OCEAN OBSERVATORIES INITIATIVE

DATA PRODUCT SPECIFICATION FOR VENT FLUID OXIDATION-REDUCTION POTENTIAL (ORP)

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Document Control Sheet

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Signature Page

This document has been reviewed and approved for release to Configuration Management.

OOI Chief Systems Engineer: ______________________________

Date: 2012-03-06

This document has been reviewed and meets the needs of the OOI Cyberinfrastructure for the purpose of coding and implementation.

OOI CI Signing Authority: ______________________________

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Table of Contents

1 Abstract

This document describes the computation used to calculate the OOI Level 1 Vent Fluid Oxidation-Reduction Potential (ORP), the ORP (oxidation-reduction potential) for a Pt-Ag/AgCl electrode pair measured by the Resistivity-Temperature Probe Instrument (TRHPH) placed in a high temperature hydrothermal vent. This data product is simple conversion from the instrument units of volts to the common ORP units of mV, and a scaling and offset to correct for instrument electronics. The primary intended use of this document is for OOI programmers to construct appropriate processes to create the L1 Vent Fluid Oxidation-Reduction Potential (ORP) data product.

2 Introduction

2.1 Author Contact Information

Please contact Giora Proskurowski (giora@uw.edu) or the Data Product Specification lead (DPS@lists.oceanobservatories.org) for more information concerning the computation and other items in this document.

2.2 Metadata Information

2.2.1 Data Product Name

The OOI Core Data Product Name for this product is

- TRHPHEH

The OOI Core Data Product Descriptive Name for this product is

- Vent Fluid Oxidation-Reduction Potential (ORP)

2.2.2 Data Product Abstract (for Metadata)

The OOI Level 1 Vent Fluid Oxidation-Reduction Potential (ORP) core data product is computed using a simple unit conversion from volts (V) to millivolts (mV), and an offset and scaling to correct for instrument electronics. Because of the large fluctuations in temperature, and an unknown relationship between ORP and high-temperature, it is critical to note that ***the ORP values measured by this instrument cannot be directly compared with other standard or in-situ ORP measurements made with a Pt-Ag/AgCl electrode pair***. One of the most functional and appropriate uses of this measurement is to quantify the change in ORP with respect to time, e.g., dORP/dt.

2.2.3 Computation Name

- Vent Fluid Oxidation-Reduction Potential (ORP) Algorithm

2.2.4 Computation Abstract (for Metadata)

This computation computes the OOI Level 1 Vent Fluid Oxidation-Reduction Potential (ORP) core data product, which is calculated by converting instrument units of volts to millivolts, and subsequently adjusting this value by introducing an offset and scaling to correct for instrument electronics.

2.2.5 Instrument-Specific Metadata

See Section 4.4 for instrument-specific metadata fields that must be part of the output data.

2.2.6 Data Product Synonyms

Synonyms for this data product are

- Redox potential

- Oxidation-reduction potential
- Reduction potential

2.2.7 Similar Data Products

- Eh

2.3 Instruments

For information on the instruments from which the L1 Vent Fluid Oxidation-Reduction Potential (ORP) core data product inputs are obtained, see the TRHPH Processing Flow document (DCN 1342-00150), which describes the flow of data from the TRHPH through all of the relevant QC, calibration, and data product computations and procedures.

Please see the Instrument Application in the OOI Software Application Framework (SAF) for specifics of instrument locations and platforms.

2.4 Literature and Reference Documents

C. R. German et al., Hydrothermal exploration with the Autonomous Benthic Explorer. Deep Sea Research Part I: Oceanographic Research Papers **55**, 203-219 (2008).
(see DPS Artifacts >> TRHPHEH_German_2008.pdf)

2.5 Terminology

2.5.1 Definitions

ORP: **Oxidation-Reduction Potential** is a measure of the tendency for a solution to be reduced (accept electrons). ORP is measured by monitoring the potential between two electrodes, in this case Pt and Ag/AgCl electrodes. The more positive the ORP value, the greater the affinity to accept electrons, that is, the more chemically oxidizing the solution is.

Eh: Eh is ORP when referenced to a Standard Hydrogen Electrode (SHE). As the reference electrode used by the Temperature Resistivity Probe is not a SHE, technically the data product is not Eh, rather the more generic ORP (Pt-Ag/AgCl).

2.5.2 Acronyms, Abbreviations and Notations

General OOI acronyms, abbreviations and notations are contained in the Level 2 Reference Module in the OOI requirements database maintained on a Dynamic Object Oriented Requirements System tool (DOORS). The following acronyms and abbreviations are defined here for use throughout this document.

N/A

2.5.3 Variables and Symbols

The following variables and symbols are defined here for use throughout this document.

ORP	oxidation-reduction potential (mV)
ORP_V	Raw ORP (V)
gain	Scale factor to correct for electronics gain
offset	Offset to correct for linear offset introduced in electronics

3 Theory

3.1 Description

Typically ORP is presented in units of millivolts, the sensor outputs ORP in units of volts. This is a simple unit conversion equation. The A/D board electronics (Onset Tattletale 8) used in the TRHPH adds an offset and a gain to the measurement during digitization, which is corrected here.

3.2 Mathematical Theory

The following formula is used to calculate the L1 Vent Fluid Oxidation-Reduction Potential (ORP) data product, ORP:

ORP = ((ORP_V*1000) - offset)/gain

3.3 Known Theoretical Limitations

The equation for converting ORP to millivolts is only valid over the input range 0 < ORP_V < 4. A global range check on ORP_V is called out in the TRHPH Data Processing Flow (DCN 1342-00150).

