes:

1. The clock must be set before the **WP-91** will allow automatic logging to start. The message "**Clock Not Set**" is displayed if the clock is not set.
2. The Battery Saver function (section 14) is disabled while the meter is in Automatic Data logging mode, to stop the meter switching off while logging data. Even when the memory is full and the meter stops logging, the Battery Saver function is still disabled. This allows the data to be downloaded and the memory to be reset remotely.

13. RS232 Port

13.1 Setting the Baud Rate

1. Select the RS232 Set-up menu (Menu → **F4:Setup** → **F4:Baud**).
2. The available baud rates are listed on the display…



   The arrow shows the current selection.

3. Press F1 to select 300 baud
   Press F2 to select 1200 baud
   Press F3 to select 9600 baud.
   Press F4 to select 19200 baud.
   Press Menu to quit and retain the current setting.

13.2 Sending Readings to the RS232 Port

Press F3 to instantly send readings to the RS232 port whenever the **WP-91** is in normal run mode. This function is disabled if the automatic logging period is set to greater than zero (see section 12).

Records can be sent directly to the RS232 port rather than stored in memory during automatic data logging. See section 12 for details.

13.3 RS232 Configuration

The **WP-91** RS232 configuration is 8 bits, No Parity, 1 Stop Bit, XON/XOFF Protocol.

13.4 Communication and Statistical Software

Communication between the **WP-91** and a PC can be handled with any RS232 communication software. **Win*TPS*** RS232 communication software for Windows® 95 and later is optionally available (part number 130086).

Once the data is saved to disk, the next problem is how to use it. The data sent by the **WP-91** is formatted in fixed-width columns that can be imported by programs such as Microsoft® Excel® and Lotus 123®.

Information on how to use the software and import data is provided in the manual provided with the **Win*TPS*** CD-ROM.

13.5 Commands

The following commands can be sent from a PC to the **WP-91**. Note that <cr> denotes carriage return and <lf> denotes a line feed.

Action	Command	Notes
Request current data	?D<cr>	Returns the current Dissolved Oxygen, pH or mV/ORP, Temperature, date and time from the **WP-91**. Also returns salinity, altitude and pressure correction values if any of these are in use. The log number returned is set to Zero.
Request logged data	?R<cr>	Returns all logged records from the **WP-91** memory. The data ends with the message **ENDS**<cr>
Erase logged data	?E<cr>	Erases all logged records from the **WP-91** memory. Returns the message **ERASED**<cr> to confirm that the records have been erased.
Request status information	?S<cr>	Returns the model name, firmware version number, instrument serial number and number of logged readings in memory, eg: **WP91♦♦V2.0♦S1234♦9999**<cr>, where ♦ are spaces. Note that the number of logged readings is right-justified.
Request GLP information	?G<cr>	Returns all calibration GLP information, plus the instrument model and current date (see section 13.7 for data format and handshaking).

13.6 Data Format

Data is returned to the RS232 Port by the **WP-91** in the following format. A "•" shown anywhere in this section denotes one space.

LLLL•DDDDDDuuu•SSSSSSppK•CCCCCCuuu•PPPPPPuuu•TTTTTToC••dd/mm/yy•hh:mm:ss

LLLL	is the Log Number. Maximum 4 characters, right justified. The **WP-91** sends a Zero for instant readings (section 13.2)
DDDDDD	is Oxygen Data. Maximum 6 characters, right justified.
uuu	is the unit description, either "**ppM**", "**%S•**", or "**%G•**".
SSSSSS	is the Salinity correction value. Maximum 6 characters, right justified.
ppK	is the salinity correction value unit description.
CCCCCC	is the Altitude **OR** Pressure correction value. Maximum 6 characters, right justified.
uuu	is the unit description, either "**m••**" for Altitude or "**HPa**" for Atmospheric Pressure.
PPPPPP	is pH or mV/ORP Data. Maximum 6 characters, right justified.
uuu	is the unit description, either "**pH•**" for pH or "**mV•**" for mV/ORP.
TTTTTT	is the Temperature Data. Maximum 6 characters, right justified.
oC•	is the Temperature unit description.
dd/mm/yy	is the date, month and year data.
hh:mm:ss	is the hours, minutes and seconds data.

When requested by a PC with the ?D or ?R commands (section 13.5), the data is terminated with a carriage return.

When the data is sent by the **WP-91** using the Print function (section 11.4) or the Send function (section 13.2) the data ends with a carriage return and a line feed.

