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Processing Argo OXYGEN data at the DAC level

Version 2.2

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part of the integrated global observation strategy

Argo data management
Processing Argo oxygen data at the DAC level
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History of the document

Version	Date	Authors	Modification
1.0		V. Thierry, D. Gilbert, T. Kobayashi	Initial version
1.1		V. Thierry	COUNTS_DOXY is replaced by COUNT_DOXY
1.2	February 2011	V. Thierry	Equation for the calculation of Ts corrected
1.3	January 2013	V. Thierry	- Text completed for new Aanderaa optode 4330 and new Seabird Optode SBE63: new variables added (TPHASE_DOXY, C1PHASE_DOXY, C2PHASE_DOXY, PHASE_DOXY, MLPL_DOXY), new calibration equations - The pressure compensation coefficient can be 0.032 and 0.04. - Use of the oxygen saturation instead of the oxygen solubility for some floats equipped with an SBE43 oxygen sensor.
2.0	September 2015	E. Brion, J.P. Rannou, K. Sato and V. Thierry, C. Schmid	- Reformatting of the document, addition of the cookbook part, integration of a section dedicated to JAC sensors (ARO_FT)
2.1	February 2016	H. Bittig, E. Brion, J.P. Rannou, K. Sato,V. Thierry, C. Schmid	- Add recommendation from the SCOR WG 142 regarding the salinity compensation equation; Update the DAC cookbook accordingly for Optode Aanderaa 4330 and JAC sensor - Pass the pressure coefficient as input parameter - Pass the salinity compensation coefficients and the coefficients used in the Aanderaa standard equation for 4330 models as input parameters to take into account SCOR WG 142 recommendations
2.2	Octobre 2016	E. Brion, H. Bittig, V. Thierry, J.P. Rannou, K. Sato, C. Schmid	- Modification of the salinity and pressure corrections, according to Bittig, H.C. recommendations (Bittig, 2015, and 2016): description in data processing, and modifications in the configurations - add 2 cases for old pressure equation on SBE63 - modifications of the temperature use, in descriptions and cases - add a brief and general description of the method to compute DOXY from the sensor output - add computation equation of PPOX_DOXY - unit modification p8 "degC" repaced by "angular degree" for XPHASE_DOXY parameters - update CAS*E*_102_207_206

Preamble: This document does NOT address the issue of oxygen data quality control (either real-time or delayed mode). As a preliminary step towards that goal, this document seeks to ensure that all countries deploying floats equipped with oxygen sensors document the data and metadata related to these floats properly. We produced this document in response to action item 14 from the AST-10 meeting in Hangzhou (March 22-23, 2009).

Action item 14: Denis Gilbert to work with Taiyo Kobayashi and Virginie Thierry to ensure DACs are processing oxygen data according to recommendations.

If the recommendations contained herein are followed, we will end up with a more uniform set of oxygen data within the Argo data system, allowing users to begin analysing not only their own oxygen data, but also those of others, in the true spirit of Argo data sharing.

Indications provided in this document are valid as of the date of writing this document. It is very likely that changes in sensors, calibrations and conversions equations will occur in the future. Please contact V. Thierry (vthierry@ifremer.fr) for any inconsistencies or missing information.

A dedicated webpage on the Argo Data Management website (http://www.argodatamgt.org/Documentation/Bio-Argo-Oxygen-data-management-by-DACs) contains all information regarding Argo oxygen data management : current and previous versions of this cookbook, oxygen sensor manuals, calibration sheet examples, examples of matlab code to process oxygen data, etc..

1 Introduction and agreement reached at ADMT10 and AST11

There are two main methods to measure dissolved oxygen concentration (referred to as O2 or oxygen in the following) with sensors in the ocean. The first method is an electrochemical method that uses a Clark-type polarographic cell. The second method is an optical method. It is based on the principle of dynamic fluorescence quenching.

The official Argo unit for dissolved oxygen concentration is umol/kg, as in JGOFS and CLIVAR, but none of the existing sensors provides O2 data in native units of umol/kg. Depending on the sensor, additional conversions must also be done to correct for pressure or salinity effects for example. **As a consequence, whatever the sensor considered, O2 sensor output must be transformed to convert the output in dissolved oxygen concentration, to take into account temperature, salinity and pressure effects or to convert the data in umol/kg.**

The following recommendations have been agreed upon at the ADMT 10 meeting (October 2009, Toulouse, France) and at the AST 11 meeting (March 2010, La Jolla, USA):

1. Store any data transmitted by the O2 sensor with meaningful names (in the form XXX_DOXY), whatever the unit of the sensor output is. It is important to store those data if changes occur in the calibration/conversion equations used to convert the sensor output in DOXY.
2. Store in **DOXY** the dissolved oxygen value in umol/kg estimated from the telemetered variables and corrected for any pressure, salinity or temperature effects.
3. Fill properly the metadata to document the calibration and conversions equations.
4. Add a second profile in the single cycle netcdf file when the Optode reports in low-resolution mode while the CTD reports in high-resolution mode (vertical sampling). This second profile contains DOXY and the data reported by the optode as well as CTD data acquired at the optode level measurements (PRES, TEMP and PSAL).

The possible outputs for each sensor model are listed in (Section 3) and the proposed names are:

- VOLTAGE_DOXY (Unit = volts)
- FREQUENCY_DOXY (Unit = hertz)
- COUNT_DOXY (no Unit)
- PHASE_DELAY_DOXY (Unit = usec)
- MLPL_DOXY (Unit = ml/L)
- RPHASE_DOXY (Unit = angular degree)
- BPHASE_DOXY (Unit = angular degree)
- DPHASE_DOXY (Unit = angular degree)
- TPHASE_DOXY (Unit = angular degree)
- C1PHASE_DOXY and C2PHASE_DOXY (Unit = angular degree)
- MOLAR_DOXY (Unit = umol/L)
- LED_FLASHING_COUNT_DOXY (no Unit)
- TEMP_DOXY (Unit = degC)
- TEMP_VOLTAGE_DOXY (Unit = volts)
- TEMP_COUNT_DOXY (no unit)
- XXX_DOXY for any new variables

2 Comment on the oxygen related metadata

The accuracy and the resolution of the sensors are provided by the manufacturers and are given in the unit of the O2 sensor, and not in the official Argo unit. Accuracy depends on the sensor type but individual calibration of optodes can change the provided accuracy. Data delivered and transmitted by the oxygen sensor have different units. **The unit of the transmitted data that is directly related to the oxygen concentration is given in the SENSOR_UNIT field.**

As for the other sensors, the model number and serial number of the O2 sensor must be provided. This can be important if a specific failure concerns all the sensors from the same batch for instance, or if the manufacturing process changes after a certain serial number.

3 Sensor outputs

Sensor maker	Sensor model	Sensor output related to oxygen concentration	Sensor units	Argo parameter name
Aanderaa	3830	RPhase (phase measurement with red excitation light) or BPhase (phase measurement with blue excitation light) or DPhase (calibrated phase measurement) or DO (dissolved oxygen concentration at zero pressure and in fresh water or at a reference salinity)	deg deg deg umol/L	RPHASE_DOXY BPHASE_DOXY DPHASE_DOXY MOLAR_DOXY
	4330/4330F[1]	TCPhase (temperature compensated phase) or C1RPhase & C2RPhase (phase measurement with blue (resp. Red) excitation light) or DO (dissolved oxygen concentration at zero pressure and in fresh water or at a reference salinity)	deg deg umol/L	TPHASE_DOXY C1PHASE_DOXY & C2PHASE_DOXY MOLAR_DOXY
Seabird	SBE43?	counts	count	COUNT_DOXY
	SBE43	voltage	V	VOLTAGE_DOXY
	SBE43F	frequency	hertz	FREQUENCY_DOXY
	SBE63	phase delay or DO (dissolved oxygen concentration at zero pressure and in fresh water or at a reference pressure and reference salinity)	usec ml/L	PHASE_DELAY_DOXY MLPL_DOXY
JAC	ARO_FT	counts which is expressive of the difference between the phase obtained with blue light excitation and the phase obtained with red light excitation and LED flashing frequency of oxygen sensor to measure oxygen	count count	COUNT_DOXY LED_FLASHING_COUNT_DOXY

Sensor maker	Sensor model	Sensor output non related to oxygen concentration	Sensor units	Argo parameter name
Aanderaa	3830/4330/4330F	Temp (sea temperature measured by the optode)	degC	TEMP_DOXY
Seabird	SBE63	Temp (sea temperature measured by the optode) Or Voltage (to be converted in sea temperature)	degC volts	TEMP_DOXY TEMP_VOLTAGE_DOXY
JAC	ARO_FT	counts which is expressive of uncalibrated temperature value measured by ARO_FT.	count	TEMP_COUNT_DOXY

[1] The Aanderaa 4330F model is a fast response version of the 4330 model.

4 Measurements and data processing

4.1 Aanderaa optodes

Information provided hereafter is taken from the "TD218 Operating Manual Oxygen Optode 3830 (September 2002)" ([RD10]), "TD218 Operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175 (April 2007)" ([RD5]) and from the "TD269 Operating manual oxygen optode 4330, 4835, 4831 (August 2012)" ([RD6]) (copy available at ADM website http://www.argodatamgt.org/Documentation/Bio-Argo-Oxygen-data-management-by-DACs).

4.1.1 Optode 3830

The optode 3830 measures raw phase data that is converted in degrees. The calibrated phase measurement DPhase is calculated as a 3rd degree polynomial of the uncalibrated phase measurement. The uncalibrated phase measurement (UNCAL_Phase) is the difference between the phase obtained with blue light excitation (BPhase) and the phase obtained with red light excitation (RPhase).

$$\boldsymbol{UNCAL\_Phase = BPhase - RPhase}$$

For some 3830 optode model, RPhase is set to zero because the red light excitation is not used and BPhase equals UNCAL_Phase.

According to Bittig, H.C., 2015 ([RD15]), a first pressure correction should be done at this stage:

$$Phase\_Pcorr = UNCAL\_Phase + P_{coef1} \times P$$

Where P is the pressure (dbar).

We strongly recommend setting P_{coef1} to 0.1°. However, to recover the previous formula, P_{coef1} may be set to 0.

The compensated phase, DPhase, is calculated from Phase_Pcorr by use of a 3rd order polynomial:

$$\boldsymbol{DPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Phase^2 + PhaseCoef_3 \times Phase\_Pcorr^3}$$

The $PhaseCoef_0$ to $PhaseCoef_3$ coefficients are provided in the optode calibration certificate.

Note that the coefficients $\mathbf{PhaseCoef_2}$ and $\mathbf{PhaseCoef_3}$ are usually equal to zero, so that the calibrated phase DPhase is a linear function of the uncalibrated phase.

Similarly, the temperature measured by the optode in degree Celsius is calculated from RawTemp (temperature expressed as a voltage from the thermistor bridge) by use of a similar polynomial with coefficients called $TempCoef_0$ to $TempCoef_5$:

$$\boldsymbol{T = TempCoef_0 + TempCoef_1 \times RawTemp + TempCoef_2 \times RawTemp^2 + \cdots + TempCoef_5 \times RawTemp^5}$$

The $TempCoef_0$ to $TempCoef_5$ coefficients are provided in the optode calibration certificate.

DPhase is then converted to dissolved oxygen concentration in umol/L. Two methods are possible and the choice of the method depends on the calibration performed on the sensor.

4.1.1.1 First method: the Aanderaa polynomial standard calibration

The equations are described in details in [RD5].

DPhase is converted to dissolved oxygen concentration in umol/L using 20 sensor-dependant coefficients (C_{ij}) in a 4th degree polynomial:

$$MOLAR\_DOXY = C_0 + C_1 \times DPhase + C_2 \times DPhase^2 + C_3 \times DPhase^3 + C_4 \times DPhase^4$$

where C_0, C_1, ..C_4 are temperature dependent coefficients valid for batches of foils and calculated as:

$$C_i = C_{i0} + C_{i1} \times T + C_{i2} \times T^2 + C_{i3} \times T^3$$

With T the temperature in degree Celsius.

Each of the Cij coefficients are provided by the calibration sheet as C0 coefficient to C4 coefficient with index from 0 to 3 (§12.1.1.1 in ANNEX A).

To improve the optode calibration, some laboratories perform either a quick two points or a more complete calibration generating new calibration coefficients. In that case, the 20 factory calibrations coefficients (C_{ij}) should be replaced by the new ones and the metadata must be filled accordingly.

The obtained dissolved oxygen concentration (MOLAR_DOXY) must then be corrected for salinity and pressure effects (see §4.1.4 and 4.1.5).

Finally, dissolved oxygen concentration in umol/kg (DOXY) can be converted from dissolved oxygen concentration corrected for salinity and pressure effects (see §5).

4.1.1.2 Second method: the Stern-Volmer equation

This method is based on the initial form of the Stern Volmer equation. The equations are described in the TD218 manual from September 2002 ([RD10]). This equation was only used in the earlier shipments of the optode 3830.

DPhase is converted to dissolved oxygen concentration in umol/L by use a modified Stern-Volmer function:

$$MOLAR\ DOXY = \left\{ \frac{f_1}{\frac{DPhase}{K_0(T)} - f_2} - 1 \right\} . K_1(T)$$

where
f_1 and f_2 are temperature independent coefficients
K_0 and K_1 are temperature dependent coefficients
DPhase is the compensated phase difference

Each of the K_0 and K_1 coefficients are calculated by use of a 3rd-degree polynomial with temperature as
argument and the coefficients *K0Coef* and *K1Coef* provided by the calibration sheet (Section 12.1.1.2 in ANNEX A).

The obtained dissolved oxygen concentration (MOLAR_DOXY) must then be corrected for salinity and pressure effects (see §4.1.4 and 4.1.5).

Finally, dissolved oxygen concentration in umol/kg (DOXY) can be converted from dissolved oxygen concentration corrected for salinity and pressure effects (see §0).

4.1.2 Optode 4330

As for the optode 3830, the uncalibrated phase measurement (TCPhase) is the difference between the phase obtained with blue light excitation (C1RPhase) and the phase obtained with red light excitation (C2RPhase). This time, the red light excitation is actually used and C2RPhase usually should be different from 0°.

$$\boldsymbol{TCPhase = C1RPhase - C2RPhase}$$

Temperature (T) compensation could be applied to the phase measurements as follows:

$$TCPhase = A(T) + [C1RPhase - C2RPhase] \times B(T)$$

However, this option is currently not used and A(T) = 0 and B(T) = 1. See [RD6] for more details.

The temperature measured by the optode in degree Celsius is calculated from RawTemp (temperature expressed as a voltage from the thermistor bridge) by use of a similar polynomial with coefficients called $TempCoef_0$ to $TempCoef_5$:

$$\boldsymbol{T = TempCoef_0 + TempCoef_1 \times RawTemp + TempCoef_2 \times RawTemp^2 + \cdots + TempCoef_5 \times RawTemp^5}$$

The $TempCoef_0$ to $TempCoef_5$ coefficients are provided in the optode calibration certificate.

According to Bittig, H.C., 2015 ([RD15]), a first pressure correction should be done at this stage:

$$TCPhase = TCPhase + P_{coef1} \times P/1000$$

Where P is the pressure (dbar).

We strongly recommend setting P_{coef1} to 0.1°. However, to recover the previous formula, P_{coef1} may be set to 0.

TCPhase is then converted to dissolved oxygen concentration in umol/L. Five methods are possible and the choice of the method depends on the calibration performed on the sensor.

4.1.2.1 First method: the Aanderaa polynomial standard calibration

The equations are described in details in [RD6].

The calibrated phase CalPhase is calculated from TCPhase by use of a 3rd order polynomial:

$$\boldsymbol{CalPhase = PhaseCoef_0 + PhaseCoef_1 \times TCPhase + PhaseCoef_2 \times TCPhase^2 + PhaseCoef_3 \times TCPhase^3}$$

The $PhaseCoef_0$ to $PhaseCoef_3$ coefficients are provided in the optode calibration certificate. Note that the coefficients $\boldsymbol{PhaseCoef_2}$ and $\boldsymbol{PhaseCoef_3}$ are usually equal to zero, so that the calibrated phase CalPhase is a linear function of TCPhase.

Based on the calibrated phase (CalPhase) and temperature T, the partial pressure of O_2 is calculated by use of a two dimensional polynomial:

$$\Delta p = C_0 \times T^{m0} \times CalPhase^{n0} + C_1 \times T^{m1} \times CalPhase^{n1} + \cdots + C_{27} \times T^{m27} \times CalPhase^{n27}$$

The polynomial coefficients C_0 to C_{13} and C_{14} to C_{27} are provided in the optode calibration certificate (as $FoilCoefA_0$ to $FoilCoefA_{13}$ and $FoilCoefB_0$ to $FoilCoefB_{13}$ respectively).

The temperature exponents m0 to m27 are provided in the optode calibration certificate (as $FoilPolyDegT_0$ to $FoilPolyDegT_{27}$). The phase exponents n0 to n27 are provided in the optode calibration certificate (as $FoilPolyDegO_0$ to $FoilPolyDegO_{27}$) (see §12.1.2.1 in ANNEX A).

From the partial pressure of O_2, the air saturation is then calculated as:

$$AirSaturation(\%) = \Delta p \times 100 / \left[\left(NomAirPress - p_{vapour}(T) \right) \times NomAirMix \right]$$

Where *NomAirPress* is the nominal air pressure (usually 1013.25 hPa), and *NomAirMix* is the nominal O_2 content in air (by default 0.20946).

Where $p_{vapour}(T)$ is the vapour pressure calculated from temperature by the following equation:

$$p_{vapour}(T) = e^{\left[52.57 - \frac{6690.9}{T+273.15} - 4.681 \times ln(T+273.15) \right]}$$

The oxygen concentration (in umol/L) compensated for the salinity effect at a prescribed salinity S_0 but not compensated for the pressure effect is finally calculated as:

$$\boldsymbol{MOLAR\_DOXY = C^{*} \times 44.614 \times AirSaturation/100}$$

Where C^* is the oxygen solubility (in cm^3/dm^3) calculated from the Garcia and Gordon equation of 1992 ([RD1]):

$$\ln(C^*) = A_0 + A_1 \times T_S + A_2 \times {T_S}^2 + A_3 \times {T_S}^3 + A_4 \times {T_S}^4 + A_5 \times {T_S}^5 + S_0 \times \left(B_0 + B_1 \times T_S + B_2 \times {T_S}^2 + B_3 \times {T_S}^3 \right) + C_0 \times {S_0}^2$$

Where T_s is the scaled temperature expressed as a function of the temperature T (in degC):

$$T_S = ln((298.15 - T)/(273.15 + T))$$

Where S_0 is the reference salinity given in the optode settings (default set to zero)

And, following Aanderaa manuals, where:

A_0 = 2.00856
A_1 = 3.22400
A_2 = 3.99063
A_3 = 4.80299
A_4 = 9.78188e-1
A_5 = 1.71069

B_0 = -6.24097e-3
B_1 = -6.93498e-3
B_2 = -6.90358e-3
B_3 = -4.29155e-3
C_0 = -3.11680e-7

However, it is strongly recommended by the SCOR Working Group 142 on "Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders" [RD13] to use the following coefficients instead:

A_0 = 2.00907
A_1 = 3.22014
A_2 = 4.0501
A_3 = 4.94457

A_4 = -2.56847e-1
A_5 = 3.88767

B_0 = –6.24523e–3

$B_1 = -7.37614e-3$ $B_3 = -8.17083e-3$

$B_2 = -1.03410e-3$ $C_0 = -4.88682e-7$

Also note that the conversion of partial pressure to oxygen saturation and oxygen concentration from Aanderaa [RD6] outlined above does not conform to the SCOR WG 142 recommendations on O_2 quantity conversions [RD13] . Since the Aanderaa equations were used to derive the calibration coefficients from O_2 reference data in the first place, however, they could be kept for consistency.

The obtained dissolved oxygen concentration (MOLAR_DOXY) must then be corrected for salinity and pressure effects (see §4.1.4 and 4.1.5).

Finally, dissolved oxygen concentration in umol/kg (DOXY) can be converted from dissolved oxygen concentration corrected for salinity and pressure effects (see §0).

4.1.2.2 Second method: the Aanderaa standard calibration followed by a two-point adjustment

In the second method, the oxygen concentration (in umol/L) not compensated for pressure and salinity effect (MOLAR_DOXY) resulting from the first method is linearly adjusted:

$$\boldsymbol{MOLAR\_DOXY = ConcCoef_0 + ConcCoef_1 \times MOLAR\_DOXY}$$

The $ConcCoef_0$ and $ConcCoef_1$ coefficients are provided in the optode calibration certificate (see §12.1.2.2 in ANNEX A).

The obtained dissolved oxygen concentration (MOLAR_DOXY) must then be corrected for salinity and pressure effects (see §4.1.4 and 4.1.5).

Finally, dissolved oxygen concentration in umol/kg (DOXY) can be converted from dissolved oxygen concentration corrected for salinity and pressure effects (see §0).

Note that this method is performed for 4330 optodes with serial number 1000 and above ([RD6]).

4.1.2.3 Third method: the Stern-Volmer equation

In the third method, the oxygen concentration (in umol/L) not compensated for pressure and salinity effects (MOLAR_DOXY) is computed by the Stern-Volmer equation proposed by Uchida et al 2008 ([RD2]).

$$\boldsymbol{MOLAR\_DOXY = [(P_0/P_c) - 1]/K_{SV}}$$

Where

$$K_{SV} = c_0 + c_1 \times T + c_2 \times T^2$$

$$P_0 = c_3 + c_4 \times T$$

$$P_c = c_5 + c_6 \times CalPhase$$

where T is the temperature (in degC).

The calibrated phase CalPhase is calculated from TCPhase by use of a 3rd order polynomial:

$$\boldsymbol{CalPhase = PhaseCoef_0 + PhaseCoef_1 \times TCPhase + PhaseCoef_2 \times TCPhase^2 + PhaseCoef_3 \times TCPhase^3}$$

The $PhaseCoef_0$ to $PhaseCoef_3$ coefficients are provided in the optode calibration certificate (see §12.1.2.2 in ANNEX A) but for newer optodes this function is normally not in use (i.e. *PhaseCoef0=0, PhaseCoef1=1, PhaseCoef2=0, PhaseCoef3=0*), which means that **CalPhase = TCPhase** (see §12.1.2.3 in ANNEX A).

The c_0 to c_6 coefficients are provided in the optode calibration certificate (as $SVUFoilCoef_0$ to $SVUFoilCoef_6$) (see §12.1.2.3 in ANNEX A).

The obtained dissolved oxygen concentration (MOLAR_DOXY) must then be corrected for salinity and pressure effects (see §4.1.4 and 4.1.5).

Finally, dissolved oxygen concentration in umol/kg (DOXY) can be converted from dissolved oxygen concentration corrected for salinity and pressure effects (see §0).

Note that this method was implemented after serial no. 1200 as an alternative. Both the standard calibration and the Stern-Volmer formula can be used (dependent on the Enable SVUFormula setting). The latter is used for all multipoint calibrated optodes from the factory.

4.1.2.4 Fourth method: the Stern-Volmer equation followed by a two-point adjustment

In the fourth method, the oxygen concentration (in umol/L) not compensated for pressure and salinity effect (MOLAR_DOXY) resulting from the third method is linearly adjusted:

$$\boldsymbol{MOLAR\_DOXY = ConcCoef_0 + ConcCoef_1 \times MOLAR\_DOXY}$$

The $ConcCoef_0$ and $ConcCoef_1$ coefficients are provided in the optode calibration certificate (see §12.1.2.2. in ANNEX A: Examples of calibration certificates)

The obtained dissolved oxygen concentration (MOLAR_DOXY) must then be corrected for salinity and pressure effects (see §4.1.4 and 4.1.5).

Finally, dissolved oxygen concentration in umol/kg (DOXY) can be converted from dissolved oxygen concentration corrected for salinity and pressure effects (see §0).

Note that this method is performed for 4330 optodes with serial number 1200 and above ([RD6]).

4.1.2.5 Fifth method: the modified Stern-Volmer equation for pO_2

To be completed if relevant.

4.1.3 Comments

4.1.3.1 The Aanderaa use of temperature

For the external computation of MOLAR_DOXY from the phase (BPhase, DPhase, TCPhase, C1RPhase and C2RPhase), it is recommended to use either the built-in temperature or the temperature of the CTD depending on the sensor model. **For the 4330 and 4831 optode models, Aanderaa recommends using the built-in temperature sensor. The 3830 optode model has a slower response temperature sensor that is also more influenced by the sampling frequency. For this model it is recommended using the CTD temperature.**

Note that for the 3830 optode, if the built-in temperature sensor has been used to determine the calibration coefficients (own laboratory calibration of the foil), it should be kept to convert DPhase to MOLAR_DOXY in §4.1.1 and §4.1.2.

Then, the correction in salinity and pressure should always be made using the CTD temperature.

4.1.3.2 The Stern-Volmer method for Aanderaa optode

The equations used to convert raw data from the 3830 optode in dissolved oxygen concentration were first based on a Stern-Volmer formula. Then a polynomial function was used by Aanderaa. For the 4330 it is the other way round. At the beginning, only a polynomial function was used. After serial no. 1200, an extended Stern-Volmer formula (Uchida Stern-Volmer [RD2]) was implemented as an alternative. Both formulas can be used (dependent on the Enable SVUFormula setting). The latter is used for all multipoint calibrated optodes from the factory.

4.1.4 Salinity compensation

The salinity compensation is estimated as:

$$DO_{PSAL} = MOLAR_{DOXY} \times S_{corr}$$

Where

$$S_{corr} = A(T,S,S_{preset}) \times e^{(S-S_{ref})(B_0+B_1\times T_s+B_2\times T_s{}^2+B_3\times T_s{}^3)+C_0\times(S^2-S_{ref}{}^2)}$$

$$A(T,S,S_{preset}) = \frac{1013.25 - pH_2O(T,S_{preset})}{1013.25 - pH_2O(T,S)}$$

$$pH_2O = 1013.25 \times e^{\left(D_0+D_1\times\left(\frac{100}{T_{abs}}\right)+D_2\times ln\left(\frac{T_{abs}}{100}\right)+D_3\times S\right)}$$

Where S is the salinity (PSAL) and S_{ref} is the reference salinity given in the optode settings (the S_0 in §4.1.2.1.). The term $A(T,S,S_{preset})$ has been introduced following the recommendations of Bittig H.C ([RD16]). To recover the old formula which neglected the water vapour effect (i.e., A = 1), S_{preset} could be set to S. However, it is not recommended: S_{preset} should be set to 0 regardless the sensor output parameter.

To summarize, Sref and Spreset should take the following recomendations:

- When MOLAR_DOXY has been internally calculated by the optode:
  - S_0 should be known and S_{ref} set to S_0.
  - S_{preset} is strongly recommended to be set to 0 (previously : S_{preset} = S) (water vapour pressure effect neglected)
- When MOLAR_DOXY is calculated on-shore from BPhase, DPhase or TCPhase:
  - S_{ref} and S_0 are not used and must be set to 0 in the above equations.
  - S_{preset} is strongly recommended to be set to 0 (previously : S_{preset} = S)

Where T_s is the scaled temperature expressed as a function of the temperature T (in degC): T should be the temperature from the CTD if possible.

$$T_s = ln((298.15 - T)/(273.15 + T))$$

T_{abs} is the temperature in Kelvin.

