Congratulations !

You have purchased the latest in Handheld Dissolved Oxygen-pH-mV-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.

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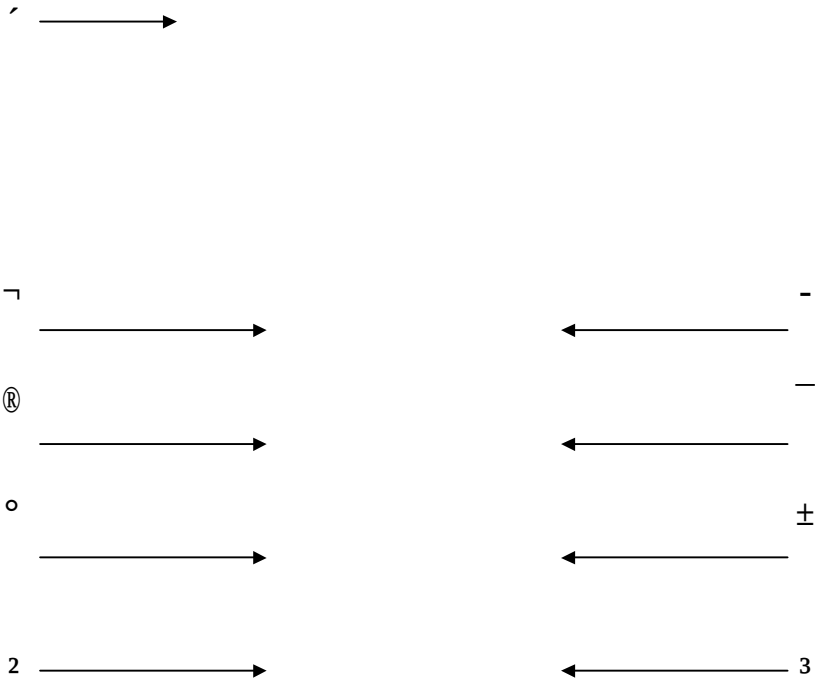
Model WP-91
Dissolved Oxygen - pH-mV-Temp Meter

Version : 1.01
Date : 19/02/2003
Author : MS

Contents

1. Introduction

1.1 WP-91 Display and Controls



¬ **F1**

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.

- **F2**

Press to alternate temperature, date/time, and manual Salinity/Altitude/ Pressure values on the display. See section 15.2.

Also used to select pH6.88 or pH7.00 as the primary pH buffer (section 16).

® **F3**

Press to start or stop automatic logging. See section 12.

Alternatively, press to transmit current reading plus date and time to the RS232 port (optional) See section 13.2.

– **F4**

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

o **Menu**

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

± **▲** and 3 **▼**

The ▲ and ▼ keys are used for calibrating temperature readout (section 7.1), setting the clock (section 15.1), setting the automatic logging period (section 12), and displaying GLP information (section 10.1).

The ▲ key is also used to intialise the **WP-91** at turn-on. See section 17.

2 **ON OFF**

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

´ **Display**

32 character alpha-numeric display with user-friendly menu and prompting system. Shows Dissolved Oxygen, pH 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-Temp Instrument	123150
2. pH6.88 Buffer, 200mL	121306
3. pH4.00 Buffer, 200mL	121381
4. Battery charger	130037
5. **WP-91** Handbook	130050

	Part No
Options that may have been ordered with your **WP-91**:	
1. YSI Dissolved Oxygen-Temperature Sensor	123204
2. 3m Cable for DO_2 Sensor	123221
3. Combination pH Sensor, 1m	121207
4. Combination Redox Sensor, 1m	121262
5. Temperature Sensor, 1m	121253
(when Dissolved Oxygen sensor not in use)	
6. RS232 Serial Interface Option (includes cable)	130039
7. Communication software for Windows 3.1, 95 & NT	130086
8. Communication software for DOS	130085
9. Hard Carry Case	130059
10. Battery charger lead for 12V cigarette lighter socket	130046
11. Solar Panel	130012
12. RS232 Printer	130031

Other spares:	
1. 6V NiCad Battery	130038
2. RS232 Interface Cable	130041
3. Membrane, Filling Solution & Zero DO_2 Kit	123300
4. Sodium Sulphite for Zero DO_2 calibration, 50g	123302
5. Filling Solution for EDYSI Sensor, 45mL	123307

1.3 Specifications

Mode	Range*	Resolution	Accuracy
Dissolved Oxygen ppM (mg/L)	0 to 20.00 ppM 20.0 to 40.0 ppM	0.01 ppM 0.1 ppM	±0.2% of full scale of selected range
Dissolved Oxygen % Saturation	0 to 240.0 % Sat 240 to 450 % Sat	0.1 % Sat 1 % Sat	±0.3% Saturation
% Gaseous Oxygen	0 to 45.0 % Gas 45 to 100 % Gas	0.1% Gas 1 % Gas	±0.1 % Gaseous
pH	0 to 14.00 pH	0.01 pH	±0.01 pH
mV	0 to +/-500.0 mV 0 to ±1500 mV	0.15 mV 1 mV	±0.3 mV ±1 mV
Temperature	-10.0 to 120.0 ^{O}C	±0.1 ^{O}C	±0.2 ^{O}C

*Oxygen ranges subject to sensor performance.

