USER MANUAL

CS512
Oxyguard Type III
Dissolved Oxygen Sensor

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CSL 576

Guarantee

This equipment is guaranteed against defects in materials and workmanship. This guarantee applies for 24 months from date of delivery. We will repair or replace products which prove to be defective during the guarantee period provided they are returned to us prepaid. The guarantee will not apply to:

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- Batteries
- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

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Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.

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PLEASE READ FIRST

About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area:	1 in^2 (square inch) = 645 mm^2		1 lb (pound weight) = 0.454 kg
Length:	1 in. (inch) = 25.4 mm 1 ft (foot) = 304.8 mm 1 yard = 0.914 m 1 mile = 1.609 km	**Pressure:** **Volume:**	1 psi (lb/in^2) = 68.95 mb 1 UK pint = 568.3 ml 1 UK gallon = 4.546 litres 1 US gallon = 3.785 litres
Mass:	1 oz. (ounce) = 28.35 g		

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a "#" symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

Recycling information

At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.

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Campbell Scientific CS512 Oxyguard Type III Dissolved Oxygen Sensor

An accurate and reliable sensor is a critical element in any measurement system. The Oxyguard Stationary Sensor meets these criteria for the measurement of dissolved oxygen.

1. General Information

The Oxyguard Stationary Sensor is a galvanic sensor which produces a millivolt signal proportional to the amount of oxygen present in the measured medium. Oxygen diffuses through the membrane onto the cathode, reacts chemically, and combines with the anode. An electrical current is produced by this chemical reaction which is converted from microamps to millivolts by an in-line resistor. An in-line thermistor also conditions the signal providing automatic temperature compensation. With these features, the sensor produces a millivolt output proportional to the oxygen present in the medium in which it is placed. The sensor consists of two parts, an upper part with cathode, anode and cable, and a lower part comprising a screw on membrane cap with fitted membrane. The cap is filled with electrolyte and simply screwed onto the top component.

The sensor is self-polarizing and requires no external power source. There are two wires to connect.

Because the sensor's output is linear, it is possible to connect it directly to a data acquisition system capable of handling the small millivolt signal.

The sensor's robust construction and simple design make maintenance and servicing it straightforward. There is no need to send the sensor back to the factory for servicing. It utilizes a strong, easy-to-clean and easy-to-change membrane in a screw-on membrane cap. Regular servicing is not required. When necessary the sensor can be fully overhauled in five minutes.

Figure 1-1. CS512

2. Specifications

Principle of Measurement:	Membrane covered galvanic oxygen sensor
Output Signal:	2.5 to 5 mV per mg 1^{-1}
Repeatability:	Better than ±0.2 mg/l calibration temperature equals measuring temperature ±5°C
Output Impedance:	~1 kohm
Response Time:	After equilibration, 1 minute for 95% of final value
Materials of Construction:	
Sensor body:	Delrin
O-rings:	Membrane O-ring = Buna N Body Seal O-ring = Viton
Membrane:	0.05 mm (2 mil) Teflon
Dimensions and Weight:	5.7 cm (2.28”) diameter x 5.8 cm (2.3”) height 450 g (15.9 oz.)
Cable:	standard length 7 m (23 ft); other lengths available upon request 2-wire 22 awg shielded, PVC jacketed
Operating Conditions:	
Temperature	0° to 40°C (32° to 122°F)
Pressure:	0 to 29 psig
Minimum Submersion Depth:	60 mm (2 ½ in)
Minimum Water Flow:	1 cm/s (.39 in/sec) across membrane
Calibration:	In air or in air saturated water
Temperature Compensation:	Automatic from 4° - 40°C (40° - 104°F)
Range of Dissolved Oxygen:	0-20 mg/l, 0-200% Sat
Ships with:	5 spare membranes with O-rings 50 ml electrolyte cathode cleaning pad

3. Optional Sensor Accessories

009994 — PT4 Agitator for stagnant conditions
010315 — DO electrolyte, 1 litre
010314 — Membrane kit, 10 membranes

4. Optional Agitator – available to special order only

The PT4 Agitator is a reliable and robust agitator for use in conjunction with sensors subjected to bio-fouling in ponds and stagnant water conditions.