The coefficients D_0 to D_3 are provided in the SCOR WG (SCOR Working Group 142 on "Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders" [RD13]).

The coefficients B_0 to B_3 and C_0 provided by Aanderaa differ from those recommended by the SCOR WG 142. **The SCOR Working Group 142 coefficients are strongly recommended for the computation of the salinity compensation.**

Consequently, when MOLAR_DOXY is computed on board the float with Sref different from 0, one would want to have the salinity compensation re-calculated by

1. removing the optode-internal Sref compensation using the Aanderaa Salinity Compensation coefficients and converting it to S=0 (i.e., a "MOLAR_DOXY"), and then
2. apply the salinity compensation with the correct PSAL, setting $S_{preset} = 0$, and with the SCOR WG 142 recommended coefficients.

4.1.4.1 Aanderaa Salinity Compensation coefficients

B_0 = -6.24097e-3
B_1 = -6.93498e-3
B_2 = -6.90358e-3
B_3 = -4.29155e-3
C_0 = -3.11680e-7

4.1.4.2 SCOR WG 142 recommendation for Salinity Compensation coefficients

B_0 = -6.24523e-3
B_1 = -7.37614e-3
B_2 = -1.03410e-3
B_3 = -8.17083e-3
C_0 = -4.88682e-7

4.1.5 Pressure compensation

The pressure compensation has been estimated as:

$$\mathbf{DO_{PSAL\&PRES}} = \mathbf{DO_{PSAL}} \cdot \left[\mathbf{1} + \frac{\mathbf{Pcoef\ x\ PRES}}{\mathbf{1000}}\right]$$

where, following Uchida et al (2008) ([RD2]), Pcoef = 0.032. This coefficient superseded the original coefficient proposed by Aanderaa that was set to 0.04. Note that the pressure compensation was calculated with Pcoef = 0.032 for most floats but for some floats the pressure compensation was calculated by using Pcoef = 0.04.

where PRES is the pressure in dbar.

According to Bittig et al. (2015), Pressure Response of Aanderaa and Sea-Bird Oxygen Optodes. *J. Atmos. Oceanic Technol.*, ([RD15]), a new equation have been specified to compute DO_{PSAL} :

$$\mathbf{DO_{PSAL\&PRES}} = \mathbf{DO_{PSAL}} \times \left[\mathbf{1} + \frac{\left(P_{coef2} \times T + P_{coef3}\right) \times PRES}{\mathbf{1000}}\right]$$

We strongly recommend the use of this new equation, with the coefficients Pcoef2 and Pcoef3 set to the following values:

- Phase_Pcorr / TCPhase has been corrected for the pressure effect (Pcoef1 = 0.1, see §4.1.1 and §4.1.2): Pcoef2 = 0.00022, Pcoef3 = 0.0419
- Phase_Pcorr / TCPhase has not been corrected for the pressure effect effect (Pcoef1 = 0, see §4.1.1 and §4.1.2): Pcoef2 = 0.00025, Pcoef3 = 0.0328
- To recover the previous formula, set Pcoef2 = 0, Pcoef3 = 0.032

To obtain DOXY, $DO_{PSAL\&PRES}$ must be converted in umol/kg, the official Argo unit, by dividing by potential density (see §5.1). The potential density has to be estimated from the CTD temperature and salinity (TEMP and PSAL).

4.2 SeaBird Electronics sensors

Information provided hereafter is taken from the Seabird Application Note No 64 ([RD8]) and from the SBE63 User's manual ([RD7]).

4.2.1 SBE43-IDO sensor

The SBE DO sensor, SBE43-IDO, determines dissolved oxygen concentration by counting the number of oxygen molecules per second (flux) that diffuse through the membrane from the ocean environment to the working electrode. 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 (from Application note No. 64, revised in June 2013; prepared by Sea-Bird Electronics, Inc, [RD8])

The measurable electrical current is converted to a voltage by the sensor electronics. The voltage signal varies linearly with partial pressure of oxygen. Among SBE DO sensors, the SBE43-IDO outputs the voltage itself whereas the SBE43F-IDO converts it to a frequency signal which is proportional to the voltage. Some SBE DO sensors transmit count. Count, voltage or frequency signals, which are transmitted by floats, are then converted in dissolved oxygen concentration on shore. The conversion uses a set of sensor-dependant coefficients with temperature, salinity, and pressure measured by the floats. The dissolved oxygen concentration unit converted from the outputs of the SBE DO sensor is ml/L. It must be converted to umol/kg.

SBE calibrated DO sensors with the oxygen saturation equation of Weiss (1970) up until 2008. They now use the Garcia and Gordon' (1992) ([RD1]) equations. Note that for some floats, the oxygen saturation is used instead of the oxygen solubility.

It is known that dissolved oxygen (DO) measurements by DO sensors of the SBE-IDO series are influenced by changes of sensor membrane characteristics due to temperature and pressure. The sensor has a circuit for compensation of the temperature effect on membrane permeability; however a residual temperature effect remains after the compensation. Changes occur in gas-permeable Teflon membranes that affect their permeability characteristics under higher pressures than e.g., 1000 dbar. These changes have long time constants, depend on the sensor's time-pressure history, and result in hysteresis at depths greater than 1000 meters.

These effects are considered to be predictable and also correctable; however, until now there is no effective method for the adjustments of the pressure effects for the DO sensor of profiling floats under operation. Thus, scientific calibration of the DO measurements by the SBE-IDO sensor remains an important issue for the future.

To be completed from APPLICATION NOTE NO. 64-3 Revised August 2014: SBE 43 Dissolved Oxygen (DO) Sensor – Hysteresis Corrections, that can be found on the website http://www.seabird.com/sites/default/files/documents/appnote64-3Aug14.pdf : Hysteresis correction, sensor time constant put to 0 or not ?

4.2.1.1 Calibration Equation

$$O_2(ml/L) = \left\{S_{oc}.\left(V + V_{offset} + tau20.e^{(D_1P+D_2(T-20))}.\frac{\partial V}{\partial t}\right)\right\}.O_{xsol}(T,S).(1.0 + A.T + B.T^2 + C.T^3).e^{\left(\frac{E.P}{K}\right)}$$

Where O2 is oxygen concentration (ml/L), T is temperature output from SBE 43's CTD in degC, V is SBE 43 temperature-compensated output oxygen signal (volts), V_{offset} is the voltage at zero oxygen signal, tau20 is the sensor time constant tau(T,P) at 20 degC, 1 atm, 0 PSU, t the time.

Where ∂V/∂t is the time derivative of V (volts/second), computed over a default window of 2 seconds

Where O_{xsol} is the oxygen saturation value calculated from the equations of Garcia and Gordon (1992) ([RD1]), depending on temperature (see §4.2.1.2 for the equation)

Where D1 and D2 are temperature and pressure correction factors, A, B and C are residual temperature correction factors, a0, a1, a2, b0, b1 are calibration coefficients (Uchida et al, 2008)

4.2.1.2 Oxygen saturation

O_{xsol} is the oxygen saturation, depending on the water temperature :

$$O_{xsol}(T,S) = e^{\{A_0+A_1.T_S+A_2.T_S{}^2+A_3.T_S{}^3+A_4.T_S{}^4+A_5.T_S{}^5+S.[B_0+B_1.T_S+B_2.T_S{}^2+B_3.T_S{}^3]+C_0.S^2\}}$$

Where $O_{xsol}(T,S)$ is the oxygen saturation value, i.e. the volume of oxygen gas at standard temperature and pressure conditions (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)

Where T_s is the scaled temperature expressed as a function of the temperature T (in degC):

$$\boldsymbol{T_s = ln((298.15 - T)/(273.15 + T))}$$

Where S is the salinity (psu), T the water temperature (ITS-90, degC)

Where

A0 = 2.00907
A1 = 3.22014
A2 = 4.0501
A3 = 4.94457
A4 = -0.256847
A5 = 3.88767

B0 = -0.00624523
B1 = -0.00737614
B2 = -0.00103410
B3 = -0.00817083
C0 = -0.000000488682

4.2.2 SBE63 sensor

The equations are described in details in [RD7].

The SBE63 optode measures oxygen concentration following the same principle as for the Aanderaa optode.

Sea-Bird provides two calibration sheets with each SBE 63:

- One relates the SBE 63 oxygen sensor output to oxygen concentration in ml/L - with coefficients a_0, a_1, a_2, b_0, b_1, c_0, c_1, c_2, and E. (see § 4.2.2.2 for the equation and see § 12.2.2.1 in ANNEX A for an example)
- One relates the SBE 63 thermistor output to temperature (°C) - with coefficients t_{a0}, t_{a1}, t_{a2}, t_{a3} (see § 4.2.2.1 for the equation and see § 12.2.2.2 in ANNEX A for an example)

4.2.2.1 Temperature equation

The following equation relates the voltage output of the SBE63 thermistor to the temperature in degree Celsius.

$$\boldsymbol{T_{O2}} = \frac{\mathbf{1}}{(\boldsymbol{TA0} + \boldsymbol{TA1} \times \boldsymbol{L} + \boldsymbol{TA2} \times \boldsymbol{L^2} + \boldsymbol{TA3} \times \boldsymbol{L^3})} - \mathbf{273.15}$$

Where $L = ln\left(\frac{100000 \times V}{3.3 - V}\right)$ and V is the thermistor voltage output from the SBE63 sensor.

The thermistor calibration coefficients TAx (x=0,1,2,3) are provided in the calibration sheets (see § 12.2.2.2).

V could be expressed from the phase delay output φ_r in usec (PHASE_DELAY_DOXY in the Argo stream), as follow:

$$\boldsymbol{V} = \boldsymbol{\varphi_r}/\mathbf{39.457071}$$

4.2.2.2 Calibration equation

The SBE63 output is either a raw phase delay (in µsec) or an oxygen concentration in ml/L. The calibration equation is the following:

$$\mathbf{O_2(ml/L)} = \left[\frac{\left[\frac{\mathbf{a_0} + \mathbf{a_1.T} + \mathbf{a_2.V^2}}{(\mathbf{b_0} + \mathbf{b_1.V})} - \mathbf{1}\right]}{\mathbf{K_{SV}}}\right] . [\mathbf{S_{Corr}}] . [\mathbf{P_{Corr}}]$$

Where O2 is the oxygen concentration (ml/L), T is the temperature output from SBE 63's thermistor (degC) (see § 4.2.2.1).

Where V is the raw measured phase delay expressed in volts $V = \varphi_r/39.457071$

According to Bittig, H.C., 2015 ([RD15]), a first pressure correction should be done on the phase delay φ_r, leading to:

$$V = \varphi_{adj}/39.457071 \text{ and } \varphi_{adj} = \varphi_r + P_{coef1} \times P/1000$$

Where P is the pressure (dbar).

We strongly recommend setting P_{coef1} to 0.115 usec. However, to recover the previous formula, P_{coef1} may be set to 0.

Where a_0, a_1, a_2, b_0, b_1 are the calibration coefficients (Uchida et al, 2008 [RD2]), K_{sv} is Stern-Volmer constant, with calibration coefficients c_0, c_1, c_2 (Demas et al, 1999), calculated as:

$$K_{SV} = c_0 + c_1 \times T + c_2 \times T^2$$

These coefficients are available in the calibration sheets (example in §12.2.2.1 in ANNEX A: Examples of calibration certificates). T could be the optode thermistor temperature calculated from the thermistor voltage or the temperature from the CTD if the previous one is not provided.

Where S_{Corr} is the salinity correction function (with calibration coefficients Sol_{B0}, Sol_{B1}, Sol_{B2}, Sol_{B3}, Sol_{C0}) (see § 4.2.2.3) and P_{Corr} is the pressure correction function (with calibration coefficient E) (see § 4.2.2.4)

4.2.2.3 Salinity correction

The salinity correction equation is:

$$S_{Corr} = A(T,S,S_{preset}) \times e^{\left(S \times (Sol_{B0} + Sol_{B1} \times T_s + Sol_{B2} \times {T_s}^2 + Sol_{B3} \times {T_s}^3) + Sol_{C0} \times S^2\right)}$$

Where

$$A(T,S,S_{preset}) = \frac{1013.25 - pH_2O(T,S_{preset})}{1013.25 - pH_2O(T,S)}$$

$$pH_2O = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{T_{abs}}\right) + D_2 \times ln\left(\frac{T_{abs}}{100}\right) + D_3 \times S\right)}$$

Where the salinity correction coefficients, which are the same as the one recommended by the SCOR Working Group 142 on "Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders" [RD13]), are constants (Benson and Krause, 1984) :

Sol_{B0} = -6.24523e-3
Sol_{B1} = -7.37614e-3
Sol_{B2} = -1.03410e-3
Sol_{B3} = -8.17083e-3
Sol_{C0} = -4.88682e-7

Where T_s is the scaled temperature expressed as a function of the temperature output from SBE's thermistor T (in degC):

$$\boldsymbol{T_s = ln((298.15 - T)/(273.15 + T))}$$

Where S is the salinity from CTD data if available, and T_{abs} is the temperature in Kelvin.

The coefficients D_0 to D_3 used in the pH_2O computation are provided in the SCOR WG (SCOR Working Group 142 on "Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders" [RD13]):

D0 = 24.4543
D1 = -67.4509
D2 = –4.8489
D3 = –5.44e–4

Note that for oxygen in ml/L output directly from SBE 63, a reference salinity S_{ref} (set in SetRefSal) is used as the salinity value in the previous salinity correction equation ($S=S_{ref}$). Therefore, an additional salinity correction should be applied as follows:

$$S_{corr} = A(T,S,S_{preset}) \times e^{\left((S - S_{ref}) \times (Sol_{B0} + Sol_{B1} \times T_s + Sol_{B2} \times {T_s}^2 + Sol_{B3} \times {T_s}^3) + Sol_{C0}(S^2 - {S_{ref}}^2)\right)}$$

Where S_{ref} = SetRefSal (in SBE63 manual) is a reference salinity and S is the salinity from the CTD.

The term $A(T,S,S_{preset})$ has been introduced following the recommendations of Bittig H.C ([RD16]). To recover the old formula which neglected the water vapour effect (i.e., A = 1), S_{preset} could be set to S. However, it is not recommended: S_{preset} should be set to 0 regardless the sensor output parameter:

4.2.2.4 Pressure correction

The manufacturer pressure correction equation is:

$$P_{Corr} = e^{\left(\frac{E \times P}{K}\right)}$$

Where P is the pressure (dbar) from the CTD if available. If not, it is a reference pressure set in SetRefP (see [RD7]).

Where the pressure correction coefficient is a constant E = 0.011, and K is the temperature in Kelvin $K = T + 273.15$ and T is the temperature output from the CTD (or the SBE 63's thermistor) in degree Celsius.

It has to be noted that the constant E is currently being reassessed and a consensus appear on a new value E = 0.009.

Note that for oxygen in ml/L output directly from SBE 63, a reference pressure P_{ref} (set in SetRefP) is used as the pressure value in the above pressure correction equation ($P=P_{ref}$). Therefore, an additional pressure correction should be applied as follows:

$$P_{corr} = e^{\left(\frac{E \times (P - P_{ref})}{K}\right)}$$

According to Bittig et al. (2015), Pressure Response of Aanderaa and Sea-Bird Oxygen Optodes. *J. Atmos. Oceanic Technol.*, ([RD15]), a new equation has been specified for the pressure compensation:

$$\boldsymbol{P_{corr} = 1 + \frac{(P_{coef2} \times T + P_{coef3}) \times PRES}{1000}}$$

We strongly recommend the use of this new equation, with the coefficients Pcoef2 and Pcoef3 set to the following values:

- Voltage / phase_delay has been corrected from pressure effect (Pcoef1 = 0.115, see §4.2.2.2): Pcoef2 = 0.00022, Pcoef3 = 0.0419

- Voltage / phase_delay has not been corrected from pressure effect (Pcoef1 = 0, see §4.2.2.2): Pcoef2 = 0.00016, Pcoef3 = 0.0307

4.3 JAC sensor

4.3.1 ARO_FT sensor

The ARO_FT sensor is an optical dissolved oxygen sensor. The principle of its measurement is similar to that of Aanderaa optode sensors. It detects the length of the phosphorescence life using the phase difference detection method using blue and red lights.

4.3.1.1 Calibration equation

The ARO_FT sensor measures two variables for oxygen. The first is the difference between the phase obtained with blue light excitation and the phase obtained with red light excitation in count

(COUNT_DOXY). The second is the irradiation time of LED in count (LED_FLASHING_COUNT_DOXY).

The MOLAR_DOXY is calculated by using COUNT_DOXY, its irradiation time (t(sec)) calculated from LED_FLASHING_COUNT_DOXY and optode thermistor temperature T (in degC).

$$\mathbf{MOLAR\_DOXY} = \left\{ \left(\frac{1 + d_0 \cdot T}{d_1 + d_2 \cdot N + d_3 \cdot t + d_4 \cdot t \cdot N} \right)^{e_0} - 1 \right\} \cdot \frac{1}{c_0 + c_1 \cdot T + c_2 \cdot T^2}$$

Where

$$N = COUNT\_DOXY + 0{,}0001$$

$$t = LED\_FLASHING\_COUNT\_DOXY \times 0{,}01$$

The c_0, c_1, c_2, d_0, d_1, d_2, d_3, d_4, and e_0 are coefficients provided in the RINKO calibration certificate. Note that d_4 is usually equal to zero, but it is not equal to zero when the sensor cannot keep its temporal stability. The value of d_4 will be decided by the amount of its drift.

4.3.1.2 Salinity compensation

The salinity compensation is estimated as:

$$DO_{PSAL} = MOLAR\_DOXY \times S_{corr}$$

Where

$$S_{corr} = A(T,S,S_{preset}) \times e^{(S-S_{ref})(B_0+B_1 \times T_s + B_2 \times T_s{}^2 + B_3 \times T_s{}^3) + C_0 \times (S^2 - S_{ref}{}^2)}$$

$$A(T,S,S_{preset}) = \frac{1013.25 - pH_2O(T,S_{preset})}{1013.25 - pH_2O(T,S)}$$

$$pH_2O = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{T_{abs}}\right) + D_2 \times \ln\left(\frac{T_{abs}}{100}\right) + D_3 \times S\right)}$$

Where S is the salinity (PSAL) and S_{ref} is the reference salinity which is equal to zero. The term *A(T,S,*S_{preset}*)* has been introduced following the recommendations of Bittig H.C ([RD16]). To recover the old formula which neglected the water vapour effect (i.e., A = 1), S_{preset} could be set to S. However, it is not recommended: S_{preset} should be set to 0, regardless to the sensor output parameter.

To summarize, S_{ref} and S_{preset} have to takes the the following values

- When MOLAR_DOXY has been internally calculated by the optode:
  - S_0 should be known and S_{ref} set to S_0.
  - S_{preset} is strongly recommended to be set to 0 (previously : S_{preset} = S) (water vapour pressure effect neglected)
- When MOLAR_DOXY is calculated on-shore from COUNT_DOXY and LED_FLASHING_COUNT_DOXY:
  - S_{ref} and S_0 are not used and must be set to 0 in the above equations.
  - S_{preset} is strongly recommended to be set to 0 (previously : S_{preset} = S)

Where T_s is the scaled temperature expressed as a function of the temperature T (in degC): T should be the temperature from the CTD or the optode thermistor temperature if the previous one is not provided.

$$T_s = ln((298.15 - T)/(273.15 + T))$$

The coefficients D_0 to D_3 are provided in the SCOR WG (SCOR Working Group 142 on "Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders" [RD13]).

The coefficients B_0 to B_3 and C_0 are same as the SCOR WG recommendations (SCOR Working Group 142 on "Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders" [RD13]).

B_0 = -6.24523e-3
B_1 = -7.37614e-3
B_2 = -1.03410e-3
B_3 = -8.17083e-3
C_0 = -4.88682e-7

4.3.1.3 Pressure compensation

The pressure compensation is then estimated as:

$$DO_{PSAL\&PRES} = DO_{PSAL} \cdot \left[1 + \frac{Pcoef \times PRES}{1000}\right]$$

where PRES is the pressure in dbar and Pcoef is the coefficient.

The unit of $DO_{PSAL\&PRES}$ is umol/L.

As a result of the comparison between the first profile of DO_{PSAL} and high-quality ship board CTDO measurements at the launching point, Pcoef = 0.032. Note that Pcoef is subject to be changed over time.

According to Bittig et al. (2015), Pressure Response of Aanderaa and Sea-Bird Oxygen Optodes. *J. Atmos. Oceanic Technol.*, ([RD15]), a new equation has been specified to compute DO_{PSAL} :

$$DO_{PSAL\&PRES} = DO_{PSAL} \times \left[1 + \frac{(P_{coef2} \times T + P_{coef3}) \times PRES}{1000}\right]$$

Pcoef2 and Pcoef3 have not yet been specified for the ARO_FT optode, so they should be set to Pcoef2 = 0 and Pcoef3 = Pcoef = 0.032.

To obtain DOXY, $DO_{PSAL\&PRES}$ must be converted in umol/kg, the official Argo unit, by dividing by density (see §5). The density has to be estimated from the CTD temperature and salinity (TEMP and PSAL).

4.3.1.4 Temperature measured by ARO_FT sensor

The ARO_FT sensor also measures temperature in count (TEMP_COUNT_DOXY). TEMP_DOXY (in degC) is calculated as a 5th polynomial of the TEMP_COUNT_DOXY.

$$\begin{aligned} TEMP\_DOXY = {} & A + B \times TEMP\_COUNT\_DOXY + C \times TEMP\_COUNT\_DOXY^2 \\ & + D \times TEMP\_COUNT\_DOXY^3 + E \times TEMP\_COUNT\_DOXY^4 \\ & + F \times TEMP\_COUNT\_DOXY^5 \end{aligned}$$

Where A, B, C, D, E, and F are coefficients provided in the RINKO calibration certificate.

5 Unit conversion of oxygen

5.1 DOXY

The unit of DOXY is umol/kg in Argo data and the oxygen measurements are sent from Argo floats in another unit such as umol/L for the Optode and ml/L for the SBE-IDO. Thus the unit conversion is carried out by DACs as follows:

O_2 [umol/L] = 44.6596×O_2 [ml/L]

O_2 [umol/kg] = O_2 [umol/L] / ρ

Here, ρ is the potential density of water [kg/L] at zero pressure and at the potential temperature (e.g., 1.0269 kg/L; e.g., UNESCO, 1983). The value of 44.6596 is derived from the molar volume of the oxygen gas, 22.3916 L/mole, at standard temperature and pressure (0°C, 1 atmosphere; e.g., García and Gordon, 1992).

This unit conversion follows the "Recommendations on the conversion between oxygen quantities for Bio-Argo floats and other autonomous sensor platforms" by SCOR Working Group 142 on "Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders" [RD13] .

The unit conversion should always be done with the best available temperature, i.e., TEMP of the CTD unit.

5.2 PPOX_DOXY

The SCOR WG 142 (ref. RD14) recommends to make in air measurements of oxygen optodes on Argo floats mandatory.

These measurements are stored in the B-trajectory file. The oxygen measurements sent from the Argo floats are in another unit and need to be converted to the oxygen partial pressure, PPOX_DOXY. The unit of PPOX_DOXY is mbar. The calculation of PPOX_DOXY follows along the same lines as DOXY (see specific cases).

The conversion between DOXY and PPOX_DOXY is described in the "Recommendations on the conversion between oxygen quantities for Bio-Argo floats and other autonomous sensor platforms" by SCOR Working Group 142 on "Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders" [RD13] . The general case of this conversion needs PSAL, which is typically unavailable when the CTD pump is stopped during the surface in air measurements.

However, DOXY calculations generally involve MOLAR_DOXY or MLPL_DOXY as intermediate, an "O_2 concentration in umol/L that needs to be salinity corrected" with the factor Scorr. The same factor Scorr is used in the DOXY to PPOX_DOXY conversion, so the effect of PSAL cancels out. The reason is that oxygen optodes are actually sensitive to the O_2 partial pressure, not the O_2 concentration, so the optode sensor reading in units of O_2 partial pressure needs only a pressure but no salinity correction.

To calculate PPOX_DOXY for the B-trajectory file, DOXY is calculated in an intermediate step with PSAL = 0 and the specific calculation case. It is then converted to PPOX_DOXY with PSAL = 0, too, as shown below:

[*Details from RD13; conversion E with the revised Scorr and Spreset=0; (It comes down to conversion D with Spreset=0, since Scorr=1)*]

6 General scheme of the method

From beginning to end, here is the general modus operandi recommended for the computation of DOXY, whenever possible:

1. Do the pressure adjustment on the PHASE (if available. Not done for sensor output MOLAR_DOXY)
2. Convert the adjusted PHASE to MOLAR_DOXY using TEMP_DOXY whenever possible (except Aanderaa 3830, for which the use of TEMP is highly recommended).
3. Convert and adjust MOLAR_DOXY for salinity and pressure effects using TEMP and PSAL from the CTD, to obtain DOXY.

7 CTD and oxygen data reported with different vertical sampling schemes

Some floats with SBE41CP CTD operating in continuous mode are paired with Aanderaa optodes. In these cases, the CTD T and S data in continuous mode are reported at high vertical resolution (e.g. 2-dbar bin average), while the optode oxygen and optode temperature are reported at low vertical resolution.

As CTD and oxygen data are reported with different vertical sampling schemes, a second profile is added in the single cycle netcdf file.

CTD data acquired at high vertical resolution are stored in the first profile.

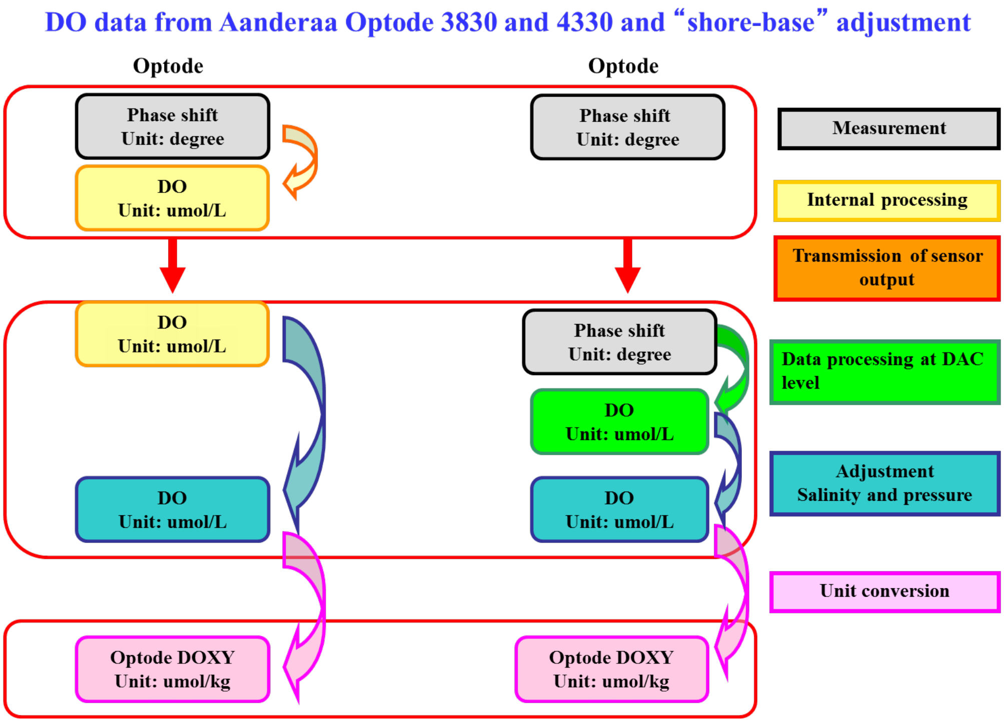
The second profile contains DOXY and DOXY related fields, the intermediate variables reported by the optode as well as the instantaneous CTD data acquired at the optode level measurements.