Dissolved Oxygen Specifications

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

Barometric Pressure Correction : User-set, from 800 to 1100 HPa

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

Temperature Compensation : Dual automatic temperature compensation system.

DO_2 Sensor Span Range : 70 to 135%

DO_2 Sensor Zero Range : 0 to 7.5%

Automatic Calibration : Zero in Sodium Sulphite (Na_2SO_3) Solution
Span in Air.

pH Specifications

Input Impedance : >3 x 10^{12} Ω

Asymmetry Range : -1.00 to 1.00 pH

Slope Range : 85.0 to 105.0 %

Temperature Compensation : Automatic, 0 to 100 ^{O}C

Temperature Specifications

Temp. Sensor Offset Range : -10.0°C to +10.0°C

General Specifications

Memory : 150 readings including date and time

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

RS232 Output (optional) : 300, 1200 & 9600 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 optional 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 optional RS232 port at any time.

Power : 6V NiCad Rechargeable Battery for approx 75 hours operation.

Dimensions : 187 x 110 x 51 mm

Mass : Instrument only : Approx 440g
Full Kit : Approx 2.0 kg

Environment Temperature : 0 to 45 °C
Humidity : 0 to 90 % 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 menu functions available for the **WP-91**.

Press the function keys in normal display mode, to perform the following tasks:

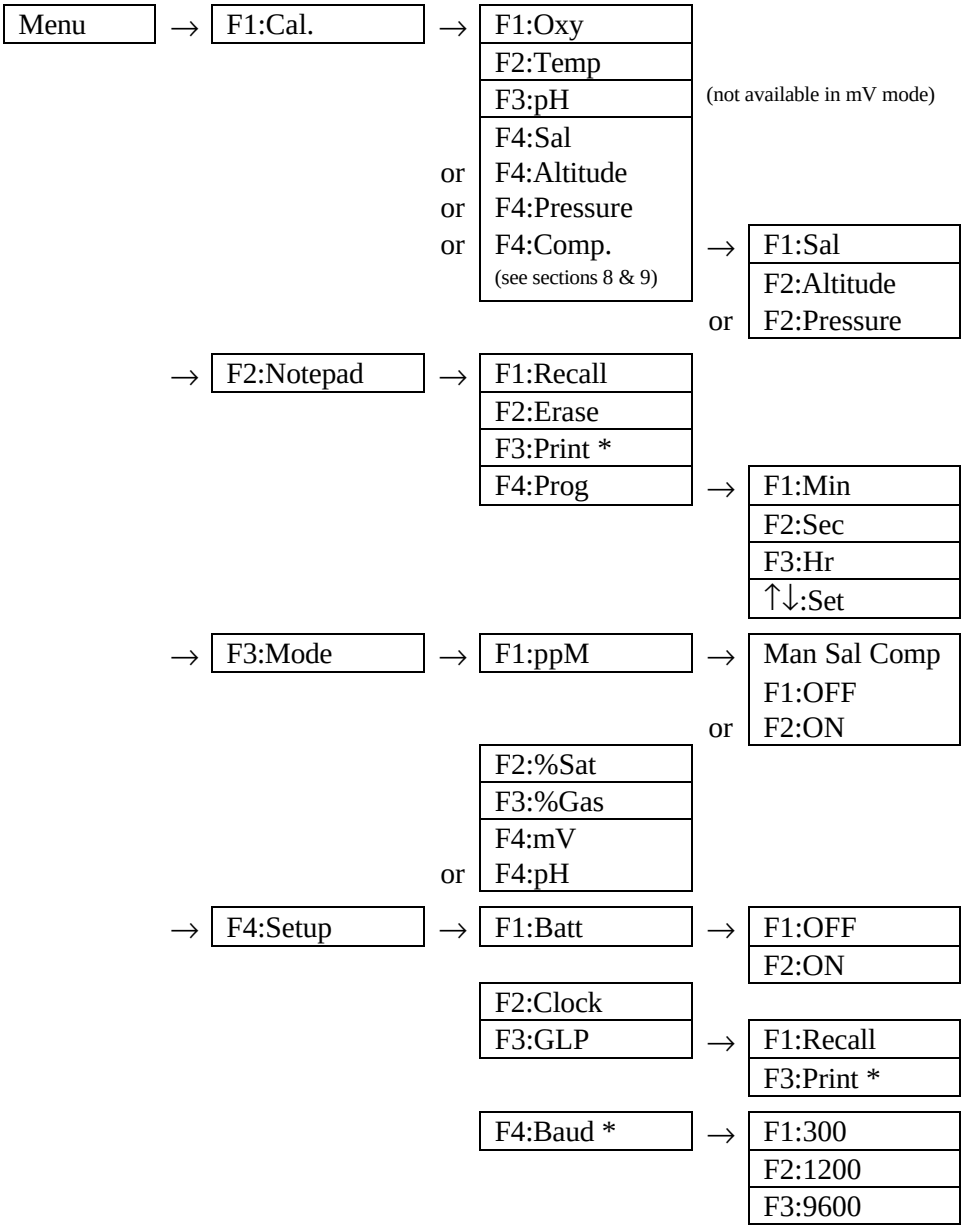
F1 : Press to record current data plus date and time into memory.