O_2 sensors require a minimum water velocity across their membranes to function properly. Therefore, to measure DO in stagnant water conditions, it is necessary to move the water past the membrane to get accurate and reliable DO measurements. In many instances the water also has a high bio-loading and the sensors become fouled resulting in inaccurate DO measurements.

Figure 4-1. Preventing Bio-fouling of the CS512

The PT4 Agitator overcomes these problems. The device is designed so that a soft bristle brush sweeps across the sensor membrane or sensor tip. This sweeping action of the brush provides the required water velocity as well as prevents the membrane from becoming bio-fouled.

The optimum sweeping frequency depends upon the design of sensor and type of membrane used and water conditions. An ON-time of 0.25 seconds and OFF-time of 5 seconds is suitable in most circumstances.

Agitator's overall size: 180 mm x 83 mm, diameter, 0.6 kg (7-1/8" x 3-1/4", 1-1/4 lb). Supplied with 3 metres (10 ft.) cable.

Power required: 10.5 to 18 VDC at the agitator, 1.1 amps. Maximum ON-time is 3 seconds.

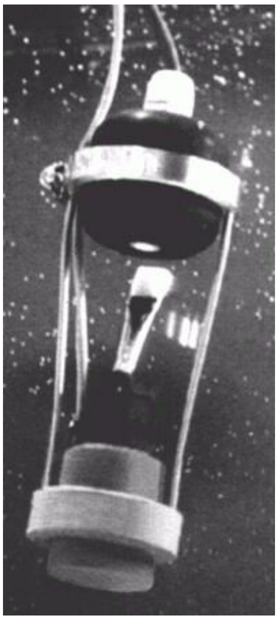

Figure 4-2. CS512 with PT4 Agitator

Optional Repeat Cycle Timer for Agitators: Reciprocating action may be controlled by the optional solid state Repeat Cycle Timer. It sends 12 VDC pulses to the agitator coil. The ON-time is 0.25 sec. The OFF-time is adjustable from 3 to 12 sec.; requires supply voltage 10 to 17 VDC; housed in watertight cylinder 170 mm x 50 mm diameter (6.6" x 2").

5. Application Information

NOTE SCWin users: This manual was written primarily for those whose needs are not met by SCWin. Your procedure is much simpler: just add the CS512 sensor (it's in the water folder), save your program, and follow the wiring shown in Step 2 of SCWIN.

6. Wiring

The CS512 sensor can use one differential channel or one single-ended channel. Differential wiring is better at rejecting electrical noise and ground loop error.

Table 6-1. Sensor Wiring

Colour	Function	CR510, CR10X, CR800, CR850, CR23X, CR1000, CR3000	CR200 Series
Brown	Signal +	Differential High, or Single-Ended Channel	Single-Ended Channel
Blue	Signal -	Differential Low or AG	Ground

7. Programming

7.1 CRBasic

In the CR800, CR850, CR1000, CR3000, and CR5000, the VoltDiff or VoltSE can be used to measure the CS511. In the CR200-series dataloggers, only the VoltSE instruction can be used since these dataloggers do not support differential measurements. Example program 1 is a CR1000 program that uses the VoltDiff instruction. Example Program 2 is a CR200 program.

EXAMPLE 1. Sample CR1000 Program using VoltDiff

This example is a CR1000 program but programming for the CR800, CR850, CR3000, and CR5000 is similar. Table 7-1 shows the wiring for the example.

