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Author : MS

TPS Model 900-D
Microprocessor Dissolved Oxygen and Conductivity Meter

Congratulations !
You have purchased the latest in Instrumentation for Laboratory Dissolved Oxygen measurement with accompanying Conductivity and Salinity. We hope that your new 900-D 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 directly.

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Contents

1. General Information

1.1 Introduction

The TPS Model 900-D is a multipurpose laboratory instrument designed for the measurement of Oxygen in both Gaseous and Dissolved states as well as Conductivity and Linearised Salinity. Direct Temperature Readout function is provided. Automatic Temperature Compensation of Oxygen is included for ppM as well as Salinity Compensation (equivalent NaCl) for ppM mode. The Conductivity and Salinity are Automatically Normalised to 25^{o}C.

The 900-D is a major step forward in laboratory and field electrochemical measurement. Operation of the 900-D is via a fully sealed, membrane keypad. This keypad and the intelligent 80 character LCD display, make operation of the 900-D very simple.

On-line "HELP" messages, at calibration and other functions are included.

An RS232 computer interface port can be fitted to the 900-D, if required. With this option, the 900-D can download readings directly into a computer or a serial printer.

1.2 Display

An 80 character LCD alphanumeric display shows Readings, Error Messages and On-line Help.

1.3 Keypad

A water-resistant membrane keypad of 20 keys allows input of Setup information and the selection of operating Modes.

There are 2 groups of keys…

- 5 function keys and a Menu key
- 10 numeric entry keys, decimal, minus, backspace(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.

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.
   Use backspace key [←], to correct typing errors, one at a time.
4. If the Data entered exceeds the allowable limits, the 900-D will beep
   and display the limits. Enter new data or exit unchanged, with [Menu].

1.5 Connectors

Dissolved Oxygen Sensor : 6 Pin DIN Connector

Conductivity/Salinity Sensor : 5 Pin DIN Connector
The cell k factor MUST be selected using the [F4] "k factor" function of the Setup Menu. See section 4.1 and 5.1.

Temperature Sensor : 3.5mm phono jack

1.6 "Help" Information

The 900-D 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 keypad of the 900-D is splash resistant, avoid using in damp areas and wipe dry immediately if wet.

Prolonged exposure to direct sunlight should be avoided.

The 900-D should be operated in a cool dry environment.

2.2 Turn On

Plug in the plug-pack and turn ON. The 900-D will perform a memory test and display Model and Option details and proceed to "RUN MODE" displaying Oxygen, Conductivity/Salinity and Temperature Data.

Corruption of Memory contents can 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 900-D will perform an Initialization. See section 8 for details.

3. Oxygen

The Oxygen operating mode of the 900-D is selected using the "Mode" Menu.

Enter the following sequence of key presses to select the required oxygen mode…

Menu → F2:Mode → F1:Oxygen → F1:ppM
or F2:ppM (Sal)
or F3:% Sat
or F4:% Gas

The arrow on the display points to the current mode.

F1:ppM. : Selects ppM Dissolved Oxygen mode. No salinity compensation is performed.
F2:ppM (Sal) : Selects salinity-compensated ppM Dissolved Oxygen. During normal measurements, an (S) is displayed following the ppM, indicating that Salinity Compensation is being performed. If the Salinity exceeds 50ppK, useful correction is doubtful. The (S) starts to FLASH and the compensation is stopped. Measurement is as though the Salinity were 0ppK.
F3:% Sat : Selects % Saturation Dissolved Oxygen mode.
F4:% Gas : Selects % Gaseous Oxygen mode.

A "*" will replace the decimal point if a satisfactory Oxygen Calibration has NOT been performed.

Please note that it will take at least three minutes for the oxygen probe to polarize and for dissolved oxygen readings to stabilize after the meter is turned on.

3.1 Oxygen Calibration

NOTE: Before attempting to calibrate Oxygen, Conductivity or Salinity, ensure the Temperature section is correctly calibrated.

