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90-BOC Field Analyser

Congratulations ! You have purchased the latest in Instrumentation for Field Water Analysis. We trust that your new ***90-BOC*** will provide you with many years of reliable service.

This manual has extensive details. Please read carefully.

If at any stage we can be of assistance, please contact either your local TPS representative or the TPS factory in Brisbane.

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1 General Information

1.1 Introduction

The TPS Model ***90-BOC*** is a multipurpose field or laboratory instrument designed for the measurement of Dissolved Oxygen, pH, 2 channels of mV and Temperature. Automatic Temperature Compensation is provided for Dissolved Oxygen and pH.

The ***90-BOC*** has a data storage system which can be used for manual storage (Notepad) or Automatic Datalogging.

The TPS Model ***90-BOC*** Microprocessor Analyser is a major step forward in laboratory and field electrochemical measurement. Operation of the ***90-BOC*** is via a fully sealed, membrane keypad. This keypad and the intelligent 80 character LCD display, make operation of the ***90-BOC*** very simple. The case, the keypad and all input connectors are water resistant. Cover caps are provided. On-line "HELP" messages, at calibration and other functions are included.

The ***90-BOC*** uses the renowned YSI 5739 Dissolved Oxygen sensor. This sensor gives an extremely stable readout. It also has a pressure compensated membrane, so it can be submersed to 60 metres. This sensor can also be fitted with a stirrer. In this case, the power for the stirrer can be derived from the ***90-BOC***. The stirrer decreases the battery life between charges.

1.1.1 Notepad Memory

A standard feature of the ***90-BOC*** is a Notepad memory function. This function allows the user to record up to 1760 readings without the need to write them down. Readings are stored, and can be viewed or downloaded later. Manual errors in logging readings are now a thing of the past.

1.1.2 Automatic Datalogging

Two automatic datalogging modes are provided on the ***90-BOC***.

The first mode can be programmed to take a number of readings per day, from 1 to 288. The meter spaces the programmed number of readings so that they are taken at logical intervals. For example, if the ***90-BOC*** is programmed to take 24 readings per day, they will be recorded every hour, exactly on the hour. In this data-logging mode, the ***90-BOC*** is dormant between readings. It then "wakes up" at the required time, takes a reading, stores it along with the date and time, and then returns to dormant mode. By using this "sleep" mode, the battery life is extended considerably.

The second automatic datalogging mode is used for automatically taking readings at rapid intervals. This mode is specifically designed for use in rapidly changing environments. When programming the ***90-BOC*** for this logging mode, the user can set the sampling period (1 to 300 seconds) and duration (1 to 720 minutes) of logging. For example, if the sampling period is set to 5 seconds and the duration is set to 10 minutes, then the ***90-BOC*** will automatically log readings every 5 seconds for a total of 10 minutes. The user can stop logging at any time during the logging period.

1.1.3 Computer Interface

An RS232 computer interface port is fitted to the ***90-BOC***. With this feature, the ***90-BOC*** can download all of the recorded readings directly to a computer or RS232 printer. The ***90-BOC*** can also be remotely powered up by the RS232 activity from a computer or terminal. The RS232 port is also used to download data that has been previously logged.

1.1.4 Alternate Power Options

A 12v Car Battery Adaptor and a Solar Charger are optionally available.

1.2 Display

An 80 character LCD alphanumeric display shows Readings, Error Messages and On-line Help. The user-friendly menu system makes the ***90-BOC*** a breeze to operate.

1.3 Keypad

A water-resistant membrane keypad of 22 keys allows input of Setup information and the selection of operating Modes.

There are 3 groups of keys…

- 5 function keys (F1 to F5) and a Menu key,
- ON and OFF keys,
- 10 numeric entry keys, decimal, − (minus), ← (delete) and an Enter key.

The Function Keys F1, F2, F3 and F4 are used to select menus and parameters.
The F5 key will display HELP information.

DO NOT USE ANY SOLVENT TO CLEAN THE KEYPAD.

1.4 Data Entry

The following notes are a general guide to Data Entry.

1. The present value of the Data will be displayed until a key is pressed.
2. Pressing the Menu key will exit Data Entry and leave the Data unchanged.
3. Press the required keys to enter the desired data.
   For negative data, press the − key first.
   Press Enter to finish data entry and store new data.
   Press ← to correct typing errors, one at a time.
4. If the Data entered exceeds the allowable limits, the ***90-BOC*** will beep and display the limits. Enter new data and press Enter, or exit unchanged with Menu.

1.5 Connectors

Oxygen	7 Pin	Dissolved Oxygen Sensor, plus power out for optional stirrer.
pH	BNC	pH Sensor
Temp	9 Pin	Temperature Sensor. This sensor provides temperature readout, plus automatic temperature compensation for dissolved oxygen and pH.
mV1	BNC	Redox or Sulphide sensor input (shown on display as “mV1”).
mV2	BNC	Redox or Sulphide sensor input (shown on display as “mV2”).
Charger/RS232	8 Pin	Dual purpose for Battery Charger input and RS232 port.

1.6 “HELP” Information

The ***90-BOC*** has help messages available when using Menus and Functions.
Press function key F5 and "HELP" message will be displayed.

2 Startup

2.1 General Requirements

While the ***90-BOC*** is water resistant, care should be taken to avoid splashing the connectors. Always replace the connector covers when not using connectors. Avoid immersing the unit. Prolonged exposure to direct sunlight should be avoided. The ***90-BOC*** should be operated in a cool dry environment.

