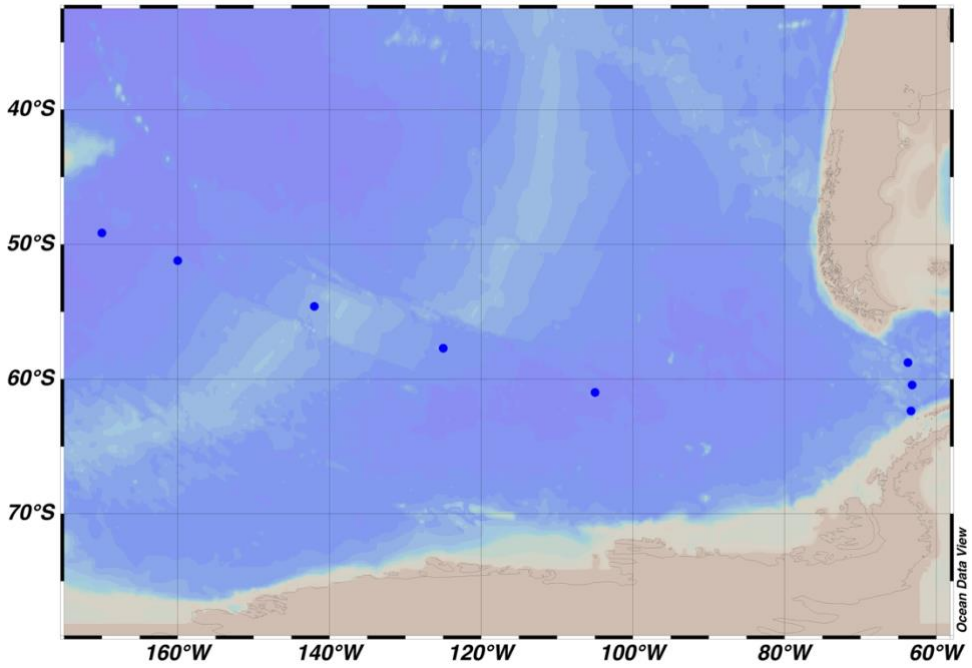
DATA REPORT: NBP2211

Created: May 2026



Highlights

Cruise Summary Information

Section Designation	NBP2211
Expedition Designation (ExpoCode)	**320620221108**
Chief Scientists	**Lynne Talley, SIO**
Dates	8 November – 9 December 2022
Ship	RVIB *Nathaniel B. Palmer*
Ports of Call	
Geographic Boundaries	49.15°S 170°W 63.12°W 62.36°S
Stations	8 in dataset
Floats and Drifters Deployed	10 SOCCOM flaots
Moorings Deployed and Recovered	0

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Report assembled by Savannah Lewis

Sarmiento

Data Report NBP2211

RVIB Nathaniel B. Palmer

November 8th, 2022 – December 9th, 2022

United States Antarctic Program

Data Report Prepared By:
Brian Bailey

Table of Contents

Introduction

The NBP data acquisition systems continuously log data from the instruments used during the cruise. This document describes:

- The structure and organization of the data on the distribution media
- The format and contents of the data strings
- Formulas for calculating values
- Information about the specific instruments in use during the cruise
- A log of acquisition problems and events during the cruise that may affect the data
- Scanned calibration sheets for the instruments in use during the cruise.

The data is distributed on a USB Drive that is formatted as NTFS. It is readable by virtually every computing platform.

All the data has been archived using 'tar' and compressed using 'gzip', identified by the '.tz' extension. Tools are available on all platforms for uncompressing and de-archiving these formats: On Macintosh use the built-in Archive Utility, or tar in the terminal. On Windows operating systems use WinZip or 7Zip.

MultiBeam and Bathymetry data, if collected, are distributed separately.

IMPORTANT: Read the last section, "Acquisition Problems and Events," for important information that may affect the processing of this data.

Distribution Contents at a Glance

Volume 1 of 1: NBP2211

File	Description
/	Root level directory
EOCmsg.txt	Log file of data distro creation
INSTCOEF.TXT	Instrument Coefficient File
NBP2211.mgd	Full Cruise MGD77 data file
NBP2211.trk	Text file of cruise track
2211DATA.docx	Data Report NBP2211 (MS Word)
2211DATA.pdf	Data Report NBP2211 (PDF format)
/ocean	Ocean data
2211ctd.tz	CTD Data
/plots	Cruise track plots
NBP2211.kml	KML formatted file of cruise track
NBP2211trk.png	PNG image of cruise track plot
/process	Processed data
2211JGOF.tz	JGOFS format data files
2211MGD.tz	MGD Data
2211PCO2.tz	Merged pCO2 data files
2211PROC.tz	Other processed data
2211QC.tz	Daily RVDAS QC postcript plots
/rvdas/nav	Navigation data
2211gyr1.tz	Gyro raw data
2211s330.tz	Seapath 330 data
2211s380.tz	Seapath 380 data
/rvdas/uw	Underway data
2211bwnc.tz	Baltic winch data
2211ctdd.tz	CTD depth data
2211eng1.tz	Engineering data
2211grv1.tz	Gravity Raw data
2211hdas.tz	HydroDAS raw data
2211knud.tz	Knudsen raw data
2211mbdp.tz	Multi-beam depth
2211mwx1.tz	Meteorology raw data
2211ndfl.tz	Fluorometer
2211oxyg.tz	Oxygen Optode data
2211pco2.tz	pCO_2 raw data
2211pguv.tz	GUV raw data
2211rtmp.tz	Remote Temperature data
2211tsg1.tz	Micro TSG1 data
2211tsg2.tz	Micro TSG2 data
2211twnc.tz	Trawl winch data

Extracting Data

The data files will have a ".tz" extension on the filename. The ".tz" extension is for files whose contents have been archived using the "tar" utility and compressed with the "gzip" utility.

An example of creating a compressed archive file:

```
tar -czvf archive_filename files_to_archive
```

An example of listing the files in an archive:

```
tar -tzvf archive_filename
```

An example redirecting the list output to a file, where `contents.list` is the name of the file to create:

```
tar -tzvf archive_filename > contents.list
```

An example extracting all files from the archive:

```
tar -xzvf archive_filename
```

An example extracting specific files from the archive:

```
tar -xzvf archive_filename list_of_files_to_extract
```

Distribution Contents

Cruise Track

The distribution media includes a cruise track file (NBP2211.trk). It contains the longitude and latitude at one-minute intervals extracted from the NBP2211.mgd file.

Satellite Images **No satellite imagery available for this cruise**

Satellite Images processed for this cruise can be found in the directory, /Imagery in two subdirectories, ice and wx (weather). Files are named using the convention, IdDDDYYA.jpg where:

Id = image type (ice = ice, wx = weather)
DDD = year-day
YY = year
A = allows for multiple images of one type for one day

NBP Data Products

Two datasets are created on each cruise: JGOFS and MGD77.

The data processing scripts used to produce JGOFS and MGD77 data sets create a lot of intermediate files. These files are included on the data distribution media in a file called 2211PROC.tz. They are included to make re-processing easier in the event of an error, but no extensive detail of the formats is included in this document. If you have any questions, please contact itvessel@usap.gov.

JGOFS

The JGOFS data set can be found on the distribution media in the file /process/NBP2211JGOF.tz. The archive contains one file produced for each day named jgDDD.dat.gz, where DDD is the year-day the data was acquired. The ".gz" extension indicates that the individual files are compressed before archiving. Each daily file consists of 22 columnar fields in text format as described in the table below. The JGOFS data set is created from calibrated data decimated at one-minute intervals. Several fields are derived measurements from more than a single raw input. For example, Course Made Good (CMG) and Speed Over Ground (SOG) are calculated from gyro and GPS inputs. Daily plots during the cruise are produced from the JGOFS data set. Note: Null, unused, or unknown fields are indicated as "NAN" as 9999 in the JGOFS data.

Field	Data	Units
01	UTC Date	dd/mm/yy
02	UTC Time	hh:mm:ss
03	Seapath Latitude (negative is South)	tt.tttt
04	Seapath Longitude (negative is West)	ggg.gggg
05	Speed Over Ground	knots
06	GPS HDOP	-
07	Gyro Heading	Degrees (azimuth)
08	Course Made Good	Degrees (azimuth)
09	Mast PAR	µEinstein's/meter2
10	Sea Surface Temperature	°C
11	Sea Surface Conductivity	siemens/meter
12	Sea Surface Salinity	PSU
13	Sea Depth (uncorrected, calc. sw soud vel. 1500 m/s)	meters
14	True Wind Speed (max speed windbird)	meters/sec
15	True Wind Direction (max speed windbird)	degrees (azimuth)
16	Ambient Air Temperature	°C
17	Relative Humidity	%
18	Barometric Pressure	mBars
19	Sea Surface Fluorometry	volts (0-5 FSO)
20	Transmissometry	%
21	PSP	W/m2
22	PIR	W/m2

MGD77

The MGD77 data set is contained in a single file for the entire cruise. It can be found in the top level of the distribution data structure as NBP2211.mgd. The file NBP2211.gmt is created from the MGD77 dataset using the “mgd77togmt” utility. NBP2211.gmt can be used with the GMT plotting package.

The data used to produce the NBP2211.mgd file can be found on the distribution media in the file /process/2211proc.tz. The data files in the archive contain a day’s data and follow the naming convention Dddd.fnl.tz, where ddd is the year-day. These files follow a space-delimited columnar format that may be more accessible for some purposes. They contain data at one-second intervals rather than one minute and are individually “gzipped” to save space. Below is a detailed description of the MGD77 data set format. The other files in the archive contain interim processing files and are included to simplify possible reprocessing of the data using the RVDAS NBP processing scripts.

All decimal points are implied. Leading zeros and blanks are equivalent. Unknown or unused fields are filled with 9’s. All “corrections”, such as time zone, diurnal magnetics, and EOTVOS, are understood to be added.

Col	Len	Type	Contents	Description, Possible Values, Notes
1	1	int	Data record type	Set to "5" for data record
2-9	8	char	Survey identifier	
10-12	3	int	Time zone correction	corrects time (in chars 13-27) to UTC when added; 0=UTC
13-16	4	int	Year	4 digit year
17-18	2	int	Month	2 digit month
19-20	2	int	Day	2 digit day
21-22	2	int	Hour	2 digit hour
23-27	5	real	Minutes x 1000	
28-35	8	real	Latitude x 100000	Positive = North, Negative = South. (-9000000 to 9000000)
36-44	9	real	Longitude x 100000	Positive = East, Negative = West. (-18000000 to 18000000)
45	1	int	Position type code	1 = Observed fix, 3 = Interpolated, 9 = Unspecified
46-51	6	real	Bathymetry, 2-way travel time	In 10,000th of seconds. Corrected for transducer depth and other such corrections.
52-57	6	real	Bathymetric, corrected depth	In tenths of meters
58-59	2	int	Bathymetric correction code	This code details the procedure used for determining the sound velocity correction to depth
60	1	int	Bathymetric type code	1 = Observed, 3 = Interpolated (Header Seq. 12), 9 = Unspecified
61-66	6	real	Magnetics total field, 1st sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2nd sensor	In tenths of nanoteslas (gammas), for trailing sensor
73-78	6	real	Magnetics residual field	In tenths of nanoteslas (gammas). The reference field used is in Header Seq. 13
79	1	int	Sensor for residual field	1 = 1st or leading sensor, 2 = 2nd or trailing sensor, 9 = Unspecified
80-84	5	real	Magnetics diurnal correction	In tenths of nanoteslas (gammas). (In nanoteslas) if 9-filled (i.e., set to "+9999"), total and residual fields are assumed to be uncorrected; if used, total and residual are assumed to have been already corrected.
85-90	6	F6.0	Depth or altitude of magnetics sensor	(In meters). Positive = Below sea level, 3 = Above sea level
91-97	7	real	Observed gravity	In 10th of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In 10th of mgals. E=7.5 V cos phi sin alpha + 0.0042 V*V
104-108	5	real	Free-air anomaly	In 10th of mgals, G = observed, G = theoretical
109-113	5	char	Seismic line number	Cross reference for seismic data
114-119	6	char	Seismic shot-point number	
120	1	int	Quality code for navigation	5 = Suspected, by the originating institution 6 = Suspected, by the data center 9 = No identifiable problem found

Science of Opportunity

ADCP

The shipboard ADCP system measures currents in a depth range from about 30 to 300 m -- in good weather. In bad weather or in ice, the range is reduced, and sometimes no valid measurements are made. ADCP data collection is the OPP-funded project of Eric Firing (University of Hawaii) and Teri Chereskin (Scripps Institution of Oceanography). Data is collected on both the LMG and the NBP for the benefit of scientists on individual cruises, and for the long-term goal of building a profile of current structure in the Southern Ocean.

pCO_2

The NBP carries a pCO2 measurement system from Lamont-Doherty Earth Observatory (LDEO). pCO2 data is recorded by RVDAS and transmitted to LDEO at the end of each cruise. You will find pCO2 data in a file named 2211PCO2.tz in the /process directory, which contains the pCO2 instrument's data merged with GPS, meteorological and other oceanographic measurements. For more information contact Colm Sweeney (csweeney@ldeo.columbia.edu).