Table 7-1. Wiring for Example 1

CR1000 Connection	Sensor Wire
1H	Brown
1L	Blue
Ground	Clear

```
'CR1000
'Created by Short Cut (2.5 Beta)

'Declare Variables and Units
Public Batt_Volt
Public DOmV
Public DOppm

Units Batt_Volt=Volts
Units DOmV=mV
Units DOppm=ppm

'Define Data Tables
DataTable(Table1,True,-1)
    DataInterval(0,60,Min,10)
    Sample(1,DOmV,FP2)
    Sample(1,DOppm,FP2)
    Sample(1,Batt_Volt,FP2)
EndTable

DataTable(Table2,True,-1)
    DataInterval(0,1440,Min,10)
    Minimum(1,Batt_Volt,FP2,False,False)
EndTable

'Main Program
BeginProg
    Scan(5,Sec,1,0)
        'Default Datalogger Battery Voltage measurement Batt_Volt:
        Battery(Batt_Volt)
        'CS512  Dissolved Oxygen Probe measurements DOmV and DOppm:
        VoltDiff(DOmV,1,mV250,1,True,0,_60Hz,1,0)
        DOppm=DOmV*0.34 'Note use exact calibration factor (see section 8)
        'Call Data Tables and Store Data
        CallTable(Table1)
        CallTable(Table2)
    NextScan
EndProg
```

EXAMPLE 2. Sample CR200 Program

The CR200-series must use the VoltSE instruction since these dataloggers do not make differential measurements. If the other CRBasic dataloggers use the VoltSE instruction instead of the VoltDiff instruction, their programming will be similar to this example. Table 7-2 shows the wiring for the example.

Table 7-2. Wiring for Example 2

CR200 Connection	Sensor Wire
SE1	Brown
Ground	Blue
Ground	Clear

```
'CR200 Series
'Created by Short Cut (2.5 Beta)

'Declare Variables and Units
Public Batt_Volt
Public DOmV
Public DOppm

Units Batt_Volt=Volts
Units DOmV=mV
Units DOppm=ppm

'Define Data Tables
DataTable(Table1,True,-1)
	DataInterval(0,60,Min)
	Sample(1,DOmV)
EndTable

DataTable(Table2,True,-1)
	DataInterval(0,1440,Min)
	Minimum(1,Batt_Volt,False,False)
EndTable

'Main Program
BeginProg
	Scan(10,Sec)
		'Default Datalogger Battery Voltage measurement Batt_Volt:
		Battery(Batt_Volt)
		'CS512 Dissolved Oxygen Probe measurements DOmV and DOppm:
		VoltSE(DOmV,1,1,1,0)
		DOppm=DOmV*0.34 'Note use exact calibration factor (see section 8)
		'Call Data Tables and Store Data
		CallTable(Table1)
		CallTable(Table2)
	NextScan
EndProg
```

7.2 Edlog

Edlog Instruction 1 or 2 can be used. Example 1 shows the single-ended instruction for measuring the Sensorex probe; example 2 shows the differential instruction. The example measurement instructions that follow do not store data to final storage. Additional instructions (typically P92, P77, and output processing instructions such as P70) are required to store data permanently.

EXAMPLE 3. Portion of CR10X Sample Program using P1

```
1:  Volt (SE) (P1)
  1:   1           Reps
  2:   24          250 mV 60 Hz Rejection Range   ; code 23 used for CR23X
  3:   1           SE Channel
  4:   1           Loc [ DOmV     ]
  5:   1.0         Multiplier                     *See Calibration*
  6:   0.0         Offset
```

EXAMPLE 4. Portion of CR10X Sample Program using P2

```
1:  Volt (Diff) (P2)
  1:   1           Reps
  2:   24          250 mV 60 Hz Rejection Range   ; code 23 used for CR23X
  3:   1           DIFF Channel
  4:   1           Loc [ DOmV     ]
  5:   1.0         Multiplier                     *See Calibration*
  6:   0.0         Offset
```

8. Calibration

The multiplier is used to calibrate the CS512 sensor. To calculate the multiplier:

1) Program the datalogger using a multiplier of one.

2) Place the OxyGuard sensor in the air, shaded from the sun. Wait for readings to stabilize. This may take 15 minutes or more.

3) Determine the air temperature and barometric pressure.

4) Using a calibration chart such as that provided in the sensor's manual, determine the oxygen concentration of the air.

5) Use the following equation to calculate the multiplier:
   M = P/R
   M = Multiplier
   P = Concentration in PPM of the air (from the calibration chart in Appendix A)
   R = The signal output of the OxyGuard sensor when using a multiplier of one

6) Change the multiplier in the datalogger program from one to the calculated number.