13.7 GLP Data Format

GLP information is returned as up to 8 lines terminated by a carriage return. When using the "**?G**" command (section 13.5), the computer must respond with a character after receiving each line. For example…

```
WP91    V2.0 S1234 @ 20/01/11 12:00
Oxygen      Zero=       0.0%     @ 20/01/11 11:00
Oxygen      Span=     100.0%     @ 20/01/11 11:10
Oxygen      Altitude=  5000m     @ 20/01/11 11:10
Oxygen      Pressure=  1013HPa   @ 20/01/11 11:10
pH          Asy=       0.10pH    @ 20/01/11 11:20
pH          Slope=    100.0%     @ 20/01/11 11:30
Temperature Offset=     1.0oC    @ 20/01/11 11:40
ENDS
```

Notes:

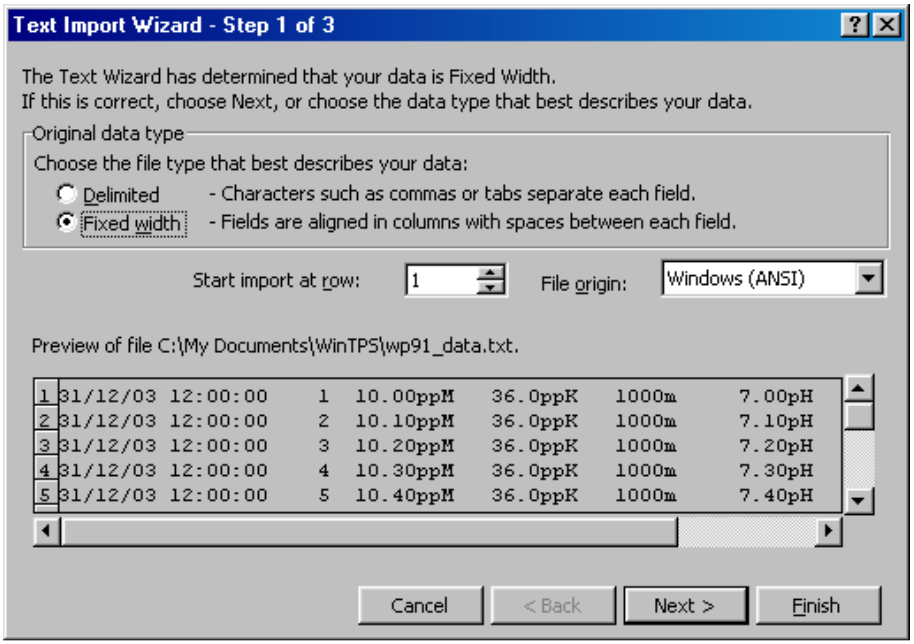
1. Either Altitude **OR** Pressure is sent, depending upon which was selected the last time the instrument was calibrated. If the Altitude or Pressure Correction was switched off at the time of the last air calibration, then neither is displayed.
2. pH Asymmetry and pH Slope calibration data are only sent when the pH mode of the **WP-91** is switched on.

13.8 Importing Data into Microsoft Excel

The following procedure details the method for importing a **WP-91** text data file into Microsoft® Excel®.

1. Start Microsoft® Excel® and select File → Open
2. In the "Files of type:" pull-down box, choose "Text Files (*prn; *.txt; *.csv)".
3. Navigate to the folder where your data file is stored and double-click it to start the Text Import Wizard.

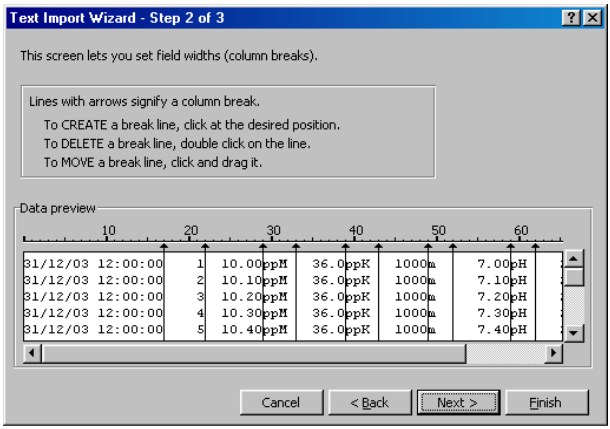
   Note: The default data folder for the WinTPS software is "C:\My Documents\WinTPS".
4. In step 1 of the Text Import Wizard select "Fixed width", as per the sample screen below, then press "Next >".

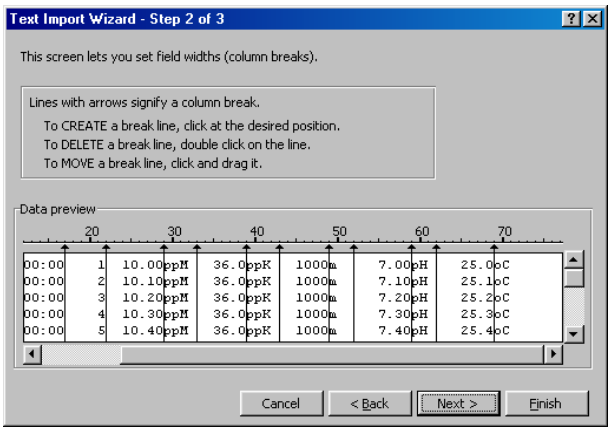


Continued over the page…

5. Step 2 of the Text Import Wizard allows you to select the points at which each data field will break into a new column. The sample screens below show where TPS recommends the breaks be inserted. There are two screens shown, as you will need to drag the scroll bar across to access Temperature.