Cruise Science

CTD

The CTD data has been placed in the tar file /ocean/NBP2211ctd.tz. The archive contains three folders process, raw, and sv.

XBT **No XBTs were collected on this cruise**

During a cruise, eXpendable BathyThermographs (XBTs) may have been used to obtain water column temperature profiles, providing corrections to the sound velocity profile for the multibeam system. The data files from those launches would be included as 2211xbt.tz in the /ocean directory.

RVDAS

The Research Vessel Data Acquisition System (RVDAS) was developed at Lamont-Doherty Earth Observatory of Columbia University and has been in use on its research ship for many years. It has been extensively adapted for use on the USAP research vessels.

Daily data processing of the RVDAS data is performed to calibrate and convert values into useable units and as a quality-control on operation of the DAS. Raw and processed data sets from RVDAS are included in the data distribution. The tables below provide detailed information on the sensors and data. Be sure to read the "Significant Acquisition Events" section for important information about data acquisition during this cruise.

Sensors and Instruments

RVDAS data is divided into two general categories, *underway and navigation*. They can be found on the distribution media as subdirectories under the top level rvdas directory: /rvdas/uw, and /rvdas/nav. Processed oceanographic data is in the top level directory, /process. Each instrument or sensor produces a data file named with its channel ID. Each data file is g-zipped to save space on the distribution media. Not all data types are collected every day or on every cruise.

The naming convention for data files produced by the sensors and instruments is

`NBP[CruiseID][ChannelID].dDDD`

Example: `NBP2211mwx1.d025`

- The CruiseID is the numeric name of the cruise, in this case, NBP2211.
- The ChannelID is a 4-character code representing the system being logged. An example is "mwx1," the designation for meteorology.
- DDD is the day of year the data was collected

Underway Sensors

Meteorology and Radiometry

Measurement	String ID	Collection Status	Rate	Instrument
Air Temperature	mwx1 (met)	Continuous	1/sec	Rotronic HC2A-S3 (Primary)
Air Temperature	mwx1 (met)	Continuous	1/sec	RM Young 41372LC (Secondary)
Relative Humidity	mwx1 (met)	Continuous	1/sec	Rotronic HC2A-S3 (Primary)
Relative Humidity	mwx1 (met)	Continuous	1/sec	RM Young 41372LC (Secondary)
Wind Speed / Direction	mwx1 (pus,sus)	Continuous	1/sec	Gill Instruments 1390-PK-062/114
Barometer	mwx1 (met)	Continuous	1/sec	Vaisala PTB210B
PAR	mwx1 (met)	Continuous	1/sec	Biospherical Instruments QSR-2200
PIR	mwx1 (met)	Continuous	1/sec	Eppley PIR
PSP	mwx1 (met)	Continuous	1/sec	Eppley PSP
GUV	pguv	Continuous	2/sec	Biospherical Instruments GUV-2511

Geophysics

Measurement	String ID	Collection Status	Rate	Instrument
Gravimeter	grv1	Continuous	1/sec	BGM3/210
Bathymetry	knud	Continuous	varies	Knudsen Chirp
Bathymetry	mbdp	Continuous	varies	Kongsberg EM122

Oceanography

Measurement	String ID	Collection Status	Rate	Instrument
Conductivity	tsg1,tsg2	Continuous	0.5/sec	Sea-Bird SBE 45
Ocean Surface Temperature	rtmp	Continuous	1.2/sec	Sea-Bird SBE 38
Transmissometer	hdas	Continuous	0.5/sec	WetLabs C-Star
Fluorometer	hdas	Continuous	0.5/sec	WetLabs FLRTD
pCO_2	pco2	Continuous	0.017/sec	LDEO instrumentation
Oxygen	oxyg	Continuous	6/min	Oxygen Optode Aanderaa 4835
Total Dissolved Gas Pressure	tdgp	Continuous	1/sec	Mini TDGP Pro Oceanus 0-2 BAR

Navigational Instruments

Measurement	String ID	Collection Status	Rate	Instrument
Heading, Speed, Course, GPS, Heave, Roll and Pitch	s330	Continuous	1/sec	Seapath 330 GPS
Heading, Speed, Course, GPS, Heave, Roll and Pitch	s380	Continuous	1/sec	Seapath 380 GPS
Heading	gyr1	Continuous	0.2/sec	Yokogawa Compass

Data

Data is received from the RVDAS system via RS-232 serial connections. A time tag is added at the beginning of each line of data in the form,

```
yy+dd:hh:mm:ss.sss [data stream from instrument]
```

where

yy	= two-digit year
ddd	= day of year
hh	= 2 digit hour of the day
mm	= 2 digit minute
ss.sss	= seconds

All times are reported in UTC.

The delimiters that separate fields in the raw data files are often spaces and commas but can be other characters such as : = @. Occasionally no delimiter is present. Care should be taken when reprocessing the data that the field's separations are clearly understood.

In the sections below a sample data string is shown, followed by a table that lists the data contained in the string.

Each section on the next page describes a type of data file (file name extension in parentheses) followed by a typical line of data in the file. In the table(s) for each section is a description of the fields within each line of data. Note: most data files listed below will be included with each cruise's data distribution; however some types of files may be omitted if the instrument was not operating during the cruise. The available data files can be found in the /rvdas/uw and /rvdas/nav directories on the distribution disc.

Underway Data /rvdas/uw

Meteorology (mwx1)

MET

```
15+055:20:27:24.636 MET,12.1,-39,-6.07,77.4,178.0729,0.809536,-0.1235019,268.1754,267.9648,970.7878
,-6.07,77.4
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	MET Flag		
3	Power Supply Voltage	vv.v	V
4	Enclosure Relative Humidity (not implemented)	xx.x	%
5	Air Temperature, Celsius	xx.xx	C
6	Air Relative Humidity	xx.x	%
7	PAR (Photosynthetically Available Radiation)	xxx.xxxx	mV
8	PSP (Shortwave Radiation)	x.xxxxxx	mV
9	PIR Thermopile (Longwave Radiation)	x.xxxxxx	mV
10	PIR Case Temperature	xxx.xxxx	K
11	PIR Dome Temperature	xxx.xxxx	K
12	Barometer	xxx.xxxx	mBar
13	Air Temperature, Celsius (Secondary Sensor RMYoung)	xx.xx	C
14	Air Relative Humidity (Secondary Sensor RMYoung)	xx.x	%

PUS

```
15+055:21:47:42.452 PUS,A,037,014.36,M,+325.38,-010.29,60,0F
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	PUS Flag		
3	A	x	A
4	Port Wind Relative Direction	xxx	degrees
5	Port Wind Relative Speed	xxx.xx	m/s
6	M = Meters (for previous)	x	M
7	Sound Speed	xxx.xx	m/s
8	Sonic Temperature	xxx.xx	C
9	Unit Status*	xx	numeric
10	Checksum	xx	alphanumeric

Status

00 = Good, 60 = Good. Any other value indicates fault

SUS

15+055:21:50:48.409 SUS,A,338,012.63,M,+326.15,-009.05,60,0F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	SUS Flag		
3	A	x	A
4	Starboard Wind Relative Direction	xxx	degrees
5	Starboard Wind Relative Speed	xxx.xx	m/s
6	M = Meters (for previous)	x	M
7	Sound Speed	xxx.xx	m/s
8	Sonic Temperature	xxx.xx	C
9	Unit Status*	xx	numeric
10	Checksum	xx	alphanumeric

Status

00 = Good, 60 = Good. Any other value indicates fault

Knudsen (knud)

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	3.5kHz = Low frequency in use	x.xxxx	3.5kHz
3	Low Frequency Depth	xxxx.xx	m
4	Valid Flag	x	0
5	12.0kHz = High frequency in use	xx.xxxx	12.0kHz
6	High Frequency Depth	xxxx.xx	m
7	Valid Flag	x	0
8	Sound Speed Velocity	xxxx	m/s
9	Latitude	xx.xxxxxx	degrees
10	Longitude	xx.xxxxxx	degrees

Gravimeter (grv1)

15+056:14:21:21.153 01:025268 00

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	01:	xx:	01
3	Gravity Count*	xxxxxx	Flit Count
4	Error Flag	xx	numeric

Error Flag

00 = All well, 01 = CPS malfunction, 02 = Sensor Malfunction, 03 = CPS and sensor Malfunction

A gravity tie is taken at the start of the cruise and applied throughout the cruise. There is no accounting for drift after the pre-cruise gravity time. The post cruise gravity tie is available by requesting it from ethq@usap.gov.

pCO_2 (pco2)

```
15+056:14:41:10.392 2015056.60236 2608.36 30.14 977.91 48.25 368.76 353.92 -1.18 -1.26 0.00 Equil
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	pCO_2 time tag*	yyyyddd.ttt	UTC
3	Raw Voltage (IR)	xxxx.xx	mV
4	Cell Temperature	xx.xx	C
5	Equilibration Pressure	xxx.xx	mBar
6	Flowrate	xxx.xx	cm^3/min
7	pCO_2 Pressure	xxx.xx	µAtm
8	VCO_2 Concentration	xx.xx	ppm
9	Equilibrator Temperature, RTD	xx.xx	C
10	Equilibrator Temperature, SBE38	xx.xx	C
11	Valve Position	xx	numeric
12	Flow Source*		text

pCO_2 time tag

ttt = fractional time of day

Flow Source

Equil = pCO_2 Measurement

Micro TSG (tsg1, tsg2)

```
15+056:15:06:06.644  -1.1809,  2.73404,  34.0574, 1442.367
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Temperature	xx.xxxx	C
3	Conductivity	xx.xxxx	s/m
4	Salinity	xx.xxxx	PSU
5	Sound Velocity	xxxx.xxx	m/s

Total Dissolved Gas Pressure (tdgp) No data collected on this cruise due to problems with the instrument

```
21+324:23:59:52.063 P 2021,11,20,23,59,14,6.85,1008.85,12.0
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Start of data line	x	P
3	Year	xxxx	
4	Month	xx	
5	Day	xx	
6	Hour	xx	
7	Minute	xx	
8	Second	xx	
9	Temperature	xx.xx	C
10	Dissolved Gas Pressure	xxxx.xx	mBar
11	Supply Voltage	xx.x	V

Oxygen (oxyg)

```
21+353:15:24:44.286 MEASUREMENT 4835    1038    O2Concentration[uM]     386.255 AirSaturation[%]
96.963  Temperature[Deg.C]      5.051   CalPhase[Deg]   32.416  TCPhase[Deg]    33.516  C1RPh[Deg]
41.837  C2RPh[Deg]      8.321   C1Amp[mV]       635.4   C2Amp[mV]       736.0   RawTemp[mV]
657.1
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	"MEASUREMENT"	string	N/A
3	Measurement	xxxx	
4	Measurement	xxxx	
5	"O2Concentration[uM]"	string	N/A
6	O2 Concentration	xxx.xxx	uM
7	"AirSaturation[%]"	string	N/A
8	Air Saturation	xx.xxx	%
9	"Temperature[Deg.C]"	string	N/A
10	Temperature	x.xxx	Deg.C
11	"CalPhase[Deg]"	string	N/A
12	Cal Phase	xx.xxx	Deg
13	"TCPhase[Deg]"	string	N/A
14	TC Phase	xx.xxx	Deg
15	"C1RPh[Deg]"	string	N/A
16	C1R Ph	xx.xxx	Deg
17	"C2RPh[Deg]"	string	N/A
18	C2R Ph	x.xxx	Deg
19	"C1Amp[mV]"	string	N/A
20	C1 Amp	xxx.x	mV
21	"C2Amp[mV]"	string	N/A
22	C2 Amp	xxx	mV
23	"RawTemp[mV]"	string	N/A
24	Raw Temp	xxx.x	mV

Remote Temperature (rtmp)

```
15+056:15:10:38.244 -1.4644
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Temperature, Seawater Intake	xx.xxxx	C

GUV (pguv)

```
15+057:14:51:33.808 022615 065133 .000132 .010878 .047479 .004407 -.002799 .014652 .027558 .094395
.417814 -4.466095
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Date	mmddyy	UTC-4
3	Time	hhmmss	UTC-4
4	Ed0GND (sensor ground voltage)	xxxxxx	V
5	Ed0320 (downwelling 320nm irradiance)	xxxxxx	µW
6	Ed0340 (downwelling 340nm irradiance)	xxxxxx	µW
7	Ed0313 (downwelling 313nm irradiance)	xxxxxx	µW
8	Ed0305 (downwelling 305nm irradiance)	xxxxxx	µW
9	Ed0380 (downwelling 380nm irradiance)	xxxxxx	µW
10	Ed0PAR (downwelling 400-700nm irradiance)	xxxxxx	µE
11	Ed0395 (downwelling 395nm irradiance)	xxxxxx	µW
12	Ed0Temp (sensor array temperature)	xxxxxx	C
13	Ed0Vin (input voltage)	x.xxxxxx	V