A more common way to enter the multiplier is to insert a separate instruction in the program. This will allow a new multiplier to be added to the program without rewriting, compiling, and downloading the program to the data logger.

In the CR510, CR10X, and CR23X, use Instruction P36. The multiplier is entered into an input location called DOmult using the numeric display in PC200W, PC208W, LoggerNet, PC400, PConnect, PConnectCE, or the CR10KD.

EXAMPLE 6. Sample Program using P36

```
57:  Z=X*Y (P36)
   1:    1                 X Loc [ DOmV         ]
   2:    2                 Y Loc [ DOmult       ]
   3:    3                 Z Loc [ DOppm        ]
```

In all dataloggers that use CRBasic, an expression is written. The multiplier value is entered into the expression through the Public Table using the numeric display in PC200W, LoggerNet, PC400, PConnect, and PConnectCE.

EXAMPLE 7. Sample Program using Expression

```
DOppm = DOMult * DOmV
```

9. Maintenance

The CS512 sensor needs little maintenance. Regular cleaning of the membrane is all that is required. The membrane is very durable and can be cleaned with a cloth or soft paper. Do not scratch it clean with your fingernail.

10. Agitator Control

In low flow conditions (less than about 5 cm/sec), it may be necessary to add an agitator to the CS512 sensor. Campbell Scientific ships the agitator with a repeat cycle timer. Using the repeat cycle timer requires no datalogger programming. However, some users choose to use a solid state relay and have the datalogger agitate the water on the sensor face either periodically throughout the day or just before measurement. Agitating just before the measurement saves on power and causes less wear and tear on the agitator and sensor membrane.

The wiring for the agitator as controlled by this example program would be as follows:

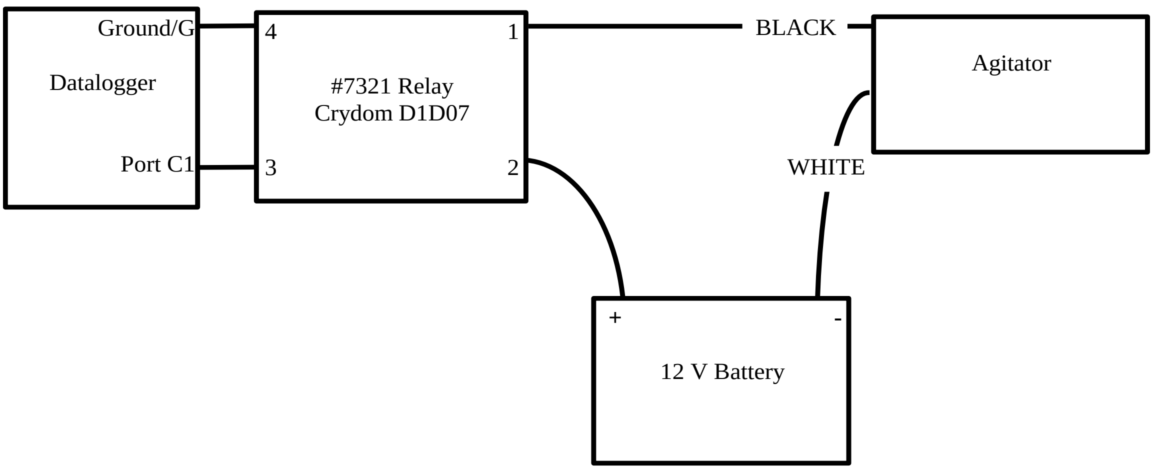

Figure 10-1. Agitator Wiring

The following instructions would trigger the agitator as discussed in the agitator manual.

In the CR510, CR10X, and CR23X, use instruction P86 and P22.

EXAMPLE 8. Sample Program using P86 and P22 Instructions

```
45:  Do (P86)
  1:  41            Set Port 1 High

46:  Excitation with Delay (P22)
  1:  1             Ex Channel
  2:  20            Delay W/Ex (units = 0.01 sec)
  3:  0             Delay After Ex (units = 0.01 sec)
  4:  0             mV Excitation

47:  Do (P86)
  1:  51            Set Port 1 Low

48:  End (P95)
```

In the CR200 series dataloggers, use the Portset instruction.