2.2 Turn On

Press the ON key to turn the ***90-BOC*** on.
The ***90-BOC*** performs a memory test and displays Model and Option details.
The model and options are shown as **90-BOCsm+,** where…

90-BOC	is the model,
s	indicates RS232 serial port installed (standard for ***90-BOC***)
m	indicates Dissolved Oxygen stirrer output is fitted (optional for ***90-BOC***)
+	indicates that the Extended Datalogging function is fitted (standard for ***90-BOC***)

The ***90-BOC*** then proceeds to "RUN MODE" displaying Oxygen, mV1, pH, mV2, and Temperature data.

Corruption of Memory contents might occur as the result of Low Battery Volts (Meter unused for very long periods), or severe electrical events (eg lightning surges). If the Memory test fails, the message…

"**Calibration, Configuration and Data Lost**"

will be displayed and the ***90-BOC*** will perform an Initialization. See section 10 for details.

2.3 Battery Saver

The ***90-BOC*** is powered by a 1200 mAH, 7.2 volt NiCad Battery which provides more than 15 hours of continuous operation (less when the optional dissolved oxygen stirrer is operating). Data logging can be up to 30 days. Battery life will be greatly increased by turning off the ***90-BOC*** between readings. The calibration data and any stored readings are kept when the ***90-BOC*** is turned off.

An external charging system (eg optional solar panel) can extend operation times indefinitely. Data is kept for months even with an exhausted battery.

Recharge is overnight (14 hours).

The battery should not be left discharged for long periods.

The ***90-BOC*** features a Battery Saver function. When no key is pressed for the nominated time the ***90-BOC*** will turn itself OFF. This prevents the unit being left ON indefinitely and draining the battery. A warning of twenty, 1/2 second beeps together with flashing the display is given prior to the unit automatically turning OFF. Press any key (other than ON or OFF) to prevent the ***90-BOC*** from turning OFF. The user can set the time delay before the ***90-BOC*** turns itself off.

If Timed Data Logging is Enabled, the battery saver is fixed at 5 minutes to help prevent loss of data logging intervals.

To change the Battery Saver Delay…

1. Press Menu to display the “MAIN” menu.
2. Press F4 for the "SETUP" menu.
3. Press F1 for the "Battery Saver" menu.
4. Press F1 to switch the battery saver function OFF, for continuous operation.
   Press F2 to set the ***90-BOC*** to turn OFF after 5 minutes, if no key has been pressed.
   Press F3 to set the ***90-BOC*** to turn OFF after 1 hour, if no key has been pressed.
   Press Menu to exit without changing the battery saver setting.
   The display arrow indicates current selection.
5. The Battery Saver Menu also displays the Battery Volts.

2.4 Battery Volts

The user can display the battery voltage by selecting the Battery Saver menu.

This display enables the user to monitor battery life and check charger operation as a diagnostic tool. It is not intended to be used to show the remaining charge/use in the battery, although user experience can establish a relationship between the battery volts and time remaining. The battery volts will be approximately 8.80 while charging a fully charged battery. Expect approximately 7.20 volts after 85% of use. Data readings may be inaccurate when the volts fall below 5.60 (Low Bat) and the ***90-BOC*** will stop operating at 5.10 volts.

The battery volts are not stored or logged. Battery voltage data can be requested via the serial port. See section 7.1.

3 Dissolved Oxygen Measurement

3.1 Mode Selection

The Dissolved Oxygen operating Mode of the ***90-BOC*** is selected using the "MODE" Menu.

To select the Dissolved Oxygen mode…

1. Press Menu to display the “MAIN” menu.
2. Press F2 for the "MODE" menu.
3. Press F1 to select Dissolved Oxygen readout in ppM (mg/L) units.
   Press F2 to select Dissolved Oxygen readout in % Saturation units.
   The display arrow indicates current selection.

A "*" will be shown in place of the decimal point if a satisfactory Oxygen Calibration has NOT been performed.

> ***Please note that the polarization voltage is not continuously applied, and it may take two to three minutes for dissolved oxygen readings to stabilize after the meter is turned on.***

3.2 Dissolved Oxygen Calibration

NOTE: Before Oxygen Calibration, ensure the TEMPERATURE Section is correctly calibrated. See section 5.1.

To calibrate the Dissolved Oxygen section…

1. Turn the Meter on with the Oxygen Sensor plugged in.

   Allow at least 3 minutes for the sensor to polarize.

   Visually check that the membrane is intact. If it is not, refer to the probe service section.

   Be careful that the probe has not been sitting in the sun, and that it is, in fact, at the actual air temperature (or water temperature if using a Winkler titration).

2. **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:Calibrate** → **F1:Oxygen**
   The ***90-BOC*** will automatically attempt a zero calibration if the reading is below 5% Saturation or 0.5 ppM.

   (d) Press the Enter key to calibrate. If ZERO calibration fails, refit the membrane ensuring there are no wrinkles. True zero may require several minutes if the filling solution has been replaced. A “*” will not be removed from the display after a Zero Calibration.

   (e) Rinse the Dissolved Oxygen sensor in distilled water and blot dry.

3. **Span Calibration, in Air**

   (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:Calibrate** → **F1:Oxygen**
   The ***90-BOC*** will automatically attempt a span calibration if the reading is above 5% Saturation or 0.5 ppM.

   (d) Press the Enter key to calibrate.

   (e) A "∗" in the display will be replaced by a decimal point after a successful air calibration.

   (f) Repeat this "AIR CALIBRATION" as often as required. The ZERO can be presumed stable unless a membrane is refitted. Note the relationship of % Saturation and ppM, depends on a number of variables, so ***always calibrate in the mode required***. Do not try to infer Oxygen content from one mode to another.

4. **Span Calibration in a known standard (ppM mode only)**

   (a) Place the Dissolved Oxygen sensor into the known standard.