Before attempting Oxygen Calibration in Salinity-compensated ppM mode, ensure the Conductivity/Salinity section is correctly calibrated.

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 (or water if using Winkler titration) temperature.

Zero Calibration

1. Auto-calibration will select ZERO mode if the Oxygen Signal is under 5%.

   To make a solution containing no dissolved oxygen, add 2 grams of Sodium Sulphite (Na_2SO_3) to 100 mL of distilled water. This zero oxygen solution can be stored for several hours in a closed tube or syringe.

2. Place the sensor into the zero oxygen solution. When the reading has stabilized (approx 2-3 minutes), press the following sequence of keys to perform a zero calibration…

   Menu → F1:Calibrate → F1:Oxygen → Enter

3. The results of the calibration are now displayed, and the 900-D will return to normal measurement mode.

   If ZERO calibration fails, refit the membrane ensuring there are no wrinkles.

   True zero may require several minutes if a filling solution has to be replaced.

Span Calibration

1. Above 5%, a SPAN CALIBRATION will be selected automatically for you.

   For all modes, the default span calibration is in air. However for salinity-corrected ppM mode, the user has the opportunity to enter a calibration value based on the average of a series of Winkler titrations.

Span Calibration in Air

1. Carefully DRY the sensor membrane tip and let it STABILISE in air. Let it hang vertically, tip downwards.

2. For ppM (only), the temperature section must be operational and calibrated.

   In this instrument, temperature is sensed by the stainless steel temperature when connected. Make sure this is at the same temperature as the dissolved oxygen sensor.

   If the temperature sensor is not connected, temperature is sensed by the dissolved oxygen sensor, although this has a much slower temperature response.

3. When the dissolved oxygen has stabilised, press the following sequence of keys to perform a span calibration.

   Menu → F1:Calibrate → F1:Oxygen → Enter

Notes

1. The 900-D has an inbuilt table of calibration values at different temperature values for optimum accuracy.

2. If a Zero calibration if performed first, the 900-D will assume that a span calibration will follow. All that is required in this situation is to simply press the [Enter] key after the sensor has been dried and allowed to stabilise in air. Follow the on-screen prompts.

3. Repeat the Air Calibration as often as required.

4. The Zero Calibration can be presumed stable unless a membrane is refitted.

5. Note the relationship of % Saturation, % Gaseous Oxygen 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.

6. Note that for Salinity Compensated ppM, the "AIR" ppM value will drop (as expected), when the Conductivity Probe itself, is put into saline water.

Alternative Oxygen SPAN Calibration (ppM only)

Calibration data from the average of several Winkler titrations can be used INSTEAD of the **Air Calibration** method above. This is available only in Salinity-corrected ppM mode.
Salinity

1. Put the Dissolved Oxygen and Salinity sensors, into the known STANDARD and let both readings stabilise (stirring etc).

2. Select Span Calibration by pressing the following sequence of key presses…

   Menu → F1:Calibrate → F1:Oxygen.

   The 900-D now prompts you for an Oxygen AIR/SPAN Calibration.

3. Instead of pressing the [Enter] key, type in the result of the Winkler titration.

   The word “AIR/SPAN”, will be replaced by “ppM” as you type, so that you can still see the current reading from the sensor. At the same time, the Salinity value (previously not displayed for "AIR/SPAN") will now be indicated.

4. Press [Enter] after you have typed in the desired value. If you make a mistake, press the ← to delete on character at a time.

3.2 Salinity Compensation of ppM Dissolved Oxygen.

If ppM. mode is being used, the user may wish to apply Salinity Compensation.

Select Salinity-corrected ppM mode by pressing the following sequence of keys…

Menu → F2:Mode → F1:Oxygen → F2:ppM (Sal)

With the Salinity at 0 ppK the Oxygen reading is as though the water were fresh. The Salinity value is limited to 50 ppK. Beyond this 50ppK limit, the Salinity Correction is doubtful and is turned off, ie. the sample is considered fresh. In such a case the (S) which follows the data and units, will FLASH.