EXAMPLE 9. Sample Program using Portset

```
Portset (1,1)
Delay(500,msec)
Portset(1,0)
```

In the CR1000, CR800, CR850, and CR3000 dataloggers, use the Portset instruction.

EXAMPLE 10. Sample Program using Portset

```
Portset (1,1)
Delay (1,500,msec)
Portset (1,0)
```

The above example is not as power efficient as possible and would require AC power to maintain a sufficient battery charge. If it is necessary to operate an agitator without AC power available, write the program so that the agitator is only operated for a short period of time just before the measurement is to be taken.

Appendix A. Dissolved Oxygen Tables

Table I: Dissolved Oxygen in Fresh Water

Solubility of dissolved oxygen (mg/L) as a function of temperature and pressure for moist air, salinity = 0.0 ppt.

TEMP.		ALTITUDE (Feet/Metres) and equivalent BAROMETRIC PRESSURE (mm Hg/mbar)													
		0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	Feet
		0	152	305	457	610	762	914	1067	1219	1372	1524	1676	1829	Metres
		760	747	733	721	708	695	683	671	659	648	636	625	614	mm Hg
°C	°F	1013	995	978	961	944	927	911	895	879	863	848	833	819	mbar
0	32.0	14.60	14.34	14.09	13.84	13.60	13.36	13.12	12.89	12.67	12.44	12.22	12.01	11.80	
1	33.8	14.20	13.95	13.70	13.46	13.22	12.99	12.76	12.54	12.32	12.10	11.89	11.68	11.47	
2	35.6	13.81	13.57	13.33	13.10	12.87	12.64	12.42	12.20	11.98	11.77	11.56	11.36	11.16	
3	37.4	13.45	13.21	12.98	12.75	12.52	12.30	12.09	11.87	11.66	11.46	11.26	11.06	10.86	
4	39.2	13.09	12.86	12.64	12.41	12.20	11.98	11.77	11.56	11.36	11.16	10.96	10.77	10.58	
5	41.0	12.76	12.53	12.31	12.09	11.88	11.67	11.47	11.26	11.07	10.87	10.68	10.49	10.31	
6	42.8	12.44	12.22	12.00	11.79	11.58	11.38	11.18	10.98	10.79	10.60	10.41	10.23	10.05	
7	44.6	12.13	11.91	11.70	11.50	11.29	11.10	10.90	10.71	10.52	10.33	10.15	9.97	9.80	
8	46.4	11.83	11.62	11.42	11.22	11.02	10.83	10.63	10.45	10.26	10.08	9.91	9.73	9.56	
9	48.2	11.55	11.34	11.15	10.95	10.76	10.57	10.38	10.20	10.02	9.84	9.67	9.50	9.33	
10	50.0	11.28	11.08	10.88	10.69	10.50	10.32	10.14	9.96	9.78	9.61	9.44	9.27	9.11	
11	51.8	11.02	10.82	10.63	10.44	10.26	10.08	9.90	9.73	9.56	9.39	9.22	9.06	8.90	
12	53.6	10.77	10.58	10.39	10.21	10.03	9.85	9.68	9.51	9.34	9.17	9.01	8.85	8.70	