   Press “Next >” after the column breaks have been inserted.





6. Simply press “Finish” at step 3 of the Text Import Wizard. TPS recommends that the data format for each column be set once the data is in spreadsheet format.

   For help on formatting the data columns, charting, graphing or other operations please consult the Microsoft® Excel® help file. Alternatively please contact TPS and we will try to provide further assistance.

14. Battery Saver Function

The **WP-91** is equipped with a battery saver function. If no button has been pressed for five minutes, the unit beeps and flashes the display for 20 seconds, and then shuts off. This function can be switched off for continuous use.

To enable or disable the battery saver function:

1. Switch the meter on.
2. Select Battery Saver Set-up (Menu → **F4:Setup** → **F1:Batt**).
3. The battery saver menu is now displayed.

   The arrow indicates the current selection.

   The bar graph and percentage indicate the approximate level of charge in the battery.

4. Press F1 to disable the battery saver function for continuous use.

   Press F2 to enable the battery saver function. The meter will switch itself off if no key has been pressed for five minutes.

   Press Menu to quit the battery saver menu and retain the current setting.

Notes:

1. For troubleshooting purposes, the battery volts can also be displayed in the battery saver menu. Press F3 to display battery volts.
2. The symbol flashes when the battery volts drops below 5.60 volts. At 5.00 volts the meter turns itself off.
3. The Battery Saver function is disabled while the meter is in Automatic Data logging mode (section 12), to stop the meter switching off while logging data. Even when the memory is full and the meter stops logging, the Battery Saver function is still disabled. This allows the data to be downloaded and the memory reset remotely.

15. Recharging the Battery

The symbol flashes when the battery drops below 5.60 volts. The battery should be recharged at this point. If the battery is not recharged, the **WP-91** will switch itself off when the battery drops below 5.00 volts.

To recharge the battery…

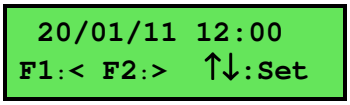
1. Plug the battery charger, solar panel, or car cigarette lighter adaptor into the **Charger/RS232** socket. **DO NOT** plug into the **Temperature** socket, as this will damage the **WP-91**.
2. Charge for approximately 8 hours for full capacity. The **WP-91** has special circuitry to prevent overcharging, so the charger can be used continuously.

To ensure optimum battery life and capacity, the **WP-91** should only be charged once the symbol starts to flash.

16. Clock Function

16.1 Setting the Clock

1. Select the Clock Set-up menu (Menu → **F4:Setup** → **F2:Clock**).
2. The display now shows the current date and time. The cursor starts at the day.



3. Press the ▲ and ▼ keys until the day is correct.
4. Press F2 to move to the month. Press the ▲ and ▼ keys until the month is correct.
5. Press F2 to move to the year. Press the ▲ and ▼ keys until the year is correct.
6. Press F2 to move to the hour. Press the ▲ and ▼ keys until the hour is correct.
7. Press F2 to move the cursor to the minutes. Press the ▲ and ▼ keys until the minutes are correct.
8. Check that the date and time are correct.

   Press F2 to save the settings.

   If any changes are needed, press the F1 key to move left to the desired position.

   Press Menu to quit without resetting the clock.

Note

The **WP-91** does not test for a valid day of the month when setting the clock (eg: attempting to enter 31/02/04 is not corrected).

16.2 Displaying or Hiding the Clock

The time is normally displayed along with the Dissolved Oxygen, pH/ORP and Temperature readings.

- Press F2 in normal display show the manual salinity correction value (only when a salinity value has been entered in ppM mode)
- Press F2 again to display the time plus the date. Temperature replaces the date after 5 seconds.

17. Selecting Buffers for Auto Buffer Recognition

The **WP-91** is factory set to automatically recognise pH4.01, pH7.00 and pH9.18 buffers. However, some users may prefer to use pH6.86 instead of pH7.00 and pH10.01 instead of pH9.18. The following procedure describes how to set which of these buffers are automatically recognised at calibration.

1. Switch the meter **OFF**.
2. Press and HOLD the F2 key while switching the meter back on.
3. The buffer selection menu is now displayed.

   ```
   Select >F1:7.00pH
   Buffer  F2:6.86pH
   ```

   The arrow indicates the current selection.
4. Press F1 to select pH7.00 as the primary buffer.