Salinity correction data is obtained from the Auto-ranging Conductivity/Salinity Sensor. If the Conductivity/Salinity Sensor is in AIR, no compensation will be done, due to the Zero salinity reading.

3.3 Measuring Unknowns

Place the sensor(s) in the unknown solution sample. Allow time for temperature stability if the unknown solution is not at room temperature.

If "ppM Salinity Mode" was selected, again the Conductivity Sensor must be present. Note that even if the user had selected CONDUCTIVITY display rather than SALINITY, the Salinity value is still computed in the background and this used to compensate the ppM Oxygen readout.

In Dissolved Oxygen modes, stir the probe in the solution slowly but steadily. Without stirring, the reading will drift downwards. 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.

4. Conductivity

1. Press the following sequence of keys to select Conductivity mode…

   Menu → F2:Mode → F3:Conductivity

2. After selecting Conductivity Mode, you will be requested to select whether the conductivity units are Siemens per centimetre or Siemens per metre.

   Press F1 to select Siemens/cm
   Press F2 to select Siemens/M
   Press [Menu] to exit without changing the current setting.

3. You will now be asked to enter the Conductivity Standard that you will be using during calibration. You will be prompted for the units after entering the standard value.

   3.1 Use the keypad to enter the value of the standard. Use the [←] key if you make an error. The 900-D displays the range of allowable standard values. Press enter to save the Conductivity Standard value. Alternatively, press the [Menu] key to keep the currently selected standard.

   3.2 Now select the units of the Conductivity standard.

   If you chose Siemens/cm in step 2, press F1 for µS/cm , or F2 for mS/cm.

   If you chose Siemens/M in step 2, press F1 for µS/M , F2 for mS/M, or F3 for S/M

4. The 900-D will now return to normal measurement mode. If the Conductivity has not been calibrated, a "*" replaces the decimal point. Before attempting calibration or measurements, ensure the cell is platinised correctly and is free of contamination.

4.1 k Factor Selection

The user MUST ensure that the k factor is correct for the cell is use. TPS glass Conductivity/Salinity cells have the k factor shown in the barrel. Press the following sequence of keys to select the k factor of the cell…

Menu → F4:k factor → F1: k=.1 for k=0.1 Sensor
or F2: k=1 for k=1.0 Sensor
or F3: k=10 for k=10 Sensor
or Press [Menu] to exit without changing settings.

4.2 Conductivity Temperature Compensation

All solutions have a conductivity temperature coefficient. The conductivity of the solution varies with temperature. This temperature effect is removed by normalizing the conductivity to the value it would be at 25 ^{o}C, by using Automatic Temperature Compensation (A.T.C.).

The 900-D uses a fixed temperature coefficient of -2.2 %/^{o}C for A.T.C. For precision work, maintain the Standard and Unknown at the same temperature. The two Temperature coefficients then cancel.

4.3 Conductivity Calibration

Ensure the conductivity cell is platinised correctly and is free of contamination.
Ensure that the k factor of the probe is set correctly.

Zero Calibration

1. Ensure the cell is dry and in air.

2. Press the following sequence of keys to perform a zero calibration.

   Menu → F1:Calibrate → F3:Conductivity

   The 900-D automatically detects a LOW value and automatically attempts a Zero Calibration.

   Press [Enter] when the reading has stabilised.

3. If the zero is not under 5%, auto-zero will not be recognised and a SPAN would have been attempted. This will almost certainly fail in due to the low value. Dry the cell better, or replace it if a sufficiently low value cannot be achieved. Replace the Cell or dry it better.

4. Repeat the ZERO.

Span Calibration

1. Place the cell into the Conductivity Standard. The Cell must have adequate clearance from the walls and the bottom of the container, as this can affect the readings.

2. Press the following sequence of keys to perform a span calibration.

   Menu → F1:Calibrate → F3:Conductivity

   The 900-D automatically detects that a span calibration is being attempted and will display the value of the conductivity standard that was entered at the beginning of this section. ***Check that this value matches the standard you are using.***

   Press [Enter] when the reading has stabilised.