13	55.4	10.53	10.34	10.16	9.98	9.80	9.63	9.46	9.29	9.13	8.97	8.81	8.66	8.50	
14	57.2	10.29	10.11	9.93	9.76	9.59	9.42	9.25	9.09	8.93	8.77	8.62	8.47	8.32	
15	59.0	10.07	9.89	9.72	9.55	9.38	9.22	9.05	8.89	8.74	8.58	8.43	8.28	8.14	
16	60.8	9.86	9.68	9.51	9.35	9.18	9.02	8.86	8.70	8.55	8.40	8.25	8.11	7.96	
17	62.6	9.65	9.48	9.31	9.15	8.99	8.83	8.68	8.52	8.37	8.22	8.08	7.94	7.80	
18	64.4	9.45	9.29	9.12	8.96	8.80	8.65	8.50	8.35	8.20	8.06	7.91	7.77	7.64	
19	66.2	9.26	9.10	8.94	8.78	8.63	8.47	8.32	8.18	8.03	7.89	7.75	7.62	7.48	
20	68.0	9.08	8.92	8.76	8.61	8.45	8.30	8.16	8.01	7.87	7.73	7.60	7.46	7.33	
21	69.8	8.90	8.74	8.59	8.44	8.29	8.14	8.00	7.86	7.72	7.58	7.45	7.32	7.19	
22	71.6	8.73	8.57	8.42	8.27	8.13	7.98	7.84	7.71	7.57	7.44	7.31	7.18	7.05	
23	73.4	8.56	8.41	8.26	8.12	7.97	7.83	7.69	7.56	7.43	7.29	7.17	7.04	6.92	
24	75.2	8.40	8.25	8.11	7.96	7.82	7.69	7.55	7.42	7.29	7.16	7.03	6.91	6.79	
25	77.0	8.24	8.10	7.96	7.82	7.68	7.54	7.41	7.28	7.15	7.03	6.90	6.78	6.66	
26	78.8	8.09	7.95	7.81	7.67	7.54	7.41	7.28	7.15	7.02	6.90	6.78	6.66	6.54	
27	80.6	7.95	7.81	7.67	7.54	7.40	7.27	7.14	7.02	6.90	6.77	6.65	6.54	6.42	
28	82.4	7.81	7.67	7.53	7.40	7.27	7.14	7.02	6.89	6.77	6.65	6.54	6.42	6.31	
29	84.2	7.67	7.54	7.40	7.27	7.14	7.02	6.90	6.77	6.65	6.54	6.42	6.31	6.20	
30	86.0	7.54	7.41	7.28	7.15	7.02	6.90	6.78	6.66	6.54	6.42	6.31	6.20	6.09	
31	87.8	7.41	7.28	7.15	7.03	6.90	6.78	6.66	6.54	6.43	6.32	6.20	6.09	5.99	
32	89.6	7.29	7.16	7.03	6.91	6.79	6.67	6.55	6.43	6.32	6.21	6.10	5.99	5.89	
33	91.4	7.17	7.04	6.92	6.79	6.67	6.56	6.44	6.33	6.22	6.11	6.00	5.89	5.79	
34	93.2	7.05	6.92	6.80	6.68	6.56	6.45	6.34	6.22	6.11	6.01	5.90	5.80	5.69	
35	95.0	6.93	6.81	6.69	6.57	6.46	6.34	6.23	6.12	6.02	5.91	5.81	5.70	5.60	
36	96.8	6.82	6.70	6.59	6.47	6.36	6.24	6.13	6.03	5.92	5.82	5.71	5.61	5.51	
37	98.6	6.72	6.60	6.48	6.37	6.26	6.15	6.04	5.93	5.83	5.72	5.62	5.52	5.43	
38	100.4	6.61	6.49	6.38	6.27	6.16	6.05	5.94	5.84	5.74	5.63	5.53	5.44	5.34	
39	102.2	6.51	6.39	6.28	6.17	6.06	5.96	5.85	5.75	5.65	5.55	5.45	5.35	5.26	
40	104.0	6.41	6.30	6.19	6.08	5.97	5.86	5.76	5.66	5.56	5.46	5.37	5.27	5.18	

Table II: Dissolved Oxygen in Saline Water

Solubility of dissolved oxygen (mg/L) as a function of temperature and salinity for moist air at sea level