   (b) Allow the reading to stabilise. After a zero calibration, this may take up to 5 minutes.

   (c) Select Oxygen Calibration: Menu → **F1:Calibrate** → **F1:Oxygen**
   The ***90-BOC*** will automatically attempt a span calibration if the reading is above 5% Saturation or 0.5 ppM.

   (d) Key in the result of the Winkler titration, using the numeric keypad. The words "**AIR/SPAN**" will be over-written by the value you type in.

   (e) Press the Enter key to calibrate.

   (f) A "∗" in the display will be replaced by a decimal point after a successful span calibration.

   (g) Repeat this "SPAN CALIBRATION" as often as required. The ZERO can be presumed stable unless a membrane is refitted. Note the relationship of % Saturation and ppM, depends on a number of variables, so ***always calibrate in the mode required***. Do not try to infer Oxygen content from one mode to another.

5. The ***90-BOC*** is now calibrated and is ready for use. When taking sample measurements, always ensure that there is adequate flow of solution past the membrane for accurate, stable readings. See section 14.7.

3.3 Measuring Unknowns

Place the Dissolved Oxygen sensor into the unknown solution sample. Allow time for temperature stability if the unknown solution is not at room temperature.

The Temperature Sensor must be present to provide the TEMPERATURE information. If not, a value of $20^{O}C$ is presumed, degrading accuracy.

In both Dissolved Oxygen modes, stir the probe in the solution slowly but steadily. The electrode consumes Oxygen, so that without stirring, the reading will drift downwards. Stir the probe tip at a speed sufficient to get a stable maximum reading. Alternatively, the probe can be "bobbed" up and down by moving it vertically on the cable. This also effectively moves the water past the membrane.

Avoid over-stirring. With over-rapid stirring, the membrane is flexed and new (oxygen bearing) electrolyte enters the cathode area causing "noise". Also, stirring too fast can cause bubbling in the sample which may raise its Oxygen level.

3.4 Using the Optional Dissolved Oxygen Stirrer

To use the stirrer, first plug the stirrer cable into the oxygen socket on the ***90-BOC*** and then plug the oxygen probe into the socket on the stirrer cable.

Function key F2 controls the stirrer when in display mode as follows:

Press the F2 key to turn the stirrer ON. A 40 second count down begins. The ***90-BOC*** beeps for the last 5 seconds indicating the user should take the reading.

Press the F2 again to turn the stirrer OFF before the 40 seconds has elapsed.

The stirrer can be turned ON and OFF remotely using the RS232 port. See section 7.1 for command details.

4 pH and mV Measurement

pH, mV1 and mV2 are displayed continuously. No Mode setup is required. A separate temperature sensor is used for Automatic Temperature Compensation of the pH display.

4.1 pH Calibration

Simple One-Point calibration (Asymmetry)

1. Select pH Calibration: Menu → **F1:Calibrate** → **F3:pH**
2. Rinse the pH and Temperature probes, and place them in a sample of the first buffer. (Either 4.00, 6.88, 9.22 or "OTHER")
3. When the reading stabilizes, press Enter to calibrate.
4. If "OTHER" Buffer Calibration is required, key in the required Buffer value and press Enter to calibrate.
5. Discard the buffer sample to prevent contamination.

The ***90-BOC*** is now one-point pH calibrated.

NOTE: The displayed reading is temperature compensated, so readings may be slightly different to the value written on the buffer bottle label due to the pH value of buffers changing with temperature.

TWO-Point calibration (Slope & Asymmetry)

1. Select pH Calibration: Menu → **F1:Calibrate** → **F3:pH**
2. Rinse the pH and Temperature probes, and place them in a sample of the first buffer. (Either 4.00, 6.88, 9.22 or "OTHER").
3. When the reading stabilizes, press Enter to calibrate.
4. If "OTHER" Buffer Calibration is required, type the required Buffer value and then press Enter to calibrate.
5. Discard the buffer sample to prevent contamination.
6. Select pH Calibration: Menu → **F1:Calibrate** → **F3:pH**
7. Rinse the pH and Temperature probes, and place them in a sample of the second buffer. (Either pH 4.00, 6.88, 9.22 or "OTHER" but different from above.)
   The second buffer must differ from the first by at least 1.5pH.
8. When the reading stabilizes, press Enter to calibrate.
9. If "OTHER" Buffer Calibration is required, type the required Buffer value and press Enter to calibrate.
10. Discard the buffer sample to prevent contamination.

The ***90-BOC*** is now TWO-point pH calibrated.

Failure to Calibrate is due to (a) pH over-range
OR (b) Asymmetry correction greater than 1 pH
OR (c) Slope not within 85 to 105%
OR (d) 4.00, 6.88, 9.22 buffer not auto-identified
The type of Failure is identified by a helpful error message. Check Probe.

Automatic buffer selection for 4.00, 6.88 and 9.22 buffers, use Manual Entry for "OTHER" buffers.

The meter stores the ASYMMETRY and SLOPE values from the electrode after calibration. These values are automatically recalled after power-on.

Press F5 in pH Mode to display Probe Asymmetry and Slope.

NOTE: The millivolt readouts are factory Calibrated for Absolute Millivolts. They require no user-calibration. The Data must be in the range -2000mV to +2000mV.

4.2 Measuring Unknown pH

To measure the pH of an unknown solution, place pH and temperature probes into the unknown solution.

A two point calibration should be performed once a week (typical) and one point (using a buffer near the unknown) daily or more often for best accuracy.

User experience will provide more detail regarding the need for re-calibration of the meter.

Stir solution and allow time to temperature stabilize.

4.3 Measuring Unknown mV

No temperature compensator is used for mV operation.