F2 : Press to show or hide temperature, date/time or manual Salinity/ Altitude/ Pressure setting.

F3 : Press to start and stop automatic logging.
If logging period is set to zero, press to transmit current reading plus date and time to the RS232 port.

Menu : Press to access the user-friendly menu system, as detailed over the page.

WP91 Menu Structure



* These functions available when RS232 option is fitted.

3. Oxygen Operating Modes

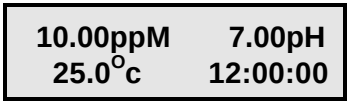
The **WP-91** has three Oxygen modes : ppM (mg/L), % Saturation, and % Gaseous.

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/mV and Temperature and the user-set Salinity value simultaneously. See section 8 for details on setting the Salinity correction value.

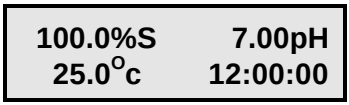
See section 15.2 for details on how to alternate temperature and date.



2. **F2:%Sat** (% Saturation readout)

Displays % Saturation Dissolved Oxygen, pH/mV and Temperature readings simultaneously.

See section 15.2 for details on how to alternate temperature and date.



3. **F3:%Gas** (% Gaseous readout)

Displays % Gaseous Oxygen, pH/mV and Temperature readings simultaneously.

See section 15.2 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 4.1, 5.1 & 7.1) or if the unit is initialised (section 17).

4. Dissolved Oxygen Calibration

4.1 Calibration Procedure

1. Plug the Dissolved Oxygen sensor into the **Dissolved Oxygen** socket.
2. Switch the meter on. ON/OFF
3. Select the mode of your choice. Menu → **F3:Mode** → **F1 to F3**
4. Ensure that temperature has already been calibrated (see section 7.1).

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.

NOTES:

When taking sample measurements, always ensure that there is adequate flow of solution past the membrane for accurate, stable readings. See section 20.6.

If salinity-corrected ppM Dissolved Oxygen readings are required, set the salinity correction value before taking sample measurements. See section 8.

If Altitude or Atmospheric Pressure Correction is selected, set the correction value before calibrating and taking measurements. See section 9.

4.2 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).

4.3 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.

Zero Cal. OK **Zero= 0.0%**

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

Air Cal. OK **Span= 100.0%**

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

Air Cal. Fail **Span= 65.0%**

or

Air Cal. Fail **Span= 140.0%**

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. ON/OFF
3. Select pH Mode. Menu → **F3:Mode** → **F4:pH**
4. Ensure that temperature has already been calibrated (see section 7.1). **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 16).

Place both sensors into a small sample of pH6.88 (or pH7.00) buffer, so that the bulb and reference junction are both covered.

DO NOT place the sensors directly into the buffer bottle.

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 pH and Dissolved Oxygen/Temperature sensors in distilled water and blot them dry.
11. Place both sensors into a small sample of pH4.00 or pH9.23 Buffer, so that the bulb and reference junction are both covered. **DO NOT** place the sensors directly into the buffer bottle.

NOTE: **pH9.23 buffer is highly unstable. Avoid using this buffer if possible. 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.

1 Point Cal. OK **Asy= 0.10pH**

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

1 Point Cal. Fail **Asy= 1.50**	or	**1 Point Cal. Fail** **Asy= -1.50**

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.

2 Point Cal. OK **Asy= 0.10pH**	then	**2 Point Cal. OK** **Slope= 100.0%**

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

2 Point Cal. Fail **Slope= 130.0%**	or	**2 Point Cal. Fail** **Slope= 70.0%**

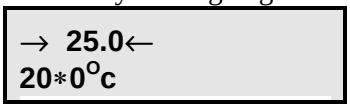
6. mV Calibration

The mV section is factory calibrated. There is no user-calibration facility 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. [ON OFF]
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 probe 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.