A description of this single cycle netcdf file with two profiles is provided in the Argo Data Management User's Manual available on the ADMT webpage (http://www.argodatamgt.org).

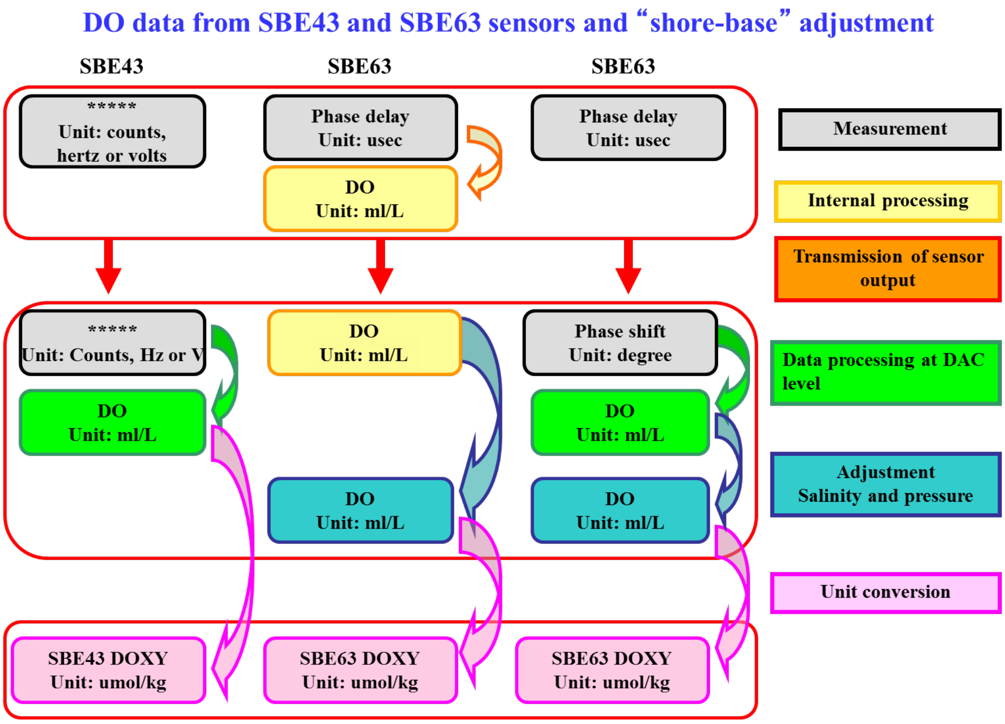
Note that when salinity is not available at the pressure levels at which oxygen measurements are done; the salinity compensation term can be estimated from salinity interpolated at the oxygen levels. A linear interpolation is suggested while extrapolation should use the value of the nearest neighbouring point with valid PSAL.

8 Schematic of the oxygen data processing

8.1 Aanderaa optodes

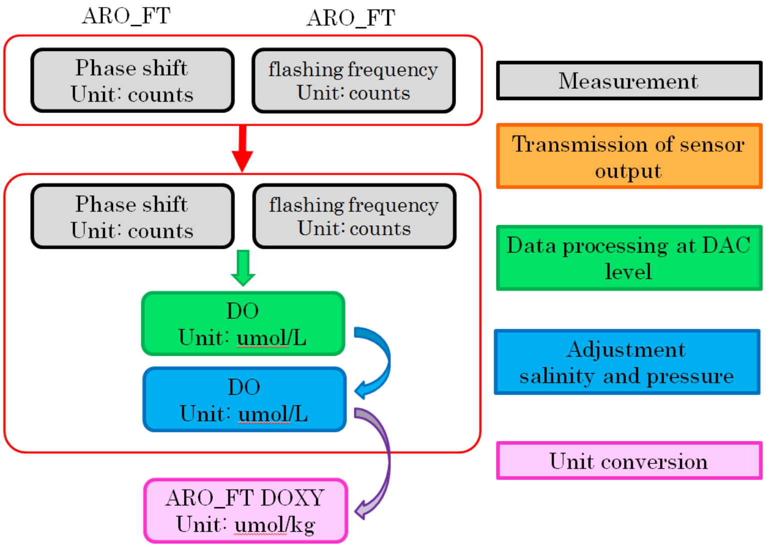


8.2 Seabird sensors



8.3 JAC sensor

DO data from ARO_FT sensor and "shore-base" adjustment



9 DAC cookbook

This section aims at describing precisely how to fill the meta-data for each already encountered configuration. These specifications are valid as of the date of writing this document. It is very likely that changes in calibrations and conversions equations will occur in the future. Metadata will then have to be filled accordingly with the new procedures.

9.1 Possible configurations for DOXY computations

In this section, to identify the different configurations that the DAC can be faced with, we use the following convention. Each configuration is named:

CASE_*SensorModelId_InputParamId_ComputationMethodId*

where *SensorModelId* refers to the Id associated to the standardized oxygen sensor model (see Table 1 and reference table 27 of the Argo User's Manual ([RD9])).

where *InputParamId* refers to the Id associated to the input parameter used to compute the parameter to be stored by the DAC (Table 2).

where *ComputationMethodId* refers to the Id associated to each method used to compute the parameter to be stored by the DAC (Table 3).

For all of cases, even if it is not specified in the Table 3, salinity and pressure compensation, as well as unit conversion must be applied.

Id	Sensor model	Comment
101	SBE43_IDO	Seabird Electrochemical Dissolved Oxygen IDO sensor (volt output)
102	SBE43F_IDO	Seabird Electrochemical Dissolved Oxygen IDO sensor (frequency output)
103	SBE63_OPTODE	Seabird Optical Dissolved Oxygen Sensor
201	AANDERAA_OPTODE_3830	Aanderaa Optical Dissolved Oxygen Sensor
202	AANDERAA_OPTODE_4330 AANDERAA_OPTODE_4330F	Aanderaa Optical Dissolved Oxygen Sensor
301	ARO_FT	JAC RINKO

Table 1: Possible configurations, *SensorModelId table*

Id	Input parameter	Comment
101	TEMP_VOLTAGE_DOXY	
102	TEMP_DOXY	
103	TEMP_COUNT_DOXY	
201	MOLAR_DOXY	Intermediate dissolved oxygen concentration; pressure and salinity compensation need to be applied as well as unit conversion
202	BPHASE_DOXY	
203	DPHASE_DOXY	
204	TPHASE_DOXY	
205	C1PHASE_DOXY & C2PHASE_DOXY	
206	VOLTAGE_DOXY	
207	FREQUENCY_DOXY	
208	PHASE_DELAY_DOXY	
209	MLPL_DOXY	Intermediate dissolved oxygen concentration; pressure and salinity compensation need to be applied as well as unit conversion
210	LED_FLASHING_COUNT_DOXY & COUNT_DOXY	
211	*COUNT_DOXY*	

Table 2: Possible configurations, *InputParamId table*

Id	Computation method Equation type	Temperature sensor	Comment
001	None		Transmitted data is not modified, it is stored as is
101	Standard temperature calibration		
202	**Aanderaa standard calibration**	**CTD temperature**	**Recommended for 3830 -** Not recommended for 4330
203	Aanderaa standard calibration + 2 points adjustment	CTD temperature	Not recommended for 4330 – Not used for the 3830.
204	Aanderaa Stern-Volmer equation	CTD temperature	Recommended for 3830 - Not recommended for 4330
205	Aanderaa Stern-Volmer equation + 2 points adjustment	CTD temperature	Not recommended for 4330 – Not used for the 3830.
206	SBE43 standard equation	CTD temperature	
301	DO computed internally from manufacturer equation. SCOR WG142 Salinity and Bittig pressure compensation + unit conversion only;	Oxygen sensor temperature	Manufacturer equation with reference salinity
302	Aanderaa standard calibration	Oxygen sensor temperature	Not recommended for 3830
303	Aanderaa standard calibration + 2 points adjustment	Oxygen sensor temperature	Not used for 3830
304	**Aanderaa Stern-Volmer equation**	**Oxygen sensor temperature**	**Recommended method for 4330 -** Not recommended for

			3830
305	**Aanderaa Stern-Volmer equation + 2 points adjustment**	**Oxygen sensor temperature**	**Recommended method for 4330 -** Not used for 3830
306	SBE43 standard equation	Oxygen sensor temperature	
307	**SBE63 standard equation (Stern-Volmer) + Bittig pressure correction**	**Oxygen sensor temperature**	**Recommended method for SBE63**
308	SBE63 standard equation (Stern-Volmer) + manufacturer Pressure correction	Oxygen sensor temperature	Not recommended
309	SBE63 DO computed internally from manufacturer equation. Salinity and manufacturer pressure compensation + unit conversion only;	Oxygen sensor temperature	Manufacturer equation with reference salinity. Not recommended
401	**ARO_FT standard equation (Stern-Volmer)**	**Oxygen sensor temperature**	**Recommended method for ARO_FT sensor**

Table 3: Possible configurations, *ComputationMethodId table*

The computation method must be deduced from the calibration certificate (see ANNEX A). The tables below provide the different possible configuration for the calculation of TEMP_DOXY (Table 4) and DOXY (Table 5 and Table 6).

Sensor model			Input parameter: 101 TEMP_VOLTAGE_DOXY	102 TEMP_DOXY	103 TEMP_COUNT_DOXY
	101	SBE43_IDO			
	102	SBE43F_IDO			
	103	SBE63_OPTODE	101 (9.2.3)	001 (9.2.4)	
	201	AANDERAA_OPTODE_3830	101 (9.2.9)	001 (9.2.10)	
	202	AANDERAA_OPTODE_4330 AANDERAA_OPTODE_4330F	101 (9.2.20)	001 (9.2.21)	
	301	ARO_FT			101 (9.2.39)

Table 4: Configurations for the calculation of TEMP_DOXY as function of the sensor model and input parameter

Sensor Model		Input parameter										
		201	202	203	204	205	206	207	208	209	210	211
		MOLAR_DOXY	BPHASE_DOXY	DPHASE_DOXY	TPHASE_DOXY	C1PHASE_DOXY & C2PHASE_DOXY	VOLTAGE_DOXY	FREQUENCY_DOXY	PHASE_DELAY_DOXY	MLPL_DOXY	LED_FLASHING_COUNT_DOXY & COUNT_DOXY	COUNT_DOXY
101	SBE43_IDO						**206 (9.2.1)**					
102	SBE43F_IDO							**206 (9.2.2)**				
103	SBE63_OPTODE								**307 (9.2.5)** **308 (9.2.6)**	**301 (9.2.7)** **309 (9.2.8)**		
201	AANDERAA_OPTODE_3830	**301 (9.2.11)**	**202 (9.2.12)** 204 (9.2.13) 302 (9.2.14) 304 (9.2.15)	**202 (9.2.16)** 204 (9.2.17) 302 (9.2.18) 304 (9.2.19)								
202	AANDERAA_OPTODE_4330 AANDERAA_OPTODE_4330F	**301 (9.2.22)**			202 (9.2.23) 203 (9.2.24) 204 (9.2.25) 205 (9.2.26) 302 (9.2.27) 303 (9.2.28) **304 (9.2.29)** **305 (9.2.30)**	202 (9.2.31) 203 (9.2.32) 204 (9.2.33) 205 (9.2.34) 302 (9.2.35) 303 (9.2.36) **304 (9.2.37)** **305 (9.2.38)**						
301	ARO_FT										**401 (9.2.40)**	

Table 5: Configurations for the calculation of DOXY as function of the sensor model and input parameter. The recommended configurations are highlighted in bold.

			O₂ response model (~Type of calibration sheet)									
				optical sensors								
			electro-chemical sensors	internal calculation	20-term polynomial	28-term polynomial	28-term polynomial + 2 points adjustment	(old) Stern-Volmer	SVU Stern-Volmer	SVU Stern-Volmer + 2 points adjustment	SBE Stern-Volmer	JAC Stern-Volmer
Sensor model	101	SBE43_IDO	**206_206 (9.2.1)**									
	102	SBE43F_IDO	**207_206 (9.2.2)**									
	103	SBE63_OPTODE		**209_301 (9.2.7)**							**208_307 (9.2.5)**	
				209_309 (9.2.8)							**208_308 (9.2.6)**	
	201	AANDERAA_OPTODE_3830		**201_301 (9.2.11)**	**202_202 (9.2.12)**			**202_204 (9.2.13)**				
					202_302 (9.2.14)			202_304 (9.2.15)				
					203_202 (9.2.16)			**203_204 (9.2.17)**				
					203_302 (9.2.18)			203_304 (9.2.19)				
	202	AANDERAA_OPTODE_4330 or AANDERAA_OPTODE_4330F		**201_301 (9.2.22)**		204_202 (9.2.23)	204_203 (9.2.24)		204_204 (9.2.25)	204_205 (9.2.26)		
						204_302 (9.2.27)	204_303 (9.2.28)		**204_304 (9.2.29)**	**204_305 (9.2.30)**		
						205_202 (9.2.31)	205_203 (9.2.32)		205_204 (9.2.33)	205_205 (9.2.34)		
						205_302 (9.2.35)	205_303 (9.2.36)		**205_304 (9.2.37)**	**205_305 (9.2.38)**		
	301	ARO_FT										**210_401 (9.2.40)**

Table 6: Configurations for the calculation of DOXY as function of the sensor model and O2 response model. The recommended configurations are highlighted in bold.

9.2 Description of DOXY computation configurations

Units used hereafter are defined in the Technical parameter units document, available in http://www.argodatamgt.org/Documentation.

In the following, the parameters highlighted in italics must be set up beforehand.

The various cases are identified by the nomenclature described in §9.1.

9.2.1 CASE_101_206_206

Note that the calibration sheet presented in §12.1.1.1 showed the case of an SBE43I, with frequency output. In this case, the sensor time constant at temperature and pressure (tau20) in the calibration equation (MLPL_DOXY from the Frequency) is put to 0.

Sensor: SBE43_IDO

Sensor output: voltage output in volts called VOLTAGE_DOXY

Calculation: standard calibration equation with TEMP, PSAL and PRES from CTD + unit conversion

Calculation Input:

- VOLTAGE_DOXY the output voltage in volts
- TEMP, PSAL and PRES from the CTD
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- *Soc* the oxygen signal slope from the calibration certificate (see §12.2.1)
- *Voffset* the voltage at zero oxygen signal from the calibration certificate (see §12.2.1)
- *A, B, C* the residual temperature correction factors from the calibration certificate (see §12.2.1)
- *E* the pressure correction factor from the calibration certificate (see §12.2.1)
- *tau20* the sensor time constant at 20 ºC, 1 atmosphere, 0 PSU; from the calibration certificate
- *D1, D2* the temperature and pressure correction factors from the calibration certificate (see §12.2.1)
- A_0, A_1, A_2, A_3, A_4, A_5, B_0, B_1, B_2, B_3, C_0 the oxygen saturation coefficients (default: A0 = 2.00907, A1 = 3.22014, A2 = 4.0501, A3 = 4.94457, A4 = -0.256847, A5 = 3.88767, B0 = -0.00624523, B1 = -0.00737614, B2 = -0.00103410, B3 = -0.00817083, C0 = -0.000000488682)

Calculation Output:

- DOXY in umol/kg

Equations:

$$MLPL\_DOXY = \left\{S_{oc}.\left(VOLTAGE\_DOXY + V_{offset} + tau20.e^{(D_1.PRES+D_2(TEMP-20))}.\frac{dVOLTAGE\_DOXY}{dt}\right)\right\}.O_{xsol}.(1.0 + A.TEMP + B.TEMP^2 + C.TEMP^3).e^{\left(\frac{E.PRES}{273.15+TEMP}\right)}$$

$$O_{xsol} = e^{\{A_0+A_1.T_s+A_2.T_s{}^2+A_3.T_s{}^3+A_4.T_s{}^4+A_5.T_s{}^5+PSAL.[B_0+B_1.T_s+B_2.T_s{}^2+B_3.T_s{}^3]+C_0.PSAL^2\}}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY(umol/kg) = 44.6596\times MLPL\_DOXY/rho$$

Float sensor information	
Name	**Value**
SENSOR	IDO_DOXY
SENSOR_MAKER	SBE
SENSOR_MODEL	SBE43_IDO
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	VOLTAGE_DOXY
PARAMETER_SENSOR	IDO_DOXY
PARAMETER_UNITS	volts
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	output voltage of the DO sensor

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	IDO_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	4 umol/kg or 2%
PARAMETER_RESOLUTION	0.4 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	MLPL_DOXY={Soc.(VOLTAGE_DOXY+Voffset}.Oxsol.(1.0+A.TEMP+B.TEMP^2+C.TEMP^3).e^(((E.PRES)/(273.15+TEMP))); Oxsol=e^{A0+A1.Ts+A2.Ts^2+A3.Ts^3+A4.Ts^4+A5.Ts^5+PSAL.[B0+B1.Ts+B2.Ts^2+B3.Ts^3]+C0.PSAL^2 }; Ts=ln(((298.15-TEMP))/((273.15+TEMP))); DOXY(umol/kg)=44.6596*MLPL_DOXY/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Soc=*Soc*, Voffset=*Voffset*, tau20=tau20, D1=*D1*, D2=*D2*, A=*A*, B=*B*, C=*C*, E=*E;* A0=*A0,* A1=*A1,* A2=*A2,* A3=*A3,* A4=*A4,* A5=*A5;* B0=*B0,* B1=*B1,* B2=*B2,* B3=*B3,* C0=*C0*
PREDEPLOYMENT_CALIB_COMMENT	see Application note #64: SBE43 Dissolved Oxygen Sensor – Background Information, Deployment Recommendations, and Clearing and Storage (revised June 2013); see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.2 CASE_102_207_206

Sensor: SBE43F_IDO

Sensor output: frequency output in Hz called FREQUENCY_DOXY

Calculation: standard calibration equation with TEMP, PSAL and PRES from CTD + unit conversion

Calculation Input:

- FREQUENCY_DOXY the ouput frequency in Hz
- TEMP, PSAL and PRES from the CTD
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- *Soc* the oxygen signal slope from the calibration certificate (see §12.2.1)
- *Foffset* the frequency at zero oxygen signal from the calibration certificate (see §12.2.1)
- *A, B, C* the residual temperature correction factors from the calibration certificate (see §12.2.1)
- *E* the pressure correction factor from the calibration certificate (see §12.2.1)
- ~~*tau20* the sensor time constant at 20 ºC, 1 atmosphere, 0 PSU; from the calibration certificate~~
- ~~*D1, D2* the temperature and pressure correction factors from the calibration certificate (see §12.2.1)~~
- A_0, A_1, A_2, A_3, A_4, A_5, B_0, B_1, B_2, B_3, C_0 the oxygen saturation coefficients (default: A0 = 2.00907, A1 = 3.22014, A2 = 4.0501, A3 = 4.94457, A4 = -0.256847, A5 = 3.88767, B0 = -0.00624523, B1 = -0.00737614, B2 = -0.00103410, B3 = -0.00817083, C0 = -0.000000488682)

Calculation Output:

- DOXY in umol/kg

Equations:

$$MLPL\_DOXY = \left\{S_{oc}.\left(FREQUENCY\_DOXY + F_{offset} + \cancel{tau20.e^{(D_1.PRES+D_2.(TEMP-20))}.\frac{\partial FREQUENCY\_DOXY}{\partial t}}\right)\right\}.O_{xsol}.(1.0 + A.TEMP + B.TEMP^2 + C.TEMP^3).e^{\left(\frac{E.PRES}{273.15+TEMP}\right)}$$

$$O_{xsol} = e^{\{A_0+A_1.T_s+A_2.T_s{}^2+A_3.T_s{}^3+A_4.T_s{}^4+A_5.T_s{}^5+PSAL.[B_0+B_1.T_s+B_2.T_s{}^2+B_3.T_s{}^3]+C_0.PSAL^2\}}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY(umol/kg) = 44.6596\times MLPL\_DOXY/rho$$

Float sensor information	
Name	**Value**
SENSOR	IDO_DOXY
SENSOR_MAKER	SBE
SENSOR_MODEL	SBE43F_IDO
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	FREQUENCY_DOXY
PARAMETER_SENSOR	IDO_DOXY
PARAMETER_UNITS	hertz
PARAMETER_ACCURACY	??

PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	output frequency of the DO sensor

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	IDO_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	4 umol/kg or 2%
PARAMETER_RESOLUTION	0.4 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; Oxsol=exp[A0+A1*Ts+A2*Ts^2+A3*Ts^3+A4*Ts^4+A5*Ts^5+PSAL*(B0+B1*Ts +B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; MLPL_DOXY=Soc*(FREQUENCY_DOXY+Foffset)*Oxsol*(1.0+A*TEMP+B*TEMP^2+ C*TEMP^3)*exp[E*PRES/(273.15+TEMP)]; DOXY=44.6596*MLPL_DOXY/rho, where rho is the potential density [kg/L] calculated from CTD data';
PREDEPLOYMENT_CALIB_COEFFICIENT	Soc=*Soc*, Foffset=*Foffset*, tau20=tau20, D1=*D1*, D2=*D2*, A=*A*, B=*B*, C=*C*, E=*E;* A0=*A0,* A1=*A1,* A2=*A2,* A3=*A3,* A4=*A4,* A5=*A5;* B0=*B0,* B1=*B1,* B2=*B2,* B3=*B3,* C0=*C0*
PREDEPLOYMENT_CALIB_COMMENT	see Application note #64: SBE43 Dissolved Oxygen Sensor – Background Information, Deployment Recommendations, and Clearing and Storage (revised June 2013); see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.3 CASE_103_101_101

Sensor: SBE63_OPTODE

Sensor output: temperature voltage output in volts called TEMP_VOLTAGE_DOXY

Calculation: standard calibration equation

Calculation Input:

- TEMP_VOLTAGE_DOXY the thermistor voltage in volts
- TA0 to TA3 values from the calibration certificate (see §12.2.2.2)

Calculation Output:

- TEMP_DOXY in °C (ITS90)

Equations:

$$TEMP\_DOXY = \frac{1}{(TA0 + TA1 \times L + TA2 \times L^2 + TA3 \times L^3)} - 273.15$$

$$L = ln\left(\frac{100000 \times TEMP\_VOLTAGE\_DOXY}{3.3 - TEMP\_VOLTAGE\_DOXY}\right)$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	SBE

SENSOR_MODEL	SBE63_OPTODE
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TEMP_VOLTAGE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	volts
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	output thermistor voltage

Float parameter information	
Name	**Value**
PARAMETER	TEMP_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degC
PARAMETER_ACCURACY	?? degC
PARAMETER_RESOLUTION	?? degC
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TEMP_DOXY=1/(TA0+TA1*L+TA2*L^2+TA3*L^3)-273.15; L=ln(100000*TEMP_VOLTAGE_DOXY/(3.3-TEMP_VOLTAGE_DOXY))
PREDEPLOYMENT_CALIB_COEFFICIENT	TA0=*TA0*, TA1=*TA1*, T2=*TA2*, T3=*TA3*
PREDEPLOYMENT_CALIB_COMMENT	optode temperature, see SBE63 User's Manual (manual version #007, 10/28/13).

9.2.4 CASE_103_102_001

Sensor: SBE63_OPTODE

Sensor output: temperature output (TEMP_DOXY) in degC (ITS90)

Calculation: none (embedded)

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	SBE
SENSOR_MODEL	SBE63_OPTODE
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TEMP_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degC
PARAMETER_ACCURACY	?? degC
PARAMETER_RESOLUTION	?? degC
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TEMP_DOXY=1/(TA0+TA1*L+TA2*L^2+TA3*L^3)-273.15;

	L=ln(100000*TEMP_VOLTAGE_DOXY/(3.3-TEMP_VOLTAGE_DOXY)); TEMP_VOLTAGE_DOXY is the thermistor voltage in volts
PREDEPLOYMENT_CALIB_COEFFICIENT	TA0=*TA0*, TA1=*TA1*, T2=*TA2*, T3=*TA3*
PREDEPLOYMENT_CALIB_COMMENT	optode temperature, see SBE63 User's Manual (manual version #007, 10/28/13).

9.2.5 CASE_103_208_307

Sensor: SBE63_OPTODE

Sensor output: phase delay in µsec called PHASE_DELAY_DOXY

Calculation: standard conversion (Stern-Volmer) of raw data to oxygen concentration on ml/L + salinity compensation + Bittig pressure compensation with oxygen sensor temperature TEMP_DOXY and PRES and PSAL from the CTD, + unit conversion

Calculation input:

- PHASE_DELAY_DOXY in µsec
- PSAL (CTD salinity)
- TEMP_DOXY (SBE63' thermistor temperature in degC)
- PRES (CTD pressure in dbar)
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.115, P_{coef2}=0.00022, P_{coef3}=0.0419)
- Sol_{B0}, Sol_{B1}, Sol_{B2}, Sol_{B3} and Sol_{C0} the salinity compensation coefficient (default Sol_{B0} = -6.24523e-3, Sol_{B1} = -7.37614e-3, Sol_{B2} = -1.03410e-3, Sol_{B3} = -8.17083e-3, Sol_{C0} = -4.88682e-7
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default S_{preset} = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- *A0, A1, A2, B0, B1, C0, C1* and *C2* are calibration coefficients provided by the calibration sheet (see §12.2.2.1 in ANNEX A for an example).