TEMP		SALINITY - Parts per Thousand								
°C	°F	0	5	10	15	20	25	30	35	40
0	32.0	14.60	14.11	13.64	13.18	12.74	12.31	11.90	11.50	11.11
1	33.8	14.20	13.73	13.27	12.83	12.40	11.98	11.58	11.20	10.83
2	35.6	13.81	13.36	12.91	12.49	12.07	11.67	11.29	10.91	10.55
3	37.4	13.45	13.00	12.58	12.16	11.76	11.38	11.00	10.64	10.29
4	39.2	13.09	12.67	12.25	11.85	11.47	11.09	10.73	10.38	10.04
5	41.0	12.76	12.34	11.94	11.56	11.18	10.82	10.47	10.13	9.80
6	42.8	12.44	12.04	11.65	11.27	10.91	10.56	10.22	9.89	9.57
7	44.6	12.13	11.74	11.37	11.00	10.65	10.31	9.98	9.66	9.35
8	46.4	11.83	11.46	11.09	10.74	10.40	10.07	9.75	9.44	9.14
9	48.2	11.55	11.19	10.83	10.49	10.16	9.84	9.53	9.23	8.94
10	50.0	11.28	10.92	10.58	10.25	9.93	9.62	9.32	9.03	8.75
11	51.8	11.02	10.67	10.34	10.02	9.71	9.41	9.12	8.83	8.56
12	53.6	10.77	10.43	10.11	9.80	9.50	9.21	8.92	8.65	8.38
13	55.4	10.53	10.20	9.89	9.59	9.30	9.01	8.74	8.47	8.21
14	57.2	10.29	9.98	9.68	9.38	9.10	8.82	8.55	8.30	8.04
15	59.0	10.07	9.77	9.47	9.19	8.91	8.64	8.38	8.13	7.88
16	60.8	9.86	9.56	9.28	9.00	8.73	8.47	8.21	7.97	7.73
17	62.6	9.65	9.36	9.09	8.82	8.55	8.30	8.05	7.81	7.58
18	64.4	9.45	9.17	8.90	8.64	8.39	8.14	7.90	7.66	7.44
19	66.2	9.26	8.99	8.73	8.47	8.22	7.98	7.75	7.52	7.30
20	68.0	9.08	8.81	8.56	8.31	8.07	7.83	7.60	7.38	7.17
21	69.8	8.90	8.64	8.39	8.15	7.91	7.69	7.46	7.25	7.04
22	71.6	8.73	8.48	8.23	8.00	7.77	7.54	7.33	7.12	6.91
23	73.4	8.56	8.32	8.08	7.85	7.63	7.41	7.20	6.99	6.79
24	75.2	8.40	8.16	7.93	7.71	7.49	7.28	7.07	6.87	6.68
25	77.0	8.24	8.01	7.79	7.57	7.36	7.15	6.95	6.75	6.56
26	78.8	8.09	7.87	7.65	7.44	7.23	7.03	6.83	6.64	6.46
27	80.6	7.95	7.73	7.51	7.31	7.10	6.91	6.72	6.53	6.35
28	82.4	7.81	7.59	7.38	7.18	6.98	6.79	6.61	6.42	6.25
29	84.2	7.67	7.46	7.26	7.06	6.87	6.68	6.50	6.32	6.15
30	86.0	7.54	7.33	7.14	6.94	6.75	6.57	6.39	6.22	6.05
31	87.8	7.41	7.21	7.02	6.83	6.65	6.47	6.29	6.12	5.96
32	89.6	7.29	7.09	6.90	6.72	6.54	6.36	6.19	6.03	5.87
33	91.4	7.17	6.98	6.79	6.61	6.44	6.26	6.10	5.94	5.78
34	93.2	7.05	6.86	6.68	6.51	6.33	6.17	6.01	5.85	5.69
35	95.0	6.93	6.75	6.58	6.40	6.24	6.07	5.92	5.76	5.61
36	96.8	6.82	6.65	6.47	6.31	6.14	5.98	5.83	5.68	5.53
37	98.6	6.72	6.54	6.37	6.21	6.05	5.89	5.74	5.59	5.45
38	100.4	6.61	6.44	6.28	6.12	5.96	5.81	5.66	5.51	5.37
39	102.2	6.51	6.34	6.18	6.03	5.87	5.72	5.58	5.44	5.30
40	104.0	6.41	6.25	6.09	5.94	5.79	5.64	5.50	5.36	5.22

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