   Press F2 to select pH6.86 as the primary buffer.

   Press Menu to quit buffer selection and retain the current setting.
5. The display will now show the currently selected high pH buffer.

   ```
   Select >F1:9.18pH
   Buffer  F2:10.0pH
   ```

   The arrow indicates the current selection.
6. Press F1 to select pH9.18 as the high pH buffer.

   Press F2 to select pH10.01 as the high pH buffer (the display shows 10.0 for the latter, but this buffer is stored as pH10.01).

   Press Menu to quit buffer selection and retain the current setting.
7. The setting is kept in memory when the meter is switched off, even if the battery is removed.

18. Initialising the WP-91

If the calibration settings of the **WP-91** exceed the allowable limits, the unit may need to be initialised to factory default values.

To initialise the **WP-91**:

1. Switch the **WP-91** OFF.
2. Press and hold the ⏏ key while switching the **WP-91** back ON.
3. The following messages are displayed…

Initialized MUST ReCalibrate	then:	WP91s V2.0 S1234 Oxygen pH ORP °C

   (The "s" after **WP-91** is shown when the RS232 serial port option is fitted)
4. The meter then displays Dissolved Oxygen, pH and Temperature. Note that the decimal points have been replaced with a "∗", to indicate that the unit requires recalibration.
5. When the **WP-91** is initialised…
   (a) The manual salinity correction value is re-set 36.0ppK. See section 8 if you wish to change this value.
   (b) The Altitude or Pressure correction system is switched off, and the instrument assumes sea level (0m) and 1013HPa.
   (c) The automatically recognised buffers are re-set to pH4.01, pH6.86 and pH9.18. To change these, see section **Error! Reference source not found.**.

19. Instrument firmware version number.

If you need to phone or fax TPS for any further technical assistance, the version number of your **WP-91** firmware may of benefit to us. The version number is displayed by the **WP-91** at turn-on.

20. Troubleshooting

20.1 General Errors

Error Message	Possible Causes	Remedy
Factory Cal. Failed	The EEPROM chip which contains the factory calibration information has failed.	The unit must be returned to TPS for service.
Memory Failed Calibration Lost **Initialised MUST ReCalibrate**	User calibration settings have been lost or corrupted.	Re-calibrate the instrument… • Zero and Air calibration for Dissolved Oxygen (section 4). • 2-point calibration for pH (section 5). • 1-point calibration for temperature (section 7).
Flashing symbol.	Battery is below 5.60 volts.	Recharge the battery. Note that the unit will switch itself off when the battery falls below 5.00 volts.
Meter displays the word **OFF**, and switches off.	Battery is below 5.00 volts.	Recharge the battery. If this fails, check the charger. If charger OK, replace the battery.
Meter will not turn on.	1. Battery is exhausted.	Recharge the battery. If this fails, check the charger. If charger OK, replace the battery.
	2. Faulty Instrument	Return to factory for repair.
Battery does not charge up when charger is connected.	3. Faulty battery charger or faulty battery.	Connect the charger and switch the power on. Display the battery volts in the battery saver menu (section 14). If the battery volts are increasing then the charger is OK. If the battery volts do not increase, then the charger is faulty. Replace the charger or the battery, as required.
	4. Faulty instrument.	Return to factory for repair.

20.2 Dissolved Oxygen Troubleshooting

Symptom	Possible Causes	Remedy
Unit fails to calibrate, even with new sensor.	Calibration settings outside of allowable limits due to previous failed calibration.	Initialise the unit. See section 18.
• Zero calibration fails (Zero is greater than 7.0%) • Air calibration fails (Span is less than 65% or greater than 200%). • Unstable or inaccurate readings.	1. Membrane is leaking or broken. 2. Gap between membrane and gold cathode is dry. 3. Incorrectly fitted membrane. 4. Sensor is empty. 5. Sensor is faulty.	Replace membrane and refill sensor. Gently pump the pressure compensation diaphragm to re-flush the membrane. Membrane should be smooth and convex with no wrinkles. Re-fit membrane if necessary. Replace membrane and re-fill sensor. Return sensor to factory for repair or replacement
Blackened Silver anode wire	Sensor has been exposed to sulphides or other chemical poisoning.	Return to the TPS factory for cleaning and service.
Tarnished or scratched Gold cathode.	Sensor has been chemically poisoned or physically damaged.	Return to the TPS factory for cleaning and service.
Meter reads **OVR ppM** or **OVR%**.	1. Sensor has not yet polarised. 2. Sensor is faulty	Wait for 2-3 minutes for the sensor to polarise after the **WP-91** is switched on. Return sensor to factory for repair or replacement.
Display flashes “ATC” and “LIMIT”	The Temperature is not within the ATC limits.	Cool/Heat solution before taking measurements.