Calculation output:

- DOXY in umol/kg

Equations:

$$\sout{V = PHASE\_DELAY\_DOXY / 39.457071}$$

$$V = \left[PHASE\_DELAY\_DOXY + P_{coef1} \times PRES/1000\right]/39.457071$$

$$K_{SV} = C0 + C1 \times TEMP\_DOXY + C2 \times TEMP\_DOXY^2$$

$$O_2(\mathrm{ml/L}) = \left[\frac{\left[\frac{A0 \ + \ A1.TEMP\_DOXY \ + \ A2.V^2}{(B0 \ + \ B1.V)} - 1\right]}{K_{SV}}\right].[S_{Corr}].[P_{Corr}]$$

$$S_{Corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left(PSAL \times \left(Sol_{B0} + Sol_{B1} \times T_s + Sol_{B2} \times T_s{}^2 + Sol_{B3} \times T_s{}^3\right) + Sol_{C0} \times PSAL^2\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP,S) = 1013.25\times e^{\left(D_0+D_1\times\left(\frac{100}{TEMP+273.15}\right)+D_2\times ln\left(\frac{TEMP+273.15}{100}\right)+D_3\times S\right)}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$P_{corr} = 1 + \frac{(P_{coef2}\times TEMP + P_{coef3})\times PRES}{1000}$$

$$DOXY(umol/kg) = 44.6596\times O_2(ml/L)/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	SBE
SENSOR_MODEL	SBE63_OPTODE
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	PHASE_DELAY_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	usec
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	output phase delay

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	3 umol/kg or 2%
PARAMETER_RESOLUTION	0.2 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	V=(PHASE_DELAY_DOXY+Pcoef1*PRES/1000)/39.457071; Ksv=C0+C1*TEMP_DOXY+C2*TEMP_DOXY^2; MLPL_DOXY=[(A0+A1*TEMP_DOXY+A2*V^2)/(B0+B1*V)-1]/Ksv; O2=MLPL_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(SolB0+SolB1*TS+SolB2*TS^2+SolB3*TS^3)+SolC0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; TS=ln[(298.15–TEMP)/(273.15+TEMP)]; DOXY[umol/kg]=44.6596*O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; A0=*A0*, A1=*A1*, A2=*A2*; B0=*B0*, B1=*B1*; C0=*C0*, C1=*C1*, C2=*C2*; Spreset=*Spreset*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*; SolB0=*SolB0*, SolB1=*SolB1*, SolB2=*SolB2*, SolB3=*SolB3*; SolC0=*SolC0*
PREDEPLOYMENT_CALIB_COMMENT	see SBE63 User's Manual (manual version #007, 10/28/13); see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.6 CASE_103_208_308

Sensor: SBE63_OPTODE

Sensor output: phase delay in µsec called PHASE_DELAY_DOXY

<u>Calculation</u>: standard conversion (Stern-Volmer) of raw data to oxygen concentration on ml/L + salinity compensation + old pressure compensation with oxygen sensor temperature TEMP_DOXY and PRES and PSAL from the CTD, + unit conversion

<u>Calculation input</u>:

- PHASE_DELAY_DOXY in µsec
- PSAL (CTD salinity)
- TEMP_DOXY (SBE63' thermistor temperature in degC)
- PRES (CTD pressure in dbar)
- P_{coef1} the pressure compensation coefficient (default P_{coef1}=0.115)
- E, the pressure correction coefficient
- Sol_{B0}, Sol_{B1}, Sol_{B2}, Sol_{B3} and Sol_{C0} the salinity compensation coefficient (default Sol_{B0} = -6.24523e-3, Sol_{B1} = -7.37614e-3, Sol_{B2} = -1.03410e-3, Sol_{B3} = -8.17083e-3, Sol_{C0} = -4.88682e-7
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default S_{preset} = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- *A0, A1, A2, B0, B1, C0, C1* and *C2* are calibration coefficients provided by the calibration sheet (see §12.2.2.1 in ANNEX A for an example).

<u>Calculation output</u>:

- DOXY in umol/kg

<u>Equations</u>:

$$V = [PHASE\_DELAY\_DOXY + P_{coef1} \times PRES/1000]/39.457071$$

$$K_{SV} = C0 + C1 \times TEMP\_DOXY + C2 \times TEMP\_DOXY^2$$

$$\mathrm{O_2(ml/L)} = \left[\frac{\left[\frac{\mathrm{A0 + A1.TEMP\_DOXY + A2.V^2}}{\mathrm{(B0 + B1.V)}} - 1 \right]}{\mathrm{K_{SV}}} \right] . [\mathrm{S_{Corr}}] . [\mathrm{P_{Corr}}]$$

$$S_{Corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left(PSAL \times \left(Sol_{B0} + Sol_{B1} \times T_s + Sol_{B2} \times T_s^2 + Sol_{B3} \times T_s^3\right) + Sol_{C0} \times PSAL^2\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S) = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$P_{Corr} = e^{\left(\frac{E \times PRES}{(TEMP + 273.15)}\right)}$$

$$DOXY(umol/kg) = 44.6596 \times O_2(ml/L)/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY

SENSOR_MAKER	SBE
SENSOR_MODEL	SBE63_OPTODE
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	PHASE_DELAY_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	usec
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	output phase delay

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	3 umol/kg or 2%
PARAMETER_RESOLUTION	0.2 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	V=(PHASE_DELAY_DOXY+Pcoef1*PRES/1000)/39.457071; Ksv=C0+C1*TEMP_DOXY+c2*TEMP_DOXY^2; MLPL_DOXY=[(A0+A1*TEMP_DOXY+A2*V^2)/(B0+B1*V)-1]/Ksv; O2=MLPL_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(SolB0+SolB1*TS+SolB2*TS^2+SolB3*TS^3)+SolC0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; TS=ln[(298.15–TEMP)/(273.15+TEMP)]; Pcorr=exp(E*PRES/(TEMP+273.15)); DOXY[umol/kg]=44.6596*O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Pcoef1=Pcoef1; E=*E*; A0=*A0*, A1=*A1*, A2=*A2*; B0=*B0*, B1=*B1*; C0=*C0*, C1=*C1*, C2=*C2*; Spreset=*Spreset*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*; SolB0=*SolB0*, SolB1=*SolB1*, SolB2=*SolB2*, SolB3=*SolB3*; SolC0=*SolC0*
PREDEPLOYMENT_CALIB_COMMENT	see SBE63 User's Manual (manual version #007, 10/28/13); see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.7 CASE_103_209_301

Sensor: SBE63_OPTODE

Sensor output: dissolved oxygen concentration output in ml/L called MLPL_DOXY

Calculation: salinity compensation + Bittig pressure compensation with oxygen sensor temperature TEMP_DOXY and PRES and PSAL from the CTD, + unit conversion

Calculation input:

- MLPL_DOXY in ml/L
- PSAL (CTD salinity)
- TEMP_DOXY (SBE63' thermistor temperature in degC)
- PRES (CTD pressure in dbar)
- *Sref* (reference salinity = SetRefSal, default value = 0)

- *Sol_{B0}, Sol_{B1}, Sol_{B2}, Sol_{B3}* and Sol_{C0} the salinity compensation coefficient (default Sol_{B0} = -6.24523e-3, Sol_{B1} = -7.37614e-3, Sol_{B2} = -1.03410e-3, Sol_{B3} = -8.17083e-3, Sol_{C0} = -4.88682e-7
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- $S_{preset,}$ the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- P_{coef2}, P_{coef3}, the pressure compensation coefficients (default: Pcoef2 = 0.00016, Pcoef3 = 0.0307)

Calculation output:

- DOXY in umol/kg

Equations:

$$O2_{PSAL\&PRES} = MLPL\_DOXY \times S_{Corr} \times P_{Corr}$$

$$S_{Corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL - S_{ref}) \times (Sol_{B0} + Sol_{B1} \times T_s + Sol_{B2} \times T_s{}^2 + Sol_{B3} \times T_s{}^3) + Sol_{C0} \times (PSAL^2 - S_{ref}{}^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY(umol/kg) = 44.6596 \times O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	SBE
SENSOR_MODEL	SBE63_OPTODE
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	MLPL_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	ml/L
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	output dissolved oxygen concentration

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	3 umol/kg or 2%
PARAMETER_RESOLUTION	0.2 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	O2=MLPL_DOXY*Scorr*Pcorr; Scorr=A*exp[(PSAL–Sref)*(SolB0+SolB1*TS+SolB2*TS^2+SolB3*TS^3)+SolC0*(PSAL^2–Sref^2)]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; TS=ln[(298.15–TEMP)/(273.15+TEMP)]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; DOXY[umol/kg]=44.6596*O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; Sref=*Sref*; Spreset=*Spreset;* D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*; SolB0=*SolB0*, SolB1=*SolB1*, SolB2=*SolB2*, SolB3=*SolB3*; SolC0=*SolC0*;
PREDEPLOYMENT_CALIB_COMMENT	see SBE63 User's Manual (manual version #007, 10/28/13); see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.8 CASE_103_209_309

Sensor: SBE63_OPTODE

Sensor output: dissolved oxygen concentration output in ml/L called MLPL_DOXY

Calculation: salinity compensation + old pressure compensation with oxygen sensor temperature TEMP_DOXY and PRES and PSAL from the CTD, + unit conversion

Calculation input:

- MLPL_DOXY in ml/L
- PSAL (CTD salinity)
- TEMP_DOXY (SBE63' thermistor temperature in degC)
- PRES (CTD pressure in dbar)
- *Sref* (reference salinity = SetRefSal, default value = 0)
- *Pref* (reference pressure = SetRefP, default value = 0)
- E, the pressure correction coefficient
- Sol_{B0}, Sol_{B1}, Sol_{B2}, Sol_{B3} and Sol_{C0} the salinity compensation coefficient (default Sol_{B0} = -6.24523e-3, Sol_{B1} = -7.37614e-3, Sol_{B2} = -1.03410e-3, Sol_{B3} = -8.17083e-3, Sol_{C0} = -4.88682e-7
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])

Calculation output:

- DOXY in umol/kg

Equations:

$$O2_{PSAL\&PRES} = MLPL\_DOXY \times S_{Corr} \times P_{Corr}$$

$$S_{Corr} = A(TEMP, PSAL, S_{preset}) \times e^{((PSAL - S_{ref}) \times (Sol_{B0} + Sol_{B1} \times T_s + Sol_{B2} \times T_s^2 + Sol_{B3} \times T_s^3) + Sol_{C0} \times (PSAL^2 - S_{ref}^2)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S)}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$P_{Corr} = e^{\left(\frac{E \times (PRES - P_{ref})}{TEMP+273.15}\right)}$$

$$DOXY(umol/kg) = 44.6596 \times O2_{PSAL\&PRES}(ml/L)/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	SBE
SENSOR_MODEL	SBE63_OPTODE
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	MLPL_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	ml/L
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	output dissolved oxygen concentration

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	3 umol/kg or 2%
PARAMETER_RESOLUTION	0.2 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	O2=MLPL_DOXY*Scorr*Pcorr; Scorr=A*exp[(PSAL–Sref)*(SolB0+SolB1*TS+SolB2*TS^2+SolB3*TS^3)+SolC0*(PSAL^2–Sref^2)]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S)]; TS=ln[(298.15–TEMP)/(273.15+TEMP)]; Pcorr=exp(E*(PRES-Pref)/(TEMP+273.15)); DOXY[umol/kg]=44.6596*O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	E=*E*; Sref=*Sref*; Spreset=*Spreset*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*; SolB0=*SolB0*, SolB1=*SolB1*, SolB2=*SolB2*, SolB3=*SolB3*, SolC0=*SolC0*;Pref=*Pref*
PREDEPLOYMENT_CALIB_COMMENT	see SBE63 User's Manual (manual version #007, 10/28/13); see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.9 CASE_201_101_101

Sensor: AANDERAA_OPTODE_3830

Sensor output: temperature voltage output in volts called TEMP_VOLTAGE_DOXY

Calculation: standard calibration equation

Calculation Input:

- TEMP_VOLTAGE_DOXY the thermistor voltage in volts
- *T0* to *T5* values from the calibration certificate as *TempCoef*

Equations:

$$TEMP\_DOXY = T0 + T1 \times TEMP\_VOLTAGE\_DOXY + T2 \times TEMP\_VOLTAGE\_DOXY^2 \ldots + T5 \times TEMP\_VOLTAGE\_DOXY^5$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_3830
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TEMP_VOLTAGE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	volts
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	output thermistor voltage

Float parameter information	
Name	**Value**
PARAMETER	TEMP_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degC
PARAMETER_ACCURACY	0.05 degC
PARAMETER_RESOLUTION	0.01 degC
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TEMP_DOXY=T0+T1*TEMP_VOLTAGE_DOXY+T2*TEMP_VOLTAGE_DOXY^2+T3*TEMP_VOLTAGE_DOXY^3+T4*TEMP_VOLTAGE_DOXY^4+T5*TEMP_VOLTAGE_DOXY^5
PREDEPLOYMENT_CALIB_COEFFICIENT	T0=*TempCoef0*, T1=*TempCoef1*, T2=*TempCoef2*, T3=*TempCoef3*, T4=*TempCoef4*, T5=*TempCoef5*
PREDEPLOYMENT_CALIB_COMMENT	optode temperature, see TD218 Operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

9.2.10 CASE_201_102_001

Sensor: AANDERAA_OPTODE_3830

Sensor output: temperature in degC transmitted by the optode, called TEMP_DOXY

Calculation: none (embedded)

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_3830
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TEMP_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degC
PARAMETER_ACCURACY	0.05 degC
PARAMETER_RESOLUTION	0.01 degC
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TEMP_DOXY=T0+T1*TEMP_VOLTAGE_DOXY+T2*TEMP_VOLTAGE_DOXY^2+T3*TEMP_VOLTAGE_DOXY^3+T4*TEMP_VOLTAGE_DOXY^4+T5*TEMP_VOLTAGE_DOXY^5; with TEMP_VOLTAGE_DOXY=voltage from thermistor bridge (mV)
PREDEPLOYMENT_CALIB_COEFFICIENT	T0=*TempCoef0*, T1=*TempCoef1*, T2=*TempCoef2*, T3=*TempCoef3*, T4=*TempCoef4*, T5=*TempCoef5*
PREDEPLOYMENT_CALIB_COMMENT	optode temperature, see TD218 Operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

9.2.11 CASE_201_201_301

Sensor: AANDERAA_OPTODE_3830

Sensor output: intermediate dissolved oxygen concentration in umol/L called MOLAR_DOXY

Calculation: pressure and salinity compensation with TEMP, PRES and PSAL from the CTD, + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- P_{coef2} and P_{coef3}, the pressure compensation coefficients (default P_{coef2}=0.0025, P_{coef3}=0.0328)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{ref} the reference salinity given in the optode settings (default S_{ref} = 0)
- $S_{preset,}$ the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])

Calculation output:

- DOXY in umol/kg

Equations:

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{Corr}] \times [P_{Corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL - S_{ref}) \times (B0 + B1.T_s + B2.T_s^2 + B3.T_s^3) + C_0 \times (PSAL^2 - S_{ref}^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S) = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = \left(1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}\right)$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_3830
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	MOLAR_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/L
PARAMETER_ACCURACY	8 umol/L or 10%
PARAMETER_RESOLUTION	1 umol/L
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	dissolved oxygen concentration at zero pressure and in fresh water or at a reference salinity; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[(PSAL-Sref)*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*(PSAL^2-Sref^2)]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Sref=*Sref;* Spreset=*Spreset*; Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3;* B0=*B0*, B1=*B1*,

	B2=*B2*, B3=*B3*; C0=*C0*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.12 CASE_201_202_202

Sensor: AANDERAA_OPTODE_3830

Sensor output: raw phase in degree BPHASE_DOXY, measured with blue excitation light

Calculation: standard conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + pressure and salinity compensation with TEMP, PSAL and PRES from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- BPHASE_DOXY from the oxygen sensor
- If available RPHASE_DOXY from the oxygen sensor, otherwise RPHASE_DOXY = 0
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default S_{preset} = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate.
- *cij* coefficients provided in the optode calibration certificate

Calculation output:

- DOXY in umol/kg

Equations:

$$UNCAL\_Phase = BPhase\_DOXY - RPhase\_DOXY$$

$$Phase\_Pcorr = UNCAL\_Phase + P_{coef1} \times PRES/1000$$

$$DPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$MOLAR\_DOXY = c_0 + c_1 \times DPhase + c_2 \times DPhase^2 + c_3 \times DPhase^3 + c_4 \times DPhase^4$$

$$c_i = c_{i0} + c_{i1} \times TEMP + c_{i2} \times TEMP^2 + c_{i3} \times TEMP^3$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_S + B2.T_S{}^2 + B3.T_S{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_3830
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	BPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Set the following information on RPHASE_DOXY only if it is provided by the oxygen sensor.

Float parameter information	
Name	**Value**
PARAMETER	RPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with red excitation light; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg

PARAMETER_ACCURACY	8 umol/kgor 5%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	UNCAL_Phase=BPHASE_DOXY-RPHASE_DOXY; Phase_Pcorr=UNCAL_Phase+Pcoef1*PRES/1000; DPHASE_DOXY=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Pcorr_Phase^2 +PhaseCoef3*Pcorr_Phase^3; MOLAR_DOXY=c0+c1*DPHASE_DOXY+c2*DPHASE_DOXY^2+c3*DPHASE_DOXY^3 +c4*DPHASE_DOXY^4; ci=ci0+ci1*TEMP+ci2*TEMP^2+ci3*TEMP^3, i=0..4; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15) /100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3;* B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3;* c00=*c00*, …, c43=*c43*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.13 CASE_201_202_204

Sensor: AANDERAA_OPTODE_3830

Sensor output: raw phase in degree BPHASE_DOXY, measured with blue excitation light

Calculation: Stern-Volmer conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + pressure and salinity compensation with TEMP, PSAL and PRES from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- BPHASE_DOXY from the oxygen sensor
- If available RPHASE_DOXY, otherwise RPHASE_DOXY = 0
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default S_{preset} = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate.
- *f1, f2* coefficients provided in the optode calibration certificate
- *K0i* coefficient and *K1i* coefficients provided in the optode calibration certificate

Calculation output:

- DOXY in umol/kg

Equations:

$$UNCAL\_Phase = BPHASE\_DOXY - RPHASE\_DOXY$$

$$Phase\_Pcorr = UNCAL_{Phase} + P_{coef1} \times PRES/1000$$

$$DPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$MOLAR\ DOXY = \left\{ \frac{f_1}{\frac{DPhase}{K_O(TEMP)} - f_2} - 1 \right\} . K_1(TEMP)$$

$$K_i = K_{i0} + K_{i1} \times TEMP + K_{i2} \times TEMP^2 + K_{i3} \times TEMP^3$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times \left(B0 + B1.T_s + B2.T_s{}^2 + B3.T_s{}^3\right) + C_0 \times \left(PSAL^2\right)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{\left(P_{coef2} \times TEMP + P_{coef3}\right) \times PRES}{1000}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_3830
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	BPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Set the following information on RPHASE_DOXY only if it is provided by the oxygen sensor.

Float parameter information	
Name	**Value**
PARAMETER	RPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with red excitation light; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	UNCAL_Phase=BPHASE_DOXY-RPHASE_DOXY; Phase_Pcorr=UNCAL_Phase+Pcoef1*PRES/1000; DPHASE_DOXY=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2 +PhaseCoef3*Phase_Pcorr^3; MOLAR_DOXY=[f1/(DPHASE_DOXY/K0(TEMP)-f2)-1]*K1(TEMP); Ki(TEMP)=Ki0+Ki1*TEMP+Ki2*TEMP^2+Ki3*TEMP^3, i=0..1; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3*; f1=*f1*, f2=*f2*; K00=*K00*, …,K13=*K13*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.14 CASE_201_202_302

Sensor: AANDERAA_OPTODE_3830

Sensor output: raw phase in degree BPHASE_DOXY, measured with blue excitation light

Calculation: standard conversion of raw data to oxygen concentration on umol/L with TEMP_DOXY from the oxygen sensor + pressure and salinity compensation with TEMP, and PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- BPHASE_DOXY from the oxygen sensor
- TEMP_DOXY, the temperature from the oxygen sensor
- If available RPHASE_DOXY, otherwise RPHASE_DOXY = 0

- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default S_{preset} = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate.
- *cij* coefficients provided in the optode calibration certificate

Calculation output:

- DOXY in umol/kg

Equations:

$$UNCAL\_Phase = BPhase\_DOXY - RPhase\_DOXY$$

$$Phase\_Pcorr = UNCAL\_Phase + P_{coef1} \times PRES/1000$$

$$DPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$MOLAR\_DOXY = c_0 + c_1 \times DPhase + c_2 \times DPhase^2 + c_3 \times DPhase^3 + c_4 \times DPhase^4$$

$$c_i = c_{i0} + c_{i1} \times TEMP\_DOXY + c_{i2} \times TEMP\_DOXY^2 + c_{i3} \times TEMP\_DOXY^3$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_s + B2.T_s^2 + B3.T_s^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA

SENSOR_MODEL	AANDERAA_OPTODE_3830
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	BPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Set the following information on RPHASE_DOXY only if it is provided by the oxygen sensor.

Float parameter information	
Name	**Value**
PARAMETER	RPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with red excitation light; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	UNCAL_PHASE=BPHASE_DOXY-RPHASE_DOXY; Phase_Pcorr=UNCAL_Phase+Pcoef1*PRES/1000; DPHASE_DOXY=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2 +PhaseCoef3*Phase_Pcorr^3; MOLAR_DOXY=c0+c1*DPHASE_DOXY+c2*DPHASE_DOXY^2+c3*DPHASE_DOXY^3 +c4*DPHASE_DOXY^4; ci=ci0+ci1*TEMP_DOXY+ci2*TEMP_DOXY^2+ci3*TEMP_DOXY^3, i=0..4; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1,* Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3;* c10=*c10*, …,c43=*c43*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI:

http://dx.doi.org/10.13155/39795)

9.2.15 CASE_201_202_304

Sensor: AANDERAA_OPTODE_3830

Sensor output: raw phase in degree BPHASE_DOXY, measured with blue excitation light

Calculation: Stern-Volmer conversion of raw data to oxygen concentration on umol/L with TEMP_DOXY from the oxygen sensor + pressure and salinity compensation with TEMP, and PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- BPHASE_DOXY from the oxygen sensor
- If available RPHASE_DOXY, otherwise RPHASE_DOXY = 0
- TEMP_DOXY, the temperature from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default S_{preset} = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate.
- *f1, f2* coefficients provided in the optode calibration certificate
- *K0i* coefficient and *K1i* coefficients provided in the optode calibration certificate

Calculation output:

- DOXY in umol/kg

Equations:

$$UNCAL\_Phase = BPHASE\_DOXY - RPHASE\_DOXY$$

$$Phase\_Pcorr = UNCAL\_Phase + P_{coef1} \times PRES/1000$$

$$DPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$MOLAR\ DOXY = \left\{ \frac{f_1}{\frac{DPhase}{K_0(TEMP\_DOXY)} - f_2} - 1 \right\} . K_1(TEMP\_DOXY)$$

$$K_i = K_{i0} + K_{i1} \times TEMP\_DOXY + K_{i2} \times TEMP\_DOXY^2 + K_{i3} \times TEMP\_DOXY^3$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL)\times(B0+B1.T_S+B2.T_S{}^2+B3.T_S{}^3)+C_0\times(PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0+D_1\times\left(\frac{100}{TEMP+273.15}\right)+D_2\times ln\left(\frac{TEMP+273.15}{100}\right)+D_3\times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2}\times TEMP + P_{coef3})\times PRES}{1000}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_3830
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	BPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Set the following information on RPHASE_DOXY only if it is provided by the oxygen sensor.