Engineering (eng1)

```
15+057:16:41:24.536 12.25 23.21 507.8  0.6 162.6 -751.9 0 0 NAN NAN -10.3  7.2
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Supply Voltage	xx.xx	V
3	Case Temperature	xx.xx	C
4	Seawater Flow, Aquarium Room	xxx.x	l / min
5	Seawater Flow, Helo-deck	x.x	l / min
6	Seawater Flow, Hydro-lab	xxx.x	l / min
7	Seismic Air Pressure	xxx.x	lbf/in^2
8	Not Currently Hooked Up	x	0 or NAN
9	Not Currently Hooked Up	x	0 or NAN
10	Not Currently Hooked Up	x	0 or NAN
11	Not Currently Hooked Up	x	0 or NAN
12	Altimeter for Yo-Yo Camera - **Rarely used***	xx.xx	m
13	Transmissometer for Yo-Yo camera - **Rarely used***	xxx.x	%

Altimeter

This is rarely used, and only provides real data when connected. When not connected, provides a value approx = -10.

Transmissometer

This is rarely used, and only provides real data when connected. When not connected, provides a value range of approx = 0 to 10.

Hydro DAS (hdas)

```
15+057:16:07:09.456 12.15038 12.39402 336.5517 4431.724 -1 20.5 64 33.5 43.5
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Supply Voltage	xx.xxxxx	V
3	Case Temperature	xx.xxxxx	C
4	Fluorometer	xxx.xxxx	mV
5	Transmissometer	xxxx.xxx	mV
6	Sea Water Valve*	x	-1 or 0
7	Flow Meter 1 Frequency	xx.x	Hz
8	Flow Meter 2 Frequency	xx.x	Hz
9	Flow Meter 3 Frequency	xx.x	Hz
10	Flow Meter 4 Frequency	xx.x	Hz

Sea Water Valve

-1 = Stern Thruster Valve, 0 = Moon Pool Valve

Winch (bwnc, cwnc, twnc)

```
15+057:14:12:24.405 02RD,2015-02-26T14:55:32.051,STBD TRAWL,00000064,-00000.0,-00023.2,3594
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	LAN ID		alphanumeric
3	LCI-90i Date and Time	yyyy-mm-ddThh:mm:ss.sss	
4	Winch Name		alphabetical
5	Tension	xxxxxxxx	lbs
6	Speed	xxxxx.x	m/min
7	Payout	xxxxx.x	m
8	Checksum	x.xxxx	numeric

Multibeam (mbdp)

```
15+058:22:04:52.826 $KIDPT,594.68,7.67,12000.0*43
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	KIDPT	x.x	m
3	Depth at Transducer	x.x	m
4	Distance to Waterline from Transducer	x.x	m
5	Maximum Range in Use	x.x	alphanumeric
6	Checksum	xx	UTC

Fluorometer (ndfl)

```
18+121:00:00:21.785 99/99/99    99:99:99        0.71    695     155     559
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Ignore	x.x	n/a
3	Ignore	x.x	n/a
4	Chlorophyll Signal	xx.xx	µg/l
5	Wavelength (Not used)	xxx	nanometers
6	Chlorophyll Counts	xxxx	Counts
7	Internal Thermistor (Not used)	xxx	Therm

Navigational Data /rvdas/nav

GPS (s330, s380)

1. ***Seapath 330***
    a. NMEA 0183 strings
        i. GPZDA
        ii. GPGGA
        iii. GPVTG
        iv. GPHDT
        v. GPRMC
    b. Proprietary Strings
        i. PSXN 20
        ii. PSXN 22
        iii. PSXN 23
2. ***Seapath 380***
    a. NMEA 0182 strings
        i. GPZDA
        ii. GPGGA
        iii. GPVTG
        iv. GPHDT
    b. Proprietary Strings
        i. PSXN 20
        ii. PSXN 22
        iii. PSXN 23

GPZDA

15+051:21:02:04.507 $GPZDA,210204.39,20,02,2015,,*6F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$GPZDA		
3	Time	hhmmss.ss	UTC
4	Day	dd	UTC
5	Month	mm	UTC
6	Year	yyyy	UTC
7	(empty field)	x	Blank or 0
8	Checksum	xx	alphanumeric

GPGGA

15+051:21:02:02.507 $GPGGA,210202.38,7712.979244,S,16741.040258,W,1,12,0.7,-5.04,M,-55.90,M,,*6F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$GPGGA		
3	Time	hhmmss.ss	UTC
4	Latitude	ddmm.mmmmmm	degrees
5	North or South (for previous)	x	N or S
6	Longitude	ddmm.mmmmmm	degrees
7	East or West (for previous)	x	E or W
8	GPS quality indicator*	x	0,1,2,3,4,5, or 6
9	Number of satellites in use (00-99)	xx	00-99
10	HDOP	x.x	
11	Antenna height	x.xx	m
12	M = Meters (for previous)	x	M
13	Geoidal height	x.xx	m
14	M = Meters (for previous)	x	M
15	Age of DGPS corrections (seconds)	x.x	seconds
16	Station ID of DGPS (if used)	x	numeric
17	Checksum	xx	alphanumeric

Quality

0 = invalid, 1 = GPS SPS, 2 = DGPS, 3 = PPS, 4 = RTK, 5 = float RTK, 6 = dead reckoning

GPVTG

15+051:16:47:06.625 $GPVTG,357.84,T,251.99,M,9.5,N,17.7,K,A*15

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$GPVTG		
3	Heading	x.xx	degrees
4	T = True (for previous)	x	T
5	Heading	x.xx	degrees
6	M = Magnetic (for previous)	x	M
7	Speed over Ground (knots)	x.x	knots
8	N = knots (for previous)	x	N
9	Speed over Ground (kilometers per hour)	x.x	km/h
10	K = km per hour (for previous)	x	K
11	Mode*	X	A,D,E, or N
12	Checksum	xx	alphanumeric

Modes

A = GPS used, D = DGPS used, E = Dead reckoning used, N = Invalid position / velocity

GPRMC

15+051:21:02:04.741 $GPRMC,210204.38,A,7712.979182,S,16741.063669,W,9.4,270.82,200215,105.6,E,A*06

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$GPRMC		
3	Time	hhmmss.sss	UTC
4	Status*	x	A or N
5	Latitude	ddmm.mmmmmm	degrees
6	North or South (for previous)	x	N or S
7	Longitude	ddmm.mmmmmm	degrees
8	East or West (for previous)	x	E or W
9	Speed over Ground, True	x.x	knots
10	Course over Ground True	x.xx	degrees
11	Date	ddmmyy	UTC
12	Magnetic Variation	x.x	degrees
13	East or West (for previous)	x	E or W
14	Mode*	x	alphanumeric
15	Checksum	xx	UTC

GPHDT

```
15+051:21:02:04.741 $GPHDT,268.87,T*06
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$GPHDT		
3	Heading, True	x.xx	degrees
4	T = True (for previous)	x	T
5	Checksum	xx	alphanumeric

GPGLL

```
16+077:00:00:00.725 $GPGLL,6356.6505,S,05716.0002,W,000000,A,A*4F
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$GPGLL		
3	Latitude	ddmm.mmmmmm	degrees
4	North or South (for previous)	x	N or S
5	Longitude	ddmm.mmmmmm	degrees
6	East or West (for previous)	x	E or W
7	Time of Position (not received)	hhmmss.ss	UTC
8	Status*	x	A or V
9	Mode*	x	alphanumeric
10	Checksum	xx	alphanumeric

Status

A = Data Valid, V = Data not valid

Modes

A = GPS used, D = DGPS used, E = Dead reckoning used, M = Manual input mode, S = Simulator Mode, N = Invalid position / velocity

GPDTM

```
16+077:00:00:02.527 $GPDTM,W84,,0000.0000,N,00000.0000,E,0.0,W84*5F
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$GPDTM		
3	Local Datum Code*	XXX	alphanumeric
4	Local datum subdivision code	x	numeric
6	Lat offset	x	alphanumeric
7	North or South (for previous)	x	N or S
8	Lon offset	x	alphanumeric
9	East or West (for previous)	x	E or W
10	Altitude offset, meters	x,x	numeric
11	Reference datum code*	xxx	alphanumeric
12	Checksum	xx	alphanumeric

Datum Codes

W84 = WGS84, W72 = WGS72, S85 = SGS85, P90 = PE90, 999 = User defined

PSXN 20

15+051:22:20:58.740 $PSXN,20,1,0,0,0*3A

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$PSXN		
3	20		
4	Horizontal position and velocity quality*	x	0,1,2
5	Height and vertical velocity quality*	x	0,1,2
6	Heading quality*	x	0,1,2
7	Roll and pitch quality*	x	0,1,2
8	Checksum	xx	alphanumeric

Qualities

0 = Normal, 1 = Reduced Performance, 2 = Invalid data

PSXN 22

15+051:22:20:59.019 $PSXN,22,0.43,0.50*3B

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$PSXN		
3	22		
4	Gyro calibration value since system startup	x.xx	degrees
5	Short-term gyro offset	x.xx	degrees
6	Checksum	xx	alphanumeric

PSXN 23

15+051:22:20:58.748 $PSXN,23,-0.20,-0.09,279.85,0.24*34

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$PSXN		
3	23		
4	Roll, port side up is positive	x.xx	degrees
5	Pitch, bow up is positive	x.xx	degrees
6	Heading, True	x.xx	degrees
7	Heave, positive is down	x.xx	m
8	Checksum	xx	alphanumeric

Gyro Compass (gyr1)

```
15+055:20:27:23.653 $HEHDT,087.31,T*12
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$HEHDT		
3	Heading	x.xx	degrees
4	T = True (for previous)	x	T
5	Checksum	xx	alphanumeric

pCO_2 – Merged

15+055:11:24:43.960 2015055.46596 2534.72 32.41 975.33 48.86 356.94 341.67 -1.20 -1.27 0.00 Equil -75.9209 178.9696 -1.435 33.852 2.26 7.86 137.38 975.34 163.80 9.31 253.75 NaN -1.27 33.84 -1.14 -1.0

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	pCO_2 time tag*	yyyyddd.ttt	UTC
3	Raw Voltage (IR)	xxxx.xx	mV
4	Cell Temperature	xx.xx	C
5	Equilibration Pressure	xxx.xx	mBar
6	Flowrate	xxx.xx	cm^3/min
7	pCO_2 Pressure	xxx.xx	µAtm
8	VCO_2 Concentration	xx.xx	ppm
9	Equilibrator Temperature, RTD	xx.xx	C
10	Equilibrator Temperature, SBE38	xx.xx	C
11	Valve Position	xx	numeric
12	Flow Source*		text
13	Latitude	xx.xxxxx	degrees
14	Longitude	xxx.xxxxx	degrees
15	Sea Water Intake Temperature	xx.xxx	C
16	Sea Surface Salinity	xx.xxx	PSU
17	Sea Surface Fluorometry	x.xxx	mg/m^3
18	True Wind Speed	x.xx	m/s
19	True Wind Direction	x.xx	degrees
20	Barometric Pressure	xxx.xx	mBar
21	Hydro-Lab H_2O Flow Rate	xxx.x	l / min
22	Speed over Ground	x.xx	knots
23	Course Made Good	xx.xx	degrees
24	Unused		
25	TSG2 Temperature	x.xx	C
26	TSG2 Salinity	xx.xx	PSU
27	TSG1 Temperature	x.xx	C
28	Sea Water Valve*	x	-1 or 0

pCO_2 time tag

ttt = fractional time of day

Flow Source

Equil = pCO_2 Measurement

Sea Water Valve

-1 = Stern Thruster Valve, 0 = Moon Pool Valve

Calculations

PAR

Coefficients parc1 and parcv for this cruise can be found in the `instrument.coeff` file as the variable labeled PAR, respectively. Variable par is the raw data in mV, as described in the "mwx1" file description. The calibration scale and probe offset dark are values taken from the PAR Cal Sheet.

```
par = raw data mV
calibration scale = 5.8644 V/(μEinstiens/cm2sec)
parc1 = 1 / scale = .17
probe offset dark = -.1 mV
parcv = dark x 1000 mV/V = -0.0001 V
((par / 1000 mV/V) – parcv) x parc1 x 10000 cm2/m2 = μEinstiens/m2sec

Calculations (extracted from the C code):
/* Convert from mV to V */
par /= 1000;
/* (par V - vdark V) / Calibration Scale Factor V/uE/cm2sec */
parCalc = (par - parcv) * parc1 * 10000;
```

PSP

Coefficient pspCoeff for this cruise can be found in the `instrument.coeff` file as the variable labeled PSP1. Variable psp is the raw data in mV, as described in the "mwx1" file description.