For ORP, the Platinum tip of the ORP sensor should be clean.

Refer to the sensor handbook for operation or maintenance.

5 Temperature Measurement

If the temperature has not been calibrated, a "*" will replace the decimal point in the displayed Temperature value.

Temperature will be displayed as "OVRoC" if no Temperature Probe is connected or the temperature sensor is faulty. A value of 20oC will be assumed for the Oxygen Temperature Compensation with consequent degradation of accuracy.

5.1 Temperature Calibration

As the ***90-BOC*** uses this thermometer to compute the Solubility Temperature Correction for Oxygen ppM, it is ESSENTIAL the thermometer is calibrated FIRST.

The temperature signal must be calibrated after changing temperature probes.

Calibrate Temperature :

1. Select Temperature Calibration: Menu → **F1:Calibrate** → **F4:Temperature**
2. Place the Temperature probe and a Mercury-in-glass Thermometer in water near room temperature. Stir for approximately two minutes to allow the temperature to stabilize.
3. When stable, key in the temperature shown on the Thermometer and press Enter. If successful, the temperature is now 1 point calibrated.
4. Press EITHER Menu to exit, as often, 1 point calibration is sufficient
   OR Enter to step on to the SPAN (2nd point) calibration.
5. SPAN: Place the Temperature probe and the thermometer in Hot water 10^{O}C or 15^{O}C warmer. The hot water vessel should be insulated to avoid rapid heat loss.
   Stir for approximately two minutes to allow the temperature to stabilize.
6. When the temperature reading is stable, key in the temperature shown on the Thermometer and press Enter. If successful, the temperature is now SPAN (2 point) calibrated.

An accurate thermometer with 0.1 ^{O}C resolution is recommended when performing a SPAN (2 point) calibration. Small errors in taking temperature readings can cause a span failure. Continuous stirring is essential.
If either calibration fails, the temperature sensor may be faulty. Check cable etc. and calibration procedure.

5.2 Measuring Unknown Temperatures

Always stir solution and allow time to stabilize when measuring temperature.

6 Data Logger

The ***90-BOC*** has an in-built data storage system which can be used to record readings manually, or set up as an automatic Datalogging System.

6.1 Manual Storage (Notepad)

When in display mode (RUN MODE), press F1 for the data storage function.

The Log Number is displayed.

Press Enter to store data or Menu to quit.

Data is stored sequentially and cannot be overwritten. Use "Erase" function to erase ALL data and reset Log Number to 1.

Up to 1760 readings including Date and Time can be stored.

6.2 Logger Menu

Select the Logger menu (Menu → F3:Logger+)

The "+" indicates the Extended Data Logger is installed (standard on the ***90-BOC***).

The following functions are available on the logger menu…

F1 Display
Displays stored data and Log Number starting from Log Number 1.
Press Enter to display next reading or type in the required log number and press Enter.
Press Menu to exit at any time.
Press F3 to print the displayed reading, to the RS232 port.

F2 Erase
Erases stored data and sets Log Number to 1.
All logged data will be lost. Use with caution.

F3 Print Log
Prints stored data using the RS232 serial port starting at Log Number 1 up to the last logged. See section 7.1 for data format.
Data is terminated with <cr><lf>, suitable for a printer.
XON/XOFF protocol is supported.

F4 Start/Stop
Enables or Disables Automatic Timed Data Logging.
If the Data Logger is Enabled you are offered "STOP".
If the Data Logger is Disabled you are offered "START".

F5 Program
This allows the user to program Data Logging Times.

Two programming methods are offered…

F1 Rate per Day	: The user can enter the number of readings per day. From 1 to 288 (12 per hour).
F3 Sampling Period and Duration	: The user can program the sampling period (eg. 1 reading every 5 seconds) and the sampling duration, (eg. log for 10 minutes).

6.3 Automatic Datalogging

6.3.1 Rate per Day

When the automatic datalogging function is set to Rate per Day (see section 6.2), logging will only occur if logging is enabled and the ***90-BOC*** is turned OFF. When the ***90-BOC*** is turned ON automatic datalogging is suspended. Manual data recording can proceed, the readings being simply in the continuing order of the automatically logged readings.

To start automatic logging at a Rate per Day…

1. Program the Rate per Day
   (Menu → F3:Logger+ → F5:Program → F1:Rate per Day).
   Enter the required number of readings per day and press Enter.
2. Set the unit to Start datalogging (Menu → F4:Start).
3. **IMPORTANT**
   Switch the ***90-BOC*** OFF.

When Timed data logging is enabled, the ***90-BOC*** will turn itself ON at the required interval, log the data and turn itself OFF.

Each reading takes approximately 10 seconds allowing maximum battery life (30 seconds if the optional dissolved oxygen stirrer is fitted.

If the battery is low, the stirrer is not enabled and data is recorded with the LOW BATTERY Flag set. If the battery recovers (eg Solar Charged), stirring will be resumed. Data logged with a low battery may not be truly valid.

At each Timed Logging the data will be transmitted down the serial port even if there is no receiver. A <cr><lf> will terminate the data. See section 7.1 for data format.

The 90-BOC is fitted with a Calendar Clock as standard. This clock's Date and Time is set using the "Setup" menu (Menu → **F4:Setup** → **F3:Set Clock**).
The current time (24 hour format) is displayed.
To set the time, key in the hour and minutes and press Enter.
Type leading zeros if required. ie. 7:03 is entered as 07:03.
The time is Set and the Date is now displayed.
Press Menu to leave the date unchanged or type in the Day of the Month and the Month and press Enter. Type leading zeros if required. ie. 3rd day of May is to be entered as 03-04.