Float parameter information	
Name	**Value**
PARAMETER	RPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with red excitation light; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Float parameter information	
Name	**Value**

PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	UNCAL_PHASE=BPHASE_DOXY-RPHASE_DOXY; Phase_Pcorr=UNCAL_Phase+Pcoef1*PRES/1000; DPHASE_DOXY=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2 +PhaseCoef3*Phase_Pcorr^3; MOLAR_DOXY=[f1/(DPHASE_DOXY/K0(TEMP_DOXY)-f2)-1]*K1(TEMP_DOXY); Ki(TEMP_DOXY)=Ki0+Ki1*TEMP_DOXY+Ki2*TEMP_DOXY^2+Ki3*TEMP_DOXY^3, i=0..1; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000]; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3*; f1=*f1*, f2=*f2*; K00=*K00*, …,K13=*K13*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.16 CASE_201_203_202

Sensor: AANDERAA_OPTODE_3830

Sensor output: calibrated phase in degree DPHASE_DOXY

Calculation: conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + pressure and salinity compensation with TEMP, PSAL and PRES from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- DPHASE_DOXY from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0,1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default S_{preset} = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- *cij* coefficients provided in the optode calibration certificate

Calculation output:

- DOXY in umol/kg

Equations:

$$Phase\_Pcorr = DPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$MOLAR\_DOXY = c_0 + c_1 \times Phase\_Pcorr + c_2 \times Phase\_Pcorr^2 + c_3 \times Phase\_Pcorr^3 + c_4 \times Phase\_Pcorr^4$$

$$c_i = c_{i0} + c_{i1} \times TEMP + c_{i2} \times TEMP^2 + c_{i3} \times TEMP^3$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL)\times(B0+B1.T_s+B2.T_s{}^2+B3.T_s{}^3)+C_0\times(PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S) = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_3830
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	DPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Calibrated phase measurement; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Phase_Pcorr=DPHASE_DOXY+Pcoef1*PCOEF1*PRES/1000; MOLAR_DOXY=c0+c1*Phase_Pcorr+c2*Phase_Pcorr^2+c3*Phase_Pcorr^3+c4*Pha

	se_Pcorr^4; ci=ci0+ci1*TEMP+ci2*TEMP^2+ci3*TEMP^3, i=0..4; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=Pcoef1, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; c00=*c00*, …, c43=*c43*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.17 CASE_201_203_204

Sensor: AANDERAA_OPTODE_3830

Sensor output: calibrated phase in degree DPHASE_DOXY

Calculation: Stern-Volmer conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + pressure and salinity compensation with TEMP, PSAL and PRES from the CTD + unit conversion

Calculation input:
- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- DPHASE_DOXY from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0,1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default S_{preset} = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- *f1, f2* coefficients provided in the optode calibration certificate
- *K0i* coefficient and *K1i* coefficients provided in the optode calibration certificate

Calculation output:
- DOXY in umol/kg

Equations:

$$Phase\_Pcorr = DPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$MOLAR\ DOXY = \left\{ \frac{f_1}{\frac{Phase\_Pcorr}{K_O(TEMP)} - f_2} - 1 \right\} . K_1(TEMP)$$

$$K_i = K_{i0} + K_{i1} \times TEMP + K_{i2} \times TEMP^2 + K_{i3} \times TEMP^3$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL)\times(B0+B1.T_s+B2.T_s{}^2+B3.T_s{}^3)+C_0\times(PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S) = 1013.25 \times e^{\left(D_0+D_1\times\left(\frac{100}{TEMP+273.15}\right)+D_2\times ln\left(\frac{TEMP+273.15}{100}\right)+D_3\times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_3830
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	DPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Calibrated phase measurement; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Phase_Pcorr=DPHASE_DOXY+Pcoef1*PCOEF1*PRES/1000; MOLAR_DOXY=[f1/(Phase_Pcorr/K0(TEMP)-f2)-1]*K1(TEMP); Ki(TEMP)=Ki0+Ki1*TEMP+Ki2*TEMP^2+Ki3*TEMP^3, i=0..1; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; f1=*f1*, f2=*f2*; K00=*K00*, …,K13=*K13*; D0=*D0*, D1=*D1*,

	D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.18 CASE_201_203_302

Sensor: AANDERAA_OPTODE_3830

Sensor output: calibrated phase in degree DPHASE_DOXY

Calculation: standard conversion of raw data to oxygen concentration on umol/L with TEMP_DOXY from the oxygen sensor + pressure and salinity compensation with TEMP, and PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- DPHASE_DOXY from the oxygen sensor
- TEMP_DOXY, the temperature from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0,1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default S_{preset} = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- *cij* coefficients provided in the optode calibration certificate

Calculation output:

- DOXY in umol/kg

Equations:

$$Phase\_Pcorr = DPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$MOLAR\_DOXY = c_0 + c_1 \times Phase\_Pcorr + c_2 \times Phase\_Pcorr^2 + c_3 \times Phase\_Pcorr^3 + c_4 \times Phase\_Pcorr^4$$

$$c_i = c_{i0} + c_{i1} \times TEMP\_DOXY + c_{i2} \times TEMP\_DOXY^2 + c_{i3} \times TEMP\_DOXY^3$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_s + B2.T_s{}^2 + B3.T_s{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_3830
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	DPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Calibrated phase measurement; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Phase_Pcorr=DPHASE_DOXY+Pcoef1*PCOEF1*PRES/1000; MOLAR_DOXY=c0+c1*Phase_Pcorr+c2*Phase_Pcorr^2+c3*Phase_Pcorr^3+c4*Phase_Pcorr^4; ci=ci0+ci1*TEMP_DOXY+ci2*TEMP_DOXY^2+ci3*TEMP_DOXY^3, i=0..4; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; c00=*c00*, …, c43=*c43*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.19 CASE_201_203_304

Sensor: AANDERAA_OPTODE_3830

Sensor output: calibrated phase in degree DPHASE_DOXY

Calculation: Stern-Volmer conversion of raw data to oxygen concentration on umol/L with TEMP_DOXY from the oxygen sensor + pressure and salinity compensation with TEMP, and PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- DPHASE_DOXY from the oxygen sensor
- TEMP_DOXY, the temperature from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0,1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default S_{preset} = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- *f1, f2* coefficients provided in the optode calibration certificate
- *K0i* coefficient and *K1i* coefficients provided in the optode calibration certificate

Calculation output:

- DOXY in umol/kg

Equations:

$$Phase\_Pcorr = DPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$MOLAR\ DOXY = \left\{ \frac{f_1}{\frac{Phase\_Pcorr}{K_O(TEMP\_DOXY)} - f_2} - 1 \right\} . K_1(TEMP\_DOXY)$$

$$K_i = K_{i0} + K_{i1} \times TEMP\_DOXY + K_{i2} \times TEMP\_DOXY^2 + K_{i3} \times TEMP\_DOXY^3$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_s + B2.T_s{}^2 + B3.T_s{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_3830
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	DPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Calibrated phase measurement; see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Phase_Pcorr=DPHASE_DOXY+Pcoef1*PCOEF1*PRES/1000; MOLAR_DOXY=[f1/(Phase_Pcorr/K0(TEMP_DOXY)-f2)-1]*K1(TEMP_DOXY); Ki(TEMP_DOXY)=Ki0+Ki1*TEMP_DOXY+Ki2*TEMP_DOXY^2+Ki3*TEMP_DOXY^3, i=0..1; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1,* Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; f1=*f1,* f2=*f2;* K00=*K00*, …, K13=*K13*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD218 operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.20 CASE_202_101_101

Sensor: AANDERAA_OPTODE_4330

Sensor output: temperature voltage output in volts called TEMP_VOLTAGE_DOXY

Calculation: standard calibration equation

Calculation Input:

- TEMP_VOLTAGE_DOXY the thermistor voltage in volts

- *T0* to *T5* values from the calibration certificate as *TempCoef*

Equations:

$$TEMP\_DOXY = T0 + T1 \times TEMP\_VOLTAGE\_DOXY + T2 \times TEMP\_VOLTAGE\_DOXY^2 \ldots + T5 \times TEMP\_VOLTAGE\_DOXY^5$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TEMP_VOLTAGE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	volts
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	output thermistor voltage

Float parameter information	
Name	**Value**
PARAMETER	TEMP_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degC
PARAMETER_ACCURACY	0.05 degC
PARAMETER_RESOLUTION	0.01 degC
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TEMP_DOXY=T0+T1*TEMP_VOLTAGE_DOXY+T2*TEMP_VOLTAGE_DOXY^2+T3*TEMP_VOLTAGE_DOXY^3+T4*TEMP_VOLTAGE_DOXY^4+T5*TEMP_VOLTAGE_DOXY^5
PREDEPLOYMENT_CALIB_COEFFICIENT	T0=*TempCoef0*; T1=*TempCoef1*; T2=*TempCoef2*; T3=*TempCoef3*; T4=*TempCoef4*; T5=*TempCoef5*;
PREDEPLOYMENT_CALIB_COMMENT	optode temperature, see TD218 Operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175

9.2.21 CASE_202_102_001

Sensor: AANDERAA_OPTODE_4330

Sensor output: TEMP_DOXY, temperature in degC transmitted by the optode

Calculation: none (embedded)

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TEMP_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degC
PARAMETER_ACCURACY	0.03 degC
PARAMETER_RESOLUTION	0.01 degC
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TEMP_DOXY=T0+T1*TEMP_VOLTAGE_DOXY+T2*TEMP_VOLTAGE_DOXY^2+T3*TEMP_VOLTAGE_DOXY^3+T4*TEMP_VOLTAGE_DOXY^4+T5*TEMP_VOLTAGE_DOXY^5; with TEMP_VOLTAGE_DOXY=voltage from thermistor bridge (mV)
PREDEPLOYMENT_CALIB_COEFFICIENT	T0=*TempCoef0*, T1=*TempCoef1*, T2=*TempCoef2*; T3=*TempCoef3*; T4=*TempCoef4*, T5=*TempCoef5*
PREDEPLOYMENT_CALIB_COMMENT	optode temperature, see TD269 Operating manual oxygen optode 4330, 4835, 4831

9.2.22 CASE_202_201_301

Sensor: AANDERAA_OPTODE_4330

Sensor output: intermediate dissolved oxygen concentration in umol/L called MOLAR_DOXY

Calculation: pressure and salinity compensation + unit conversion with TEMP, and PRES and PSAL from the CTD + unit conversion.

Calculation input:

- TEMP, PRES and PSAL, temperature, pressure and salinity from the CTD
- P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef2}=0.0025, P_{coef3}=0.0328)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- S_{ref} the reference salinity given in the optode settings (default S_{ref} = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])

Calculation output:

- DOXY in umol/kg

Equations:

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL - Sref) \times \left(B0 + B1.T_S + B2.T_S{}^2 + B3.T_S{}^3\right) + C_0 \times \left(PSAL^2 - S_{ref}{}^2\right)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	MOLAR_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/L
PARAMETER_ACCURACY	8 umol/L or 10%
PARAMETER_RESOLUTION	1 umol/L
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	dissolved oxygen concentration at zero pressure and in fresh water or at a reference salinity; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[(PSAL-Sref)*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*(PSAL^2-Sref^2)]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Sref=*Sref;* Spreset=*Spreset*; Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3;* B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.23 CASE_202_204_202

Sensor: AANDERAA_OPTODE_4330

Sensor output: uncalibrated phase in degree TPHASE_DOXY

Calculation: standard conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + pressure and salinity compensation with TEMP, PSAL and PRES from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- TPHASE_DOXY from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate.
- *ci* coefficients provided in the optode calibration certificate
- *mi and ni* coefficients provided in the optode calibration certificate
- A_0, A_1, A_2, A_3, A_4, A_5 are the coefficients for the computation equation (default A_0 = 2.00856, A_1 = 3.22400, A_2 = 3.99063, A_3 = 4.80299, A_4 = 9.78188e-1, A_5 = 1.71069)

Calculation output:

- DOXY in umol/kg

Equations:

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$\Delta p = c_0 \times TEMP^{m0} \times CalPhase^{n0} + c_1 \times TEMP^{m1} \times CalPhase^{n1} + \cdots + c_{27} \times TEMP^{m27} \times CalPhase^{n27}$$

$$AirSat(\%) = \Delta p \times \frac{100}{\left[\left(1013.25 - e^{\left[52.57 - \frac{6690.9}{TEMP+273.15} - 4.681 \times ln(TEMP+273.15)\right]}\right) \times 0.20946\right]}$$

$$MOLAR\_DOXY = C^* \times 44.614 \times AirSat/100$$

$$\ln(C^*) = A_0 + A_1 \times T_S + A_2 \times {T_S}^2 + A_3 \times {T_S}^3 + A_4 \times {T_S}^4 + A_5 \times {T_S}^5$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times \left(B0 + B1.T_s + B2.{T_s}^2 + B3.{T_s}^3\right) + C_0 \times \left(PSAL^2\right)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S) = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; deltaP=c0*TEMP^m0*CalPhase^n0+c1*TEMP^m1*CalPhase^n1+…+c27*TEMP^m27*CalPhase^n27; AirSat=deltaP*100/[(1013.25-exp[52.57-6690.9/(TEMP+273.15)-4.681*ln(TEMP+273.15)])*0.20946]; MOLAR_DOXY=Cstar*44.614*AirSat/100; ln(Cstar)=A0+A1*Ts+A2*Ts^2+A3*Ts^3+A4*Ts^4+A5*Ts^5; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*c0*, …, c27=*c27;* m0=*m0*, …, m27=*m27;* n0=*n0*, …, n27=*n27;* A0=*A0*, A1=*A1*, A2=*A2*, A3=*A3*, A4=*A4*,

	A5=*A5*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.24 CASE_202_204_203

Sensor: AANDERAA_OPTODE_4330

Sensor output: uncalibrated phase in degree TPHASE_DOXY

Calculation: standard conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + two points adjustment + pressure and salinity compensation with TEMP, PSAL and PRES from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- TPHASE_DOXY from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- $S_{preset,}$ the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_{1,}$ $PhaseCoef_2$ *and* $PhaseCoef_3$ coefficients provided in the optode calibration certificate.
- *ci* coefficients provided in the optode calibration certificate
- *mi and ni* coefficients provided in the optode calibration certificate
- *ConcCoef0 and ConcCoef1* coefficients provided in the optode calibration certificate.
- A_0, A_1, A_2, A_3, A_4, A_5 are the coefficients for the computation equation (default A_0 = 2.00856, A_1 = 3.22400, A_2 = 3.99063, A_3 = 4.80299, A_4 = 9.78188e-1, A_5 = 1.71069)

Calculation output:

- DOXY in umol/kg

Equations:

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1}\times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1\times Phase\_Pcorr + PhaseCoef_2\times Phase\_Pcorr^2 + PhaseCoef_3\times Phase\_Pcorr^3$$

$$\Delta p = c_0\times TEMP^{m0}\times CalPhase^{n0} + c_1\times TEMP^{m1}\times CalPhase^{n1} + \cdots + c_{27}\times TEMP^{m27}\times CalPhase^{n27}$$

$$AirSat(\%) = \Delta p\times \frac{100}{\left[\left(1013.25 - e^{\left[52.57-\frac{6690.9}{TEMP+273.15}-4.681\times ln(TEMP+273.15)\right]}\right)\times 0.20946\right]}$$

$$MOLAR\_DOXY = C^{*}\times 44.614\times AirSat/100$$

$$\ln(C^*) = A_0 + A_1 \times T_S + A_2 \times T_S{}^2 + A_3 \times T_S{}^3 + A_4 \times T_S{}^4 + A_5 \times T_S{}^5$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$MOLAR\_DOXY = ConcCoef_0 + ConcCoef_1 \times MOLAR\_DOXY$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_S + B2.T_S{}^2 + B3.T_S{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; deltaP=c0*TEMP^m0*CalPhase^n0+c1*TEMP^m1*CalPhase^n1+..+c27*TEMP^m

	27*CalPhase^n27; AirSat=deltaP*100/[(1013.25-exp[52.57-6690.9/(TEMP+273.15)-4.681*ln(TEMP+273.15)])*0.20946]; MOLAR_DOXY=Cstar*44.614*AirSat/100; ln(Cstar)=A0+A1*Ts+A2*Ts^2+A3*Ts^3+A4*Ts^4+A5*Ts^5; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; MOLAR_DOXY=ConcCoef0+ConcCoef1*MOLAR_DOXY; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*c0*, …, c27=*c27;* m0=*m0*, …, m27=*m27;* n0=*n0*, …, n27=*n27;* ConcCoef0 = *ConcCoef0*, ConcCoef1= *ConcCoef1;* A0=*A0,* A1=*A1,* A2=*A2,* A3=*A3,* A4=*A4,* A5=*A5*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.25 CASE_202_204_204

Sensor: AANDERAA_OPTODE_4330

Sensor output: uncalibrated phase in degree TPHASE_DOXY

Calculation: Stern-Volmer conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + pressure and salinity compensation with TEMP, PSAL and PRES from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- TPHASE_DOXY from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate. If they are not, then uses *PhaseCoef0=0, PhaseCoef1=1, PhaseCoef2=0, PhaseCoef3=0*
- *ci* coefficients provided in the optode calibration certificate

Calculation output:

- DOXY in umol/kg

Equations:

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$MOLAR\_DOXY = [((c_3 + c_4 \times TEMP)/(c_5 + c_6 \times CalPhase)) - 1]/K_{SV}$$

$$K_{SV} = c_0 + c_1 \times TEMP + c_2 \times TEMP^2$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_s + B2.T_s{}^2 + B3.T_s{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; MOLAR_DOXY=[((c3+c4*TEMP)/(c5+c6*CalPhase))-1]/KSV; KSV=c0+c1*TEMP+c2*TEMP^2; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-

	pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3*; c0=*SVUFoilCoef0*, .., c6=*SVUFoilCoef6*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.26 CASE_202_204_205

Sensor: AANDERAA_OPTODE_4330

Sensor output: uncalibrated phase in degree TPHASE_DOXY

Calculation: Stern-Volmer conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + two points adjustment + pressure and salinity compensation with TEMP, PSAL and PRES from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- TPHASE_DOXY from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ *and* $PhaseCoef_3$ coefficients provided in the optode calibration certificate. If they are not, then uses *PhaseCoef0=0, PhaseCoef1=1, PhaseCoef2=0, PhaseCoef3=0*
- *ci* coefficients provided in the optode calibration certificate
- *ConcCoef0 and ConcCoef1* coefficients provided in the optode calibration certificate.

Calculation output:

- DOXY in umol/kg

Equations:

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$MOLAR\_DOXY = [((c_3 + c_4 \times TEMP)/(c_5 + c_6 \times CalPhase)) - 1]/K_{SV}$$

$$K_{SV} = c_0 + c_1 \times TEMP + c_2 \times TEMP^2$$

$$MOLAR\_DOXY = ConcCoef_0 + ConcCoef_1 \times MOLAR\_DOXY$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL)\times(B0+B1.T_s+B2.T_s{}^2+B3.T_s{}^3)+C_0\times(PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; MOLAR_DOXY=[((c3+c4*TEMP)/(c5+c6*CalPhase))-1]/KSV; KSV=c0+c1*TEMP+c2*TEMP^2; MOLAR_DOXY=ConcCoef0+ConcCoef1*MOLAR_DOXY; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))];

	pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*SVUFoilCoef0*, .., c6=*SVUFoilCoef6*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3;* ConcCoef0=*ConcCoef0*, ConcCoef1=*ConcCoef1*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.27 CASE_202_204_302

Sensor: AANDERAA_OPTODE_4330

Sensor output: uncalibrated phase in degree TPHASE_DOXY

Calculation: standard conversion of raw data to oxygen concentration on umol/L with TEMP_DOXY from the oxygen sensor + pressure and salinity compensation with TEMP, PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- TPHASE_DOXY from the oxygen sensor
- TEMP_DOXY, the temperature from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- $S_{preset,}$ the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate.
- *ci* coefficients provided in the optode calibration certificate
- *mi and ni* coefficients provided in the optode calibration certificate
- A_0, A_1, A_2, A_3, A_4, A_5 are the coefficients for the computation equation (default A_0 = 2.00856, A_1 = 3.22400, A_2 = 3.99063, A_3 = 4.80299, A_4 = 9.78188e-1, A_5 = 1.71069)

Calculation output:

- DOXY in umol/kg

Equations:

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$\Delta p = c_0 \times TEMP\_DOXY^{m0} \times CalPhase^{n0} + c_1 \times TEMP\_DOXY^{m1} \times CalPhase^{n1} + \cdots + c_{27} \times TEMP\_DOXY^{m27} \times CalPhase^{n27}$$

$$AirSat(\%) = \Delta p \times \frac{100}{\left[\left(1013.25 - e^{\left[52.57 - \frac{6690.9}{TEMP\_DOXY+273.15} - 4.681 \times ln(TEMP\_DOXY+273.15)\right]}\right) \times 0.20946\right]}$$

$$MOLAR\_DOXY = C^* \times 44.614 \times AirSat/100$$

$$\ln(C^*) = A_0 + A_1 \times T_{S1} + A_2 \times {T_{S1}}^2 + A_3 \times {T_{S1}}^3 + A_4 \times {T_{S1}}^4 + A_5 \times {T_{S1}}^5$$

$$T_{s1} = ln((298.15 - TEMP\_DOXY)/(273.15 + TEMP\_DOXY))$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_{s2} + B2.{T_{s2}}^2 + B3.{T_{s2}}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S)}$$

$$T_{s2} = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information

Name	Value
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; deltaP=c0*TEMP_DOXY^m0*CalPhase^n0+c1*TEMP_DOXY^m1*CalPhase^n1+..+c27*TEMP_DOXY^m27*CalPhase^n27; AirSat=deltaP*100/[(1013.25-exp[52.57-6690.9/(TEMP_DOXY+273.15)-4.681*ln(TEMP+273.15)])*0.20946]; MOLAR_DOXY=Cstar*44.614*AirSat/100; ln(Cstar)=A0+A1*Ts1+A2*Ts1^2+A3*Ts1^3+A4*Ts1^4+A5*Ts1^5; Ts1=ln[(298.15-TEMP_DOXY)/(273.15+TEMP_DOXY)]; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts2+B2*Ts2^2+B3*Ts2^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Ts2=ln[(298.15-TEMP)/(273.15+TEMP)]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*c0*, …, c27=*c27;* m0=*m0*, …, m27=*m27;* n0=*n0*, …, n27=*n27;* A0 = *A0,* A1 = *A1,* A2 = *A2,* A3 = *A3,* A4 =*A4*, A5 = *A5*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.28 CASE_202_204_303

Sensor: AANDERAA_OPTODE_4330

Sensor output: uncalibrated phase in degree TPHASE_DOXY

Calculation: standard conversion of raw data to oxygen concentration on umol/L with TEMP_DOXY from the oxygen sensor + two points adjustment + pressure and salinity compensation with TEMP, PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- TPHASE_DOXY from the oxygen sensor
- TEMP_DOXY, the temperature from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ *and* $PhaseCoef_3$ coefficients provided in the optode calibration certificate.
- *ci* coefficients provided in the optode calibration certificate
- *mi and ni* coefficients provided in the optode calibration certificate

- *ConcCoef0 and ConcCoef1* coefficients provided in the optode calibration certificate.
- A_0, A_1, A_2, A_3, A_4, A_5 are the coefficients for the computation equation (default A_0 = 2.00856, A_1 = 3.22400, A_2 = 3.99063, A_3 = 4.80299, A_4 = 9.78188e-1, A_5 = 1.71069)

Calculation output:

- DOXY in umol/kg

Equations:

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$\Delta p = c_0 \times TEMP\_DOXY^{m0} \times CalPhase^{n0} + c_1 \times TEMP\_DOXY^{m1} \times CalPhase^{n1} + \cdots + c_{27} \times TEMP\_DOXY^{m27} \times CalPhase^{n27}$$

$$AirSat(\%) = \Delta p \times \frac{100}{\left[\left(1013.25 - e^{\left[52.57 - \frac{6690.9}{TEMP\_DOXY+273.15} - 4.681 \times ln(TEMP\_DOXY+273.15)\right]}\right) \times 0.20946\right]}$$

$$MOLAR\_DOXY = C^* \times 44.614 \times AirSat/100$$

$$\ln(C^*) = A_0 + A_1 \times T_{S1} + A_2 \times {T_{S1}}^2 + A_3 \times {T_{S1}}^3 + A_4 \times {T_{S1}}^4 + A_5 \times {T_{S1}}^5$$

$$T_{s1} = ln((298.15 - TEMP\_DOXY)/(273.15 + TEMP\_DOXY))$$

$$MOLAR\_DOXY = ConcCoef_0 + ConcCoef_1 \times MOLAR\_DOXY$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_{S2} + B2.{T_{S2}}^2 + B3.{T_{S2}}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S\right)}$$

$$T_{s2} = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY

SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1**Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; deltaP=c0*TEMP_DOXY^m0*CalPhase^n0+c1*TEMP_DOXY^m1*CalPhase^n1+..+c27*TEMP_DOXY^m27*CalPhase^n27; AirSat=deltaP*100/[(1013.25-exp[52.57-6690.9/(TEMP_DOXY+273.15)-4.681*ln(TEMP_DOXY+273.15)])*0.20946]; MOLAR_DOXY=Cstar*44.614*AirSat/100; ln(Cstar)=A0+A1*Ts1+A2*Ts1^2+A3*Ts1^3+A4*Ts1^4+A5*Ts1^5; Ts1=ln[(298.15-TEMP_DOXY)/(273.15+TEMP_DOXY)]; MOLAR_DOXY=ConcCoef0+ConcCoef1*MOLAR_DOXY; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts2+B2*Ts2^2+B3*Ts2^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Ts2=ln[(298.15-TEMP)/(273.15+TEMP)]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*c0*, …, c27=*c27;* m0=*m0*, …, m27=*m27;* n0=*n0*, …, n27=*n27;* ConcCoef0 = *ConcCoef0*, ConcCoef1= *ConcCoef1;* A0 = *A0,* A1 = *A1,* A2 = *A2,* A3 = *A3,* A4 =*A4,* A5 = *A5*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.29 CASE_202_204_304

Sensor: AANDERAA_OPTODE_4330

Sensor output: uncalibrated phase in degree TPHASE_DOXY

Calculation: Stern-Volmer conversion of raw data to oxygen concentration on umol/L with TEMP_DOXY from the oxygen sensor + pressure and salinity compensation with TEMP, PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- TPHASE_DOXY from the oxygen sensor
- TEMP_DOXY, the temperature from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate. If they are not, then uses *PhaseCoef0=0, PhaseCoef1=1, PhaseCoef2=0, PhaseCoef3=0*
- *ci* coefficients provided in the optode calibration certificate

Calculation output:

- DOXY in umol/kg

Equations:

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$MOLAR\_DOXY = [((c_3 + c_4 \times TEMP\_DOXY)/(c_5 + c_6 \times CalPhase)) - 1]/K_{SV}$$

$$K_{SV} = c_0 + c_1 \times TEMP\_DOXY + c_2 \times TEMP\_DOXY^2$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_s + B2.T_s{}^2 + B3.T_s{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; MOLAR_DOXY=[((c3+c4*TEMP_DOXY)/(c5+c6*CalPhase))-1]/KSV; KSV=c0+c1*TEMP_DOXY+c2*TEMP_DOXY^2; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*SVUFoilCoef0, ..,* c6=*SVUFoilCoef6*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.30 CASE_202_204_305

Sensor: AANDERAA_OPTODE_4330

Sensor output: uncalibrated phase in degree TPHASE_DOXY

Calculation: Stern-Volmer conversion of raw data to oxygen concentration on umol/L with TEMP_DOXY from the oxygen sensor + two points adjustment + pressure and salinity compensation with TEMP PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- TPHASE_DOXY from the oxygen sensor

- TEMP_DOXY, the temperature from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate. If they are not, then uses *PhaseCoef0=0, PhaseCoef1=1, PhaseCoef2=0, PhaseCoef3=0*
- *ci* coefficients provided in the optode calibration certificate
- *ConcCoef0 and ConcCoef1* coefficients provided in the optode calibration certificate.

Calculation output:

- DOXY in umol/kg

Equations:

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$MOLAR\_DOXY = [((c_3 + c_4 \times TEMP\_DOXY)/(c_5 + c_6 \times CalPhase)) - 1]/K_{SV}$$

$$K_{SV} = c_0 + c_1 \times TEMP\_DOXY + c_2 \times TEMP\_DOXY^2$$

$$MOLAR\_DOXY = ConcCoef_0 + ConcCoef_1 \times MOLAR\_DOXY$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_S + B2.T_S{}^2 + B3.T_S{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$T_S = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information

Name	Value
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TPHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; MOLAR_DOXY=[((c3+c4*TEMP_DOXY)/(c5+c6*CalPhase))-1]/KSV; KSV=c0+c1*TEMP_DOXY+c2*TEMP_DOXY^2; MOLAR_DOXY=ConcCoef0+ConcCoef1*MOLAR_DOXY; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*SVUFoilCoef0*, .., c6=*SVUFoilCoef6;* ConcCoef0 = *ConcCoef0*, ConcCoef1= *ConcCoef1*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.31 CASE_202_205_202

Sensor: AANDERAA_OPTODE_4330

Sensor output: raw phase in degree C1PHASE_DOXY and C2PHASE_DOXY

Calculation: standard conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + pressure and salinity compensation with TEMP, PSAL and PRES from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- C1PHASE_DOXY and C2PHASE_DOXY from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ *and* $PhaseCoef_3$ coefficients provided in the optode calibration certificate.
- *ci* coefficients provided in the optode calibration certificate
- *mi and ni* coefficients provided in the optode calibration certificate
- A_0, A_1, A_2, A_3, A_4, A_5 are the coefficients for the computation equation (default A_0 = 2.00856, A_1 = 3.22400, A_2 = 3.99063, A_3 = 4.80299, A_4 = 9.78188e-1, A_5 = 1.71069)

Calculation output:
- DOXY in umol/kg

Equations:

$$TPHASE\_DOXY = C1PHASE\_DOXY - C2PHASE\_DOXY$$

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$\Delta p = c_0 \times TEMP^{m0} \times CalPhase^{n0} + c_1 \times TEMP^{m1} \times CalPhase^{n1} + \cdots + c_{27} \times TEMP^{m27} \times CalPhase^{n27}$$

$$AirSat(\%) = \Delta p \times \frac{100}{\left[\left(1013.25 - e^{\left[52.57 - \frac{6690.9}{TEMP+273.15} - 4.681 \times ln(TEMP+273.15)\right]}\right) \times 0.20946\right]}$$

$$MOLAR\_DOXY = C^* \times 44.614 \times AirSat/100$$

$$\ln(C^*) = A_0 + A_1 \times T_s + A_2 \times {T_s}^2 + A_3 \times {T_s}^3 + A_4 \times {T_s}^4 + A_5 \times {T_s}^5$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times \left(B0 + B1.T_s + B2.{T_s}^2 + B3.{T_s}^3\right) + C_0 \times \left(PSAL^2\right)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	C1PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	C2PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with red excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TPHASE_DOXY=C1PHASE_DOXY-C2PHASE_DOXY; Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; deltaP=c0*TEMP^m0*CalPhase^n0+c1*TEMP^m1*CalPhase^n1+···+c27*TEMP^m27*CalPhase^n27; AirSat=deltaP*100/[(1013.25-exp[52.57-6690.9/(TEMP+273.15)-4.681*ln(TEMP+273.15)])*0.20946]; MOLAR_DOXY=Cstar*44.614*AirSat/100;

AADI
AANDERAA DATA INSTRUMENTS

CALIBRATION CERTIFICATE

Form No. 621, Dec 2005

Certificate No: 3853_2408_39876
Batch No: 2408

Product: O2 Sensing Foil PSt3 3853
Calibration Date: 4 Mars 2009

Calibration points and phase readings (degrees)

Temperature (°C)		3.30	10.16	20.02	29.87	39.61
Pressure (hPa)		975.00	975.00	975.00	975.00	975.00
O2 in % of O2+N2	0.00	74.08	73.55	72.67	71.72	70.56
	1.00	70.01	69.12	67.75	66.34	64.90
	2.00	66.39	65.23	63.48	61.77	60.08
	5.00	57.81	56.21	53.94	51.82	49.89
	10.00	48.48	46.70	44.30	42.12	40.25
	20.90	37.53	35.86	33.69	31.84	30.27
	30.00	32.48	30.96	29.04	27.40	26.03

Giving these coefficients [1)]

Index	0	1	2	3
C0 Coefficient	5.21413E+03	-1.67321E+02	3.14576E+00	-2.57702E-02
C1 Coefficient	-2.84238E+02	7.89369E+00	-1.39348E-01	1.09312E-03
C2 Coefficient	6.23425E+00	-1.46694E-01	2.40267E-03	-1.75678E-05
C3 Coefficient	-6.34528E-02	1.24323E-03	-1.86980E-05	1.21236E-07
C4 Coefficient	2.46614E-04	-3.92225E-06	5.32181E-08	-2.70264E-10

[1)] Ask for Form No 621S when this O2 Sensing Foil is used in Oxygen Sensor 3830 with Serial Numbers lower than 184.