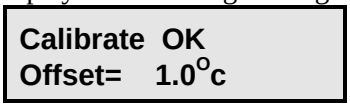
The ∗ will now be replaced by a decimal point, if calibration was successful.
Alternatively, press the [Menu] key to abort temperature calibration.

7.2 Calibration Notes

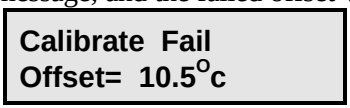
1. Temperature calibration information is retained in memory when the **WP-91** is switched off, even when the battery is removed. This information can be recalled or printed later using the GLP function (see section 10).
2. Temperature does not need to be recalibrated unless the sensor is replaced or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



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



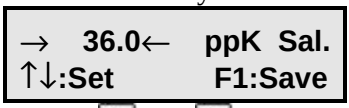
8. Salinity Correction

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.



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.

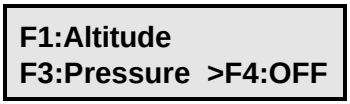
6. When manual Salinity correction is selected, an "**s**" is shown on the display.

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, by pressing the ON/OFF key.
2. Press and hold the F1 key while switching the **WP-91** back on with the ON/OFF key.
3. The Altitude or Pressure mode menu is now displayed.



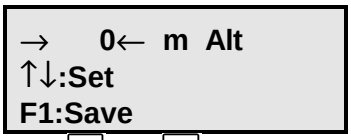
The arrow indicates the current selection.

4. Press F1 to select Altitude correction.

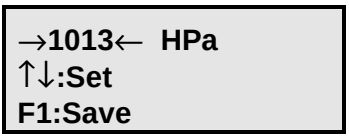
Press F3 to select Atmospheric Pressure correction.

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.



or



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 with the ON/OFF key.
2. Select Altitude or Pressure calibration, depending upon which is switched on:

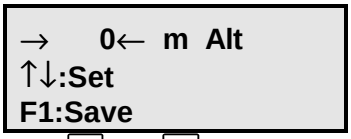
ie: Menu → **F1:Cal.** → **F4:Altitude**

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

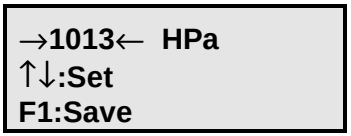
If Manual Salinity Correction is currently selected, then the above key sequence becomes Menu → **F1:Cal** → **F4:Comp** → **F2:Altitude**

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

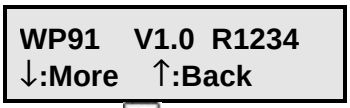
1. For optimum accuracy, the altitude or pressure should be set before calibrating or taking measurements.
2. When the altitude or atmospheric pressure correction system is switched off, the **WP-91** assumes sea level (0m) and 1013 HPa conditions. These values are satisfactory for the precision required 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 **WP-91** display in normal measurement mode.
5. % Saturation and % Gaseous readings are normalised to sea level (0m) and 1013HPa, when altitude or atmospheric pressure compensation is in use.
6. 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.

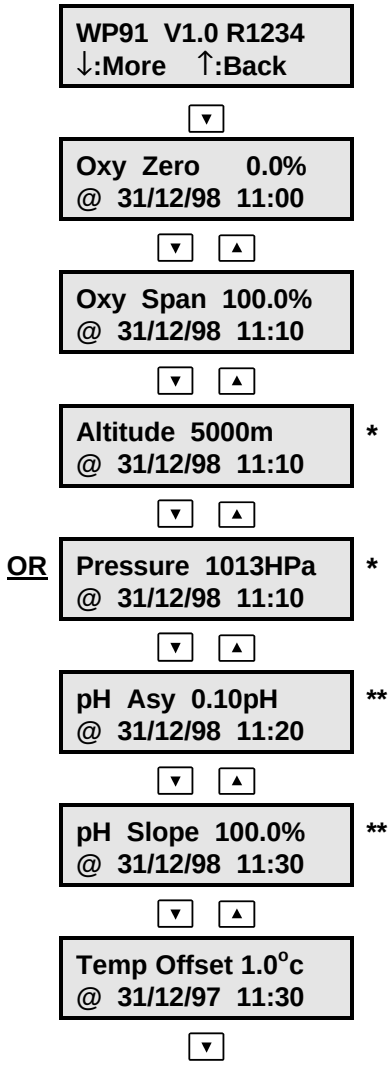
10.1 To recall GLP information on the display

1. Switch the meter on. ON/OFF
2. Select the GLP menu. Menu → **F4:Setup** → **F3:GLP**
3. Select recall. **F1:Recall**
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.

eg:

Oxy Zero 0.0%	**Oxy Span 100.0%**
@ 00/00/00 00:00	**@ 00/00/00 00:00**
Altitude 5000m	**Pressure 1013HPa**
@ 00/00/00 00:00	**@ 00/00/00 00:00**
pH Asy 0.10pH	**pH Slope 100.0%**
@ 00/00/00 00:00	**@ 00/00/00 00:00**
Temp Offset 1.0°c	
@ 00/00/00 00:00	

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. This function is available only when the optional RS232 port is fitted.