6.4 Sampling Period and Duration

To start automatic logging at a preset sampling period for a preset duration…

1. Program the Sampling Period and Duration

   (Menu → F3:Logger+ → F5:Program → F3:Sampling Period and Duration)

   Type the required sampling period in seconds and press Enter.

   Type the required logging duration in minutes and press Enter .

   Press Menu any time to quit without saving the changes.

2. To start logging in this mode, press F4 in normal display mode (RUN MODE). The following message is displayed, along with the current time…

   ```
   Press Enter to Sample every 5 seconds,
   For 10 minutes,or Menu to Quit  12:00:00
   ```

   The example shown above uses the factory default sampling period of 5 seconds and logging duration of 10 miutes).

   The current time is shown, so that the user is able to coordinate datalogging with an exact time.

3. To stop logging, press F4.

If the battery is low, the stirrer is not enabled and data is recorded with the LOW BATTERY Flag set. If the battery recovers (eg Solar Charged), stirring will be resumed. Data logged with a low battery may not be truly valid.

The data will be transmitted down the serial port each time a reading is logged, even if there is no receiver. A <cr><lf> will terminate the data. See section 7.1 for data format.

The 90-BOC is fitted with a Calendar Clock as standard. This clock's Date and Time is set using the "Setup" menu (Menu → **F4:Setup** → **F3:Set Clock**).
The current time (24 hour format) is displayed.
To set the time, key in the hour and minutes and press Enter.
Type leading zeros if required. ie. 7:03 is entered as 07:03.
The time is Set and the Date is now displayed.
Press Menu to leave the date unchanged or type in the Day of the Month and the Month and press Enter. Type leading zeros if required. ie. 3rd day of May is to be entered as 03-04.

7 RS232 Serial Port

An RS232 Serial Communication Port is fitted standard on the ***90-BOC***. This port will allow any external computer with a Serial Port, eg. IBM PC/XT/AT, access to Oxygen, pH, mV1, mV2 and Temperature measurements from the ***90-BOC***. Battery Voltage can also be requested.

To use the RS232 port, first plug the RS232 cable into the CHARGER socket on the ***90-BOC*** and then plug the other end into your computer. The battery charger can be plugged into the socket on the RS232 cable if required.

Activity on the Serial Port will turn the ***90-BOC*** on remotely. Send a string of at least 40 characters (use ">@" 20 times for best results) then wait for OK<cr> reply before sending a command.

Do not send "?",<cr> as these may be interpreted as part of REAL COMMANDS and cause unexpected results. The Host Program must be able to escape from awaiting "OK" if no reply occurs. Some versions of BASIC are prone to such hang ups.

7.1 Commands

Up to 10 commands (depending on which options are fitted) allow access to data and control the ***90-BOC***.

<cr> denotes Carriage Return (Ascii decimal 13) in this section.

• denotes a space in this section

Commands are sent in the following format : **?X<cr>**

where : X = command

The ***90-BOC*** will send ERROR**<cr>** when an Illegal Command is received. Non-Command Format requests and Control Characters will be ignored.

The ***90-BOC*** will only perform the serial commands when in Display Mode ("RUN").
BUSY**<cr>** is sent if a reply is not available eg. in CALIBRATION mode.

COMMAND 1 : ?D<**cr**> (Data Request)

Data is sent in the following format:

NNNN•DDDDDDuuu•111111mV1•PPPPPPpH••222222mV2•TTTTTToC••L•dd-mm•hh:mm:ss<cr>

where…

NNNN	is 4 character Log Number, right justified. Log Number = 0 for CURRENT Data.
•	is 1 space.
DDDDDD	is 6 character Oxygen Data, right justified.
uuu	is 3 character Dissolved Oxygen Units, "ppM", or "%S".
•	is 1 space.
111111	is 6 character mV Channel 1 Data, right justified.
mV1	is 3 character unit data for mV Channel 1.
•	is 1 space.
PPPPPP	is 6 character pH Data, right justified.
pH•	is 3 character pH units, left justified (• is one space).
•	is 1 space.
222222	is 6 character mV Channel 2 Data, right justified.
mV2	is 3 character unit data for mV Channel 2.
•	is 1 space.
TTTTTT	is 6 character Temperature data, right justified.
oC•	is 3 character Temperature units, left justified (• is one space).
•	is 1 space.
L	is the Low Battery indicator, when the battery is getting Low. A space is sent if the battery level is OK.
•	is 1 space.
dd-mm	is 4 character date and month data. The ***90-BOC*** is not capable of storing the year.
•	is 1 space.
hh:mm:ss	is 8 character hours, minutes and seconds data.
<cr>	is carriage return character, ACSII decimal 13.

NOTES

1. Decimal point is replaced with " ***** " if a Measurement is Un-calibrated.
2. -OVR or +OVR is sent for over-range data.
3. BUSY<**cr**> is sent when the ***90-BOC*** is not in "RUN" Mode or is Busy, ie in Menus, Calibration or when Data is not available etc.

COMMAND 2 : ?S<**cr**> (Status)
Status is sent in the following format : 90FXm+•LLLLEv<cr>

where…

90FX	is the model identifier (90FX is the designation for custom 90 series units).
m	indicates that the Dissolved Oxygen stirrer facility is present. A space is sent when the stirrer facility is NOT present.
+	indicates that the Extended Data Logging function is fitted. This function is standard on the ***90-BOC***.
LLLL	indicates the number of logged readings currently stored in memory. This field is 4 characters, right justified.
E	indicates that a memory error has occurred. The Logged data stored in memory must be erased to clear this message. A space is sent when there are no memory errors.
v	indicates that the firmware of the instrument is capable of reading the battery volts. This function is mainly used as a factory diagnostic tool.
<cr>	is a carriage return.