Date: 8/28/2009

Sign:

Tor-Ove Kvalvaag, Calibration Engineer

AANDERAA DATA INSTRUMENTS AS

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12.1.1.2 Method 2: Stern-Volmer

AANDERAA Calibration Certificate

Page 1 of 1

Sensor Type: O2 Sensing Foil PSt3
Certificate No: 3853 2204R 38159

Batch No: 2204R
Calibration Date: 21/Jun/04

Calibration points and phase readings (degrees)

Temperature (°C)		3.04	10.70	20.24	29.82	39.18
Pressure (hPa)		970.95	970.95	970.95	970.95	970.95
Oxygen (%)	0.00	71.53	70.80	69.82	68.57	67.96
	1.00	67.03	65.86	64.25	62.65	61.15
	2.00	63.18	61.69	59.74	57.75	55.79
	5.00	54.06	52.02	49.51	47.10	44.71
	10.00	44.03	41.75	39.11	36.66	34.39
	20.90	32.04	29.90	27.54	25.46	23.60
	30.00	26.39	24.46	22.37	20.53	18.94

Giving these coefficients [1)]

Index	0	1	2	3
K0 Coefficient	5.56127E+01	-4.84521E-02	-1.94376E-03	2.92352E-05
K1 Coefficient	3.20493E+02	-1.31261E+01	2.87585E-01	-2.59949E-03
F1	1.20486E+00			
F2	8.02149E-02			

[1)] *The coefficients are valid when this O2 Sensing Foil is used in Oxygen Optode Sensor 3830 with serial numbers lower than 184.*

Date: 07 July 2005

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Fax. +47 55 10 99 10
Form 621S, January 2003

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12.1.2 Optode 4330

12.1.2.1 Method 1: Standard calibration (polynomial)

AADI a xylem brand

TEST & SPECIFICATIONS

Form No. 712, July 2008

Layout No:
Circuit Diagram No:
Program Version: V1.23.2

Product: Oxygen Optode 4330
Serial No: 1151

Visual and Mechanical Checks:
1.1 Soldering quality
1.2 Visual surface
1.3 Galvanic isolation between housing and electronics

Current Drain and Voltages:

2.1	Average current drain at 0.5 Hz sampling (Max.: 33 mA)	23.9	mA
2.2	CANBus Current drain at 0.5 Hz sampling (Max.: 33 mA)	21.6	mA
2.3	Current drain in sleep (Max.: 180 µA)	131	µA
2.4	CANBus Current drain in sleep (Max.: 180 µA)	116	µA
2.5	DSP IO voltage, J4.18 (3.3 ±0.15V)	3.32	V
2.6	DSP Core voltage, J4.17(1.8 ±0.05 V)	1.82	V
2.7	Excitation driver voltage, C4 Analog Board (4.5 ±0.15 V)	4.58	V

Performance test:	Channel:	BLUE		RED	
3.1 Average of Receiver readings (0±150mV)		-4.5	mV	1.0	mV
3.2 Standard Deviation of Receiver readings (Max.: 45mV/10mV)		15.13	mV	3.71	mV
3.3 Amplitude measurement with non- fluorescence foil (<60mV/650-1200mV)		20.4	mV	846.8	mV
3.4 Amplitude measurement with fluorescence foil (700-1200mV)		749.3	mV	891.8	mV
3.5 CANBus Output test					

Function test at 0°C Temperature (in air with reference foil):	Channel:	BLUE		RED	
4.1 Amplitude measurement (Blue: 150 – 500mV,Red 650-1800mV)		463.3	mV	1369.7	mV
4.2 Phase measurement (Blue: 4 ±2°,Red: 4 ±2°)		4.0	°	2.7	°
4.3 Standard deviation of Phase measurement: (Max: 0.02°)		0.038	°	0.030	°
4.4 Raw data temperature measurement: (600 ±200mV)				869.5	mV

Function test at 20°C Temperature (in air with reference foil):	Channel:	BLUE		RED	
5.1 Amplitude measurement (Blue: 100 – 300mV,Red 650-1800mV)		439.7	mV	955.2	mV
5.2 Phase measurement (Blue: 5 ±2°,Red: 5 ±2°)		4.9	°	3.6	°
5.3 Standard deviation of Phase measurement: (Max: 0.02°)		0.017	°	0.014	°
5.4 Raw data Temperature measurement: (0 ±200mV)				33.8	mV

Function test at 40°C Temperature (in air with reference foil):	Channel:	BLUE		RED	
6.1 Amplitude measurement (Blue: 150 – 500mV,Red 650-1800mV)		423.1	mV	799	mV
6.2 Phase measurement (Blue: 5 ±2°,Red: 5 ±2°)		5.7	°	4.5	°
6.3 Standard deviation of Phase measurement: (Max: 0.02°)		0.016	°	0.010	°
6.4 Raw data Temperature measurement: (-400 ±200mV)				-377.2	mV

Pressure test :
7.1 Pressure (IW version: 20MPa, DW version 60MPa) .... MPa

Date: 29 Jun 2012

Sign: Katrine Lilleskare
Katrine Lilleskare, Production Engineer

CALIBRATION CERTIFICATE

AADI a xylem brand

Form No. 710, Dec 2005

Sensing Foil Batch No: 1023
Certificate No:

Product: Oxygen Optode 4330
Serial No: 1151
Calibration Date: 28 Jun 2012

This is to certify that this product has been calibrated using the following instruments:

Parameter: Internal Temperature:

Calibration points and readings:

Temperature (°C)	0.99	11.96	24.00	35.99	
Reading (mV)	855.28	530.72	142.29	-233.98	

Giving these coefficients

Index	0	1	2	3	4	5
TempCoef	2.84175E01	-3.13875E-02	3.14436E-06	-4.61402E-09	0.00000E00	0.00000E00

Parameter: Oxygen:

	O2 Concentration	Air Saturation
Range:	0-500 µM [1]	0 - 120%
Accuracy[1]:	< ±8µM or ±5% (whichever is greater)	±5%
Resolution:	< 1 µM	< 0.4%
Settling Time (63%):	< 25 seconds	

Calibration points and readings[2]:

	Air Saturated Water	Zero Solution (Na_2SO_3)
Phase reading (°)	3.20167E+01	6.31916E+01
Temperature reading (°C)	9.90531E+00	2.12306E+01
Air Pressure (hPa)	9.80074E+02	

Giving these coefficients

Index	0	1	2	3
PhaseCoef	-2.05214E00	1.01090E00	0.00000E00	0.00000E00

[1] *Valid for 0 to 2000m (6562ft) depth, salinity 33 - 37ppt*
[2] *The calibration is performed in fresh water and the salinity setting is set to:* 0

Date: 28 Jun 2012

Sign:

Tor-Ove Kvalvaag, Calibration Engineer

AANDERAA DATA INSTRUMENTS AS

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[RD13] - Recommendations on the conversion between oxygen quantities for Bio-Argo floats and other autonomous sensor platforms. SCOR WG 142: Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders. October 2015. (http://www.argodatamgt.org/Documentation/Bio-Argo-Oxygen-data-management-by-DACs).

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[RD16] – Bittig, H.C., Feb. 2016: Review of the salinity correction for oxygen optodes.

Demas et al, 1999

12 ANNEX A: Examples of calibration certificates

Note that the calibration coefficents provided in this Annex are only example. They MUST NOT be used for computing DOXY.

12.1 Aanderaa optodes

12.1.1 Optode 3830

12.1.1.1 Method 1: standard calibration (polynomial)

AANDERAA DATA INSTRUMENTS

TEST & SPECIFICATIONS

Form No. 620, Nov 2005

Layout No: 1308E, 1299G
Circuit Diagram No: -1.27
Program Version: 3, Build: 11

Product: Oxygen Optode 3830
Serial No: 1211

1. Visual and Mechanical Checks:
- 1.1. O-ring surface
- 1.2. Soldering quality
- 1.3. Visual surface
- 1.4. Pressure test (60MPa)
- 1.5. Galvanic isolation between housing and electronics

2. Current Drain and Voltages:

2.1. Average current drain at 0.5Hz sampling (Max: 38mA)	31 mA
2.2. Current drain in sleep (Max: 300µA)	208 µA
2.3. Quiescent current drain from –9V (Max: 5µA)	0 µA
2.4. DSP voltage, IC5.1 (3.3 ±0.15V)	3.29 V
2.5. Excitation driver voltage, IC1.1 (3.3 ±0.15V)	3.30 V
2.6. Flash/RS232 driver voltage, IC7.4 (5 ±0.2V)	5.07 V

3. Receiver test:

3.1. Average of Receiver readings (0 ±50mV)	2 mV
3.2. Standard Deviation of Receiver readings (Max: 10mV)	1.33 mV

4. Performance Test in Air, 0ºC Temperature:

4.1. Amplitude measurement (Blue: 220 – 470mV)	373.6 mV
4.2. Phase measurement (Blue: 32 ±5)	31.6 °
4.3. Standard deviation of Phase measurement: (Max: 0.02°)	0.001 °
4.4. Temperature measurement: (700 ±300mV)	565.81 mV
4.5. SR10 Output tested (Set_Output(-100))	

5. Performance Test in Air, 20ºC Temperature:

5.1. Amplitude measurement (Blue: 290 – 470mV)	381.69 mV
5.2. Phase measurement (Blue: 27 ±5°)	26.8 °
5.3. Standard deviation of Phase measurement: (Max: 0.02°)	0.007 °
5.4. Temperature measurement: (100 ±300mV)	-141.99 mV
5.5. SR10 Output tested (Set_Output(-100))	

6. Performance Test in Air, 40ºC Temperature:

6.1. Amplitude measurement (Blue: 320 – 500mV)	371.07 mV
6.2. Phase measurement (Blue: 25 ±5°)	24.4 °
6.3. Standard deviation of Phase measurement: (Max: 0.02°)	0.007 °
6.4. Temperature measurement: (-500 ±300mV)	-495.63 mV
6.5. SR10 Output tested (Set_Output(-100))	

Date: 27 August 2009

Sign:
Vidar Selsvik, Production Engineer

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CALIBRATION CERTIFICATE

AANDERAA DATA INSTRUMENTS

Form No. 622, Dec 2005
Page 1 of 2

Sensing Foil Batch No: 2408
Certificate No:

Product: Oxygen Optode 3830
Serial No: 1211
Calibration Date: 25 August 2009

This is to certify that this product has been calibrated using the following instruments:

Calibration Bath model FNT	321-1-40
ASL Digital Thermometer model F250	Serial: 6792/06

Parameter: Internal Temperature:

Calibration points and readings:

Temperature (°C)	1.00	11.96	23.98	35.97
Reading (mV)	664.53	315.18	-75.99	-433.03

Giving these coefficients

Index	0	1	2	3
TempCoef	2.16009E01	-3.11113E-02	2.97215E-06	-4.23388E-09

Parameter: Oxygen:

	O2 Concentration	Air Saturation
Range:	0-500 µM [1)]	0 - 120%
Accuracy[1)]:	< ±8µM or ±5% (whichever is greater)	±5%
Resolution:	< 1 µM	< 0.4%
Settling Time (63%):	< 25 seconds	

Calibration points and readings[2)]:

	Air Saturated Water	Zero Solution (Na_2SO_3)
Phase reading (°)	3.04025E+01	6.34097E+01
Temperature reading (°C)	9.92254E+00	2.20098E+01
Air Pressure (hPa)	1.00183E+03	

Giving these coefficients

Index	0	1	2	3
PhaseCoef	1.36355E00	1.12308E00	0.00000E00	0.00000E00

[1)] *Valid for 0 to 2000m (6562ft) depth, salinity 33 - 37ppt*
[2)] *The calibration is performed in fresh water and the salinity setting is set to: 0*

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CALIBRATION CERTIFICATE

AANDERAA DATA INSTRUMENTS

Form No. 622, Dec 2005
Page 2 of 2

Sensing Foil Batch No: 2408
Certificate No:

Product: Oxygen Optode 3830
Serial No: 1211
Calibration Date: 25 August 2009

SR10 Scaling Coefficients:

At the SR10 output the Oxygen Optode 3830 can give either absolute oxygen concentration in µM or air saturation in %. The setting of the internal property "Output" [3)], controls the selection of the unit. The coefficients for converting SR10 raw data to engineering units are fixed.

Output = -1	Output = -2
A = 0	A = 0
B = 4.883E-01	B = 1.465E-01
C = 0	C = 0
D = 0	D = 0
Oxygen (µM) = A + BN + CN2 + DN3	Oxygen (%)= A + BN + CN2 + DN3

[3)] The default output setting is set to -1

Date: 26 August 2009

Sign: Tor-Ove Kvalvaag

Tor-Ove Kvalvaag, Calibration Engineer

AANDERAA DATA INSTRUMENTS AS

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10 PPOX computation

As for DOXY in the previous section, this section aims at describing precisely how to fill the meta-data when PPOX is computed. These specifications are valid as of the date of writing this document. It is very likely that changes in calibrations and conversions equations will occur in the future. Metadata will then have to be filled accordingly with the new procedures.

PPOX is computed from MOLAR_DOXY, but the computation equations differ when MOLAR_DOXY was computed internally by the sensor (on-board computation) or when MOALR_DOXY is computed on shore by the DAC (see Section 5.2).

10.1 PPOX computation from MOLAR_DOXY computed on-board by the sensor

Sensor output: MOLAR_DOXY (umol/L)

Calculation: conversion of MOLAR_DOXY (umol/L) to partial pressure of oxygen (PPOX_DOXY) in mbar with TEMP and PRES

Calculation input:

- PRES, and TEMP, pressure and temperature from the CTD
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{ref} the reference salinity given in the optode settings (default $S_{ref} = 0$)
- $S_{preset,}$ the salinity used for the salinity correction (default Spreset = 0)

Calculation output:

- PPOX_DOXY in dbar

Equations:

$$\mathrm{MOLAR\_DOXY\_NEW} = \mathrm{A} * \frac{\mathrm{MOLAR\_DOXY}}{\exp[\mathrm{Sref} * (\mathrm{B0} + \mathrm{B1} * \mathrm{Ts} + \mathrm{B2} * \mathrm{Ts}^\wedge 2 + \mathrm{B3} * \mathrm{Ts}^\wedge 3) + \mathrm{C0} * \mathrm{Sref}^\wedge 2]}$$

$$A = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, 0)}$$

$$pH_2O(TEMP, S) = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S\right)}$$

$$Tcorr = 44.6596 * e^{[2.00907+3.22014*\mathrm{Ts}+4.05010*\mathrm{Ts}^2+4.94457*\mathrm{Ts}^3-2.56847e^{-1}*\mathrm{Ts}^4+3.88767*\mathrm{Ts}^5]}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$PPOX\_DOXY = MOLAR\_DOXY\_NEW * \frac{\left(0.20946 * \left(1013.25 - pH_20(TEMP, 0)\right)\right)}{Tcorr} * e^{\left(\frac{0.317*PRES}{(8.314*(\mathrm{TEMP}+273.15))}\right)}$$

Float parameter information	
Name	**Value**
PARAMETER	PPOX_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	mbar
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	MOLAR_DOXY_NEX=A*MOLAR_DOXY/exp[Sref*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*Sref^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL=0))];pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S];Tcorr=44.6596*exp[2.00907+3.22014*Ts+4.05010*Ts^2+4.94457*Ts^3-2.56847e-1*Ts^4+3.88767*Ts^5];Ts=ln[(298.15-TEMP)/(273.15+TEMP)];PPOX_DOXY=MOLAR_DOXY_NEW*(0.20946*(1013.25-pH2O(TEMP,PSAL=0)))/Tcorr*exp[0.317*PRES/(8.314*(TEMP+273.15))]
PREDEPLOYMENT_CALIB_COEFFICIENT	Sref=*Sref;* Spreset=*Spreset*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see SCOR WG 142 "Recommendations on the conversion between oxygen quantities for Bio-Argo floats and other autonomous sensor platforms", doi

10.2 PPOX computation from MOLAR_DOXY computed on-shore by the DAC

Sensor output: raw data other than MOLAR_DOXY

Calculation: conversion of MOLAR_DOXY (umol/L) to partial pressure of oxygen (PPOX_DOXY) in mbar with TEMP and PRES

Calculation input:

- MOLAR_DOXY (umol/L) calculated according to the adequate configuration (Section 9.2)
- PRES, and TEMP, pressure and temperature from the CTD
- *D0, D1, D2* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489)

Calculation output:

- PPOX_DOXY in dbar

Equations:

$$pH_2Osat = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right)\right)}$$

$$Tcorr = 44.6596 * e^{[2.00907+3.22014*\mathrm{Ts}+4.05010*\mathrm{Ts}^2+4.94457*\mathrm{Ts}^3-2.56847e^{-1}*\mathrm{Ts}^4+3.88767*\mathrm{Ts}^5]}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$PPOX\_DOXY = MOLAR\_DOXY * \frac{(0.20946 * (1013.25 - pH_20sat))}{Tcorr} * e^{\left(\frac{0.317*PRES}{(8.314*(\mathrm{TEMP}+273.15))}\right)}$$

Float parameter information

Name	Value
PARAMETER	PPOX_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	mbar
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	pH2Osat=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)];Tcorr=44.6596*exp[2.00907+3.22014*Ts+4.05010*Ts^2+4.94457*Ts^3-2.56847e-1*Ts^4+3.88767*Ts^5]; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; PPOX_DOXY=MOLAR_DOXY*(0.20946*(1013.25-pH2Osat))/Tcorr*exp[0.317*PRES/(8.314*(TEMP+273.15))]
PREDEPLOYMENT_CALIB_COEFFICIENT	D0=*D0*, D1=*D1*, D2=*D2*
PREDEPLOYMENT_CALIB_COMMENT	see SCOR WG 142 "Recommendations on the conversion between oxygen quantities for Bio-Argo floats and other autonomous sensor platforms", doi

11 References

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[RD2] - Uchida, H. T. Kawano, I. Kaneko, and M. Fukasawa (2008): In situ calibration of Optode-based oxygen sensors. J. Atmos. Oceanic Tech., 25, 2271-2281.

[RD3] - UNESCO (1983): Algorithms for computation of fundamental properties of seawater. Unesco technical papers in marine science, 44, 53pp.

[RD4] - Weiss, R. F. (1970): The solubility of nitrogen, oxygen, and argon in water and seawater. Deep Sea Res., 17, 721-735.

[RD5] – TD218 Operating manual oxygen optode 3830, 3835, 3930, 3975, 4130, 4175 (April 2007). (http://www.argodatamgt.org/Documentation/Bio-Argo-Oxygen-data-management-by-DACs).

[RD6] – TD269 Operating manual oxygen optode 4330, 4835, 4831 (August 2012). (http://www.argodatamgt.org/Documentation/Bio-Argo-Oxygen-data-management-by-DACs).

[RD7] – SBE63 User's Manual (manual version #007, 10/28/13). (http://www.argodatamgt.org/Documentation/Bio-Argo-Oxygen-data-management-by-DACs).

[RD8] – Application note #64: SBE43 Dissolved Oxygen Sensor – Background Information, Deployment Recommendations, and Clearing and Storage (revised June 2013). (http://www.argodatamgt.org/Documentation/Bio-Argo-Oxygen-data-management-by-DACs)

[RD9] – Argo User's Manual, Version, 3.04, January xxx (http://www.argodatamgt.org/Documentation/)

[RD10] - TD218 Operating Manual Oxygen Optode 3830 (September 2002). (http://www.argodatamgt.org/Documentation/Bio-Argo-Oxygen-data-management-by-DACs).

[RD11] – Millero, Frank J., and Alain Poisson (1981): International One-Atmosphere Equation of State of Seawater. Deep Sea Research Part A. Oceanographic Research Papers 28, no. 6: 625–29.

[RD12] – JAC ARO_FT sensor User's Manual

	c6=*SVUFoilCoef6;* ConcCoef0 = *ConcCoef0*, ConcCoef1= *ConcCoef1*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.39 CASE_301_103_101

Sensor: JAC_OPTODE_ARO_FT

Sensor output: temperature output in count called TEMP_COUNT_DOXY

Calculation: standard calibration equation

Calculation Input:

- TEMP_COUNT_DOXY the temperature A/D value in count
- A to F values from the calibration certificate (12.3.1.2)

Calculation Output:

- TEMP_DOXY in degC (ITS90)

Equations:

$$TEMP\_DOXY = A + B\times TEMP\_COUNT\_DOXY + C\times TEMP\_COUNT\_DOXY^2 + D\times TEMP\_COUNT\_DOXY^3 + E\times TEMP\_COUNT\_DOXY^4 + F\times TEMP\_COUNT\_DOXY^5$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	JAC
SENSOR_MODEL	ARO_FT
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	TEMP_COUNT_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	count
PARAMETER_ACCURACY	1
PARAMETER_RESOLUTION	1
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	optode temperature

Float parameter information	
Name	**Value**
PARAMETER	TEMP_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degC
PARAMETER_ACCURACY	0.01 degC
PARAMETER_RESOLUTION	0.001 degC

Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TEMP_DOXY=A+B*TEMP_COUNT_DOXY+C*TEMP_COUNT_DOXY^2+D*TEMP_COUNT_DOXY^3+E*TEMP_COUNT_DOXY^4+F*TEMP_COUNT_DOXY^5
PREDEPLOYMENT_CALIB_COEFFICIENT	A=*A*, B=*B*, C=*C*, D=*D*, E=*E*, F=*F*
PREDEPLOYMENT_CALIB_COMMENT	optode temperature, see ARO_FT manual

9.2.40 CASE_301_210_401

Sensor: JAC_OPTODE_ARO_FT

Sensor output: raw data called COUNT_DOXY (in count) and LED flashing frequency of the oxygen sensor called LED_FLASHING_COUNT_DOXY (in count)

Calculation: conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + pressure and salinity compensation with TEMP, PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL, and TEMP, pressure, salinity and temperature from the CTD
- COUNT_DOXY from the oxygen sensor
- LED_FLASHING_COUNT_DOXY from the oxygen sensor
- P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef2}=0, P_{coef3}=0.032)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP, and PSAL from CTD
- c_0, c_1, c_2, d_0, d_1, d_2, d_3, d_4, and e_0 coefficients provided in the ARO_FT calibration certificate (12.3.1.1)

Calculation output:

- DOXY in umol/kg

Equations:

$$MOLAR\_DOXY = \left\{\left(\frac{1 + d_0 \times TEMP}{d_1 + d_2 \times N + d_3 \times t + d_4 \times t \times N}\right)^{e_0} - 1\right\} \times \frac{1}{c_0 + c_1 \times TEMP + c_2 \times TEMP^2}$$

$$N = COUNT\_DOXY + 0.0001$$

$$t = LED\_FLASHING\_COUNT\_DOXY \times 0.01$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL)\times\left(B0 + B1.T_s + B2.T_s{}^2 + B3.T_s{}^3\right) + C_0 \times \left(PSAL^2\right)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	JAC
SENSOR_MODEL	ARO_FT
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	COUNT_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	count
PARAMETER_ACCURACY	1
PARAMETER_RESOLUTION	1
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	The difference between the phase obtained with blue light excitation and the phase obtained with red light excitation in count

Float parameter information	
Name	**Value**
PARAMETER	LED_FLASHING_COUNT_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	count
PARAMETER_ACCURACY	1
PARAMETER_RESOLUTION	1
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	LED flashing frequency

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	2 umol/kg or 2%
PARAMETER_RESOLUTION	0.01 umol/kg
Float calibration information	
Name	**Value**

PREDEPLOYMENT_CALIB_EQUATION	N=0.0001*COUNT_DOXY; t=0.01*LED_FLASHING_COUNT_DOXY; MOLAR_DOXY=[[(1+d0*TEMP)/(d1+d2*N+d3*t+d4*t*N)]^e0-1]*[1/(c0+c1*TEMP+c2*TEMP^2)]; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	c0=*c0*, c1=*c1*, c2=*c2*; d0=*d0*, d1=*d1*, d2=*d2*, d3=*d3*, d4=*d4*;e0=*e0*; Spreset=*Spreset*; Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see ARO_FT manual; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

- *$PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$* coefficients provided in the optode calibration certificate. If they are not, then uses *PhaseCoef0=0, PhaseCoef1=1, PhaseCoef2=0, PhaseCoef3=0*
- *ci* coefficients provided in the optode calibration certificate

Calculation output:
- DOXY in umol/kg

Equations:

$$TPHASE\_DOXY = C1PHASE\_DOXY - C2PHASE\_DOXY$$

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$MOLAR\_DOXY = [((c_3 + c_4 \times TEMP\_DOXY)/(c_5 + c_6 \times CalPhase)) - 1]/K_{SV}$$

$$K_{SV} = c_0 + c_1 \times TEMP\_DOXY + c_2 \times TEMP\_DOXY^2$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_s + B2.T_s{}^2 + B3.T_s{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho\&$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Name	Value
PARAMETER	C1PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	

Name	Value
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	C2PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with red excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TPHASE_DOXY=C1PHASE_DOXY-C2PHASE_DOXY; Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; MOLAR_DOXY=[((c3+c4*TEMP_DOXY)/(c5+c6*CalPhase))-1]/KSV; KSV=c0+c1*TEMP_DOXY+c2*TEMP_DOXY^2; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*SVUFoilCoef0*, .., c6=*SVUFoilCoef6*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.38 CASE_202_205_305

Sensor: AANDERAA_OPTODE_4330

Sensor output: raw phase in degree C1PHASE_DOXY and C2PHASE_DOXY

Calculation: Stern-Volmer conversion of raw data to oxygen concentration on umol/L with TEMP_DOXY from the oxygen sensor + two points adjustment + pressure and salinity compensation with TEMP, PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD

- C1PHASE_DOXY and C2PHASE_DOXY from the oxygen sensor
- TEMP_DOXY, the temperature from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ *and* $PhaseCoef_3$ coefficients provided in the optode calibration certificate. If they are not, then uses *PhaseCoef0=0, PhaseCoef1=1, PhaseCoef2=0, PhaseCoef3=0*
- *ci* coefficients provided in the optode calibration certificate
- *ConcCoef0 and ConcCoef1* coefficients provided in the optode calibration certificate.