1. Switch the meter on. ON/OFF
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.

eg:
```
WP91    V1.0 R1234 @ 31/12/98 12:00
Oxygen      Zero=       0.0%     @ 31/12/97 11:00
Oxygen      Span=     100.0%     @ 31/12/97 11:10
Oxygen      Altitude=  5000m     @ 31/12/97 11:10
Oxygen      Pressure=  1013HPa   @ 31/12/97 11:10
pH          Asy=       0.10pH    @ 31/12/98 11:20
pH          Slope=    100.0%     @ 31/12/98 11:30
Temperature Offset=     1.0oC    @ 31/12/97 11:40
ENDS
```

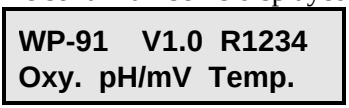
NOTE: Either Altitude **OR** Pressure is sent, depending upon which was selected the last time the instrument was calibrated.

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 **R1234** 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

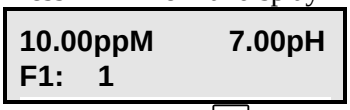
Another GLP requirement is to record the date and time of every reading. The **WP-91** does this for you when readings are recorded either with the Notepad function (section 11) or the Automatic Logging function (section 12).

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/mV, 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 150.

11.2 Recalling Records from the Notepad

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

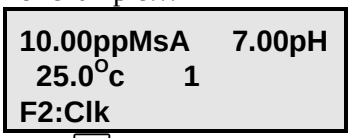
1. Select the Notepad menu [Menu] → **F2:Notepad**
2. Select Recall from the menu **F1:Recall**
3. Record number 1 is now displayed.

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

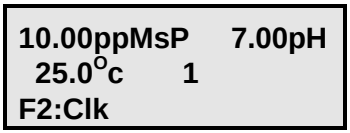
An "**A**" is displayed if Altitude correction was switched on when the reading was recorded.

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

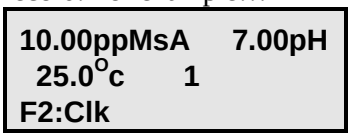
For example…



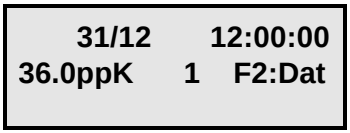
or



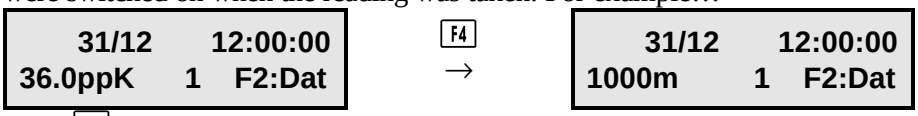
4. Press [F2] to alternate between the data and the date/time/compensation for this record. For example…



[F2] →



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 Erase from the menu **F2:Erase**
3. The **WP-91** now asks if you are sure that you wish to erase all records.

Erase, You Sure?
F1:Yes F2:No

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

This function is only available when the optional RS232 port is fitted.

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 Print from the menu. **F3:Print**

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

12. Automatic Datalogging

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:

→00← F1:Min F2:Sec
↑↓:Set Period F3:Hr

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. If the optional RS232 port is fitted, 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 150 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.
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…

10.00ppM	7.00pH
Log# 1	12:00:00

The log number will increment and the **WP-9** 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…

10.00ppM	7.00pH
Sending	12:00:00

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

8. Press [F3] to stop automatic logging.

Note: 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.

13. RS232 Port

This section is applicable if the optional RS232 port is fitted.

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.

ie: **F1:300** **F2:1200**
→ **F3:9600**

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 [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 display 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 datalogging. 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. The diskette supplied by TPS contains a BASIC program for this purpose. A Windows® version is also optionally available.

Once the data is saved to disk, the next problem is how to use it. The data is formatted columns that can be imported by programs such as Microsoft® Excel® and Lotus 123®.

Information on how to use the software is provided in the README files on the diskette.

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, 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♦♦V1.0♦R1234♦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 13.6 for data format and handshaking).

