Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 64 **MARCH 2001**

SBE 43 Dissolved Oxygen Sensor

General Description

The SBE 43 uses a membrane polarographic oxygen detector (MPOD) in its oxygen sensor. The oxygen sensor has one 0 to +5 volt output, which is proportional to the temperature-compensated oxygen current. Consult the specification sheet that was supplied with your oxygen sensor for additional information. A Sea-Bird CTD that is equipped with an oxygen sensor records this voltage for later conversion to oxygen concentration using a modified version of the algorithm by Owens and Millard (1985).

Oxygen sensors determine the dissolved oxygen concentration by *counting* the number of oxygen molecules per second (flux) that diffuse through a membrane from the ocean environment to the working electrode. The concentration of oxygen in the environment can be computed if you know the flux of oxygen and the geometry of the diffusion path. The permeability of the membrane to oxygen is a function of temperature and ambient pressure and is taken into account in the calibration equation. The algorithm to compute oxygen concentration requires measurements of **water temperature, salinity, pressure, and oxygen sensor current**. When the oxygen sensor is interfaced with a Sea-Bird CTD, all of these parameters are measured by the system.

At the working electrode (cathode), oxygen gas molecules are converted to hydroxyl ions (OH-) in a series of reaction steps where the electrode supplies four electrons per molecule to complete the reaction. The sensor counts oxygen molecules by measuring the electrons per second (amperes) delivered to the reaction. At the other electrode (anode), silver chloride is formed and silver ions (Ag+) are dissolved into solution. Consequently, the chemistry of the sensor electrolyte changes continuously as oxygen is measured, and this produces a slow but continuous change of the sensor calibration with time.

The oxygen sensor consumes the oxygen in the water near the sensor membrane. If there is not an adequate flow of new water past the membrane, the sensor will give a reading that is lower than the true oxygen concentration. This requires that the sensor be moving through the water or that water be pumped past the sensor.

Temperature differences between the water and oxygen sensor can lead to errors in the oxygen measurement. The SBE 43 minimizes this difference, as it calculates temperature compensation using a temperature measured very near the active surface of the sensor. As a result, the SBE 43 is less susceptible to error when profiling through areas of high temperature gradients than previous oxygen sensors.

Oxygen Algorithm

Sea-Bird uses a slightly modified version of the algorithm by Owens and Millard (1985) to convert SBE 43 oxygen sensor data to oxygen concentration. The Sea-Bird algorithm incorporates a term related to the offset voltage produced for zero oxygen current. In addition, a modification to the Boc term is required, because the SBE 43 output is temperature compensated by exp (-.03T) [i.e., tcor = -0.03].

Sea-Bird's algorithm has the following form:
OX = [Soc * {(v + offset) + (tau *doc/dt)} + Boc * exp (-0.03t)] * exp (Tcor * t + Pcor * p) * OXSAT(t,s)

where.....

Description	Symbol	Definition
Computed	OX	Dissolved oxygen concentration (ml/l)
Measured Parameters	t	Water temperature (ºC)
	p	Pressure (decibars)
	s	Salinity (PSU) - (ppt)
	v	Temperature-compensated oxygen current (µamps)
	doc/dt	Slope of oxygen current (µamps/sec)
Calibration Coefficients	Soc	Oxygen current slope
	Boc	Oxygen current bias
	Tcor	Residual temperature correction factor for membrane permeability
	Offset	Voltage produced for zero oxygen current
Constants	Pcor	Pressure correction factor for membrane permeability
	Tau	Oxygen sensor response time
Calculated Value	OXSAT	Oxygen saturation value after Weiss (1970)

When setting up the configuration (.con) file, Sea-Bird software requires that you input Soc, Boc, offset, Tcor, Pcor, and tau. Values for Soc, Boc, offset, Tcor, and Pcor are taken from the Calibration Sheet provided with the sensor. Sea-Bird recommends that you set tau = 0.