3.4 Revision History

No revisions to date.

4 Implementation

4.1 Overview

This is a simple unit conversion equation, from volts to millivolts, followed by a simple offset and scaling.

4.2 Inputs

- L0 ORP Volts (ORP_V, ORP voltage, word 7, 7-digit identifier TRHPHVO)
- offset from instrument calibration metadata
- gain from instrument calibration metadata

Inputs are five character, fixed width, floating point numbers, %5.3f. “Offset” and “gain” will be provided to CI when instrument is calibrated. For initial tests, assume offset = 2008 and gain = 4.00.

Input Data Formats:
Instrument provides a single line of ASCII text data with X “words”. ORP_V is word 7. Input ORP_V is a fixed width five-character number, including the decimal point, floating point value (%5.3f).

Example TRHPH Raw Data Output Line (with exact formatting)

0.135 0.681 3.426 0.000 0.021 0.079 0.911 1.929 2.40 1.318 325.3 9.2
Input ORP_V is highlighted in red.

4.3 Processing Flow

The specific steps necessary to create all calibrated and quality controlled data products for each OOI core instrument are described in the instrument-specific Data Processing Flow documents

(DCN 1342-00150 for TRHPH). These processing flow documents contain flow diagrams detailing all of the specific procedures (data product and QC) necessary to compute all levels of data products from the instrument and the order in which these procedures are executed.

The processing flow for the ORP computation is as follows (in Matlab syntax):

Step 1:
ORP = ((ORP_V*1000) – offset)/gain

4.4 Outputs

The outputs of the Vent Fluid Oxidation-Reduction Potential (ORP) Algorithm are

- ORP, mV, 4-character floating point number, %4.0f (OOI Level 1 Data Product TRHPHEH).

There is no metadata that must be included with the output.

See Appendix B for a discussion of the accuracy of the output.

4.5 Computational and Numerical Considerations

4.5.1 Numerical Programming Considerations

There are no numerical programming considerations for this computation. No special numerical methods are used.

4.5.2 Computational Requirements

- One TRHPH probe, sample rate of 1 sample every 12 seconds.

4.6 Code Verification and Test Data Set

The code will be verified using the test data set provided, which contains inputs and their associated correct outputs. CI will verify that the code is correct by checking that the output generated using the test data inputs, is identical to the test data ORP output. Inputs to Vent Fluid Oxidation-Reduction Potential (ORP) product, ORP_V is highlighted in red.

Example TRHPH Raw Data Output

V_R1	V_R2	V_R3				ORP_V	V_s	T_s	V_c	T_u	
0.906	4.095	4.095	0.000	0.019	0.076	1.806	1.506	12.01	0.000	12.0	9.2
0.890	4.095	4.095	0.000	0.021	0.077	1.541	1.479	12.67	0.015	16.3	9.2
0.891	4.095	4.095	0.000	0.021	0.079	1.810	1.926	2.47	0.001	2.7	9.2
0.184	0.915	4.064	0.000	0.022	0.074	0.735	1.932	2.34	0.274	69.5	9.2
0.198	1.002	4.095	0.000	0.020	0.075	0.745	1.927	2.45	0.306	77.4	9.2
0.172	0.857	4.082	0.000	0.022	0.073	0.715	1.930	2.38	0.393	98.7	9.2
0.183	0.926	4.076	0.000	0.020	0.079	0.775	1.929	2.40	0.383	96.2	9.2
0.233	1.182	4.072	0.000	0.021	0.075	0.799	1.930	2.38	0.388	97.4	9.2
0.146	0.747	3.634	0.000	0.018	0.078	0.757	1.930	2.38	0.469	117.3	9.2
0.134	0.681	3.405	0.000	0.021	0.078	0.542	1.931	2.36	1.077	266.2	9.2
0.131	0.673	3.293	0.000	0.021	0.078	0.831	1.926	2.47	1.288	318.0	9.2
0.133	0.678	3.396	0.000	0.019	0.077	0.867	1.926	2.47	1.305	322.2	9.2
0.135	0.681	3.409	0.000	0.021	0.079	0.911	1.928	2.43	1.319	325.5	9.2
0.135	0.681	3.426	0.000	0.021	0.079	0.911	1.929	2.40	1.318	325.3	9.2

The test data set below provides the results of the ORP calculation for the above example data set, assuming gain = 4.00 and offset = 2008.

Input	Output
ORP_V	ORP
[V]	[mV]
1.806	-50
1.541	-116
1.810	-49
0.735	-317
0.745	-315
0.715	-322
0.775	-307
0.799	-301
0.757	-312
0.542	-366
0.831	-293
0.867	-284
0.911	-273
0.911	-273

Appendix A Example Code

```
function [ORP] = resORP(ORP_V, offset, gain)

% This function computes ORP from raw Resistivity Probe
% measurements using of ORP using a Pt-Ag/AgCl electrode pair.  Initial
% inputs are the raw voltages for the ORP (ORP_V), offset, and gain

% For testing purposes, assume:
% offset = 2008;
% gain = 4.00;

ORP = ((ORP_V)*1000-offset)/gain ;
```

Appendix B Output Accuracy

Because of the wide temperature range, and the unqualified dependence of high-temperature on ORP, no claims are made as to the accuracy of this ORP measurement relative to other standard or in-situ measurements made with a Pt-Ag/AgCl electrode pair. One of the most functional and appropriate uses of this measurement is to quantify the change in ORP with respect to time, e.g. dORP/dt.

Accuracy Requirement in DOORS
N/A

Appendix C Sensor Calibration Effects

N/A