OPERATING AND MAINTENANCE MANUAL

SBE 23 DISSOLVED OXYGEN SENSOR

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Model SBE 23 Dissolved Oxygen Sensor

Operating Instructions and Maintenance Manual

DESCRIPTION

The SBE 23 Dissolved Oxygen Sensor uses a 'Beckman' type high-pressure polarographic oxygen electrode as now manufactured by Sensor-Medics Corporation. The sensor also contains a thermistor for the purpose of determining internal (compensating) temperature.

Model SBE 23-01 is intended for use to 3400 meters (5000 psi), while Model SBE 23-02 may be deployed at up to 6800 meters (10,000 psi).

The SBE 23 (schematic dwg. no. 30507, assembly dwg. 40166) contains the electronics necessary to polarize the DO sensor, and convert the resulting oxygen-dependent current to a high-level voltage. A second part of the interface circuitry converts the compensating thermistor resistance to a voltage proportional to sensor internal temperature.

The interconnections between the electronics, sensor, and the bulkhead I/O connectors are shown on assembly dwg. no. 40016. Note: drawing 40016 also shows a pH electrode (not installed on SBE 23).

The SBE 23 is designed for operation from a single-polarity power supply of 6 -16 volts. Current consumption is about 3.5 milliamperes.

The sensor provides two output voltages. The first (Vdo) is proportional to the electrode current and is in the range of 0 - 5 volts, approximately corresponding to 0 to 1.3 microamperes. The second output voltage (Vto) is proportional to the internal temperature of the sensor and has a nominal range of 0 to +5 volts for temperatures of -5 to +35 degrees C. Consult the sensor calibration sheet for specific conversion factors.

OPERATION

Connect a DC power source to the sensor's bulkhead connector as follows:

looking at the 6 pin bulkhead connector on SBE 23 (Impulse type AG306)

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                      Ground

                        O
              Vdo   o       o   DC power, 10 - 20 volts
    no connection   o       o   no connection
                        o

                       Vto
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If the connector pigtail supplied with the SBE 23 (Impulse Enterprise type AG306) is used, align the raised bump on the side of the rubber molded connector with the large pin on the bulkhead connector.

The color code with the supplied pigtail (pigtails supplied by manufacturers other than Impulse may have different color codes) is as follows:

Pin 1	Ground	white
Pin 2	Vdo	black
Pin 3	no conn	blue
Pin 4	Vto	orange
Pin 5	no conn	green
Pin 6	Power	red

Connect a voltmeter between Vdo and Ground. Apply power. The voltage at Vdo should begin reading about 5 volts. After several seconds, the voltage will start to decrease until an equilibrium value of about 2.5 - 3.5 volts is produced. This voltage is proportional to the partial pressure of oxygen in air.
Connect the voltmeter between Vto and Ground. The reading will be about 3 volts at room ambient temperature.

INTERPRETATION OF SENSOR RESPONSES

Compute the sensor current and sensor compensation temperature using the relationships and coefficients given on the accompanying calibration sheet.

The new algorithm by Owens and Millard (1985) may be used to convert SBE 23 oxygen sensor data to oxygen concentration.

OXYGEN ALGORITHM

The algorithm has the following form:

$$OX = [Soc * (oc + tau * doc/dt) + Boc] * OXSAT(T,s) * \exp(tcor * [T + wt * (To - T)] + pcor * p)$$

where

OX	dissolved oxygen value in ml/l
T	water temperature in deg C
s	salinity in parts per thousand
p	pressure in decibars
oc	oxygen current in microamps
Boc	oxygen current bias
Soc	oxygen current slope
To	oxygen sensor internal temperature in deg C
wt	weighting fraction of oxygen sensor internal temperature
tcor	temperature correction factor for membrane permeability
pcor	pressure correction factor for membrane permeability
tau	oxygen sensor response time
OXSAT(T,s)	oxygen saturation value after Weiss (1970).

Values for tcor, pcor, tau and wt are taken from the Beckman polarographic oxygen sensor technical memorandum:

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tcor  =   -0.033
pcor  =    1.50e-4
tau   =    2.0
wt    =    0.67
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Values for Boc and Soc at the time of factory calibration are shown on the calibration sheet supplied with the sensor.

RECALIBRATION

For recalibration, the program OXFIT, written for the IBM PC/XT/AT and compatibles, computes the value for Soc, oxygen current slope.

Determination of sensor zero (Boc)

To measure the zero oxygen response of the oxygen sensor, flush the sensor with an inert gas (e.g. N_2, Ar, He) or place the sensor in a 2%-5% solution of sodium sulfite (Na_2SO_3). When using an inert gas, make sure that there are no air leaks; when using the sodium sulfite solution, make sure that there are no air bubbles trapped on the oxygen sensor membrane. In our experience, the sodium sulfite method produces better (consistently lower) results.