Software

The following versions of Sea-Bird software allow you to select the SBE 43 oxygen sensor (labeled *Oxygen, SBE*) when setting up the configuration file for the CTD:
- SEASOFT (DOS) version 4.248 or later
- SEASAVE (Windows) version 1.20 or later
- SBE Data Processing (Windows) version Beta 1.3 or later

The latest version of the software is available for download from our website (www.seabird.com)

Oxygen Sensor Cleaning and Storage

1. Avoid fouling the oxygen membrane with oil or grease.

2. **Active Use**: After each cast, rinse the oxygen sensor with fresh distilled water and then flush with a 1% distilled water-solution of Triton X-100, using a 60 cc syringe.

3. **Storage between deployments**:
   - If there is no danger of freezing, loop tubing from inlet to outlet and partly fill the tubing with fresh distilled water.
   - **If there is danger of freezing, shake all excess water out of the plenum and loop tubing from inlet to outlet. Do not fill the tubing with water or Triton solution.**

4. For routine cleaning, soak the sensor for 30 minutes in a 1% solution of Triton X-100 warmed to 40 ºC (104 ºF). After the soak, drain and flush with warm (not hot) fresh water for 1 minute.

Appendix A - Computation of OXSAT

$$OXSAT(t,s) = \exp[A1 + A2*(100/t) + A3*\ln(t/100) + A4*(t/100) + s * (B1 + B2(t/100) + B3*(t/100)*(t/100))]$$

where

OXSAT(t,s) = oxygen saturation value - the volume of oxygen gas (STP) absorbed from humidity-saturated air at a total pressure of one atmosphere, per unit volume of the liquid at the temperature of measurement (ml/l)
s = salinity in psu
t = absolute temperature (^{o}C + 273.15)

A1 = -173.4292	A2 = 249.6339	A3 = 143.3483	A4 = -21.8492
B1 = -0.033096	B2 = 0.014259	B3 = -0.00170	

Appendix B - Compilation of Oxygen Saturation Values

The table below contains oxygen saturation values at atmospheric pressure calculated using the OXSAT equation from Appendix A. Oxygen units are ml/l. To compute mg/l, multiply the values in the table by 1.42903.

	Salinity (PSU)								
Temp (°C)	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**32**	**35**
-2	10.82	10.46	10.10	9.76	9.42	9.10	8.79	8.67	8.49
0	10.22	9.88	9.54	9.22	8.91	8.61	8.33	8.21	8.05
2	9.67	9.35	9.04	8.74	8.45	8.17	7.90	7.79	7.64
4	9.16	8.86	8.57	8.30	8.02	7.76	7.51	7.41	7.26
6	8.70	8.42	8.15	7.89	7.64	7.39	7.15	7.06	6.92
8	8.28	8.02	7.76	7.52	7.28	7.05	6.82	6.74	6.61
10	7.89	7.64	7.41	7.17	6.95	6.73	6.52	6.44	6.32
12	7.53	7.30	7.08	6.86	6.65	6.44	6.24	6.17	6.05
14	7.20	6.99	6.77	6.57	6.37	6.17	5.99	5.91	5.80
16	6.90	6.69	6.49	6.30	6.11	5.93	5.75	5.68	5.58
18	6.62	6.42	6.23	6.05	5.87	5.70	5.53	5.46	5.36
20	6.35	6.17	5.99	5.81	5.64	5.48	5.32	5.26	5.17
22	6.11	5.93	5.76	5.60	5.44	5.28	5.13	5.07	4.98
24	5.88	5.71	5.55	5.39	5.24	5.09	4.95	4.89	4.81
26	5.66	5.51	5.35	5.20	5.06	4.92	4.78	4.73	4.65
28	5.46	5.31	5.17	5.03	4.89	4.75	4.62	4.57	4.50
30	5.28	5.13	4.99	4.86	4.73	4.60	4.47	4.43	4.35
32	5.10	4.96	4.83	4.70	4.58	4.45	4.34	4.29	4.22

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