```
psp = raw data mV
calibration scale =  pspCoeff x 10^-6  V/(W/m2)
psp / (scale x 1000 mV/V) = W/m2

Calculations (extracted from the C code):
     /* Convert from mV to W/m^2  */
     pspCalc = (psp * 1000 / pspCoeff);
```

PIR

Coefficient pirCoeff for this cruise can be found in the `instrument.coeff` file as the variable labeled PIR1. Variable pir_thermo is the raw data in mV, pir_case is the PIR case temperature in Kelvins and pir_dome is the PIR dome temperature in Kelvins, as described in the "mwx1" file description. Hard-coded "C" coefficients are shown below:

```
Dome constant = 3.5
Sigma = 5.6704e-8

pir_thermo = raw data mV
calibration scale = pirCoeff x 10^-6  V/(W/m2)
pir_thermo / (scale x 1000 mV/V) = W/m2

Calculations (extracted from the C code):
      /* convert mV to W/m^2 */
     pirCalc = (pir_thermo * 1000 / pirCoeff)
     /* correct for case temperature */
     pirCalc += sigma * pow(pir_case,4)
     /* correct for dome temperature */
     pirCalc -= 3.5 * sigma * (pow(pir_dome, 4) - pow(pir_case, 4))
```

Acquisition Problems and Events

This section lists problems with acquisition noted during this cruise including instrument failures, data acquisition system failures and any other factor affecting this data set. The format is ddd:hh:mm (ddd is year-day, hh is hour, and mm is minute). Times are reported in UTC.

Start	End	Description
		Mini TDGP was not collected on this cruise due to problems with the instrument
314:19:12		Data collection begins. **58 14.214S 63 55.794W**
318:11:12	321:15:51	Multibeam and Waterwall disabled due to proximity to Palmer Station
318:19:32	321:15:20	Data collection paused while at Palmer Station
	338:06:00	Data collection completes. **47 54.438S 175 49.368W**

Appendix A: Sensors

NBP2211 Sensors

Meteorology and Radiometry

Sensor	Serial No.	Manufacturer	Model	Last Cal Date	Comments
Anemometer	WM128975	RM Young	5106	10/27/2011	ECO Bridge Windbird
Anemometer, U/S	924057	Gill Instruments	1390-PK-062	2/11/2021	Stbd Side (SUS)
Anemometer, U/S	1004041	Gill Instruments	1390-PK-114	10/1/2013	Port Side (PUS)
Barometer	M2750445	Vaisala	PTB210B	7/13/2016	
Humidity/Temp/Dew Pt	0020286073	Rotronic	HC2A-S3	7/12/2018	Primary Temp/RH
Humidity/Wet Temp	06135	RM Young	41372LC	7/31/2017	Secondary Temp/RH
PAR	10704	Biosph. Inst.	QSR-2200	2/24/2021	Mast PAR
PIR	32845F3	Eppley	PIR	2/2/2021	
PSP	32850F3	Eppley	PSP	2/2/2021	
GUV (Mast)	25110203114	Biosph. Inst.	GUV-2511	5/20/2021	Mast
GUV Deckbox	25110203114	Biosph. Inst.	GUV-2511	N/A	Deckbox

Underway Seawater Sampling System

Sensor	Serial No.	Manufacturer	Model	Last Cal Date	Comments
Digital Remote Temp	3846730-0352	Sea-Bird	SBE 38	3/23/2021	Intake Temperature
Fluorometer	FLRTD-4158	WetLabs	FLRTD	3/9/2021	
Micro-TSG	4549120-0226	Sea-Bird	SBE 45	4/5/2021	Primary TSG
Micro-TSG	4546167-0199	Sea-Bird	SBE 45	4/5/2021	Secondary TSG
Mini TDGP	41-861-31	Pro Oceanus	0 -2 BAR	N/A	Installed 11/18/2021
Oxygen Optode	1038	Aanderaa	4835	N/A	Installed 11/17/2021
Transmissometer	CST-557DR	WET Labs	C-Star	5/4/2021	

CTD

Sensor	Serial No.	Manufacturer	Model	Last Cal Date	Comments/Stations
Altimeter	51520	Valeport	VA-500	7/10/2015	
Bottom Contact Switch	#3	Sea-Bird	90149.2	N/A	
Carousel Water Sampler	3214153-0140	Sea-Bird	SBE-32	N/A	24 Bottle Rosette
SBE 11+ Deck Unit	11P47914-0768	Sea-Bird	11+	N/A	
Conductivity	041798	Sea-Bird	4C 6800m	9/23/2020	Primary Cond.
Conductivity	041314	Sea-Bird	4 - 02/O	7/7/2020	Secondary Cond.
CTD Fish	09P70675-1130	Sea-Bird	SBE 9+	3/22/2021	
Dissolved Oxygen	432512	Sea-Bird	SBE 43	8/10/2022	Primary DO
Dissolved Oxygen	433170	Sea-Bird	SBE 43	8/13/2022	Secondary DO
Fluorometer	FLRTD-397	WET Labs	FLRTD	3/9/2021	
PAR	4361	Biosph. Inst.	QSP-200L4S	6/4/2019	
CTD Pressure Sensor	120089	Paroscientific	410K-105	3/22/2021	
CTD Pump	055643 3.0K	Sea-Bird	5T, PN 90160	7/1/2020	Primary Pump
CTD Pump	055641 3.0K	Sea-Bird	5T, PN 90160	7/1/2020	Secondary Pump
Temperature	031457	Sea-Bird	3-02/F	3/13/2021	Primary Temp.
Temperature	031238	Sea-Bird	3-02/F	3/10/2021	Secondary Temp.
Transmissometer	CST-1316DR	WET Labs	C-Star	5/17/2022	

Appendix B: Calibration Sheets

Gravity

BGM3 ship-to-shore gravity tie report

A. Robinson/A. Brett, vessel: RV/IB Nathaniel B Palmer

Release Date: 2022/05/18 12:56:34 UTC

Sensor: S226
Software version: 1.2
Port/Pier/Berth: Prat Pier

Gravity station number	9337-50 (3)
Station name	Harbour Admin Bldg
mGal at pier	981320.82
Tie start time UTC	2022/05/18 11:53:11.487
Samples used	3600
Land tie used	Yes
Water height to pier 1	6 ft 3 in
Water height to pier 2	6 ft 0 in
Water height to pier 3	5 ft 4 in
Average of filtered counts	25065.538658444
Filter length	361
Scale factor	4.990626252
NEW BIAS	**856228.64**

Table 1: Gravity tie information

Meteorology

Anemometers

Cal sheet not required

Barometer

VAISALA

1 (1)
Certificate report no. H44-16280023

CALIBRATION CERTIFICATE

Instrument	PTB210B Digital Barometer
Serial number	M2750445
Manufacturer	Vaisala Oyj, Finland
Calibration date	13th July 2016

The above instrument was calibrated by comparing the readings of the instrument to the factory working standard of Vaisala.

The pressure readings of the factory working standard have been calibrated at an ISO/IEC 17025 accredited calibration laboratory (FINAS), Vaisala Measurement Standards Laboratory (MSL), by using MSL working standards traceable to NIST.

Calibration results

Reference hPa	Observed hPa	Correction* hPa	Acceptance limit hPa
510.0	510.0	0.0	± 0.2
610.0	610.0	0.0	± 0.2
700.0	700.0	0.0	± 0.2
810.0	810.0	0.0	± 0.2
910.0	910.0	0.0	± 0.2
950.0	950.0	0.0	± 0.2
1000.0	1000.0	0.0	± 0.2
1098.0	1098.0	0.0	± 0.2

*To obtain the true pressure, add the correction to the barometer reading.
Interpolated corrections may be used at intermediate readings of the scale of the barometer.

Equipment used in calibration

Type	Serial number	Calibration date	Certificate number
PPC4	670	2015-08-21	K008-Y01989

Uncertainty (95 % confidence level, k=2)

Pressure	± 0.15 hPa

Ambient Conditions

Humidity	39 %RH ± 5 %RH
Temperature	21 °C ± 1 °C
Pressure	1002 hPa ± 1 hPa

Technician

doc223087-B

Vaisala Oyj | PO Box 26, FI-00421 Helsinki, Finland

Humidity / Temperature / Dew Pt (Primary)

CERTIFICATE

rotronic
LEADING IN HUMIDITY MEASUREMENT

Device type	**HC2A-S3**
Serialnumber	**0020286073**
RPC-number	**19-0356518119**

ROTRONIC AG certifies that this instrument meets the published specifications. It has been calibrated using standards and instruments as stated below and corresponds to the process requirements of ISO 9001-2008. The references are traceable to national standards. The calibrated values are only valid at the time of measurement and are referenced to the indicated references and working standards.

FACTORY CALIBRATION

Adjustment

Temperature	23.55°C
Humidity 1	11.52%rH (@23.56°C)
Humidity 2	34.68%rH (@23.61°C)
Humidity 3	79.27%rH (@23.71°C)

Calibration

	Device	Reference
Temperature	23.60°C	23.60°C
Humidity	50.27%rH	50.14%rH

Date of calibration: 12.07.2018

Reference System

HC2-S (SCS certified)

FUNCTION TEST

Firmware	V1.2
Analog Output	Out1: Humi 0..100%rH (0..1V) Set: 40.00%rH, measured 40.01%rH (0.400V) Out2: Temp -40..60°C (0..1V) Set: 20.00°C, measured 20.01°C (0.600V)
Printnumber	66.1085.0301

Final test passed – 16.08.2018 – quality engineer: V. Doan
Control number: 304

ROTRONIC AG, Grindelstrasse 6, CH - 8303 Bassersdorf
www.rotronic.com

Humidity / Temperature (Secondary)

R.M. Young Company
2801 Aero Park Drive
Traverse City, Michigan 49686 USA

YOUNG

CALIBRATION REPORT
Temperature & Humidity

Customer: *Leidos Innovations Corp*

Test Number: 7731-01T
Test Date: 31 July 2017

Customer PO: 21800
Sales Order: 6363

Instrument Under Test (IUT)

Model: 41372LC
Description: Temp / Humidity Sensor

Serial Number: TS06135

Temperature: Report of calibration comparison with National Institute of Standards and Technology traceable standard thermometer(s) at three temperatures in the R.M. Young Company controlled temperature calibration facility. The following data describe the relationship between actual temperature, as determined by the NIST calibrated thermometer, and test sensor temperature, as determined by its output.

Reference Temperature Celcius	IUT Output mA	Indicated (1) Temperature Celcius
-49.85	4.0	-49.93
-0.01	12.0	0.07
50.03	20.0	50.01

(1) Calculate from IUT voltage output. Calibration accuracy ± 0.1° Celcius.

Humidity: Report of calibration comparison with National Institute of Standards and Technology traceable standard humidity sensor at five humidity levels in the R.M. Young Company controlled humidity chamber. The following data describe the relationship between actual humidity, as determined by the NIST calibrated humidity sensor, and test sensor humidity, as determined by its output.

Reference Humidity %	IUT Output mA	Indicated (1) Humidity %
10.0	6	11.9
30.0	9	31.4
50.0	12	51.8
70.0	15	71.2
90.0	18	88.3

(1) Calculate from IUT voltage output. Calibration accuracy ± 2.0 %.

National Institute of Standards and Technology Reference	Serial No.	Reference No.
Brooklyn Thermometer Model 43-FC	8006-118	W204690
Brooklyn Thermometer Model 22332-D5-FC	25071	W204691
Brooklyn Thermometer Model 2X400-D7-FC	77532	W204692
Keithley Multimeter Model 191	15232	8604897
Vaisala Humidity Sensor Model 35AC	N475040	TN 266152
Fluke Multimeter Model 8060A	4865407	8604897

Tested By S Sage

METEOROLOGICAL INSTRUMENTS
Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: youngusa.com
ISO 9001:2008 CERTIFIED

PAR (Mast)

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	2/24/2021
Model Number	QSR2200
Serial Number	10704
Operator	TPC
Standard Lamp	V-040(11/12/20)
Probe Excitation Voltage Range:	6 to 18 VDC(+)
Output Polarity:	POSITIVE

Probe Conditions at Calibration(in air):

Calibration Voltage:	6	VDC(+)
Probe Current:	3.7	mA

Probe Output Voltage:

Probe Illuminated	107.99	mV
Probe Dark	1.0	mV
Probe Net Response	107.0	mV
RG780	1.1	mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

9.385E+15	quanta/cm²sec
0.015584	uE/cm^{2}sec

Calibration Scale Factor:
(To calculate irradiance, divide the net voltage reading in Volts by this value.)

Dry:	1.1397E-17	V/(quanta/cm²sec)
	6.8633E+00	V/(uE/cm^{2}sec)

Notes:
1. Annual calibration is recommended.
2. Calibration is performed using a Standard of Spectral Irradiance traceable to the National Institute of Standards and Technology (NIST).
3. The collector should be cleaned frequently with alcohol.
4. Calibration was performed with customer cable, when available.

QSR240R 05/24/95

PIR

EPLAB

THE EPPLEY LABORATORY, INC.

12 Sheffield Avenue, PO Box 419, Newport, Rhode Island USA 02840
Phone: 401.847.1020 Fax: 401.847.1031 Email: info@eppleylab.com

Calibration Certificate

Instrument:	Precision Infrared Radiometer, Model PIR, Serial Number 32845F3