COMMAND 3 : ?L<**cr**> (Logged Data Request)
Logged Data is sent from Log number 1 to the end of the data file.
Logged Data can also be requested FROM a log number TO a log number as follows…

?Lnnnn,NNNN<cr>	Where nnnn is starting number, NNNN is end number.
?L,NNNN<cr>	ie START is missing so from the FIRST to NNNN
?Lnnnn,<cr>	ie END is missing so from nnnn to the LAST on File.
?Lnnnn<cr>	ie Send number nnnn only.

NOTES

- Data format is the same as for Data Request (see COMMAND 1).
- After each line of data is sent, the ***90-BOC*** will wait for a character from the Host before sending the next line.
- If the Host replies with a "Z" (Ascii 90), the Data Request is terminated and EXIT<cr> is sent.
- The data transmission is terminated with ENDS<cr>.
- If the data transmission is interrupted by the operator pressing the Menu key, then EXIT<cr> will be sent to the Host.

COMMAND 4 : ?E<**cr**> (Erase Logged Data)
Erases Logged Data in the instrument's memory and resets the Log Number to 1.
Sends ERASED<cr> to the Host when data erased.

COMMAND 5 : ?K<**cr**> (System Shutdown)
This puts the ***90-BOC*** into SLEEP mode remotely.
Sends SSD<cr> to the Host prior to turning OFF.

COMMAND 6 : ?V**<cr>** (Battery Volts)
Battery Voltage is sent in the following format.
BBB.BBV••, where B is volts and V•• is units with 2 trailing spaces.

COMMAND 7 : ?G**<cr>** (Enable Data Logging)
Enable the automatic data logger at the predefined RATE.
Sends LOG START<cr> to the Host when Enabled.
Use the System Shutdown command (COMMAND 5) after enabling logging to ensure Data Logging will occur.

COMMAND 8 : ?F**<cr>** (Disable Data Logging)
Disable the automatic data logger.
Sends LOG STOP<cr> to the Host when stopped.

When the Dissolved Oxygen Stirrer option is installed, two further commands are recognised. These are…

COMMAND 9 : ?M**<cr>** (Turn Stirrer On)
This turns the optional Stirrer ON. The stirrer will remain ON until turned off or the battery saver feature turns the ***90-BOC*** off.
Sends SON<cr>_ when turned on.

COMMAND 10 : ?N**<cr>** (Turn Stirrer Off)
This turns the optional Stirrer OFF.
Sends SOFF<cr> when turned off.

7.2 Immediate Data Request

CURRENT data is sent immediately, by pressing F3 in Display Mode ("RUN").
The data format is the same as for the Data Request Command, see 7.1.

The Log Number will be zero and the data is terminated by <cr><lf>.

7.3 RS232 Port Configuration

The RS232 Port is configured as 8 bits, No parity, 1 stop bit.

Set the baud rate as follows…

1. Select the Baud Rate menu (Menu → F4:Setup → F2:Baud Rate).
2. Press F1 to select 300 baud

   Press F2 to select 1200 baud

   Press F3 to select 9600 baud

   Press Menu to quit without changing the baud rate

NOTES

- Software for IBM compatible computers is available from TPS.
- The [RS232] PORT does not ECHO commands.
- XON/XOFF protocol is supported when printing data.

8 Servicing

8.1 Desiccator

The ***90-BOC*** has an Air-breather system to maintain equal pressure inside and outside the box. The unit is NOT intended for immersion. The breather system includes a desiccator to dry the air inside the box. Silica-gel in a plastic bottle is used to absorb moisture. The silica-gel changes colour with moisture. Fresh/Dry Silica-gel is blue in colour, and turns pink/clear when exhausted.

Periodically remove the back cover and check the Silica-gel.

If no blue colour is visible the gel requires drying.

ALWAYS CHECK THE SILICA-GEL AFTER THE *90-BOC* HAS BEEN WET.

Any fog/mist on the inside of the display indicates a problem with the desiccator and should be checked IMMEDIATELY. Dry the gel and allow the inside of the ***90-BOC*** to dry before replacing the lid. Check for corrosion.

8.1.1 Drying The Silica-Gel

1. Turn the ***90-BOC*** OFF and remove the lid. Do not detach the battery lead.
2. Gently pull the plastic bottle from its holding clamp.
3. Hold the bottle upright and unscrew the lid. Do not detach the plastic tubing from the lid.
4. Pull the plastic tubing from the bottle and pour the gel onto a clean heatproof dish/plate.
5. Heat the silica-gel until it turns blue (at least 70oC) in a conventional or microwave oven set on LOW. High power will shatter the crystals. Do not use a metal container or dish in a microwave oven.
6. Allow to cool and pour back into bottle.
7. Replace tubing and lid.
8. Clip the bottle back onto its holding clamp.
9. Replace the lid taking care to position the long, fold-out feet towards the handle end of the box. Avoid detaching the battery lead at any stage as damage will occur if it is replaced incorrectly.

9 Troubleshooting

Display

NO DISPLAY
1: Press the ON button.
2: Battery needs re-charging.
3: Battery faulty. Will it run on the Charger ?

Display fog/mist
Check the desiccator system. See section 8.1.

Incorrect readings/Cannot Calibrate

Operation with a very flat battery may result in the corruption of the calibration data.
1: Check probe parameters for possible corruption. See sections 3.2, 4.1, or 5.1.
2: Perform INITIALIZATION. Hold ⇦ while turning power ON. See section 10.

Oxygen

NOISY READINGS
1: Check input plug is correctly fitted.
2: Check the Oxygen probe membrane is OK.
3: Bubbles inside probe ? Refit the membrane.