13.6 Data Format

Data is returned to the RS232 port by the **WP-91** in the following format…

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

where:	**LLLL**	is the Log Number. Maximum 4 characters, right justified. The **WP-91** sends a Zero for instant readings (section 13.2)
	♦	is one space.
	DDDDDD	is Oxygen Data. Maximum 6 characters, right justified.
	uuu	is the unit description, either "ppM**"**, "%S**♦"**, or "%G**♦**", (where **♦** is 1 space)
	♦	is one space.
	SSSSSS	is the Salinity correction value. Maximum 6 characters, right justified.
	ppK	is the salinity correction value unit description.
	♦	is one space.
	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, (where **♦** is 1 space).
	♦	is one space.
	PPPPPP	is pH or mV Data. Maximum 6 characters, right justified.
	uuu	is the unit description, either "pH**♦**" for pH or "mV**♦**" for mV, (where **♦** is one space).
	♦	is one space.
	TTTTTT	is the Temperature Data. Maximum 6 characters, right justified.
	oC♦	is the Temperature unit description, (where **♦** is 1 space).
	♦	is one space.
	dd/mm/yy	is the date, month and year data.
	♦	is one space.
	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 it is sent by the **WP-91** using the Print function (section 11.4) or the Instant 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 4, 5, 6 or 7 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    V1.0 R1234 @ 31/12/98 12:00
Oxygen      Zero=       0.0%     @ 31/12/98 11:00
Oxygen      Span=     100.0%     @ 31/12/98 11:10
Oxygen      Altitude=  5000m     @ 31/12/98 11:10
Oxygen      Pressure=  1013HPa   @ 31/12/98 11:10
pH          Asy=       0.10pH    @ 31/12/98 11:20
pH          Slope=    100.0%     @ 31/12/98 11:30
Temperature Offset=     1.0oC    @ 31/12/98 11:40
ENDS
```

NOTE: 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.

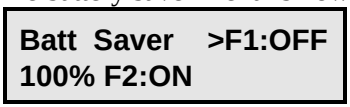
pH Asymmetry and pH Slope calibration data are only sent when the pH mode of the **WP-91** is switched on.

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. [ON/OFF]
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.

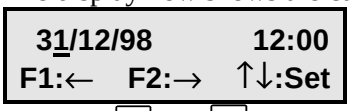
Press [Menu] to quit the battery saver menu and retain the current setting.

NOTE: For troubleshooting purposes, the battery volts can also be displayed in the battery saver menu. Press [F3] to display battery volts. The symbol flashes when the battery volts drops below 5.60 volts. At 5.00 volts the meter turns itself off.

15. Clock Function

15.1 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 31/02/96 is not corrected).

15.2 Displaying or Hiding the Clock

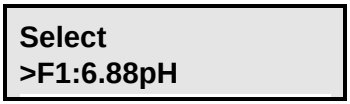
The time is normally displayed along with the Dissolved Oxygen, pH and Temperature readings.

- 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.

16. Selecting pH6.88 or pH7.00 as the Primary Buffer

The **WP-91** is factory set to automatically recognise pH6.88 as the primary buffer. However, some users may prefer to use pH7.00. The following procedure describes how to alternate between pH6.88 and pH7.00 as the primary buffer.

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



The arrow indicates the current selection.

4. Press F1 to select pH6.88 as the primary buffer.

Press F2 to select pH7.00 as the primary buffer.

Press Menu to quit buffer selection and retain the current setting.

5. The setting is kept in memory when the meter is switched off, even if the battery is removed. The primary buffer is re-set to pH6.88 during initialisation.

Note: pH6.88 buffer is a DIN 19266 and NBS Primary-standard pH solution. Its use is highly recommended for the most accurate possible results. If pH7.00 buffer is used, ensure that it is manufactured to 0.01pH accuracy. pH7.00 buffer has a buffer capacity less than half that of pH6.88 buffer and is therefore much less stable.

17. 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, by pressing the ON/OFF key.
2. Press and hold the ▲ key while switching the **WP-91** back on with the ON/OFF key.
3. The following messages should be displayed…

Initialized **MUST ReCalibrate**	then:	**WP91s V1.0** **R1234** **Oxy. pH/mV Temp.**