Procedure:	This pyrgeometer was compared against Eppley's Blackbody Calibration System under radiation intensities of approximately 350 Wm^{-2} with an average ambient temperature of 21°C according to procedures described in Technical Procedure, TP05 of The Eppley Laboratory, Inc.'s Quality Assurance Manual on Calibrations.
Transfer Standard:	Eppley Precision Infrared Radiometer, Model PIR, Serial Number 32227F3
Results:	**Sensitivity: S = 4.14 µV / Wm^{-2}** Uncertainty: U_{95} = ±1.7% (95% confidence level, k=2) Resistance: 712 Ω at 23°C
	Date of Test: February 2, 2021
Traceability:	This calibration is traceable to the International Practical Temperature Scale (IPTS). Additionally, transfer standard PIR #32227F3 provides traceability to the World Infrared Standand Group (WISG) of pyrgeometers housed at the Infrared Radiometry Section of the World Radiation Centre (WRC-IRS). Unless otherwise stated in the remarks section below or on the Sales Order, the results of this calibration are "AS FOUND / AS LEFT".
Due Date:	Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy.
Customer:	NSF / Leidos / Antarctic Support Port Hueneme, CA
In Charge of Test:	Thomas J Kucharski
Eppley SO:	65895
Date of Certificate	February 4, 2021
Remarks:	

End of Report

PSP

EPLAB

THE EPPLEY LABORATORY, INC.

12 Sheffield Avenue, PO Box 419, Newport, Rhode Island USA 02840
Phone: 401.847.1020 Fax: 401.847.1031 Email: info@eppleylab.com

Calibration Certificate

Instrument:	Precision Spectral Pyranometer, Model PSP, Serial Number 32850F3
Procedure:	This pyranometer was compared in Eppley's Integrating Hemisphere according to procedures described in ***ISO 9847 Section 5.3.1*** and Technical Procedure, TP01 of The Eppley Laboratory, Inc.'s Quality Assurance Manual on Calibrations.
Transfer Standard:	Eppley Standard Precision Pyranometer, Model SPP, Serial Number 37501F3
Results:	**Sensitivity: S = 6.87 µV / Wm^{-2}** Uncertainty: U_{95} = ±0.91% (95% confidence level, k=2) Resistance: 706 Ω at 23°C
	Date of Test: February 2, 2021
Traceability:	This calibration is traceable to the World Radiation Reference (WRR) through comparisons with Eppley's AHF standard self-calibrating cavity pyrheliometers which participated in the Twelfth International Pyrheliometric Comparisons (IPC XII) at Davos, Switzerland in September-October 2015. Unless otherwise stated in the remarks section below or on the Sales Order, the results of this calibration are "AS FOUND / AS LEFT".
Due Date:	Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy.
Customer:	NSF / Leidos / Antarctic Support Port Hueneme, CA
In Charge of Test:	
Eppley SO:	65896
Date of Certificate	February 4, 2021
Remarks:	

End of Report

GUV (Mast)

Biospherical Instruments Inc.

System Calibration Certificate

THE INSTRUMENTS REFERENCED BELOW WERE FACTORY TESTED AND CALIBRATED BY

BIOSPHERICAL INSTRUMENTS INC.
5340 Riley Street
San Diego, California 92110 USA

Instruments: GUV-2511 No 25110203114

Optical Calibrations:

NIST Traceability. For wavelengths longer than 313 nm, the specific instruments cited here were calibrated using a 1000W FEL #V-040(11/12/20) following procedures and standards traceable to NIST Standard of Spectral Irradiance F616. Traceability paths and all procedures for all calibrated lamps and associated apparatus (shunts, power supplies, DMMs, etc) are maintained following calibration methodologies per National Bureau of Standards (US) (NBS) Special Publication 250-20 Spectral Irradiance Calibrations (1987) and NBS Publication 594–13 Optical Radiation Measurements: The 1973 Scale of Spectral Irradiance (1977).

Solar Calibrations. Lamp calibrations are problematic for solar UV measurements (wavelengths below 320 nm) because the solar spectrum is radically different from the lamp spectrum and changes greatly as a function of wavelength. Solar calibrations are achieved through direct comparison with measurements of a high resolution scanning spectroradiometer in San Diego (SUV-100), which is part of the National Science Foundation's UV Monitoring Network. The SUV-100 instrument has a bandwidth of 1 nm. Calibrated filter radiometer data therefore report spectral irradiance at the channel's nominal wavelengths with a bandwidth of 1 nm. Solar calibrations are typically accurate to within ±10% for solar zenith angles smaller than 75°. At larger solar zenith angles, UV channels have a greater uncertainty due to the rapid change of the solar UV spectrum.

Note that this certificate contains a subset of the information delivered in the calibration database 25110203114v11_5-2021.mdb. This database is required for operation of this system using Biospherical Instruments Inc.'s Logger® software.

Biospherical Instruments Inc.

GUV-2511 Calibration Certificate

System Serial Number	25110203114	Date of Calibration	5/20/2021
Calibration database	25110203114v11_5-2021.mdb	Date of Certificate	5/21/2021
DASSN	0069	Standard of Spectral Irradiance	V-040(11/12/20)
Microprocessor Tag Number	4	Operator	TC

Monochromatic Channels	Address	Wavelength [nm]	Responsivity [Amps per μW/(cm²·nm)]	ScaleSmall [Volts per μW/(cm²·nm)]	ScaleMedium [Volts per μW/(cm²·nm)]	ScaleLarge [Volts per μW/(cm²·nm)]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0320	2	320	2.3255E-10	2.3720E-05	6.9300E-03	2.1873E+00	3.4492E-05	3.2554E-05	5.6504E-04	μW/(cm²nm)
Ed0340	6	340	1.8473E-10	1.8843E-05	5.5051E-03	1.8885E+00	4.2136E-05	4.1875E-05	7.6934E-04	μW/(cm²nm)
Ed0313	8	313	2.2363E-10	2.2810E-05	6.6642E-03	2.3393E+00	9.1228E-04	9.0624E-04	-1.2773E-03	μW/(cm²nm)
Ed0305	10	305	1.2387E-11	1.2634E-06	3.6912E-04	1.2687E-01	3.5080E-04	3.5087E-04	1.1382E-03	μW/(cm²nm)
Ed0380	12	380	8.3088E-11	8.4750E-06	2.4760E-03	7.9417E-01	2.8388E-04	2.7513E-04	-3.8577E-05	μW/(cm²nm)
Ed0395	18	395	2.9037E-10	2.9618E-05	8.6530E-03	2.7352E+00	3.8212E-04	3.8356E-04	1.4618E-03	μW/(cm²nm)

Broadband Channels	Address	Wavelength [nm]	Responsivity [Amps per μE/(cm²·s)]	ScaleSmall [Volts per μE/(cm²·s)]	ScaleMedium [Volts per μE/(cm²·s)]	ScaleLarge [Volts per μE/(cm²·s)]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0PAR	13	400-700	1.7156E-05	1.7499E+00	5.1124E+02	1.8068E+05	5.6671E-04	5.6137E-04	-4.7669E-04	μE/(cm²sec)

Auxilliary Channels	Address	Wavelength	Responsivity	ScaleS	ScaleM	ScaleL	OffsetS	OffsetM	OffsetL	Measurement Units
Ed0Temp	22	0	1	0.01	0.01	0.01	0	0	0	C
Ed0Vin	27	0	1	-0.25	-0.25	-0.25	0	0	0	V

Calibration Data – Do Not Destroy

page 2 of 2

Underway Seawater Sampling System

Digital Remote Temp

SEA-BIRD SCIENTIFIC
Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 0352
CALIBRATION DATE: 23-Mar-21

SBE 38 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

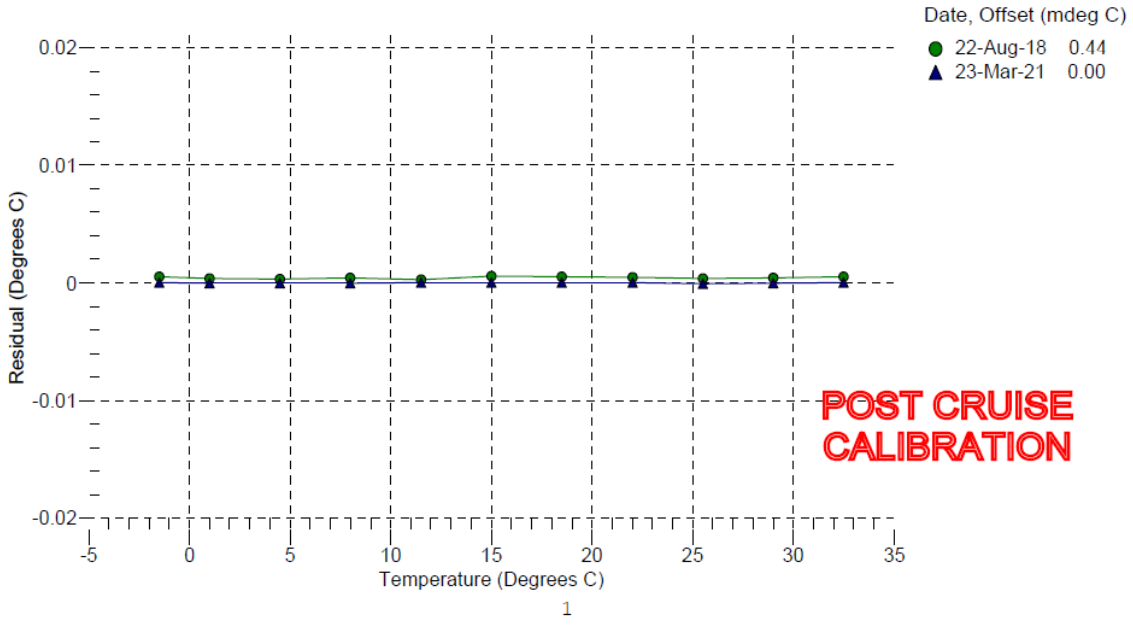
```
a0 = -1.565804e-005
a1 =  2.743535e-004
a2 = -2.249952e-006
a3 =  1.512456e-007
```

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	809818.8	-1.5000	0.0000
1.0000	723181.1	1.0000	-0.0000
4.5000	619012.2	4.5000	-0.0000
8.0000	531582.5	8.0000	-0.0000
11.5000	457953.0	11.5000	0.0000
15.0000	395741.3	15.0000	0.0000
18.5000	343006.2	18.5000	0.0000
22.0000	298165.2	22.0000	0.0000
25.5000	259921.1	25.4999	-0.0001
29.0000	227205.4	29.0000	-0.0000
32.5000	199138.8	32.5000	0.0000

n = Instrument Output (counts)

Temperature ITS-90 (°C) = $1/\{a0 + a1[ln(n)] + a2[ln^2(n)] + a3[ln^3(n)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



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Fluorometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

(541) 929-5650
Fax (541) 929-5277
www.wetlabs.com

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 3/9/2021 S/N: FLRTD-4158

Chlorophyll concentration expressed in µg/l can be derived using the equation:

CHL (µg/l) = Scale Factor * (Output - Dark Counts)

	Analog Range 1	Analog Range 2	Analog Range 4 (default)		Digital	
Dark Counts	0.070	0.040	0.025	V	49	counts
Scale Factor (SF)	6	13	25	µg/l/V	0.0077	µg/l/count
Maximum Output	5.01	5.01	5.01	V	16380	counts
Resolution	0.7	0.7	0.7	mV	1.0	counts

Ambient temperature during characterization 21.0 °C

Analog Range: 1 (most sensitive, 0–4,000 counts), 2 (midrange, 0–8,000 counts), 4 (entire range, 0–16,000 counts).

Dark Counts: Signal output of the meter in clean water with black tape over detector.

SF: Determined using the following equation: SF = x ÷ (output - dark counts), where x is the concentration of the solution used during instrument characterization. SF is used to derive instrument output concentration from the raw signal output of the fluorometer.

Maximum Output: Maximum signal output the fluorometer is capable of.

Resolution: Standard deviation of 1 minute of collected data.

The relationship between fluorescence and chlorophyll-a concentrations *in-situ* is highly variable. The scale factor listed on this document was determined using a mono-culture of phytoplankton (*Thalassiosira weissflogii*). The population was assumed to be reasonably healthy and the concentration was determined by using the absorption method. To accurately determine chlorophyll concentration using a fluorometer, you must perform secondary measurements on the populations of interest. This is typically done using extraction-based measurement techniques on discrete samples. For additional information on determining chlorophyll concentration see "Standard Methods for the Examination of Water and Wastewater" part 10200 H, published jointly by the American Public Health Association, American Water Works Association, and the Water Environment Federation.

FLRTD-4158 Revision J 3/17/08

Micro-TSG 1

Sea-Bird Scientific
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Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 0226
CALIBRATION DATE: 03-Apr-21

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

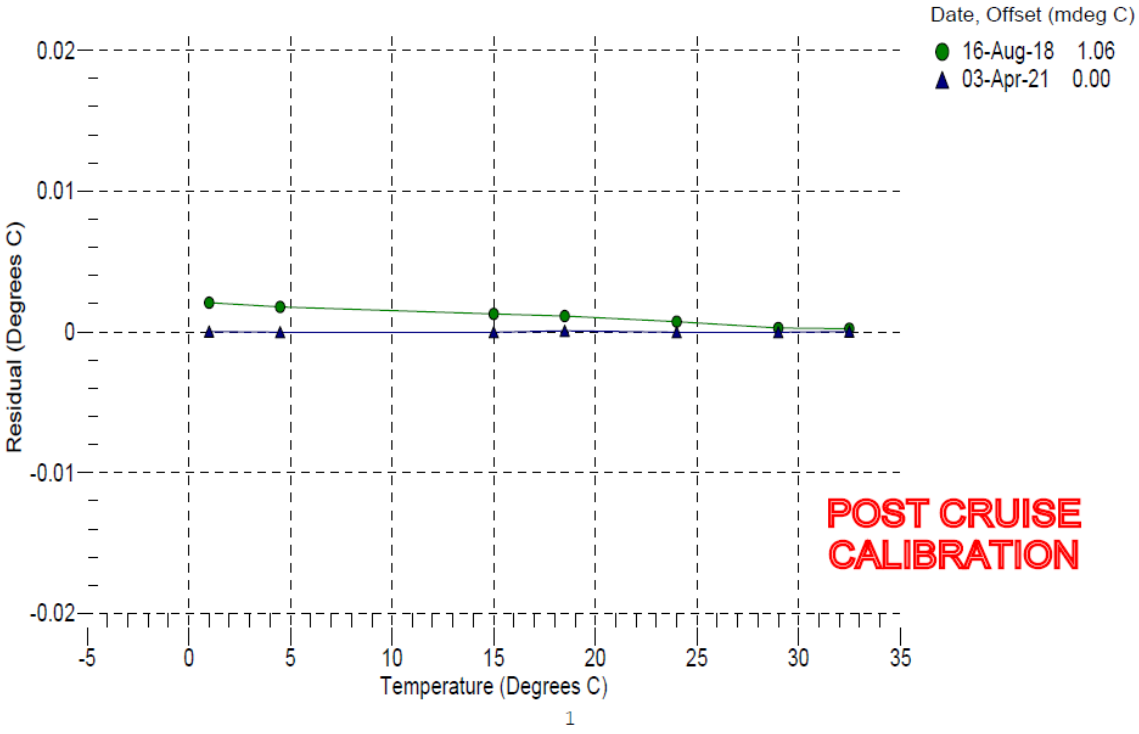
```
a0 = -1.138487e-005
a1 =  2.743646e-004
a2 = -2.306493e-006
a3 =  1.501778e-007
```

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
0.9999	744359.1	0.9999	0.0000
4.4999	636509.7	4.4999	-0.0000
15.0000	405784.6	15.0000	-0.0000
18.5000	351398.3	18.5001	0.0001
24.0000	281940.6	24.0000	-0.0000
29.0000	232179.7	29.0000	-0.0000
32.5000	203337.0	32.5000	0.0000

n = Instrument Output (counts)

Temperature ITS-90 (°C) = $1/\{a0 + a1[ln(n)] + a2[ln^2(n)] + a3[ln^3(n)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



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USA

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seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 0226
CALIBRATION DATE: 03-Apr-21

SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g = -1.013179e+000          CPcor = -9.5700e-008
h =  1.566635e-001          CTcor =  3.2500e-006
i = -4.446451e-004          WBOTC =  9.8072e-007
j =  6.163195e-005
```