CAN'T ZERO
1: Is the membrane wrinkled ?
2: Replace the membrane on the probe.
3: Filling solution may be contaminated.
4: Contamination of gold or silver.

CAN'T CALIBRATE
1: Is the membrane wrinkled ?
2: Replace the membrane on the probe.

pH or Millivolts

1: Are the pH or mV connectors plugged in correctly?
2: Is the outer barrel reference chamber tight ? (IJ types only)
3: Does the Reference section require refilling ? See spares.

UNSTABLE READINGS
In low ionic strength solutions, pH readings may be unstable if the pH probe does not have sufficient flow of reference electrolyte from the white ceramic reference junction at near the glass bulb of the electrode.
See the pH probe maintenance for service and cleaning.

READINGS DON'T CHANGE
1: Have you removed the plastic "wetting cap" ?
2: Is the bulb of the pH probe cracked ?
If cracked, the pH probe must be replaced.

Temperature

If no Temperature sensor is present, a temperature of "OVRoC" will be displayed. If the Temperature Sensor is plugged in and "OVRoC" is still displayed, the temperature sensor may be faulty.
Check using another sensor.

9.1 pH Electrode Maintenance

A pH electrode actually consists of 2 electrodes in 1 body:

1. The centre pH sensing electrode with its glass end bulb, and
2. The reference electrode, which makes contact with the sample solution a porous contact on the side or tip of the outer plastic body near the bulb end.

The inner pH electrode is sealed, and needs no maintenance for the life of the electrode. The outer reference electrode is designed to leak slowly into the sample. In this way, it makes correct electrical connection. This reference section is generally a sealed GEL type.

The refillable type will occasionally require re-filling with saturated Potassium Chloride solution. This procedure for this type is as follows…

1. Unscrew the plug from the electrode side-arm.
2. Use a syringe or pipetter and fill the outer Reference electrode chamber with saturated KCl solution, to within 2 cm from the vent hole.
3. No air bubbles must remain trapped in the inner pH electrode bulb. "Flick" the electrode to remove trapped bubbles.

If the electrode has been left dry for several days, its immediate use will sometimes give a slow response. The electrode should be immersed in a standard buffer solution or in distilled water for about 24 hours before its use. Immersing the electrode bulb in a little Dilute Hydrochloric Acid for a few minutes will speed up this rejuvenation.

9.2 pH DO's and DONT's.

DO store the pH electrode in water or storage solution, or with the "wetting cap". (A 1:1 mix of pH4 buffer and 1 Molar KCl makes an ideal storage solution.)

DO keep your meter in a cool, dry place when not in use.

DO check there are no air bubbles in the pH glass bulb before use.

DO keep the outer filling solution in the reference topped up.

DON'T keep the meter in a wet, or very humid environment.

DON'T let filling solution or chemicals of any type "wet" the connectors at the side of the unit.

Cracks in the Glass Bulb

If the ***90-BOC*** indicates that the electrode has low slope, there may be a crack in the glass membrane, or there simply may be no filling solution. A cracked bulb requires the replacement of the electrode.

Insulation and Internal Resistance

Because the glass electrode has a membrane resistance of several hundred million ohms, every part of the meter has been carefully insulated. If this insulation value is lowered, pH signals may become unstable.

Great care must be taken not to wet the plug of the electrode or the meter and connector themselves.

Only if necessary, clean the connectors with pure alcohol and cotton wool.

Blow dry with a heat gun, or hair dryer, set at moderate temperature.

10 Initialization

Initialization of the ***90-BOC*** may be required as a result of corruption of the Battery-protected Memory. Corruption of Memory contents can occur as the result of Low Battery Volts (Meter unused for very long periods), or severe electrical supply events (eg lightning surges). An internal check of the Memory contents is performed at Power-ON. If this check fails, the message…

Calibration, Configuration and Data Lost

will be displayed.

The unit should be re-configured to suit application and re-calibrated.

All Logged Data will be Lost.

11 Corrosion Protection

The ***90-BOC*** is fitted with an anti-corrosion gas emitting pad. This protects the internal circuitry from accidental leakage etc. for a period of one year. The pad is attached to the lid, and is factory fitted prior to despatch. Check the expiry date shown on the pad approximately one year after purchase. If you wish to renew the pad contact T.P.S. for a replacement.

12 Specifications

Dissolved Oxygen

Ranges	: 0-60.00 ppM 0-600.0 % Saturation
Resolution	: 0.01 ppM 0.1 % Saturation
Accuracy	: Better than ±0.3 % of reading ±1 count
Membrane Temperature Compensation	: AUTOMATIC
Solubility Temperature Compensation (ppM)	: AUTOMATIC
Depth Compensation	: AUTOMATIC
Zero Calibration	: AUTOMATIC (at less than 5%)
Oxygen Calibration	: AUTOMATIC

pH

Range	: 0.00 to 14.00 pH
Resolution	: 0.01 pH
Accuracy	: ±0.01 pH
Calibration	: 2 Point AUTOMATIC
pH Buffers	: Auto recognition of pH4.00, pH6.88 and pH 9.23. Other buffers can be keyed in at calibration.
Temperature Compensation	: AUTOMATIC

mV (2 channels)

Range	: -2000mV to +2000mV
Resolution	: 1 mV
Accuracy	: ±1 mV
mV Calibration	: ZERO and SPAN factory hardware set.

Temperature

Range	: -30 to +110 ^{O}C
Temperature Calibration	: 2 Point AUTOMATIC

Stability : Instrument: Better than 0.1 % of any Mode Full Scale.

Display : 2 line x 40 Character alphanumeric LCD for readings, Menus, Help and Error Messages.