(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 primary pH buffer is re-set to pH6.88. See section 16 if you wish to use pH7.00 buffer.

18. 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.

19. Troubleshooting

19.1 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 4.1). • 2-point calibration for pH (section 5.1). • 1-point calibration for temperature (section 7.1).
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. 2. Faulty Instrument	Recharge the battery. If this fails, check the charger. If charger OK, replace the battery. Return to factory for repair.
Battery does not charge up when charger is connected.	1. Faulty battery charger or faulty battery. 2. Faulty instrument.	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. Return to factory for repair.

19.2 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 17.
• Zero calibration fails (Zero is greater than 7.0%) • Air calibration fails (Span is less than 70% or greater than 135%). • 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.

19.3 pH and mV Troubleshooting

Symptom	Possible Causes	Remedy
Unit fails to calibrate, even with new probe.	Calibration settings outside of allowable limits due to previous failed calibration.	Initialise the unit. See section 17.
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 16).
	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 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.

19.4 Temperature Troubleshooting

Symptom	Possible Causes	Remedy
Displays "**OVR°C**" 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.

20. 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 probe 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 probes 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 (few cms./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.

20.1 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%/^{o}C at 25^{o}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%/^{o}C. This gives an accurate temperature compensation for the temperature/permeability effect of the membrane to oxygen, over a range of ±20^{o}C about a centre value of 25^{o}C. Note this compensation is not for the solubility effects. A separate sensor also included achieves this.

20.2 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.

20.3 Probe Storage

The Oxygen probe 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 probe 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 probe). 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.

20.4 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 (25^{o}C) 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 probe linear readout is then a linear function of % Saturation. Organic cell walls behave like the probe 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. probe).

If mass units are used for measurement of Dissolved Oxygen, the temperature problem of relating the linear partial pressure reading of the probe, 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.

20.5 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.

20.6 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.

21. 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.

21.1 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 21-1 illustrates how asymmetry is expressed.

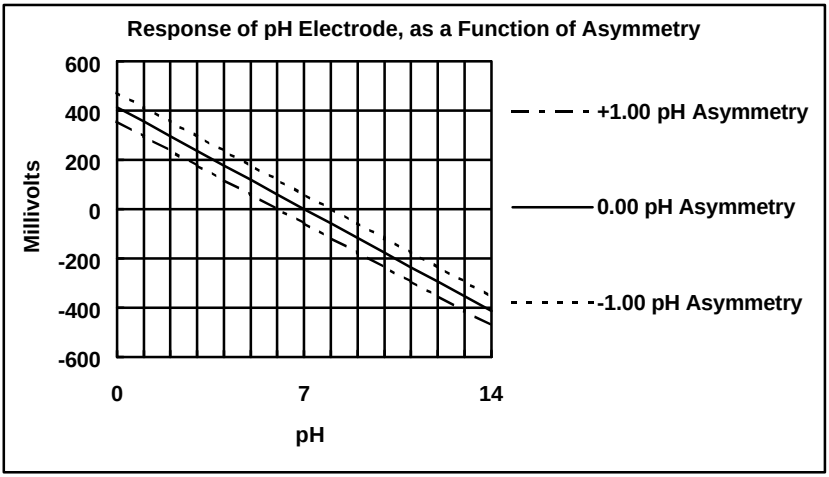


Figure 21-1

21.2 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 ^{o}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 21-2).

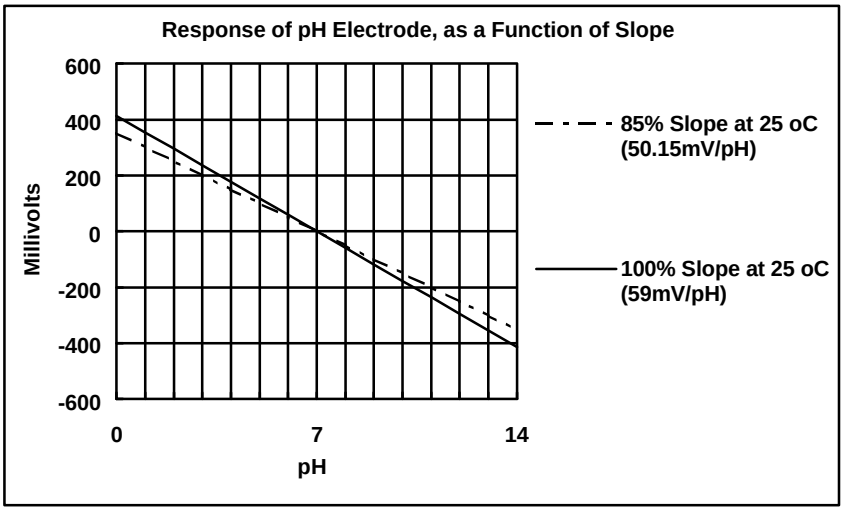


Figure 21-2

21.3 pH Temperature Compensation

The slope of a pH sensor (section 21.2) is affected by temperature. This effect is compensated for either by using an Automatic Temperature Compensation (ATC) probe or by entering the sample temperature manually. Figure 21-3 shows the slope of a pH sensor at various temperatures.

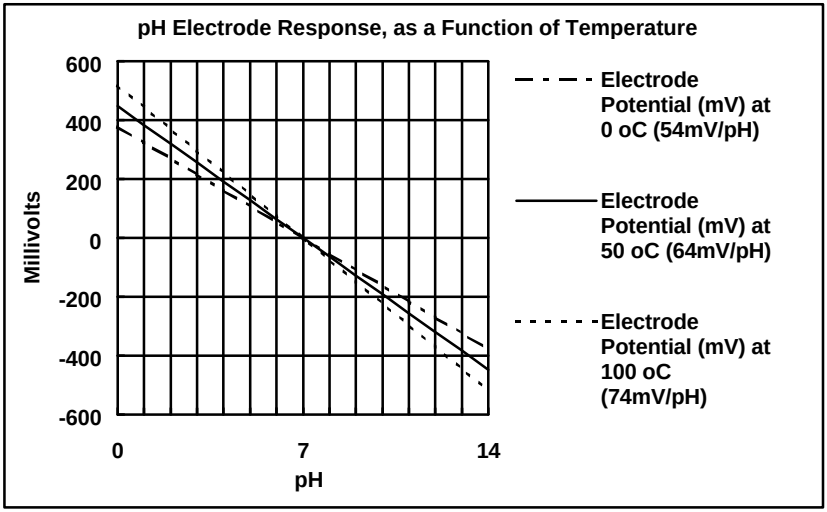


Figure 21-3

21.4 Checking the reference junction of a pH sensor

If pH readings are inaccurate or unstable, the reference junction of the sensor may be blocked. The following test can be performed to determine if the reference junction of a pH sensor is making adequate contact with the sample solution.