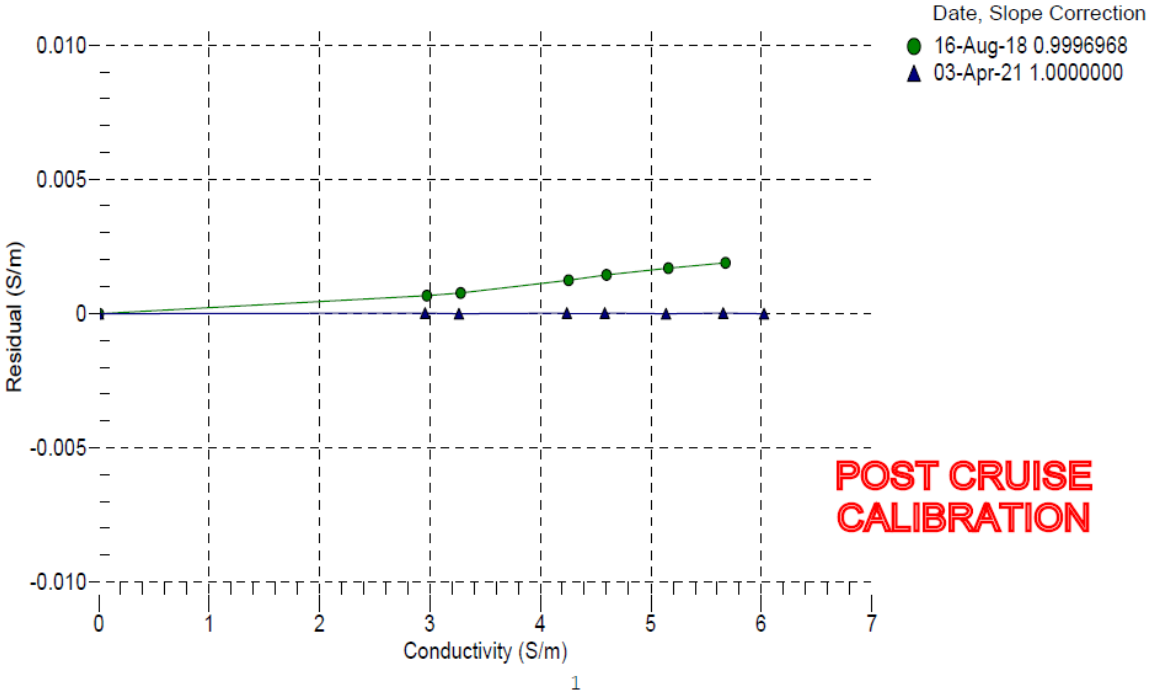
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2549.02	0.00000	0.00000
0.9999	34.5827	2.95788	5045.53	2.95789	0.00000
4.4999	34.5632	3.26318	5235.30	3.26318	-0.00000
15.0000	34.5224	4.23936	5799.73	4.23936	0.00000
18.5000	34.5143	4.58261	5985.26	4.58261	0.00000
24.0000	34.5059	5.13753	6273.25	5.13752	-0.00001
29.0000	34.5023	5.65665	6530.80	5.65665	0.00001
32.5000	34.5012	6.02723	6708.38	6.02722	-0.00000

f = Instrument Output(Hz) * sqrt(1.0 + WBOTC * t) / 1000.0

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



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Micro-TSG2

Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 0199
CALIBRATION DATE: 03-Apr-21

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

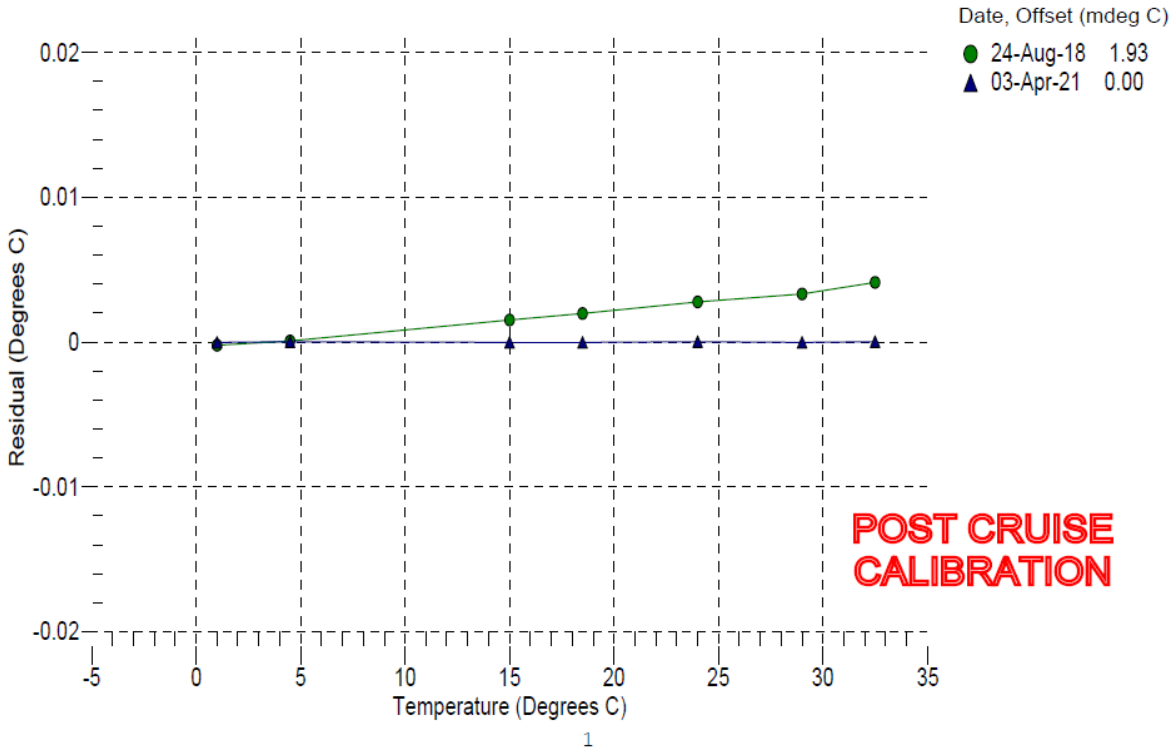
a0 = 2.860888e-005
a1 = 2.694712e-004
a2 = -1.943437e-006
a3 = 1.450157e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
0.9999	678470.7	0.9999	-0.0000
4.4999	580582.9	4.4999	0.0000
15.0000	370865.4	15.0000	-0.0000
18.5000	321355.8	18.5000	-0.0000
24.0000	258067.8	24.0000	0.0000
29.0000	212684.0	29.0000	-0.0000
32.5000	186358.0	32.5000	0.0000

n = Instrument Output (counts)

Temperature ITS-90 (°C) = $1/\{a0 + a1[ln(n)] + a2[ln^2(n)] + a3[ln^3(n)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 0199
CALIBRATION DATE: 03-Apr-21

SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g = -9.847556e-001
h =  1.401190e-001
i = -1.575649e-004
j =  3.435432e-005