20.3 pH and mV/ORP Troubleshooting

Symptom	Possible Causes	Remedy
Unit fails to calibrate, even with new sensor.	Calibration settings outside of allowable limits due to previous failed calibration.	Initialise the unit. See section 18.
1 Point calibration fails (Asymmetry is greater than +/- 1.00 pH).	1. Reference junction blocked.	Clean reference junction, as per instructions supplied with the sensor.
	2. Reference electrolyte contaminated.	Flush with distilled water and replace electrolyte.
2 Point calibration fails (Slope is less than 85.0%).	1. Incorrect primary buffer.	Ensure that you are using the primary buffer for which the **WP-91** has been set (see section **Error! Reference source not found.**).
	2. Glass bulb not clean.	Clean glass bulb as per instructions supplied with the sensor.
	3. Sensor is aged.	Attempt rejuvenation, as per instructions supplied with the sensor. If not successful, replace sensor.
	4. Connector is damp.	Dry in a warm place.
	5. Buffers are inaccurate.	Replace buffers.
Unstable readings.	1. Electrolyte chamber needs to be refilled.	Refill with saturated KCl filling solution.
	2. Reference junction blocked.	Clean reference junction, as per instructions supplied with the sensor.
	3. Glass bulb not clean.	Clean glass bulb as per instructions supplied with the sensor.
	4. Bubble in glass bulb.	Flick the sensor to remove bubble.
	5. Faulty connection to meter.	Check connectors. Replace if necessary.
	6. Reference junction not immersed.	Ensure that the bulb AND the reference junction are fully immersed.
	7. KCl crystals around reference junction, inside the electrolyte chamber.	Rinse electrolyte chamber with warm distilled water until dissolved. Replace electrolyte.

Continued next page…

pH and mV/ORP Troubleshooting, continued…

Inaccurate readings, even when calibration is successful.	Reference junction blocked.	Clean reference junction, as per instructions supplied with the sensor.
Displays 7.00 for all solutions.	Electrical short in connector.	1. Check connector. Replace if necessary. 2. Replace sensor.
Displays 4-5 pH for all solutions.	Glass bulb or internal stem cracked.	Replace sensor.

20.4 Temperature Troubleshooting

Symptom	Possible Causes	Remedy
Displays "**OVRºC**" when Dissolved Oxygen or Temperature sensor is plugged in.	1. Faulty sensor. 2. Faulty instrument.	Return sensor to factory for repair or replacement. Return to factory for repair.
Temperature inaccurate and cannot be calibrated.	1. Faulty connector. 2. Faulty Dissolved Oxygen or Temperature sensor. 3. Faulty instrument.	Check the connector and replace if necessary. Return sensor to factory for repair or replacement. Return to factory for repair.

21. Dissolved Oxygen Sensor Fundamentals

The sensor used, is the amperometric type of Clark Sensor and is suitable for the measurement of oxygen pressures in the range 0 to 100 cm of mercury. While the sensor actually reads partial pressure of oxygen, the circuit is calibrated to be read in percentage saturation or parts per million (Milligrams/litre). The operation of sensors of the Clark type relies on the diffusion of oxygen through a suitable membrane into a constant environment of 0.1 molar potassium chloride. Measurements are best performed with a reasonable flow past the membrane. At sufficiently high flow rates, the oxygen current is totally independent of the flow (a few cm/sec.). The cell must not be shaken however or unstable readings will result from electrolyte surge bringing new oxygen from the reservoir to the working cathode surface.

21.1 Operating Principle

The Clark oxygen sensor consists of a gold cathode and a silver/silver chloride anode, placed in an electrolyte solution. This solution is contained behind a plastic membrane. In this case the plastic is 0.025mm intermediate density polyethylene sheet. PTFE (Teflon) can be supplied for special applications. It must be realised that using membranes of very different thicknesses will result in an error in the temperature compensation that is applied in the instrument for the membrane permeability. This coefficient (here +4.2%/°C at 25°C) is for this thickness polyethylene. A polarising voltage of about 800 millivolts is applied between the two electrodes. The gold electrode is placed close to the membrane and because of the polarising voltage, oxygen diffusing through the membrane will be reduced at the gold electrode.

Equation: $O_2 + 2H^+ + 2\text{ electrons} \rightarrow H_2O_2$

This reduction process will produce a current through the oxygen sensor. A load resistor (actually a thermistor in this case) situated in the sensor itself, converts this current into a voltage proportional to the oxygen partial pressure. The thermistor provided within the body of the sensor can have a temperature coefficient of -4.2%/°C. This gives an accurate temperature compensation for the temperature/permeability effect of the membrane to oxygen, over a range of ±20°C about a centre value of 25°C. Note this compensation is not for the solubility effects. A separate sensor also included achieves this.