Calculation output:

- DOXY in umol/kg

Equations:

$$TPHASE\_DOXY = C1PHASE\_DOXY - C2PHASE\_DOXY$$

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$MOLAR\_DOXY = [((c_3 + c_4 \times TEMP\_DOXY)/(c_5 + c_6 \times CalPhase)) - 1]/K_{SV}$$

$$K_{SV} = c_0 + c_1 \times TEMP\_DOXY + c_2 \times TEMP\_DOXY^2$$

$$MOLAR\_DOXY = ConcCoef_0 + ConcCoef_1 \times MOLAR\_DOXY$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_s + B2.T_s{}^2 + B3.T_s{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S\right)}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Name	Value
PARAMETER	C1PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	C2PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with red excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TPHASE_DOXY=C1PHASE_DOXY-C2PHASE_DOXY; Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; MOLAR_DOXY=[((c3+c4*TEMP_DOXY)/(c5+c6*CalPhase))-1]/KSV; KSV=c0+c1*TEMP_DOXY+c2*TEMP_DOXY^2; MOLAR_DOXY=ConcCoef0+ConcCoef1*MOLAR_DOXY; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*SVUFoilCoef0*, ..,

Name	Value
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	C2PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with red excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TPHASE_DOXY=C1PHASE_DOXY-C2PHASE_DOXY; Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; deltaP=c0*TEMP_DOXY^m0*CalPhase^n0+c1*TEMP_DOXY^m1*CalPhase^n1+…+c27*TEMP_DOXY^m27*CalPhase^n27; AirSat=deltaP*100/[(1013.25-exp[52.57-6690.9/(TEMP_DOXY+273.15)-4.681*ln(TEMP_DOXY+273.15)])*0.20946]; MOLAR_DOXY=Cstar*44.614*AirSat/100; ln(Cstar)=A0+A1*Ts1+A2*Ts1^2+A3*Ts1^3+A4*Ts1^4+A5*Ts1^5; Ts1=ln[(298.15-TEMP_DOXY)/(273.15+TEMP_DOXY)]; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts2+B2*Ts2^2+B3*Ts2^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Ts2=ln[(298.15-TEMP)/(273.15+TEMP)]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*c0*, …, c27=*Cc27;* m0=*m0*, …, m27=*m27;* n0=*n0*, …, n27=*n27;* A0=*A0*, A1=*A1*, A2=*A2*, A3=*A3*, A4=*A4*, A5=*A5*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.36 CASE_202_205_303

Sensor: AANDERAA_OPTODE_4330

Sensor output: raw phase in degree C1PHASE_DOXY and C2PHASE_DOXY

Calculation: standard conversion of raw data to oxygen concentration on umol/L with TEMP_DOXY from the oxygen sensor + two points adjustment + pressure and salinity compensation with TEMP, PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- C1PHASE_DOXY and C2PHASE_DOXY from the oxygen sensor
- TEMP_DOXY, the temperature from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate.
- *ci* coefficients provided in the optode calibration certificate
- *mi and ni* coefficients provided in the optode calibration certificate
- *ConcCoef0 and ConcCoef1* coefficients provided in the optode calibration certificate.
- A_0, A_1, A_2, A_3, A_4, A_5 are the coefficients for the computation equation (default A_0 = 2.00856, A_1 = 3.22400, A_2 = 3.99063, A_3 = 4.80299, A_4 = 9.78188e-1, A_5 = 1.71069)

Calculation output:

- DOXY in umol/kg

Equations:

$$TPHASE\_DOXY = C1PHASE\_DOXY - C2PHASE\_DOXY$$

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$\Delta p = c_0 \times TEMP\_DOXY^{m0} \times CalPhase^{n0} + c_1 \times TEMP\_DOXY^{m1} \times CalPhase^{n1} + \cdots + c_{27} \times TEMP\_DOXY^{m27} \times CalPhase^{n27}$$

$$AirSat(\%) = \Delta p \times \frac{100}{\left[\left(1013.25 - e^{\left[52.57 - \frac{6690.9}{TEMP+273.15} - 4.681 \times ln(TEMP+273.15)\right]}\right) \times 0.20946\right]}$$

$$MOLAR\_DOXY = C^* \times 44.614 \times AirSat/100$$

$$\ln(C^*) = A_0 + A_1 \times T_{s1} + A_2 \times {T_{s1}}^2 + A_3 \times {T_{s1}}^3 + A_4 \times {T_{s1}}^4 + A_5 \times {T_{s1}}^5$$

$$T_{s1} = ln((298.15 - TEMP\_DOXY)/(273.15 + TEMP\_DOXY))$$

$$MOLAR\_DOXY = ConcCoef_0 + ConcCoef_1 \times MOLAR\_DOXY$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_{s1} + B2.T_{s1}{}^2 + B3.T_{s1}{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S) = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP + 273.15}\right) + D_2 \times ln\left(\frac{TEMP + 273.15}{100}\right) + D_3 \times S\right)}$$

$$T_{s1} = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Name	Value
PARAMETER	C1PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	C2PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with red excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information

Name	Value
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TPHASE_DOXY=C1PHASE_DOXY-C2PHASE_DOXY; Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; deltaP=c0*TEMP_DOXY^m0*CalPhase^n0+c1*TEMP_DOXY^m1*CalPhase^n1+…+c27*TEMP_DOXY^m27*CalPhase^n27; AirSat=deltaP*100/[(1013.25-exp[52.57-6690.9/(TEMP+273.15)-4.681*ln(TEMP+273.15)])*0.20946]; MOLAR_DOXY=Cstar*44.614*AirSat/100; ln(Cstar)=A0+A1*Ts1+A2*Ts1^2+A3*Ts1^3+A4*Ts1^4+A5*Ts1^5; Ts1=ln[(298.15-TEMP_DOXY)/(273.15+TEMP_DOXY)]; MOLAR_DOXY=ConcCoef0+ConcCoef1*MOLAR_DOXY; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts2+B2*Ts2^2+B3*Ts2^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Ts2=ln[(298.15-TEMP)/(273.15+TEMP)]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*c0*, …, c27=*c27;* m0=*m0*, …, m27=*m27;* n0=*n0*, …, n27=*n27;* ConcCoef0 = *ConcCoef0*, ConcCoef1= *ConcCoef1;* A0=*A0*, A1=*A1*, A2=*A2*, A3=*A3*, A4=*A4*, A5=*A5*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.37 CASE_202_205_304

Sensor: AANDERAA_OPTODE_4330

Sensor output: raw phase in degree C1PHASE_DOXY and C2PHASE_DOXY

Calculation: Stern-Volmer conversion of raw data to oxygen concentration on umol/L with TEMP_DOXY from the oxygen sensor + pressure and salinity compensation (Aanderaa) with TEMP, PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- C1PHASE_DOXY and C2PHASE_DOXY from the oxygen sensor
- TEMP_DOXY, the temperature from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- $S_{preset,}$ the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])

	ln(Cstar)=A0+A1*Ts+A2*Ts^2+A3*Ts^3+A4*Ts^4+A5*Ts^5; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*c0*, …, c27=*c27;* m0=*m0*, …, m27=*m27;* n0=*n0*, …, n27=*n27;* A0 = *A0,* A1 = *A1,* A2 = *A2,* A3 = *A3,* A4 =*A4,* A5 = *A5*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.32 CASE_202_205_203

Sensor: AANDERAA_OPTODE_4330

Sensor output: raw phase in degree C1PHASE_DOXY and C2PHASE_DOXY

Calculation: standard conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + two points adjustment + pressure and salinity compensation with TEMP, PSAL and PRES from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- C1PHASE_DOXY and C2PHASE_DOXY from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- $S_{preset,}$ the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ *and* $PhaseCoef_3$ coefficients provided in the optode calibration certificate.
- *ci* coefficients provided in the optode calibration certificate
- *mi and ni* coefficients provided in the optode calibration certificate
- *ConcCoef0 and ConcCoef1* coefficients provided in the optode calibration certificate.
- A_0, A_1, A_2, A_3, A_4, A_5 are the coefficients for the computation equation (default A_0 = 2.00856, A_1 = 3.22400, A_2 = 3.99063, A_3 = 4.80299, A_4 = 9.78188e-1, A_5 = 1.71069)

Calculation output:

- DOXY in umol/kg

Equations:

$$TPHASE\_DOXY = C1PHASE\_DOXY - C2PHASE\_DOXY$$

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$\Delta p = c_0 \times TEMP^{m0} \times CalPhase^{n0} + c_1 \times TEMP^{m1} \times CalPhase^{n1} + \cdots + c_{27} \times TEMP^{m27} \times CalPhase^{n27}$$

$$AirSat(\%) = \Delta p \times \frac{100}{\left[\left(1013.25 - e^{\left[52.57 - \frac{6690.9}{TEMP+273.15} - 4.681 \times ln(TEMP+273.15)\right]}\right) \times 0.20946\right]}$$

$$MOLAR\_DOXY = C^* \times 44.614 \times AirSat/100$$

$$\ln(C^*) = A_0 + A_1 \times T_s + A_2 \times T_s{}^2 + A_3 \times T_s{}^3 + A_4 \times T_s{}^4 + A_5 \times T_s{}^5$$

$$T_s = ln((298.15 - TEMP\_DOXY)/(273.15 + TEMP\_DOXY))$$

$$MOLAR\_DOXY = ConcCoef_0 + ConcCoef_1 \times MOLAR\_DOXY$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_s + B2.T_s{}^2 + B3.T_s{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES} = /rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Float parameter information	
Name	**Value**
PARAMETER	C1PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	C2PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with red excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TPHASE_DOXY=C1PHASE_DOXY-C2PHASE_DOXY; Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; deltaP=c0*TEMP^m0*CalPhase^n0+c1*TEMP^m1*CalPhase^n1+…+c27*TEMP^m27*CalPhase^n27; AirSat=deltaP*100/[(1013.25-exp[52.57-6690.9/(TEMP+273.15)-4.681*ln(TEMP+273.15)])*0.20946]; MOLAR_DOXY=Cstar*44.614*AirSat/100; ln(Cstar)=A0+A1*Ts+A2*Ts^2+A3*Ts^3+A4*Ts^4+A5*Ts^5; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; MOLAR_DOXY=ConcCoef0+ConcCoef1*MOLAR_DOXY; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*c0*, …, c27=*c27;* m0=*m0*, …, m27=*m27;* n0=*n0*, …, n27=*n27;* A0 = *A0*, A1 = *A1*, A2 = *A2*, A3 = *A3*, A4 =*A4*, A5 = *A5;* ConcCoef0 = *ConcCoef0*, ConcCoef1= *ConcCoef1*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.33 CASE_202_205_204

Sensor: AANDERAA_OPTODE_4330

Sensor output: raw phase in degree C1PHASE_DOXY and C2PHASE_DOXY

Calculation: Stern-Volmer conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + pressure and salinity compensation (Aanderaa) with TEMP, PSAL and PRES from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- C1PHASE_DOXY and C2PHASE_DOXY from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate. If they are not, then uses *PhaseCoef0=0, PhaseCoef1=1, PhaseCoef2=0, PhaseCoef3=0*
- *ci* coefficients provided in the optode calibration certificate

Calculation output:

- DOXY in umol/kg

Equations:

$$TPHASE\_DOXY = C1PHASE\_DOXY - C2PHASE\_DOXY$$

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$MOLAR\_DOXY = [((c_3 + c_4 \times TEMP)/(c_5 + c_6 \times CalPhase)) - 1]/K_{SV}$$

$$K_{SV} = c_0 + c_1 \times TEMP + c_2 \times TEMP^2$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_S + B2.T_S{}^2 + B3.T_S{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S\right)}$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Name	Value
PARAMETER	C1PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	C2PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with red excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	TPHASE_DOXY=C1PHASE_DOXY-C2PHASE_DOXY; Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; MOLAR_DOXY=[((c3+c4*TEMP)/(c5+c6*CalPhase))-1]/KSV; KSV=c0+c1*TEMP+c2*TEMP^2; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*SVUFoilCoef0*, …, c6=SVUFoilCoef6; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.34 CASE_202_205_205

Sensor: AANDERAA_OPTODE_4330

Sensor output: raw phase in degree C1PHASE_DOXY and C2PHASE_DOXY

Calculation: Stern-Volmer conversion of raw data to oxygen concentration on umol/L with TEMP from the CTD + two points adjustment + pressure and salinity compensation with TEMP, PSAL and PRES from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- C1PHASE_DOXY and C2PHASE_DOXY from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate. If they are not, then uses *PhaseCoef0=0, PhaseCoef1=1, PhaseCoef2=0, PhaseCoef3=0*
- *ci* coefficients provided in the optode calibration certificate
- *ConcCoef0 and ConcCoef1* coefficients provided in the optode calibration certificate.

Calculation output:

- DOXY in umol/kg

Equations:

$$TPHASE\_DOXY = C1PHASE\_DOXY - C2PHASE\_DOXY$$

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$MOLAR\_DOXY = [((c_3 + c_4 \times TEMP)/(c_5 + c_6 \times CalPhase)) - 1]/K_{SV}$$

$$K_{SV} = c_0 + c_1 \times TEMP + c_2 \times TEMP^2$$

$$MOLAR\_DOXY = ConcCoef_0 + ConcCoef_1 \times MOLAR\_DOXY$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_S + B2.T_S{}^2 + B3.T_S{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S) = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S\right)}$$

$$T_s = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Name	Value
PARAMETER	C1PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with blue excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	C2PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	
Name	**Value**
PREDEPLOYMENT_CALIB_EQUATION	none
PREDEPLOYMENT_CALIB_COEFFICIENT	none
PREDEPLOYMENT_CALIB_COMMENT	Phase measurement with red excitation light; see TD269 Operating manual oxygen optode 4330, 4835, 4831

Float parameter information	
Name	**Value**
PARAMETER	DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	umol/kg
PARAMETER_ACCURACY	8 umol/kg or 10%
PARAMETER_RESOLUTION	1 umol/kg
Float calibration information	

Name	Value
PREDEPLOYMENT_CALIB_EQUATION	TPHASE_DOXY=C1PHASE_DOXY-C2PHASE_DOXY; Phase_Pcorr=TPHASE_DOXY+Pcoef1*PRES/1000; CalPhase=PhaseCoef0+PhaseCoef1*Phase_Pcorr+PhaseCoef2*Phase_Pcorr^2+PhaseCoef3*Phase_Pcorr^3; MOLAR_DOXY=[((c3+c4*TEMP)/(c5+c6*CalPhase))-1]/KSV; KSV=c0+c1*TEMP +c2*TEMP^2; MOLAR_DOXY=ConcCoef0+ConcCoef1*MOLAR_DOXY; O2=MOLAR_DOXY*Scorr*Pcorr; Scorr=A*exp[PSAL*(B0+B1*Ts+B2*Ts^2+B3*Ts^3)+C0*PSAL^2]; A=[(1013.25-pH2O(TEMP,Spreset))/(1013.25-pH2O(TEMP,PSAL))]; pH2O(TEMP,S)=1013.25*exp[D0+D1*(100/(TEMP+273.15))+D2*ln((TEMP+273.15)/100)+D3*S]; Pcorr=1+((Pcoef2*TEMP+Pcoef3)*PRES)/1000; Ts=ln[(298.15-TEMP)/(273.15+TEMP)]; DOXY=O2/rho, where rho is the potential density [kg/L] calculated from CTD data
PREDEPLOYMENT_CALIB_COEFFICIENT	Spreset=*Spreset*; Pcoef1=*Pcoef1*, Pcoef2=*Pcoef2*, Pcoef3=*Pcoef3*; B0=*B0*, B1=*B1*, B2=*B2*, B3=*B3*; C0=*C0*; PhaseCoef0=*PhaseCoef0*, PhaseCoef1=*PhaseCoef1*, PhaseCoef2=*PhaseCoef2*, PhaseCoef3=*PhaseCoef3* ; c0=*SVUFoilCoef0, ..,* c6=*SVUFoilCoef6;* ConcCoef0 = *ConcCoef0*, ConcCoef1= *ConcCoef1*; D0=*D0*, D1=*D1*, D2=*D2*, D3=*D3*
PREDEPLOYMENT_CALIB_COMMENT	see TD269 Operating manual oxygen optode 4330, 4835, 4831; see Processing Argo OXYGEN data at the DAC level, Version 2.2 (DOI: http://dx.doi.org/10.13155/39795)

9.2.35 CASE_202_205_302

Sensor: AANDERAA_OPTODE_4330

Sensor output: raw phase in degree C1PHASE_DOXY and C2PHASE_DOXY

Calculation: standard conversion of raw data to oxygen concentration on umol/L with TEMP_DOXY from the oxygen sensor + pressure and salinity compensation with TEMP, PRES and PSAL from the CTD + unit conversion

Calculation input:

- PRES, PSAL and TEMP, pressure, salinity and temperature from the CTD
- C1PHASE_DOXY and C2PHASE_DOXY from the oxygen sensor
- TEMP_DOXY, the temperature from the oxygen sensor
- P_{coef1}, P_{coef2}, P_{coef3}, the pressure compensation coefficients (default P_{coef1}=0.1, P_{coef2}=0.00022, P_{coef3}=0.0419)
- *B0, B1, B2, B3* and *C0* the salinity compensation coefficient (default B0 = -6.24523e-3; B1 = -7.37614e-3; B2 = -1.03410e-3; B3 = -8.17083e-3; C0 = -4.88682e-7)
- *D0, D1, D2 and D3* the pH20 computation coefficient (default D0 = 24.4543, D1 = -67.4509, D2 = –4.8489, D3 = –5.44e–4)
- S_{preset}, the salinity used for the salinity correction (default Spreset = 0)
- rho, the potential density of water [kg/L] at zero pressure and at the potential temperature computed from PRES, TEMP and PSAL (from CTD) (UNESCO, 1983 [RD3] and Millero, 1981 [RD11])
- $PhaseCoef_0$, $PhaseCoef_1$, $PhaseCoef_2$ and $PhaseCoef_3$ coefficients provided in the optode calibration certificate.
- *ci* coefficients provided in the optode calibration certificate
- *mi and ni* coefficients provided in the optode calibration certificate
- A_0, A_1, A_2, A_3, A_4, A_5 are the coefficients for the computation equation (default A_0 = 2.00856, A_1 = 3.22400, A_2 = 3.99063, A_3 = 4.80299, A_4 = 9.78188e-1, A_5 = 1.71069)

Calculation output:

- DOXY in umol/kg

Equations:

$$TPHASE\_DOXY = C1PHASE\_DOXY - C2PHASE\_DOXY$$

$$Phase\_Pcorr = TPHASE\_DOXY + P_{coef1} \times PRES/1000$$

$$CalPhase = PhaseCoef_0 + PhaseCoef_1 \times Phase\_Pcorr + PhaseCoef_2 \times Phase\_Pcorr^2 + PhaseCoef_3 \times Phase\_Pcorr^3$$

$$\Delta p = c_0 \times TEMP\_DOXY^{m0} \times CalPhase^{n0} + c_1 \times TEMP\_DOXY^{m1} \times CalPhase^{n1} + \cdots + c_{27} \times TEMP\_DOXY^{m27} \times CalPhase^{n27}$$

$$AirSat(\%) = \Delta p \times \frac{100}{\left[\left(1013.25 - e^{\left[52.57 - \frac{6690.9}{TEMP\_DOXY+273.15} - 4.681 \times ln(TEMP\_DOXY+273.15)\right]}\right) \times 0.20946\right]}$$

$$MOLAR\_DOXY = C^* \times 44.614 \times AirSat/100$$

$$\ln(C^*) = A_0 + A_1 \times T_{s1} + A_2 \times T_{s1}{}^2 + A_3 \times T_{s1}{}^3 + A_4 \times T_{s1}{}^4 + A_5 \times T_{s1}{}^5$$

$$T_{s1} = ln((298.15 - TEMP\_DOXY)/(273.15 + TEMP\_DOXY))$$

$$O2_{PSAL\&PRES} = MOLAR\_DOXY \times [S_{corr}] \times [P_{corr}]$$

$$S_{corr} = A(TEMP, PSAL, S_{preset}) \times e^{\left((PSAL) \times (B0 + B1.T_{s2} + B2.T_{s2}{}^2 + B3.T_{s2}{}^3) + C_0 \times (PSAL^2)\right)}$$

$$A(TEMP, PSAL, S_{preset}) = \frac{1013.25 - pH_2O(TEMP, S_{preset})}{1013.25 - pH_2O(TEMP, PSAL)}$$

$$pH_2O(TEMP, S] = 1013.25 \times e^{\left(D_0 + D_1 \times \left(\frac{100}{TEMP+273.15}\right) + D_2 \times ln\left(\frac{TEMP+273.15}{100}\right) + D_3 \times S\right)}$$

$$T_{s2} = ln((298.15 - TEMP)/(273.15 + TEMP))$$

$$P_{corr} = 1 + \frac{(P_{coef2} \times TEMP + P_{coef3}) \times PRES}{1000}$$

$$DOXY[umol/kg] = O2_{PSAL\&PRES}/rho$$

Float sensor information	
Name	**Value**
SENSOR	OPTODE_DOXY
SENSOR_MAKER	AANDERAA
SENSOR_MODEL	AANDERAA_OPTODE_4330
SENSOR_SERIAL_NO	*Sensor serial number*

Name	Value
PARAMETER	C1PHASE_DOXY
PARAMETER_SENSOR	OPTODE_DOXY
PARAMETER_UNITS	degree
PARAMETER_ACCURACY	??
PARAMETER_RESOLUTION	??
Float calibration information	

AADI a xylem brand

CALIBRATION CERTIFICATE

Form No 770. , Jun 2008

Certificate No: 3853_1023E_40413
Batch No: 1023E

Product: O2 Sensing Foil PSt3
Calibration Date: 23 Aug 2010

Serial No: 1023

Calibration points and phase readings

Index	Temperature (°C)	Phase Reading (°)	Oxygen reference (µM)	Index	Temperature (°C)	Phase Reading (°)	Oxygen reference (µM)
0	3.235	63.147	0.00	32	39.382	33.884	85.70
1	3.229	58.878	18.96	33	39.372	25.748	179.15
2	3.231	55.875	37.91	34	39.372	22.226	257.16
3	3.237	48.935	94.76	35	6.653	62.918	0.00
4	3.231	41.229	189.56	36	6.651	58.425	17.42
5	3.233	32.081	396.16	37	6.652	55.336	34.85
6	3.239	27.938	568.55	38	6.655	48.150	87.11
7	10.071	62.690	0.00	39	6.650	40.324	174.24
8	10.072	57.973	15.89	40	6.656	31.274	364.12
9	10.072	54.798	31.78	41	6.658	27.164	522.63
10	10.073	47.366	79.46	42	14.974	62.331	0.00
11	10.069	39.420	158.93	43	14.982	57.348	14.30
12	10.079	30.467	332.09	44	14.979	54.028	28.59
13	10.077	26.389	476.70	45	14.980	46.388	71.48
14	19.878	61.973	0.00	46	14.983	38.401	142.96
15	19.891	56.723	12.70	47	14.986	29.569	298.74
16	19.885	53.258	25.40	48	14.986	25.584	428.83
17	19.888	45.410	63.50	49	24.774	61.602	0.00
18	19.896	37.381	126.98	50	24.779	56.071	11.54
19	19.893	28.671	265.40	51	24.779	52.471	23.08
20	19.895	24.780	380.95	52	24.781	44.482	57.71
21	29.669	61.232	0.00	53	24.781	36.457	115.42
22	29.668	55.420	10.38	54	24.781	27.882	241.22
23	29.673	51.684	20.77	55	24.778	24.088	346.27
24	29.675	43.554	51.92	56	34.531	60.691	0.00
25	29.666	35.533	103.85	57	34.529	54.718	9.48
26	29.669	27.092	217.04	58	34.528	50.887	18.95
27	29.661	23.396	311.59	59	34.526	42.675	47.39
28	39.393	60.151	0.00	60	34.524	34.709	94.78
29	39.390	54.017	8.57	61	34.521	26.420	198.09
30	39.383	50.091	17.14	62	34.517	22.811	284.37
31	39.377	41.797	42.86	63			

AANDERAA DATA INSTRUMENTS AS

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CALIBRATION CERTIFICATE

Page 2 of 2

Giving these coefficients

Index	FoilCoefA	FoilCoefB
0	-3.604788E-06	-7.934825E-07
1	-6.843659E-06	3.792412E+03
2	1.839203E-03	-4.935136E+01
3	-1.984442E-01	6.335210E-01
4	8.121225E-04	-1.085494E-02
5	-1.220733E-06	1.218953E-04
6	1.086894E+01	-7.344973E-07
7	-7.093984E-02	0.000000E+00
8	2.810467E-04	0.000000E+00
9	-1.328850E-06	0.000000E+00
10	-3.093750E+02	0.000000E+00
11	2.923687E+00	0.000000E+00
12	-2.222011E-02	0.000000E+00
13	2.146338E-04	0.000000E+00

Using the following monomial degrees

Index	FoilPolyDegT	FoilPolyDegO
0	1	4
1	0	5
2	0	4
3	0	3
4	1	3
5	2	3
6	0	2
7	1	2
8	2	2
9	3	2
10	0	1
11	1	1
12	2	1
13	3	1
14	4	1
15	0	0
16	1	0
17	2	0
18	3	0
19	4	0
20	5	0
21	0	0
22	0	0
23	0	0
24	0	0
25	0	0
26	0	0
27	0	0

Date: 23 Aug 2010

Sign: Tor-Ove Kvalvaag

Tor-Ove Kvalvaag, Calibration Engineer

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12.1.2.2 Method 2: Standard calibration followed by two point adjustment