1. Calibrate the **WP-91**, as per section 5.1.
2. Dilute 1 part of pH6.88 buffer with 9 parts of distilled water.
3. Measure the pH of the diluted buffer. The result should be 7.06 +/-0.02 pH.
4. If the value obtained is outside of these limits, then clean the reference junction, as per the instructions supplied with the pH sensor.
5. Re-calibrate the **WP-91** and repeat the test.
6. If the value obtained is still outside 7.06 +/-0.02 pH, then the sensor should be replaced.

21.5 Determining if a pH meter or an sensor is faulty

The following test can be performed to help determine if the **WP-91** or the pH sensor is faulty.

1. Initialise the **WP-91** (see section 17).
2. Disconnect the pH sensor.
3. Connect the centre pin of the **pH/mV** connector with the outside frame of the connector, using a short piece of wire or a paper clip etc.
4. The meter should read approximately 7.00. If you press the Cal key, the **WP-91** will calibrate to around 6.88 pH, depending upon the temperature readout.
5. If the **WP-91** is operating correctly, the reading should be totally stable with the wire firmly in place. If not, the meter requires servicing.
6. Now carefully disconnect the wire from the centre pin only (make sure the other end of the wire remains connected to the outside frame of the connector).
7. The reading should steadily drift away from 7.00 (either up or down) at a rate of approximately 1 pH or less every 3 seconds. If the drift rate is faster than this, then input circuitry of the **WP-91** is faulty and requires servicing.

22. 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 Factory, or Authorised Service Station, 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 three (3) months.

There are no express or implied warranties which extend beyond the face hereof, and TPS Pty. Ltd. is not liable for any incidental or consequential damages arising from the use or misuse of this equipment, or from interpretation of information derived from the equipment.

Shipping damage is not covered by this warranty.

PLEASE NOTE

A guarantee card is packed with the instrument or sensor. This card must be completed at the time of purchase and the registration section returned to TPS Pty. Ltd. within 7 days. No claims will be recognised without the original guarantee card or other proof of purchase. This warranty becomes invalid if modifications or repairs are attempted by unauthorised persons, or the serial number is missing. simultaneously

PROCEDURE FOR 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.

TPS Pty. Ltd. has a fine reputation for prompt and efficient service. In just a few days, our factory service engineers and technicians will examine and repair your equipment to your full satisfaction.

To obtain this service, please follow this procedure:

Return the instrument AND ALL SENSORS to TPS freight pre-paid and insured in its original packing or suitable equivalent. INSIST on a proof of delivery receipt from the carrier for your protection in the case of shipping claims for transit loss or damage. It is your responsibility as the sender to ensure that TPS receives the unit.

Please check that the following is enclosed with your equipment:

- **Your Name and daytime phone number.**
- **Your company name, ORDER number, and return street address.**
- **A description of the fault. (Please be SPECIFIC.)**

(Note: "Please Repair" does NOT describe a fault.)

- **either $13.50 for return freight for units under warranty,**
  or $24 to cover inspection costs and return freight.
  (These amounts are not applicable to full-account customers.)

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

For out-of-warranty units, a repair cost will be calculated from parts and labor costs. If payment is not received for the additional charges within 30 days, or if you decline to have the equipment repaired, the complete unit will be returned to you freight paid, not repaired. For full-account customers, the repair charges will be debited to your account.

- **Always describe the fault in writing.**
- **Always return the sensors with the meter.**