3. The 900-D is now calibrated ***for this cell***.

Calibration Notes

1. The Zero and Span percentages of the cell are displayed shown momentarily before leaving CALIBRATE. This data can assist in fault finding if calibration fails.

2. Span calibration should be repeated at intervals depending on use, and the Zero Calibration only when changing cells, or as required.

3. The Cell will fail an automatic Span Calibration if the Cell Constant is less than 75% or greater than 125%. If this is the case, check that the Conductivity Standard is correct and that the cell is not dirty, damaged, or needs re-platinisation. Calibration failures retain the previous Calibration values. A "*" replaces the decimal point if a Cell remains uncalibrated.

4. The unit must be re-calibrated when changing cells.

5. Never return Standards to stock as they may be contaminated.

6. Press [F5] ie "HELP" while in "CALIBRATE" to display CURRENT cell % parameters.

4.4 Measuring Conductivity in Unknown Solutions

1. Ensure the Cell is Calibrated for ZERO and recently for SPAN. See it is platinised correctly and clean.
2. Place cell in the unknown solution sample. The Cell must have adequate clearance from the walls and the bottom of the container. Allow time for temperature stability if the unknown solution is not at room temperature.
3. Accuracy is improved if the temperature of the unknown is near 25 ^{o}C or if the temperature of the Standard is near that of the unknown during calibration.

5. Salinity

1. Press the following sequence of keys to select Salinity mode…

   Menu → F2:Mode → F4:Salinity

2. You will now be asked to enter the Salinity Standard that you will be using during calibration. You will be prompted for the units after entering the standard value.

   3.1 Use the keypad to enter the value of the standard (e.g. 36.00). Use the [←] key if you make an error. The 900-D displays the range of allowable standard values. Press [Enter] to save the Salinity Standard value. Alternatively, press the [Menu] key to keep the currently selected standard.

   3.2 Now select the units of the Salinity standard.

   Press F1 for ppM (parts per million).
   or Press F2 for ppK (parts per thousand).
   or Press [Menu] to exit without change.

3. The 900-D will now return to normal measurement mode. If the Salinity has not been calibrated, a "*" replaces the decimal point. Before attempting calibration or measurements, ensure the cell is platinised correctly and is free of contamination.

5.1 k Factor Selection

The user MUST ensure that the k factor is correct for the cell is use. TPS glass Conductivity/Salinity cells have the k factor shown in the barrel. Press the following sequence of keys to select the k factor of the cell…

Menu → F4:k factor → F1: k=.1 for k=0.1 Sensor
or F2: k=1 for k=1.0 Sensor
or F3: k=10 for k=10 Sensor
or Press [Menu] to exit without changing settings.

For Salinity measurements, the k=0.1 cell has too high current density for very accurate results. The k=10 cell is essential for applications above about 10 ppK.

5.2 Salinity Temperature Compensation

All solutions have a salinity temperature coefficient. The salinity of the solution varies with temperature. This temperature effect is removed by normalizing the salinity to the value it would be at 25 ^{o}C, by using Automatic Temperature Compensation (A.T.C.).

The 900-D uses a fixed temperature coefficient of -2.2 %/^{o}C for A.T.C. For precision work, maintain the Standard and Unknown at the same temperature. The two Temperature coefficients then cancel.

5.3 Salinity Calibration

Ensure the conductivity/salinity cell is platinised correctly and is free of contamination. Ensure that the k factor of the probe is set correctly.

Zero Calibration

1. Ensure the cell is dry and in air.

2. Press the following sequence of keys to perform a zero calibration.

   Menu → F1:Calibrate → F3:Salinity

   The 900-D automatically detects a LOW value and automatically attempts a Zero Calibration.

   Press [Enter] when the reading has stabilised.