CPcor = -9.5700e-008
CTcor =  3.2500e-006
WBOTC = -1.0552e-005
```

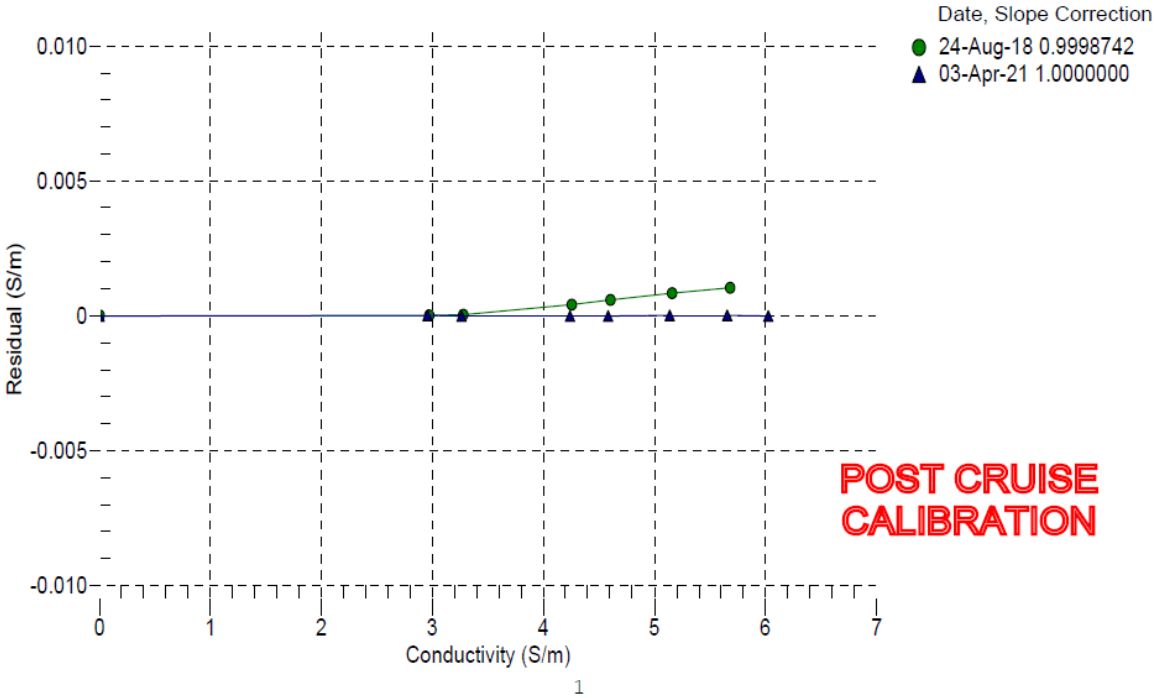
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2653.01	0.00000	0.00000
0.9999	34.5827	2.95788	5302.09	2.95790	0.00002
4.4999	34.5632	3.26318	5502.81	3.26316	-0.00002
15.0000	34.5224	4.23936	6099.72	4.23935	-0.00001
18.5000	34.5143	4.58261	6295.89	4.58260	-0.00000
24.0000	34.5059	5.13753	6600.42	5.13754	0.00001
29.0000	34.5023	5.65665	6872.77	5.65667	0.00002
32.5000	34.5012	6.02723	7060.54	6.02721	-0.00002

f = Instrument Output(Hz) * sqrt(1.0 + WBOTC * t) / 1000.0

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



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Mini TDGP

Mini TDGP™

Sensor Specifications

Sensor Performance

TDGP Range *other ranges available	0-2 bar Absolute 0-5 bar Absolute 0-14 bar Absolute
Resolution	0.002% of Full Scale
Accuracy	± 0.1% (Temperature compensated from -10 to 50° C)
Equilibration rate (t_{63})	Dependent on gas composition

Physical

Length	28 cm (11 in)
Diameter	5.3 cm (2.1 in)
Weight	Air: 0.53 kg (1.2 lbs) Water: -0.06 kg (-0.1 lbs)
Housing Material	Acetal Plastic
Depth Rating	0-600 meters (plastic) up to 0-6000 meters (titanium)
Water Temperature	-2° to 50° C

Electrical

Input voltage	7-24 VDC
Power consumption	0.06 W (5 mA at 12 V)
Data output	digital: RS-232, ASCII CSV
4-Pin Male MCBH Impulse connector	

Optional Accessories

Titanium Housings
Rated up to 6000 m depth

Internal battery power

External battery pack
19, 76 or 134 Amp-hour capacity

Water-pumped head
Reduces biofouling and improves response rate

Mooring cage or frame with instrument brackets

Pigtail Cables with Locking Sleeves
5, 10, 25, 50 meters, or longer

Water-Pumped Head Accessory

Pigtail Cable with Locking Sleeve

Copper Antifouling Shield

Instrument and Battery Mooring Bracket

PRO OCEANUS Stability in a sea of change.

Pro-Oceanus.com
sales@pro-oceanus.com

80 Pleasant Street,
Bridgewater, Nova Scotia
Canada B4V 1N1

T +1-902-530-3550
F +1-902-530-3551
Toll-Free (Canada/US) 1-855-530-3550

Oxygen Optode

AANDERAA a xylem brand

TEST & SPECIFICATIONS

Form No. 712 V3, May 2020

Program Version: V5.1.1

Product: Oxygen Optode 4835
Serial No: 1038

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)	20.0	mA
2.2	CANBus Current drain at 0.5 Hz sampling (Max.: 33 mA)	19.0	mA
2.3	Current drain in sleep (Max.: 270 µA)	105	µA
2.4	CANBus Current drain in sleep (Max.: 180 µA)	99	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)	1.80	V
2.7	Excitation driver voltage, C4 Analog Board (4.3 ±0.1 V)	4.35	V

Performance test:	Channel:	Blue		Red	
3.1	Average of Receiver readings (0±150mV)	-26.4	mV	-16.9	mV
3.2	Standard Deviation of Receiver readings (Max.: 45mV/10mV)	2.39	mV	0.64	mV
3.3	Amplitude measurement with non-fluorescence foil (<60mV/650-1200mV)	7.4	mV	775	mV
3.4	CANBus Output test				

Function test from 0 to 40°C:	Channel:	Blue		Red	
4.1	Minimum amplitude measurement (Blue: >550 mV, Red >550 mV)	694.4	mV	629.8	mV
4.2	Maximum amplitude measurement (Blue: <1600 mV, Red <1400 mV)	1007.8	mV	953.9	mV
4.3	Minimum phase measurement (Blue: >32°, Red: >3°)	36.52	°	8.77	°
4.4	Maximum phase measurement (Blue: <45°, Red: <10°)	42.4	°	9.21	°
4.5	Maximum standard deviation of Phase measurement: (< 0.07°)	0.04	°	0.03	°
4.6	Minimum temperature raw data measurement: (<-200 mV)			-455	mV
4.7	Maximum temperature raw data measurement: (>450 mV)			700	mV

Date: 07 Apr 2021

Sign:

Juni Skaar, Production Engineer

AANDERAA a xylem brand

CALIBRATION CERTIFICATE

Form No. 710, Nov 2013

Sensing Foil Batch No: 2019
Certificate No:

Product: Oxygen Optode 4835
Serial No: 1038
Calibration Date: 23 Jan 2021

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

Parameter: Internal Temperature:

Calibration points and readings:

Temperature (°C)	1.03	11.99	24.01	35.99
Reading (mV)	777.64	438.03	43.17	-329.34

Giving these coefficients

Index	0	1	2	3	4	5
TempCoef	2.53423E01	-3.09388E-02	2.87117E-06	-4.22893E-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 (°)	3.29175E+01	6.22911E+01
Temperature reading (°C)	9.89441E+00	1.94275E+01
Air Pressure (hPa)	9.58514E+02	

Giving these coefficients

Index	0	1	2	3
PhaseCoef	-1.10000E00	1.00000E00	0.00000E00	0.00000E00
ConcCoef				

[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: 25 Jan 2021

Sign:

Tor-Ove Kvalvaag, Calibration Engineer

AANDERAA a xylem brand

PRESSURE CERTIFICATE

Form No. 667, Sept 2009

Product: Oxygen Optode 4835
Serial No: 1038
Date: 07.04.2021

Certificate No: 1831611851038

This is to certify that this product has been pressure tested with the following instrument, and we confirm that no irregularities were found during the test:

Autoklav 800 bar – sn: 0210005

Pressure readings:

Pressure (Bar)	Pressure time (hour)
30	1

Date: 07 Apr 2021

Sign:

Juni Skaar, Production Engineer

Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

SEA-BIRD SCIENTIFIC

(541) 929-5650
Fax (541) 929-5277
www.sea-birdscientific.com

C-Star Calibration

Date May 4, 2021 S/N# CST-557DR Pathlength 25

	Analog output	Digital output
V_d	0.007 V	0 counts
V_{air}	4.776 V	15657 counts
V_{ref}	4.702 V	15414 counts

Temperature of calibration water	23.2 °C
Ambient temperature during calibration	23.9 °C

Relationship of transmittance (Tr) to beam attenuation coefficient (c), and pathlength (x, in meters): $\mathbf{Tr = e^{-cx}}$

To determine beam transmittance: $\mathbf{Tr = (V_{sig} - V_{dark}) / (V_{ref} - V_{dark})}$

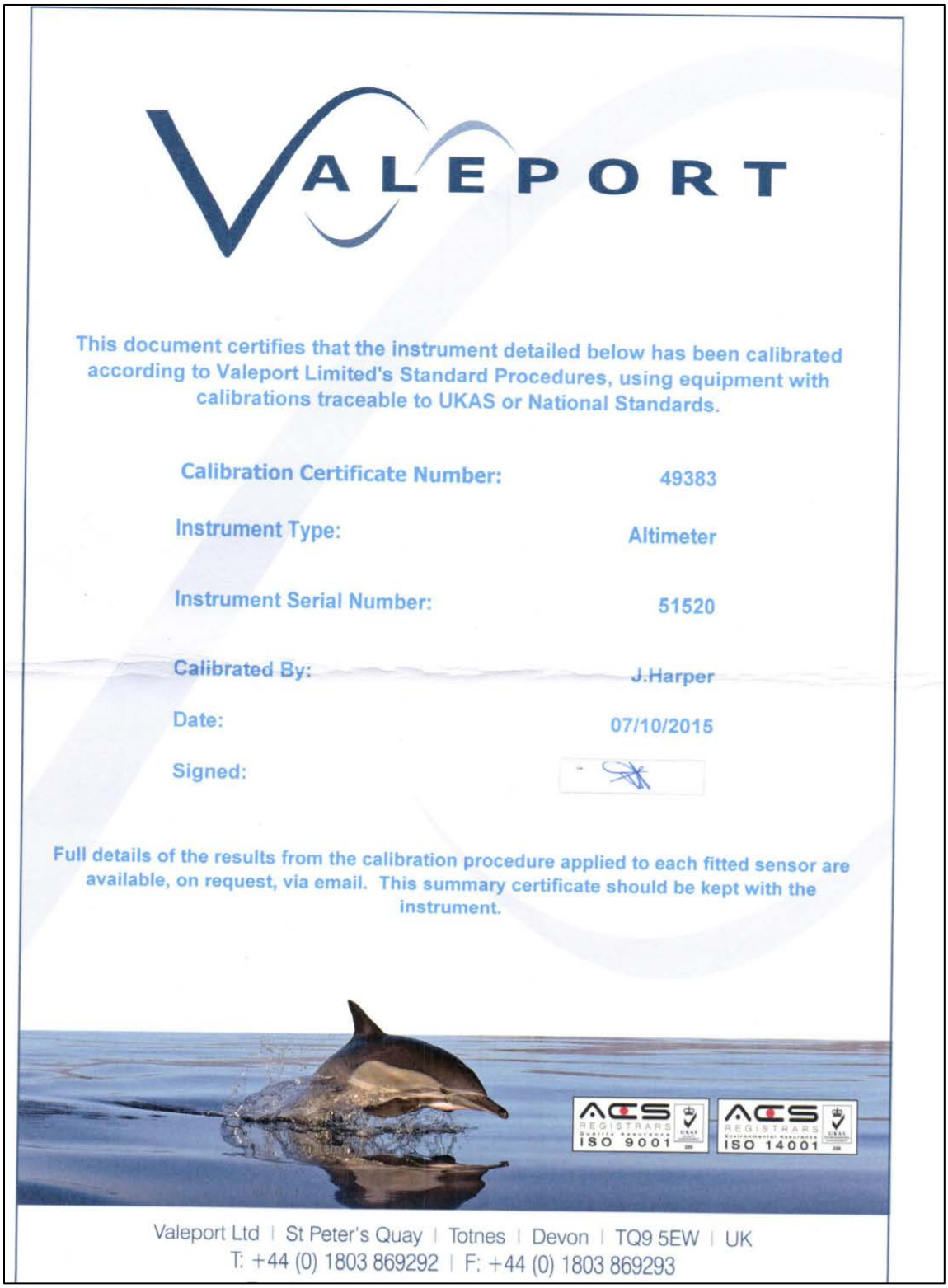
To determine beam attenuation coefficient: $\mathbf{c = -1/x * \ln (Tr)}$

V_d Meter output with the beam blocked. This is the offset.
V_{air} Meter output in air with a clear beam path.
V_{ref} Meter output with clean water in the path.
Temperature of calibration water: temperature of clean water used to obtain V_{ref}.
Ambient temperature: meter temperature in air during the calibration.
V_{sig} Measured signal output of meter.

Revision L 6/9/09

CTD

Altimeter



VALEPORT

This document certifies that the instrument detailed below has been calibrated according to Valeport Limited's Standard Procedures, using equipment with calibrations traceable to UKAS or National Standards.

Calibration Certificate Number:	49383
Instrument Type:	Altimeter
Instrument Serial Number:	51520
Calibrated By:	J.Harper
Date:	07/10/2015
Signed:	

Full details of the results from the calibration procedure applied to each fitted sensor are available, on request, via email. This summary certificate should be kept with the instrument.

ACS REGISTRARS ISO 9001 ACS REGISTRARS ISO 14001

Valeport Ltd | St Peter's Quay | Totnes | Devon | TQ9 5EW | UK
T: +44 (0) 1803 869292 | F: +44 (0) 1803 869293

Conductivity (primary)

Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 1798
CALIBRATION DATE: 23-Sep-20

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g =  -1.01000041e+001          CPcor = -9.5700e-008 (nominal)
h =   1.30340583e+000          CTcor =  3.2500e-006 (nominal)
i =   3.53024899e-004
j =   3.99816850e-005
```