21.2 Maintenance Of The Membrane

The membrane does not require replacement as long as it remains intact. If punctured or suspected of leaking around the edges, it must be replaced.

To replace the membrane, please see the separate instruction leaflet supplied with the EDYSI sensor.

21.3 Sensor Storage

The Oxygen sensor should be kept moist when not in use to prevent the thin film of electrolyte behind the membrane from drying out. To achieve this, the sensor can be stored with the tip in water.

If the membrane does dry out, gently pump the pressure compensating diaphragm (approx half way up the sensor). This will re-flush the gap between the gold cathode and the membrane with fresh electrolyte. DO NOT USE A SHARP OBJECT, AS THIS MAY RUPTURE THE DIAPHRAGM.

For long term storage of several weeks or more…

1. Remove the membrane
2. Hold the sensor with the tip facing downwards and gently pump the pressure compensating diaphragm until the sensor is empty.
3. Rinse the inside of the sensor tip with distilled water.
4. Fit a new membrane WITHOUT REPLACING THE ELECTROLYTE.
5. Remember to re-fill the sensor and fit a new membrane before its next use.

21.4 Notes On Units Of Dissolved Oxygen

The terms "Oxygen Concentration" and "Oxygen Partial Pressure" frequently give rise to some confusion.

- Oxygen Concentration is the absolute quantity of oxygen present per unit mass of the liquid.
- Oxygen Partial Pressure is the oxygen fraction of the total pressure of all of the gases present.

For any one liquid system, Oxygen Concentration and Oxygen Partial Pressure are proportional. However, if the solubility of oxygen in the liquid should change owing to increased quantities of solutes, etc., then the ratio of the Concentration to the Partial Pressure must change. Thus, if one saturates distilled water and a 25% solution of Sodium Chloride with air at atmospheric pressure (25ºC) both solutions will have almost exactly the same Oxygen Partial Pressure, namely 15.5 cms of mercury. However, the dissolved Oxygen Concentration parts per million (milligrams per litre) will be 8.2 in the distilled water and 2.01 in the salt solution. This is a rather extreme example, as ocean water is only 3.6% saline. It does however stress the importance of correct interpretation of the salinity, etc.

The Clark Sensor measures the partial pressure of oxygen diffusing through a membrane. The current is a linear measure of this partial pressure, assuming liquid flow conditions are met.

With air, at sea level, the 20.9% oxygen exerts about 15.5 cms (mercury standard) pressure. Water in equilibrium with air and with no C.O.D. or B.O.D., etc., is saturated and has this dissolved oxygen partial pressure. If we define 100% Saturation in Partial Pressure terms, then 15.5 cm. Hg = 100% Saturation. This is a practical unit to use. The sensor linear readout is then a linear function of % Saturation. Organic cell walls behave like the sensor and pressure units are valuable.

% Saturation is the best unit for industrial control and not ppM, contrary to popular beliefs. The partial pressure (and consequently the pressure defined % Saturation) varies only slightly with temperature. (Recall at this stage that the permeability of the membrane has a temperature coefficient, but the electronics has scaled this out by the operation of the Automatic Membrane Temperature Compensator Thermistor incorporated in the D.O. sensor).

If mass units are used for measurement of Dissolved Oxygen, the temperature problem of relating the linear partial pressure reading of the sensor, to the mass (ppM or mg/L) at different temperatures becomes more involved. As well, there is the mass variation due to dissolved salts (salinity correction). Therefore, the fully corrected instrument would need 3 correction systems.

(a) Membrane correction for temperature permeability effects.
(b) Solubility correction of Dissolved Oxygen with temperature and
(c) Salinity correction of Dissolved Oxygen by weight (Salinity has no effect on pressure units readout).

In the **WP-91** instrument,
(a) is achieved AUTOMATICALLY.
(b) To provide the mass units (ppM) readout (so popular due to the Winkler process used in the past), the **WP-91** Meter has Solubility Correction via an additional temperature sensor in the sensor.
(c) Salinity correction is provided by manual entry of the salinity of the sample. This must first be measured with a good quality salinity meter, such as a TPS model MC-84 or a WP-84.

21.5 Equilibrium Conditions

Whilst Saline Water has a lower ppM than does Fresh Water, it does not mean it necessarily has less oxygen, biologically available. Both have 100% Saturation (presuming no Chemical Oxygen Demand (C.O.D.), Biological Oxygen Demand (B.O.D.), etc.) because both are in partial pressure equilibrium with air. Any usage of oxygen is immediately supplied by the dissolving of more from air, to meet partial pressure equilibrium requirements. This is so for both saline and fresh water. The reporting of oxygen at a lower level (in ppM units) in the Salt Water is therefore QUITE MISLEADING!