3. If the zero is not under 5%, auto-zero will not be recognised and a SPAN would have been attempted. This will almost certainly fail in due to the low value. Dry the cell better, or replace it if a sufficiently low value cannot be achieved. Replace the Cell or dry it better.

4. Repeat the ZERO.

Span Calibration

1. Place the cell into the Salinity Standard. The Cell must have adequate clearance from the walls and the bottom of the container, as this can affect the readings.

2. Press the following sequence of keys to perform a span calibration.

   Menu → F1:Calibrate → F3:Salinity

   The 900-D automatically detects that a span calibration is being attempted and will display the value of the salinity standard that was entered at the beginning of this section. ***Check that this value matches the standard you are using.***

   Press [Enter] when the reading has stabilised.

3. The 900-D is now calibrated ***for this cell***.

Calibration Notes

1. The Zero and Span percentages of the cell are displayed shown momentarily before leaving CALIBRATE. This data can assist in fault finding if calibration fails.

2. Span calibration should be repeated at intervals depending on use, and the Zero Calibration only when changing cells, or as required.

3. The Cell will fail an automatic Span Calibration if the Cell Constant is less than 75% or greater than 125%. If this is the case, check that the Salinity Standard is correct and that the cell is not dirty, damaged, or needs re-platinisation. Calibration failures retain the previous Calibration values. A "*" replaces the decimal point if a Cell remains uncalibrated.

4. The unit must be re-calibrated when changing cells.

5. Never return Standards to stock as they may be contaminated.

6. Press [F5] ie "HELP" while in "CALIBRATE" to display CURRENT cell % parameters.

5.4 Measuring Salinity in Unknown Solutions

1. Ensure the Cell is Calibrated for ZERO and recently for SPAN. See it is platinised correctly and clean.
2. Place cell in the unknown solution sample. The Cell must have adequate clearance from the walls and the bottom of the container. Allow time for temperature stability if the unknown solution is not at room temperature.
3. Accuracy is improved if the temperature of the unknown is near 25 ^{o}C or if the temperature of the Standard is near that of the unknown during calibration.

6. Temperature Measurement

The 900-D uses a separate stainless steel sensor for temperature measurement. If this temperature sensor is not connected, the 900-D automatically reverts to measuring temperature via the dissolved oxygen sensor. The temperature response from the dissolved oxygen sensor is much slower than through the stainless steel sensor.

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

Temperature will be displayed as "OVR°C" if no temperature or dissolved oxygen sensor is connected or if the temperature sensor is faulty. A value of 20°C will be assumed for the Oxygen Temperature Compensation with consequent degradation of accuracy.

6.1 Temperature Calibration

As the 900-D uses its 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 oxygen sensors.

Temperature Calibration:

1. Place the temperature probe into a water bath at room temperature, alongside a good quality mercury thermometer. If a separate temperature probe is not being used, place the dissolved oxygen sensor into the water bath instead. Stir and allow time for the reading to stabilise.

2. Press the following sequence of keys to select temperature calibration…

   Menu → F1:Calibrate → F2:Temperature

3. The 900-D now prompts you to enter the actual temperature. The current reading from the sensor is displayed. The 900-D also lets you know if the temperature reading is being taken from a separate temperature sensor or the dissolved oxygen sensor.

4. Enter the temperature value measured by the mercury thermometer, using the numeric keypad. Press [←] if you need to make a correction.

   Press [Enter] to calibrate, or press [Menu] to exit without saving the changes.

5. If temperature calibration fails, the temperature sensor may be faulty. Check cable etc., and calibration procedure.

6.2 Measuring Unknown Temperatures

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

7. Servicing

7.1 Troubleshooting

Display

Fault	Suggested Remedy
No Display	Is the power lead plugged in ?
Incorrect readings/Cannot Calibrate	Check probe parameters for possible corruption. See section 3.13.1 and 4.3 or 5.3 Initialise the meter (if all else fails)… 1. Turn the meter off. 2. Press and hold the [←] key 3. Switch the meter back on 4. Release the [←] key. (See section 8)

Dissolved Oxygen

Fault	Suggested Remedy
Noisy readings	1. Check input plug is correctly fitted. 2. Check the Oxygen probe membrane is OK. 3. Bubbles inside probe? Refit the membrane.
Cannot 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.
Cannot Calibrate	1. Is the membrane wrinkled ? 2. Replace the membrane on the probe.