Keypad : 5 Function Keys, Menu key & 14 data entry keys, OFF, ON

Stability : Instrument: Better than 0.1 % of any Mode Full Scale.

Datalogger	: 1760 Reading Capacity Includes RS232 port and Calendar Clock Can be programmed from 1 to 288 readings per day, or preset sampling period and duration.
RS232 Port	: 8 bits, No Parity, 1 Stop Bit, XON/XOFF when printing. 300, 1200, and 9600 baud available.
Power	: 7.2 V Rechargeable Ni-Cad battery Any 12V DC supply will re-charge the battery.
Battery Saver	: OFF, 5 mins(Timed Logger is ON), 1 hour
Dimensions	: 230 x 140 x 100 mm.
Mass	: Typical System Shipping Weight 4 Kg

13 Ordering Information

The 90-BOC standard kit includes…

	Part No
90-BOC meter	191142
240v AC Charger	130009
NiCad battery (fitted)	130027
90-BOC Handbook	130050
pH Buffer 6.88	121306
pH Buffer 4.00	121381

Sensors (order separately)…

YSI Dissolved Oxygen sensor	123204
(includes filling solution and membrane kit)	
5 metre Cable for Dissolved Oxygen sensor	123219
Dissolved Oxygen stirrer	123306
pH Electrode, non-flow, 5m	111224
ORP Electrode, non-flow, 5m	111260
Temperature Sensor, 5m	124210

Battery Charger Options

AC/DC Adaptor for 110-120V AC	130017
Solar Panel	130012
Charger cable for 12V DC, with battery clips	130013

Spares…

Dissolved Oxygen sensor filling solution	123307
Dissolved Oxygen sensor Membrane kit	123300
Re-filling solution for liquid filled pH probe	121326

14 Appendices

14.1 Solubility Of Oxygen In Water (760mm Mercury)

g/l Cl^-	0.00	4.00	8.00	16.00	20.00
ppK NaCl	0.00	6.60	13.20	26.40	33.00
Temp ^OC	Dissolved Oxygen - mg/L				
0	14.57	13.91	13.26	11.94	11.29
1	14.17	13.54	12.90	11.63	11.00
2	13.79	13.18	12.56	11.33	10.72
3	13.43	12.83	12.24	11.05	10.45
4	13.08	12.50	11.93	10.78	10.20
5	12.74	12.19	11.63	10.52	9.96
6	12.42	11.88	11.34	10.27	9.73
7	12.11	11.59	11.07	10.03	9.51
8	11.81	11.31	10.81	9.80	9.30
9	11.53	11.04	10.56	9.58	9.09
10	11.26	10.79	10.31	9.37	8.90
11	10.99	10.54	10.08	9.17	8.72
12	10.74	10.30	9.86	8.98	8.54
13	10.50	10.07	9.65	8.79	8.37
14	10.27	9.86	9.44	8.62	8.20
15	10.05	9.65	9.25	8.45	8.04
16	9.83	9.44	9.06	8.28	7.89
17	9.63	9.25	8.87	8.12	7.74
18	9.43	9.06	8.70	7.97	7.60
19	9.24	8.88	8.53	7.82	7.46
20	9.06	8.71	8.36	7.67	7.32
21	8.88	8.54	8.20	7.53	7.19
22	8.71	8.38	8.05	7.39	7.06
23	8.55	8.22	7.90	7.25	6.93
24	8.39	8.07	7.76	7.12	6.80
25	8.24	7.93	7.61	6.99	6.68
26	8.09	7.78	7.47	6.86	6.55
27	7.95	7.64	7.34	6.73	6.42
28	7.81	7.51	7.21	6.60	6.30
29	7.68	7.38	7.07	6.47	6.17
30	7.55	7.25	6.95	6.34	6.04
31	7.42				
32	7.30				
33	7.18				
34	7.07				
35	6.95				
36	6.84				
37	6.73				
38	6.63				
39	6.52				
40	6.42				

14.2 The Oxygen Electrode

The electrode used, is the amperometric type of Clark Electrode 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.

14.3 Operating Principle

The Clark oxygen electrode 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 polarizing voltage of about 800 millivolts is applied between the two electrodes. The gold electrode is placed close to the membrane and because of the polarizing 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 electrode. A load resistor (actually a thermistor in this case) situated in the electrode itself, converts this current into a voltage proportional to the oxygen partial pressure. The thermistor provided within the body of the electrode 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.

14.4 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. See the YSI Dissolved Oxygen sensor instruction leaflet for details on how to replace the membrane.

NOTE

Make sure the Teflon membrane is stretched downwards to form a "cap" in the membrane. If this in not done, and the membrane is simply laid across the end of the electrode, wrinkles at the membrane edge will be formed as the "o-ring" is rolled into place. In this case, the membrane will leak and the silver anode can become contaminated, destroying the electrode.

This damage is NOT covered by the warranty.

14.5 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°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 Electrode 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 ***90-BOC…***
(a) is achieved AUTOMATICALLY.
(b) To provide the mass units (ppM) readout (so popular due to the Winkler process used in the past), the ***90-BOC*** Meter has Solubility Correction via an additional temperature sensor in the electrode.
(c) Salinity correction must be done manually by the user, using the solubility table in section 14.1)

14.6 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.

14.7 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 electrode 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 electrode to be used with this instrument, very little changes in diffusion current are caused by altering the pH of the external environment. Pressure changes over a moderate range exerted on the membrane also cause no change. The probe is sealed by glands for total immersion up to 3 metres.

15 Warranty

TPS Pty. Ltd. guarantees all instruments and electrodes 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 electrodes and batteries 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 electrode. 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.

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 electrode 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 labour 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.**