In closed systems, such as tanks, pipes and deep waters, equilibrium is not so readily available and the Salinity Effect gains the importance in the reporting of Dissolved Oxygen. It is suggested, unless such closed (or deep, low diffusion) systems are encountered, that Oxygen should be reported in % Saturation or ppM of equivalent Fresh Water.

21.6 Velocity Past The Membrane

Workers have shown that the relationship between the diffusion current (oxygen current) and the external velocity of the liquid is expotential. Some workers using thicker membranes have shown even less dependence of the diffusion current on liquid velocity. Because of the expotential nature of the relationship, very considerable changes in velocity have to be made before noticing any change in the diffusing current once the flow is sufficiently high. Tests with this sensor have shown that flow rates above 0.2 litres/minute past the membrane give results indistinguishable from those with appreciably higher flow rates (5 litres/minute). Fluctuations in readings due to air bubbles passing through the membrane are, however, a different matter. With the type of sensor to be used with this instrument, very little changes in diffusion current are caused by altering the pH of the external environment. The EDYSI sensor is fitted with a pressure compensating diaphragm, so pressure changes will also cause no change. The EDYSI can be immersed up to 60 metres.

22. pH Sensor Fundamentals

A combination pH Sensor is two sensors in one. The sensing membrane is the round or spear shaped bulb at the tip of the sensor. This produces a voltage that changes with the pH of the Solution. This voltage is measured with respect to the second part of the sensor, the reference section. The reference section makes contact with the sample solution using a salt bridge, which is referred to as the reference junction. A saturated solution of KCl is used to make contact with the sample. It is vital that the KCl solution has an adequate flow rate in order to obtain stable, accurate pH measurements.

22.1 Asymmetry of a pH Sensor

An “ideal” pH sensor produces 0 mV output at 7.00 pH. In practice, pH sensors, generally produce 0 mV output at slightly above or below 7.00 pH. The amount of variance from 7.00 pH is called the asymmetry. Figure 22-1 illustrates how asymmetry is expressed.

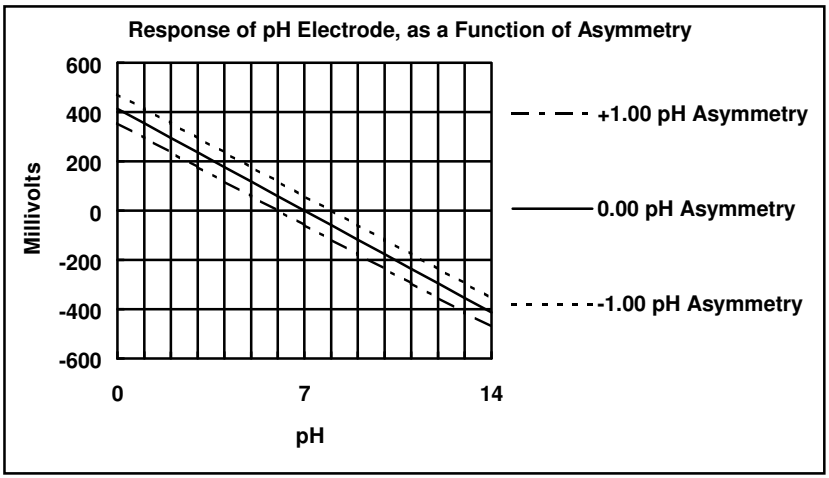


Figure 22-1

22.2 Slope of a pH Sensor

As mentioned above, a pH sensor produces 0 mV output at around 7.00 pH. As the pH goes up, an “ideal” pH sensor produces -59mV/pH unit at 25 °C As the pH goes down, an ideal pH sensor produces +59mV/pH unit. In practice, pH sensors usually produce slightly less than this. The output of a pH sensor is expressed as a percentage of an ideal sensor. For example, an ideal sensor that produces 59mV/pH unit has “100% Slope”. An sensor that produces 50.15mV/pH unit has “85% Slope” (see Figure 22-2).