AADI a xylem brand

TEST & SPECIFICATIONS

Form No. 712, July 2008

Layout No:
Circuit Diagram No:
Program Version: V4.5.6

Product: Oxygen Optode 4330
Serial No: 1334

Visual and Mechanical Checks:

1.1 Soldering quality
1.2 Visual surface
1.3 Galvanic isolation between housing and electronics

Current Drain and Voltages:

2.1	Average current drain at 0.5 Hz sampling (Max.: 33 mA)	22.9	mA
2.2	CANBus Current drain at 0.5 Hz sampling (Max.: 33 mA)	22.0	mA
2.3	Current drain in sleep (Max.: 180 µA)	130	µA
2.4	CANBus Current drain in sleep (Max.: 180 µA)	115	µA
2.5	DSP IO voltage, J4.18 (3.3 ±0.15V)	3.29	V
2.6	DSP Core voltage, J4.17(1.8 ±0.05 V)	1.81	V
2.7	Excitation driver voltage, C4 Analog Board (4.5 ±0.15 V)	4.60	V

Performance test:	**Channel:**	**BLUE**		**RED**	
3.1 Average of Receiver readings (0±150mV)		-5.5	mV	-2.4	mV
3.2 Standard Deviation of Receiver readings (Max.: 45mV/10mV)		9.66	mV	4.07	mV
3.3 Amplitude measurement with non- fluorescence foil (<60mV/650-1200mV)		13.2	mV	943	mV
3.4 Amplitude measurement with fluorescence foil (700-1200mV)		821.5	mV	916.4	mV
3.5 CANBus Output test					

Function test at 0°C Temperature (in air with reference foil):	**Channel:**	**BLUE**		**RED**	
4.1 Amplitude measurement (Blue: 150 – 500mV,Red 650-1800mV)		438.8	mV	1359.8	mV
4.2 Phase measurement (Blue: 4 ±2°,Red: 4 ±2°)		6.1	°	6.0	°
4.3 Standard deviation of Phase measurement (Max: 0.02°)		0.014	°	0.009	°
4.4 Raw data temperature measurement: (600 ±200mV)				605.1	mV

Function test at 20°C Temperature (in air with reference foil):	**Channel:**	**BLUE**		**RED**	
5.1 Amplitude measurement (Blue: 100 – 300mV,Red 650-1800mV)		428.1	mV	1004.1	mV
5.2 Phase measurement (Blue: 5 ±2°,Red: 5 ±2°)		6.7	°	6.5	°
5.3 Standard deviation of Phase measurement (Max: 0.02°)		0.021	°	0.013	°
5.4 Raw data Temperature measurement: (0 ±200mV)				-112.2	mV

Function test at 40°C Temperature (in air with reference foil):	**Channel:**	**BLUE**		**RED**	
6.1 Amplitude measurement (Blue: 150 – 500mV,Red 650-1800mV)		403.7	mV	845.5	mV
6.2 Phase measurement (Blue: 5 ±2°,Red: 5 ±2°)		7.4	°	7.2	°
6.3 Standard deviation of Phase measurement (Max: 0.02°)		0.012	°	0.007	°
6.4 Raw data Temperature measurement: (-400 ±200mV)				-485.8	mV

Pressure test :

7.1 Pressure (IW version: 20MPa, DW version 60MPa) .... MPa

Date: 12 Mar 2013

Sign: Jan Øyvind Trellevik

Jan Øyvind Trellevik,
Production Engineer

CALIBRATION CERTIFICATE

AADI a xylem brand

Form No. 710, Dec 2005

Sensing Foil Batch No: 1206
Certificate No:

Product: Oxygen Optode 4330
Serial No: 1334
Calibration Date: 06 Mar 2013

This is to certify that this product has been calibrated using the following instruments:

Parameter: Internal Temperature:

Calibration points and readings:

Temperature (°C)	1.04	11.92	23.91	35.84
Reading (mV)	663.83	312.66	-82.41	-441.40

Giving these coefficients

Index	0	1	2	3	4	5
TempCoef	2.13622E01	-3.07016E-02	2.90114E-06	-4.18443E-09	0.00000E00	0.00000E00

Parameter: Oxygen:

	O2 Concentration	Air Saturation
Range:	0-500 µM [1]	0 - 120%
Accuracy[1]:	< ±8µM or ±5% (whichever is greater)	±5%
Resolution:	< 1 µM	< 0.4%
Settling Time (63%):	< 25 seconds	

Calibration points and readings[2]:

	Air Saturated Water	Zero Solution (Na_2SO_3)
Phase reading (°)	3.14690E+01	6.25211E+01
Temperature reading (°C)	9.89363E+00	2.09254E+01
Air Pressure (hPa)	9.88609E+02	

Giving these coefficients

Index	0	1	2	3
PhaseCoef	0.00000E00	1.00000E00	0.00000E00	0.00000E00
ConcCoef	3.29041E-01	1.02862E00		

[1] *Valid for 0 to 2000m (6562ft) depth, salinity 33 - 37ppt*
[2] *The calibration is performed in fresh water and the salinity setting is set to:* 0

Date: 07 Mar 2013

Sign:

Tor-Ove Kvalvaag, Calibration Engineer

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CALIBRATION CERTIFICATE

AADI a xylem brand

Form No 770, Jun 2008

Certificate No: 3853_1206E_41134
Batch No: 1206E
Product: O2 Sensing Foil PSt3
Calibration Date: 13 Aug 2012
Serial No: 1206

Calibration points and phase readings

Index	Temperature (°C)	Phase Reading (°)	Oxygen reference (µM)	Index	Temperature (°C)	Phase Reading (°)	Oxygen reference (µM)
0	3.088	63.586	0.00	32	39.178	34.676	86.08
1	3.087	59.547	19.04	33	39.178	26.472	179.90
2	3.091	56.583	38.07	34	39.173	22.918	258.25
3	3.091	50.047	95.17	35	6.512	63.396	0.00
4	3.088	42.297	190.35	36	6.512	59.118	17.49
5	3.088	33.166	397.83	37	6.514	56.071	34.98
6	3.087	28.868	571.06	38	6.513	49.146	87.46
7	9.936	63.206	0.00	39	6.513	41.334	174.92
8	9.937	58.688	15.95	40	6.515	32.286	365.56
9	9.937	55.558	31.90	41	6.514	28.070	524.73
10	9.936	48.245	79.75	42	14.845	62.851	0.00
11	9.937	40.371	159.49	43	14.846	58.053	14.34
12	9.941	31.406	333.29	44	14.847	54.780	28.69
13	9.941	27.271	478.41	45	14.846	47.231	71.72
14	19.753	62.495	0.00	46	14.845	39.292	143.45
15	19.756	57.418	12.74	47	14.849	30.439	299.78
16	19.757	54.002	25.48	48	14.851	26.415	430.28
17	19.755	46.217	63.70	49	24.657	62.056	0.00
18	19.753	38.213	127.40	50	24.641	56.776	11.58
19	19.756	29.471	266.26	51	24.639	53.228	23.16
20	19.761	25.559	382.15	52	24.642	45.285	57.89
21	29.560	61.617	0.00	53	24.640	37.283	115.79
22	29.526	56.133	10.42	54	24.641	28.666	241.99
23	29.521	52.454	20.84	55	24.643	24.833	347.33
24	29.528	44.354	52.08	56	34.379	61.214	0.00
25	29.527	36.353	104.17	57	34.356	55.482	9.51
26	29.526	27.861	217.71	58	34.354	51.696	19.02
27	29.525	24.107	312.51	59	34.355	43.480	47.56
28	39.198	60.811	0.00	60	34.353	35.515	95.12
29	39.186	54.832	8.61	61	34.352	27.167	198.81
30	39.186	50.938	17.21	62	34.349	23.513	285.38
31	39.182	42.606	43.03	63			

AANDERAA DATA INSTRUMENTS AS

5851 BERGEN, NORWAY Tel. +47 55 60 48 00 Fax. +47 55 60 48 01 E-mail: info@aadi.no Web: http://www.aadi.no

AADI a xylem brand

CALIBRATION CERTIFICATE

Giving these coefficients

Index	FoilCoefA	FoilCoefB
0	-2.988314E-06	-3.560390E-07
1	-6.137785E-06	3.816713E+03
2	1.684659E-03	-4.475507E+01
3	-1.857173E-01	4.386164E-01
4	6.784399E-04	-7.146342E-03
5	-5.597908E-07	8.906236E-05
6	1.040158E+01	-6.343012E-07
7	-5.986907E-02	0.000000E+00
8	1.360425E-04	0.000000E+00
9	-4.776977E-07	0.000000E+00
10	-3.032937E+02	0.000000E+00
11	2.530496E+00	0.000000E+00
12	-1.267045E-02	0.000000E+00
13	1.040454E-04	0.000000E+00

Using the following monomial degrees

Index	FoilPolyDegT	FoilPolyDegO
0	1	4
1	0	5
2	0	4
3	0	3
4	1	3
5	2	3
6	0	2
7	1	2
8	2	2
9	3	2
10	0	1
11	1	1
12	2	1
13	3	1
14	4	1
15	0	0
16	1	0
17	2	0
18	3	0
19	4	0
20	5	0
21	0	0
22	0	0
23	0	0
24	0	0
25	0	0
26	0	0
27	0	0

Date: 13 Aug 2012

Sign: Tor-Ove Kvalvaag

Tor-Ove Kvalvaag, Calibration Engineer

AANDERAA DATA INSTRUMENTS AS

5851 BERGEN, NORWAY Tel. +47 55 60 48 00 Fax. +47 55 60 48 01 E-mail: info@aadi.no Web: http://www.aadi.no

12.1.2.3 Method 3: Stern-Volmer

AADI
a xylem brand

CALIBRATION CERTIFICATE

Form No. 830, January 2012
Page 1 of 2

Certificate No: 4330_1083_41102 **Product:** 4330 **Serial No:** 1083
Calibration Date: 12.07.2012

Calibration data

Index	Temperature Reference (°C)	$[O_2]$ Reference (µM)	Phase Reading (°)	Temperature Raw Data (mV)
0	30.363	0.52	60.888	-83.70
1	19.912	0.67	62.197	251.40
2	9.670	1.50	62.974	578.87
3	0.581	3.28	63.570	846.20
4	0.836	24.12	60.110	839.17
5	0.952	46.99	56.818	835.95
6	1.001	68.78	54.091	834.57
7	1.027	108.19	49.937	833.84
8	1.038	152.35	46.182	833.52
9	1.044	229.64	41.171	833.40
10	1.044	330.46	36.531	833.40
11	1.041	431.05	33.211	833.43
12	1.039	552.07	30.259	833.50
13	10.260	17.72	59.017	560.55
14	10.205	33.13	55.923	562.23
15	10.181	51.19	52.803	563.00
16	10.187	85.41	47.971	562.81
17	10.186	117.92	44.359	562.86
18	10.170	176.69	39.433	563.35
19	10.157	268.46	34.210	563.72
20	10.145	341.50	31.339	564.12
21	10.137	440.37	28.478	564.39
22	19.983	11.13	58.386	249.12
23	19.940	25.65	54.384	250.51
24	19.905	41.53	50.765	251.64
25	19.888	67.28	46.079	252.19
26	19.882	94.14	42.293	252.40
27	19.880	146.13	36.971	252.50
28	19.883	212.76	32.438	252.39
29	19.887	285.32	29.102	252.20
30	19.892	356.66	26.767	252.09
31	30.298	7.17	57.834	-81.68
32	30.302	20.94	52.761	-81.80
33	30.301	32.57	49.315	-81.78
34	30.297	53.44	44.419	-81.62
35	30.290	75.07	40.571	-81.40
36	30.285	115.72	35.391	-81.28
37	30.280	172.12	30.753	-81.10
38	30.276	231.58	27.565	-80.99
39	30.271	296.01	25.176	-80.80

Calibration Coefficients

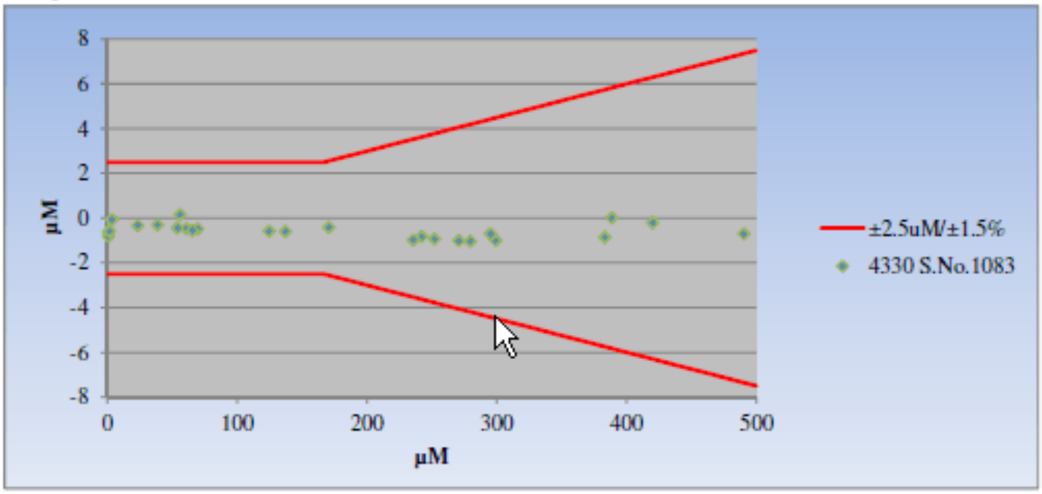
Index	SVUFoilCoef	TempCoef
0	3.38145E-03	2.76984E+01
1	1.40607E-04	-3.15241E-02
2	2.45409E-06	3.39381E-06
3	2.32730E+02	-4.73523E-09
4	-4.67903E-01	0.00000E+00
5	-5.85937E+01	0.00000E+00
6	4.53826E+00	

CALIBRATION CERTIFICATE

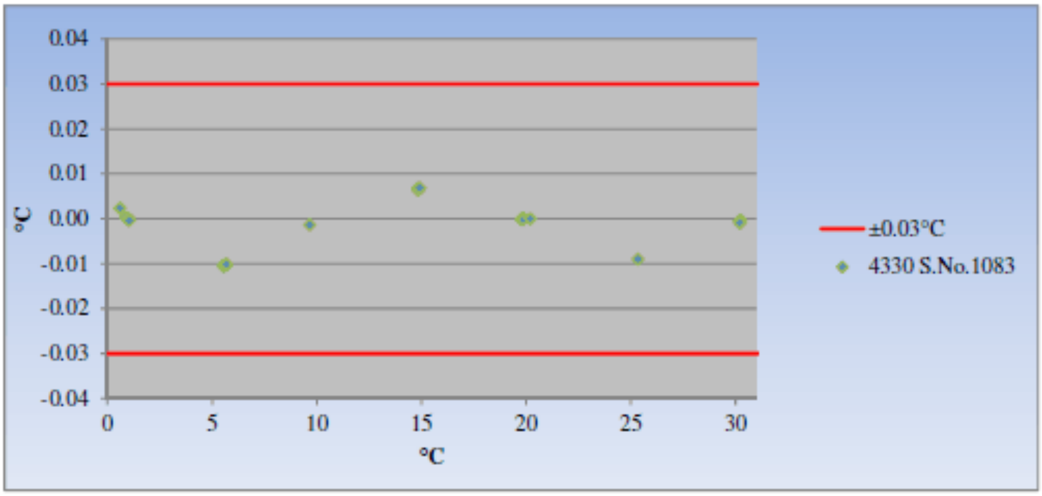
Form No. 830, January 2012
Page 2 of 2

Certificate No: 4330_1083_41102 **Product:** 4330 **Serial No:** 1083
Calibration Date: 12.07.2012

Oxygen Validation



Temperature Validation



Date: October 30, 2012

Sign:

Jostein Hovdenes
Product Development Manager

12.1.2.4 Method 4: Stern-Volmer calibration followed by two point adjustment

12.2 Seabird sensors

12.2.1 SBE43 sensor

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0122
CALIBRATION DATE: 30-Aug-05p

SBE 43I OXYGEN CALIBRATION DATA

COEFFICIENTS

Soc = 4.5887e-005 (DI)
Foffset = -3246.38

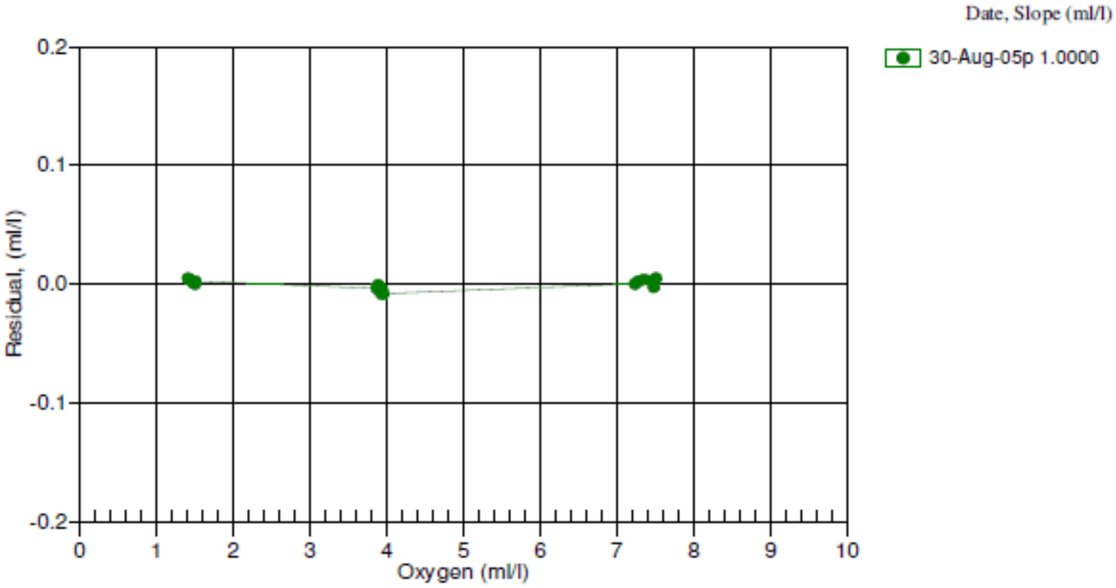
A = -2.5015e-003
B = 2.3999e-004
C = -3.8096e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS

D1 = 1.92634e-4 H1 = -3.30000e-2
D2 = -4.64803e-2 H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(Hz)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.41	6.00	0.00	6816.20	1.42	0.00
1.43	2.00	0.00	6481.96	1.43	0.00
1.44	12.00	0.00	7418.88	1.44	0.00
1.48	30.00	0.00	9124.59	1.48	0.00
1.51	26.00	0.00	8854.54	1.51	-0.00
1.51	20.00	0.00	8336.45	1.51	0.00
3.87	30.00	0.00	18583.38	3.86	-0.00
3.89	26.00	0.00	17729.65	3.89	-0.00
3.90	12.00	0.00	14530.04	3.90	-0.00
3.93	6.00	0.00	13135.59	3.92	-0.01
3.94	20.00	0.00	16514.93	3.93	-0.00
3.95	2.00	0.00	12169.12	3.95	-0.01
7.24	30.00	0.00	31964.24	7.24	0.00
7.27	6.00	0.00	21583.33	7.28	0.00
7.35	2.00	0.00	19876.48	7.35	0.00
7.48	12.00	0.00	24916.59	7.48	0.00
7.48	20.00	0.00	28471.71	7.48	-0.00
7.51	26.00	0.00	31229.92	7.51	0.00

Oxygen (ml/l) = Soc * (F + Foffset) * $(1.0 + A * T + B * T^2 + C * T^3)$ * OxSol(T,S) * exp(E * P / K)
F = frequency output from SBE43I, T = temperature [deg C], S = salinity [PSU], K = temperature [deg K]
OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar]
Residual = instrument oxygen - bath oxygen



12.2.2 SBE63 sensor

12.2.2.1 Oxygen sensor

Sea-Bird Electronics, Inc.
13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0242
CALIBRATION DATE: 14-Sep-12

SBE 63 OXYGEN CALIBRATION DATA

COEFFICIENTS

A0 = 1.0513e+000	B0 = -2.4323e-001	C0 = 1.0912e-001	E = 1.1000e-002
A1 = -1.5000e-003	B1 = 1.6036e+000	C1 = 4.6500e-003	
A2 = 3.7483e-001		C2 = 6.2813e-005	

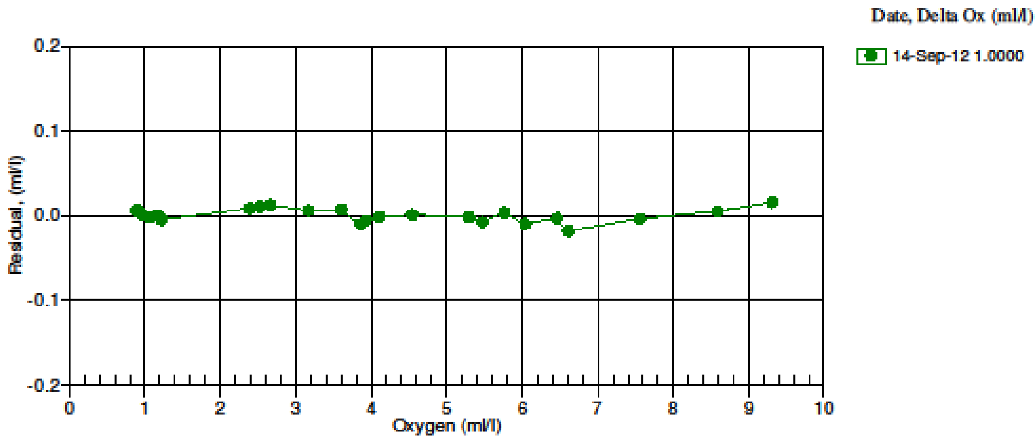
BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(U)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
0.888	30.00	0.00	29.48	0.895	0.007
0.921	26.00	0.00	30.19	0.925	0.004
0.970	20.00	0.00	31.34	0.971	0.001
1.063	12.00	0.00	32.84	1.061	-0.002
1.169	6.00	0.00	33.89	1.170	0.000
1.223	2.00	0.00	34.78	1.219	-0.005
2.387	30.00	0.00	21.94	2.395	0.008
2.528	26.00	0.00	22.48	2.539	0.011
2.664	20.00	0.00	23.68	2.676	0.013
3.167	12.00	0.00	24.69	3.174	0.006
3.603	6.00	0.00	25.64	3.610	0.007
3.855	30.00	0.00	18.29	3.845	-0.010
3.924	2.00	0.00	26.41	3.918	-0.006
4.107	26.00	0.00	18.72	4.105	-0.002
4.542	20.00	0.00	19.45	4.543	0.001
5.288	12.00	0.00	20.53	5.287	-0.002
5.471	26.00	0.00	16.65	5.464	-0.008
5.761	30.00	0.00	15.47	5.764	0.003
6.036	6.00	0.00	21.40	6.026	-0.010
6.454	20.00	0.00	16.86	6.450	-0.003
6.608	2.00	0.00	22.08	6.590	-0.018
7.555	12.00	0.00	17.78	7.551	-0.004
8.582	6.00	0.00	18.60	8.588	0.005
9.309	2.01	0.00	19.27	9.324	0.015

$V = U / 39.457071$

$\text{Oxygen (ml/l)} = \{((A0 + A1*T + A2 * V^2)/(B0 + B1 * V) - 1.0)/(C0 + C1 * T + C2 * T^2)\} * \exp(E * P / K)$

T = temperature [deg C], K = temperature [Kelvin], P = pressure [dbar]

Residual = instrument oxygen - bath oxygen



12.2.2.2 Temperature sensor

Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0242 SBE 63 OXYGEN CALIBRATION DATA
CALIBRATION DATE: 14-Sep-12

COEFFICIENTS

TA0 = 6.711077e-004 TA2 = 8.228029e-007
TA1 = 2.480232e-004 TA3 = 9.213712e-008

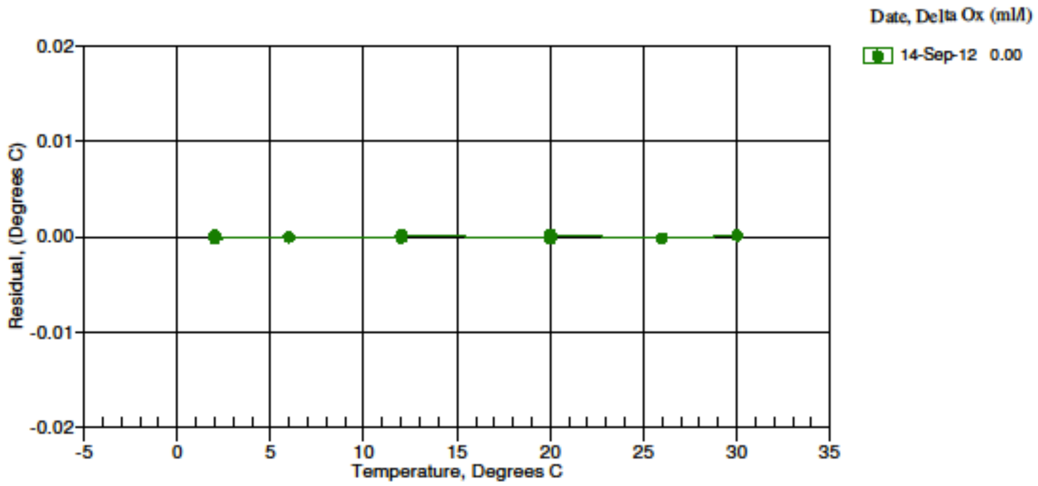
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
2.0000	1.26912	2.0001	0.00014
2.0000	1.26912	2.0001	0.00014
2.0001	1.26912	2.0001	0.00004
2.0108	1.26876	2.0106	-0.00020
6.0000	1.13620	5.9999	-0.00005
6.0000	1.13620	5.9999	-0.00005
6.0000	1.13620	5.9999	-0.00005
6.0000	1.13620	5.9999	-0.00005
11.9999	0.95559	11.9999	-0.00001
11.9999	0.95559	11.9999	-0.00001
12.0000	0.95559	11.9999	-0.00011
12.0001	0.95558	12.0003	0.00015
19.9999	0.75137	20.0002	0.00026
19.9999	0.75138	19.9997	-0.00018
20.0000	0.75137	20.0002	0.00016
20.0000	0.75137	20.0002	0.00016
26.0000	0.62467	25.9999	-0.00015
26.0000	0.62467	25.9999	-0.00015
26.0000	0.62467	25.9999	-0.00015
26.0000	0.62467	25.9999	-0.00015
30.0000	0.55173	30.0001	0.00009
30.0000	0.55173	30.0001	0.00009
30.0000	0.55173	30.0001	0.00009

Temperature ITS-90 = $1 / (TA0 + TA1 * L + TA2 * L^2 + TA3 * L^3) - 273.15$ (°C)

$L = \ln(100000 * V / (3.3 - V))$

V = thermistor voltage

Residual = instrument temperature - bath temperature



12.3 JAC sensors

12.3.1 ARO_FT sensor

12.3.1.1 Oxygen sensor

12.3.1.2 Temperature sensor