Allow the sensor to stabilize and measure Vdo. Compute the sensor current (oc) which will typically be 0.05 microamperes or less. Since the Owens-Millard algorithm assumes that Boc + oc = 0, Boc must be chosen = -oc.

Determination of sensitivity slope (Soc)

To determine the sensitivity slope of the sensor, place the oxygen sensor and a temperature sensor (accuracy about +/- 0.1 degrees C) in a bath of air saturated water (use an aquarium bubbler to oxygenate the water). The oxygen sensor must be pumped (approximately 15 ml/second) to avoid formation of a low oxygen boundary layer at the oxygen sensor membrane.

Wait until the oxygen sensor has had time to come to thermal equilibrium with the air saturated water (approximately 30 minutes).

Read Vdo and Vto, compute the water temperature and oxygen sensor current, and verify that the internal oxygen sensor temperature is within about 0.5 degrees of the water temperature.

For most accurate results the temperature of the air saturated water should be as close as possible to the temperature of the water at which the oxygen measurements will be made. However, note that it will be difficult to obtain equilibrium values at temperatures other than room ambient unless a temperature-controlled bath is employed.

Determine local atmospheric pressure.

Run the program OXFIT to compute Soc. The algorithm used by OXFIT is described in Appendix A. OXFIT will prompt for the following:

local barometric pressure (millibars)

this is the pressure that would be read on a barometer (**not** corrected to sea level)

water temperature (deg C)

water temperature read by the temperature sensor (bath temperature, not compensating temperature

oxygen current (microamps)

air-saturated water value

boc

enter the value of boc determined previously

MAINTENANCE and STORAGE

The sensor module (the brown cylindrical cartridge in the plastic part of the SBE 23) has a working life of at least 6 months if kept moist. If the sensor is stored in dry air, however, operating life may be appreciably shorter. When possible, store the sensor with a loop of Tygon tubing containing distilled or deionized water.

Care must be taken to avoid fouling the oxygen membrane with oil or grease. It is recommended that the oxygen sensor be flushed with distilled water after each use and be kept filled with distilled water between use. An additional important benefit of keeping the sensor closed with Tygon is to keep air born contaminants (of which there are an abundance on most research vessels) from entering the sensor.

If it is not practical to keep the sensor filled with distilled water between use (for example, in Arctic environments where freezing is a hazard), at least flush it with clean fresh water (preferably distilled) and close the cell with Tygon. Also, remember to keep the Tygon in a clean place (so that it does not pick up contaminants) while the instrument is in use.

For routine cleaning, fill the sensor with a 1% solution of Triton X-100 and let soak for 30 minutes. This is most easily done by using a length of 7/16" Tygon tubing to form a closed loop including the sensor. The teflon membrane should be pointing up so that an air bubble does not block the cleaning solution. After the soak, drain and flush with warm (not hot) fresh water for 1 minute. Refill the sensor with distilled water until the next usage.

SENSOR MODULE REPLACEMENT

When satisfactory calibrations are no longer obtained, or there is evidence of calibration drift, follow the procedures in the Disassembly (Reassembly) Instructions supplied with the sensor. Replacement modules (P/N 147737) may be obtained from Sea-Bird Electronics, or directly from the manufacturer:

Sensor-Medics Corporation
1630 South State College Blvd
Anaheim, CA 92806
800-231-2466

APPENDIX A

Correction factor for non-standard atmosphere:

$$nsa(T,bp) = (bp/p0) * (1 - (pH_2O/bp) / (1 - pH_2O/p0)$$

bp	=	barometric pressure in kilopascals
p0	=	101.325 kilopascals
pH_2O	=	water vapor pressure in kilopascals
T	=	water temperature in deg C

$$pH_2O = \exp[(-216961 * X - 3840.7) * X + 16.4754]$$

$$X = 1/(T + 273.15)$$

For air saturated water at the surface:

$$((Soc * oc + Boc) / nsa(T,bp)) * \exp(tcor * T) = 1$$

$$Soc = \{[nsa(T,bp) / \exp(tcor * T)] - boc \} / oc$$

APPENDIX B

Computation of OXSAT

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

The units are ml/l , the oxygen saturation value is the volume of the gas (STP) absorbed from water saturated air at a total pressure of one atmosphere, per unit volume of the liquid at the temperature of measurement.

where:

s	=	salinity in parts per 1000
T	=	deg C + 273.15 (absolute temperature)
A1	=	-173.4292
A2	=	249.6339
A3	=	143.3438
A4	=	-21.8492
B1	=	-0.033096
B2	=	0.014259
B3	=	-0.00170

REFERENCES

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