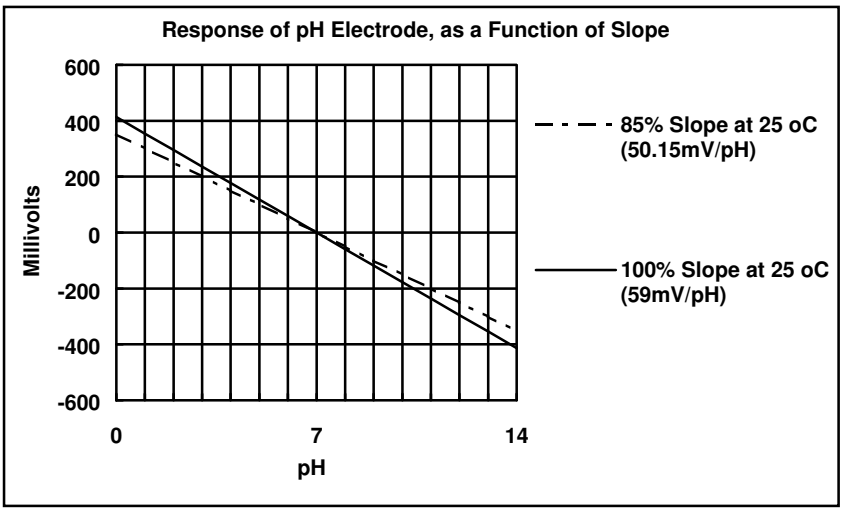


Figure 22-2

22.3 pH Temperature Compensation

The slope of a pH sensor (section 22.2) is affected by temperature. This effect is compensated for either by using an Automatic Temperature Compensation (ATC) sensor or by entering the sample temperature manually. Figure 22-3 shows the slope of a pH sensor at various temperatures.

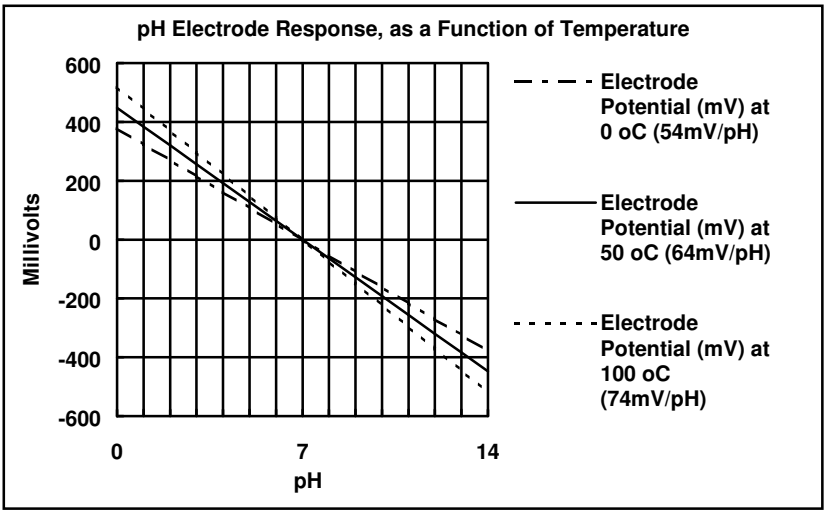


Figure 22-3

23. Warranty

TPS Pty Ltd guarantees all instruments and sensors to be free from defects in material and workmanship when subjected to normal use and service. This guarantee is expressly limited to the servicing and/or adjustment of an instrument returned to the TPS Pty Ltd Factory Service Centre, freight prepaid, within twelve (12) months from the date of delivery, and to the repairing, replacing, or adjusting of parts which upon inspection are found to be defective. Warranty period on sensors is six (6) months.

Freight costs to and from the factory are the responsibility of the purchaser. Shipping damage is not covered by this warranty.

TPS Pty Ltd accepts no liability for any incidental or consequential damages caused by or resulting from the use or misuse of this equipment either due to failure of the equipment, incorrect calibration, incorrect operation, or from interpretation of information derived from the equipment. Specifications are subject to change without notice. This warranty becomes invalid if modifications or repairs are carried out on this unit by unauthorised persons. There are no express or implied warranties which extend beyond the face hereof.

Procedure for Service

Please read service details on our **'Service' web page** first:
http://www.tps.com.au/service.htm

TPS Pty Ltd has a reputation for prompt and efficient service. If you feel that this equipment is in need of repair, please re-read the manual. Sometimes, instruments are received for "repair" in perfect working order. This can occur where batteries simply require replacement or re-charging, or where the sensor simply requires cleaning or replacement.

Return the instrument AND ALL SENSORS to TPS Pty Ltd freight pre-paid. It is your responsibility as the sender to ensure that TPS Pty Ltd receives the unit, so consider using a traceable freight service.

Please check that the following is enclosed with your equipment:

- **A TPS 'Service / Return Goods Form' – see web link below:**
  http://www.tps.com.au/Service/Service%20form_web.pdf
- **Your full name**
- **Your company name**
- **Your email address or fax number**
- **Your return street address**
- **A description of the fault. (Please be specific - "Please Repair" does not describe a fault.)**

Your equipment will be repaired and returned to you by express air freight where possible.

For instruments beyond warranty period, a repair cost will be calculated from parts and labour costs and emailed to you. If you decline to have the equipment repaired, the complete instrument will be returned to you freight paid, not serviced.

TPS Pty Ltd has only one service location, which is located at our factory in Brisbane:

Service Department
TPS Pty Ltd
Unit 6 / 253 Leitchs Road
Brendale, QLD 4500
Australia
T: (07) 3205 8027
F: (07) 3808 4871
E: tps@tps.com.au
W: www.tps.com.au