Conductivity/Salinity

Noise and poor cell performance can be due to the loss of platinum black coating or a build up of material on the plates of the cell. Inspect cell and clean if necessary.

Temperature

If no Temperature or Dissolved Oxygen sensor is present a temperature of "OVR^{o}C" will be displayed. 20 ^{o}C will be used for temperature compensation for dissolved oxygen.

If the Temperature or Dissolved Oxygen Sensor is plugged in and "OVR^{o}C" is displayed, the sensor may be faulty. Check using another probe.

8. Initialisation

Initialisation of the 900-D may be required as a result of corruption of the Rechargeable 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 following message will be displayed:

Calibration, Configuration and Data Lost

The following default values will be loaded when initialised. The unit should be reconfigured to suit application and re-calibrated.

The 900-D can also be initialized by holding down the [←] key at power ON.

Parameter	**Default**	**Range Of User Setting**
Oxygen Mode	Salinity-corrected ppM	1. ppM 2. Salinity-corrected ppM 3. % Saturation 4. % Gaseous
Oxygen cell zero	0 %	N/A, set by auto-calibration
Oxygen cell span	100 %	N/A, set by auto-calibration
Conductivity/Salinity Mode	Conductivity	1. Conductivity 2. Salinity
Conductivity units	Siemens/cm	1. Siemens/cm 2. Siemens/m
Conductivity cell zero	0 %	N/A, set by auto-calibration
Conductivity cell span	100 %	N/A, set by auto-calibration
k factor	k=10	1. k=0.1 2. k=1.0 3. k=10
Conductivity Standard	2.76 mS/cm	20 µS/cm to 2000 mS/cm
Salinity Standard	36.0 ppK	20 ppM to 500 ppK
Temperature Zero	0 %	N/A, set by auto-calibration
Temperature Span	100 %	N/A, set by auto-calibration

9. Specifications

Dissolved Oxygen

Ranges

ppM Dissolved Oxygen	: 0-30.00 ppM in Fresh Water
Salinity-corrected ppM Dissolved Oxygen	: 0-25.00 ppM in Salt Water (36ppK Salinity)
% Saturation Dissolved Oxygen	: 0-300.0 %
% Gaseous Oxygen	: 0-65.0 %
Resolution	: 0.01 ppM, 0.1% Saturation, 0.1 % Gaseous
Accuracy	: Better than ±0.3% of reading, ±1 digit

Compensation

Membrane Temperature Compensation	: AUTOMATIC
Solubility Temp Compensation (ppM)	: AUTOMATIC
Gaseous and %Saturation Compensation	: AUTOMATIC
Salinity Compensation	: AUTOMATIC

Calibration

Zero Calibration	: AUTOMATIC (at less than 5%)
Span Calibration	: AUTOMATIC

Conductivity/Salinity

Ranges

Siemens/cm	: 0 to 200.0 mS/cm in 4 ranges (auto-ranging)
Siemens/m	: 0 to 20,000 mS/M in 4 ranges (auto-ranging)
Linearised Salinity	: 0 to 100.0 ppK in 4 ranges (auto-ranging)
Resolution	: 0.1% of selected Conductivity range 0.2% of selected Salinity range
Accuracy	: Better than ±0.2% of reading, ±1 digit

Compensation

Temperature	: Automatically normalised to 25 ^{O}C
ATC Coefficient	: -2.2%/^{o}C

Calibration

Zero Calibration	: AUTOMATIC (at less than 5%)
Span Calibration	: AUTOMATIC

Temperature

Range	: -30 to 110 ^{o}C (Oxygen sensor limit 50 ^{o}C)
Calibration	: 1 point automatic calibration for user (2nd point is factory set)
Resolution	: 0.1 ^{o}C
Accuracy	: ±0.2 ^{o}C

Display	: 2 line x 40 Character alphanumeric LCD for readings, Menus, Help and Error Messages.
Keypad	: 5 Function Keys, Menu key and 14 data entry keys.
Sensors	
Dissolved Oxygen/Temperature	: TPS ED500L Dissolved Oxygen Probe.
Conductivity/Salinity	: TPS Lab. Conductivity Cell
Temperature	: TPS ETPL1 Temperature Probe
Stability	
Instrument	: Better than 0.1 % of any Mode Full Scale
Sensors	: Subject to sensor condition
Power	: 240 V AC, 50 Hz using plug-pack. Other voltages by request.
Dimensions	: 270 x 210 x 75 mm.
Weight:	: Typical System Shipping Weight: 3 Kg

10. Spares and Accessories

The 900-D standard kit includes :

	Part No
900-D Meter	123103
900-D Handbook	130050

Sensors

ED500L Dissolved Oxygen sensor for 900 Series	123240
Conductivity probe, k= 10 with ATC	122222
Conductivity probe, k= 1 with ATC	122226
Conductivity probe, k= 0.1 with ATC	122224
Temperature Sensor	121245

Spares and Replacements

Mains power lead	WMIEC
Dissolved Oxygen Sensor Membrane kit	123301
Probe filling solution	123303
Sodium Sulphite, 50g, for Zero Calibration	123302
Conductivity Standard, 2.76 mS/cm, 200 mL	122306
Conductivity Standard, 2.76 mS/cm, 1 Litre	122305
Salinity Standard, 36ppK NaCl, 1 Litre,	122304

Please contact the factory for the name of your nearest TPS distributor.

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11. Appendices

11.1 Solubility of Oxygen in Water

Solubility of Oxygen in Water Exposed to Water-Saturated Air (76 cm/Hg)

Salinity					
g/L Cl^-	0	4	8	16	20
ppK NaCl	0	6.6	13.2	26.4	33
Temp ^oC	**Dissolved Oxygen**				
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
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				

11.2 Dissolved Oxygen Sensor Fundamentals

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.

11.3 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
$\pm$ 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.

11.4 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.

To replace the membrane:

1. Unscrew the lower barrel and carefully remove it from the probe. Ensure that the internal lexan barrel is not touched with the fingers, as the metallic surfaces are easily contaminated.
2. Remove the plastic cap and membrane from the end of the barrel.
3. Cut a 30 mm square (approx) piece of membrane material from your probe maintenance kit. Hold this over the end of the barrel, and push the plastic retaining cap back into place evenly. A little moisture on the outside of the membrane will let the cap slip on easily. The excess membrane may be trimmed off with a razor blade.
4. Pour enough 0.1 Molar KCl solution into the barrel to fill only 1/3.
5. Push the barrel carefully onto the lexan internal rod. As this is done, check for leaks on the membrane. The internal rod can be used to gently "pump" the membrane to check for leaks.
6. If no leaks can be seen, screw the outer barrel into place, so that the membrane is evenly and smoothly stretched over the gold internal cathode (gold bead at end). DO NOT OVERTIGHTEN.

   If the probe is washed off and put in fresh water, then, by viewing obliquely in a strong light, it is possible to see electrolyte "streaming" from the tip if it is leaking (even slowly). The effect is one of differential refractive index and is quite sensitive.

   If the response is low, or zero impossible, or reading overranged, fit a new membrane.

11.5 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.

For long term storage of several weeks or more, remove and empty the barrel. Replace the barrel with the membrane intact. When the electrode is stored in this way, the membrane should be replaced and the electrode refilled before use.

11.6 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 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 900-D 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 900-D Meter has Solubility Correction via an additional temperature sensor in the electrode.
(c) Salinity correction is provided automatically performed via the salinity sensor.

11.7 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.

11.8 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.

12. 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 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.)

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.