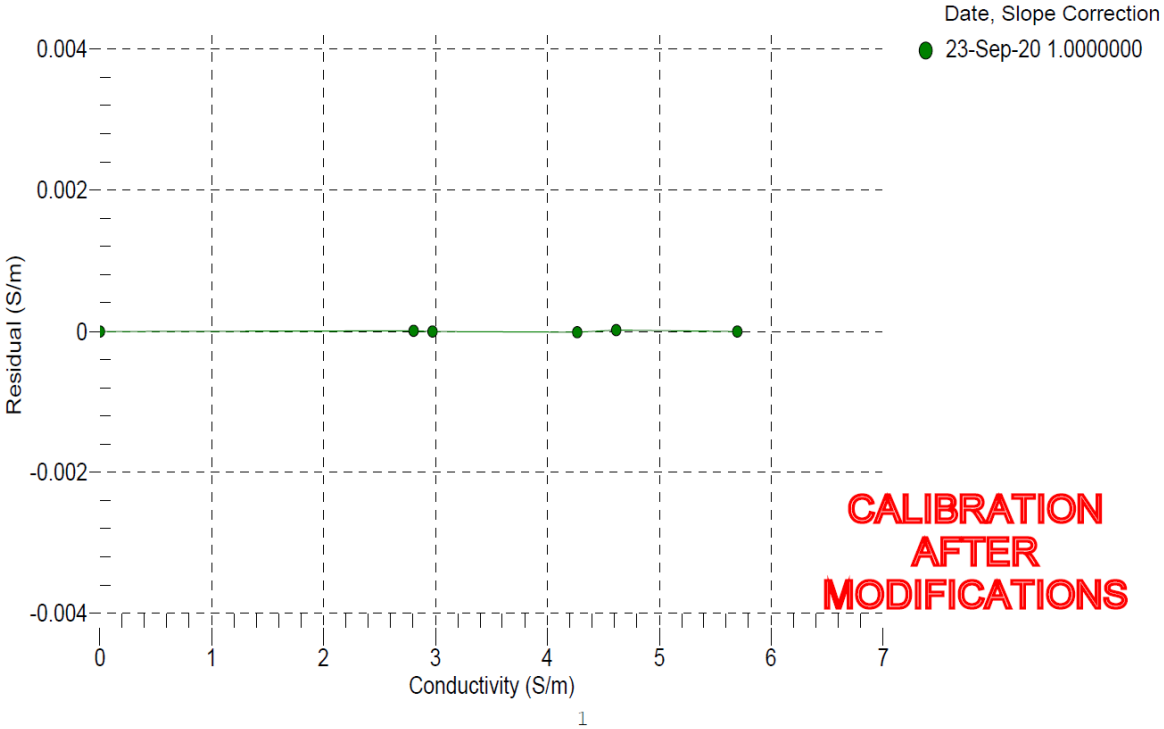
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.78231	0.00000	0.00000
-1.0000	34.8029	2.80360	5.40276	2.80360	0.00000
1.0000	34.8032	2.97495	5.52262	2.97495	-0.00000
15.0000	34.8029	4.27014	6.35549	4.27013	-0.00001
18.5000	34.8009	4.61655	6.56026	4.61656	0.00001
29.0000	34.7956	5.69931	7.16234	5.69931	-0.00000
32.5000	34.7831	6.07086	7.35745	6.07074	-0.00012

f = Instrument Output (kHz)

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



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Conductivity (secondary)

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Bellevue, WA 98005
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+1 425-643-9866
seabird@seabird.com
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SENSOR SERIAL NUMBER: 1314
CALIBRATION DATE: 07-Jul-20

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g =  -3.96019327e+000
h =   4.57720285e-001
i =  -4.55260289e-005
j =   2.81347476e-005

CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

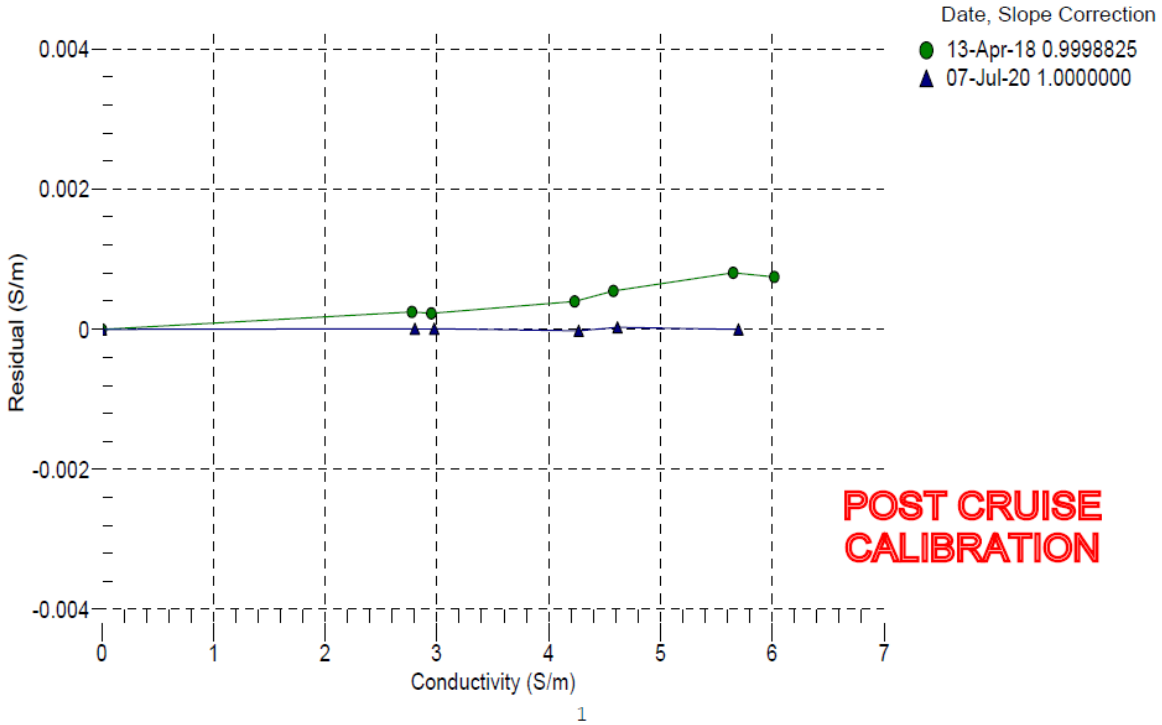
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.94107	0.00000	0.00000
-1.0003	34.8040	2.80365	8.34649	2.80366	0.00000
0.9997	34.8046	2.97503	8.56624	2.97503	0.00000
14.9997	34.8050	4.27034	10.07081	4.27032	-0.00003
18.4997	34.8035	4.61682	10.43591	4.61685	0.00003
28.9997	34.7961	5.69935	11.50025	5.69935	-0.00000
32.4997	34.7787	6.07014	11.84220	6.07007	-0.00007

f = Instrument Output (kHz)

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



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Fish

Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

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seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 1130
CALIBRATION DATE: 22-Mar-21

SBE 9plus PRESSURE CALIBRATION DATA
10000 psia S/N 120089

DIGIQUARTZ COEFFICIENTS:

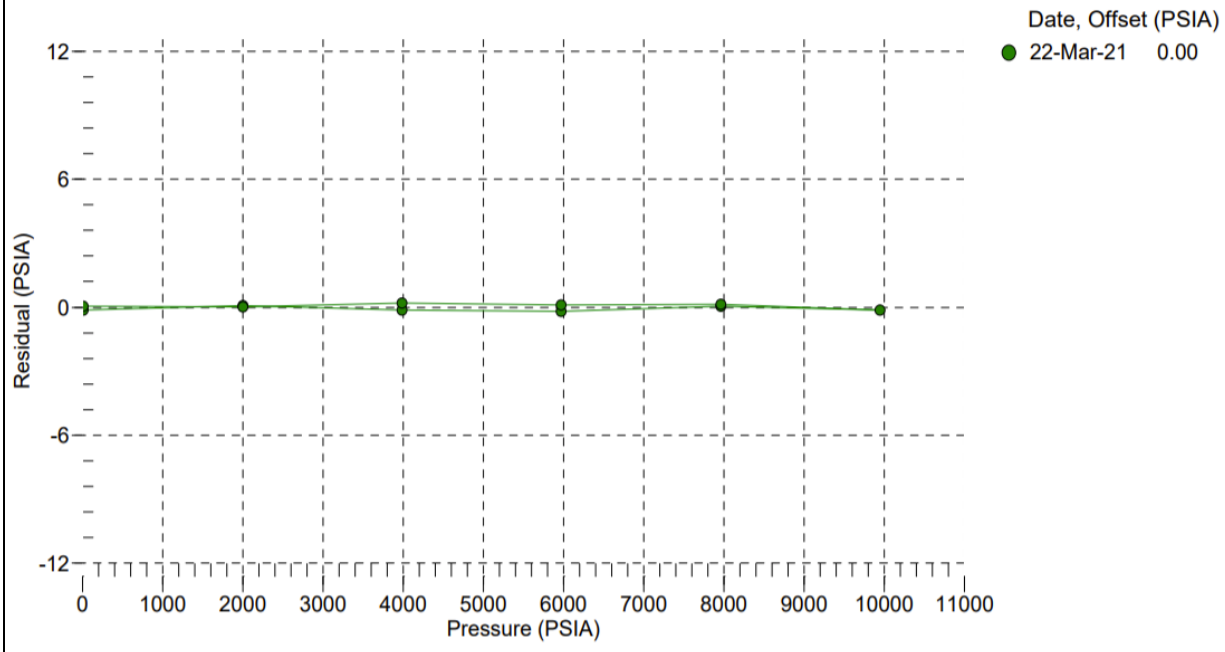
C1 =	-4.230776e+004
C2 =	1.490078e-001
C3 =	1.507500e-002
D1 =	3.473000e-002
D2 =	0.000000e+000
T1 =	3.002251e+001
T2 =	-2.774200e-004
T3 =	4.796030e-006
T4 =	1.754420e-009
T5 =	0.000000e+000

AD590M, AD590B, SLOPE AND OFFSET:

AD590M =	1.28100e-002
AD590B =	-8.83931e+000
Slope =	0.99999
Offset =	1.2528 (dbars)

PRESSURE (PSIA)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT TEMPERATURE (°C)	INSTRUMENT PRESSURE (PSIA)	CORRECTED PRESSURE (PSIA)	RESIDUAL (PSIA)
14.531	33317.40	21.1	12.581	14.398	-0.133
2000.754	34089.30	21.3	1999.023	2000.816	0.062
3988.219	34842.00	21.3	3986.325	3988.093	-0.126
5975.739	35576.50	21.3	5973.808	5975.552	-0.187
7963.340	36294.00	21.3	7961.673	7963.393	0.053
9951.154	36995.30	21.4	9949.321	9951.017	-0.137
7963.255	36294.00	21.4	7961.662	7963.382	0.127
5975.681	35576.60	21.4	5974.051	5975.795	0.114
3988.143	34842.10	21.4	3986.557	3988.325	0.182
2000.761	34089.30	21.4	1998.977	2000.770	0.009
14.539	33317.50	21.5	12.757	14.575	0.036

Residual (PSIA) = corrected instrument pressure - reference pressure



1

Dissolved Oxygen (primary)

PRIMARY

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13431 NE 20th Street
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seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 2512
CALIBRATION DATE: 10-Aug-22

SBE 43 OXYGEN CALIBRATION DATA

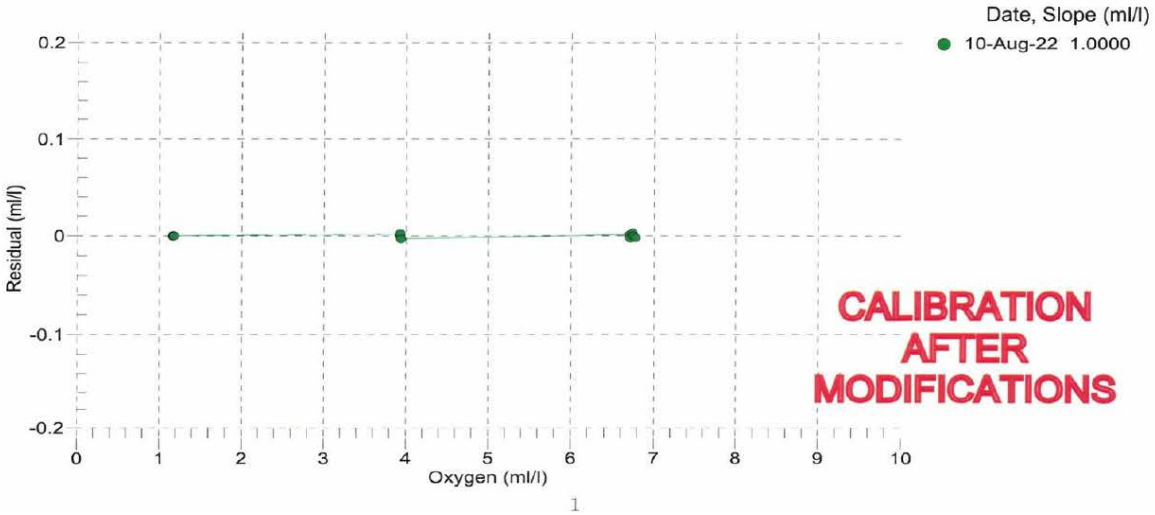
COEFFICIENTS:
Soc = 0.5437
Voffset = -0.4889
Tau20 = 1.15

A = -4.9492e-003
B = 1.4118e-004
C = -1.7963e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4
D2 = -4.64803e-2
H1 = -3.300000e-2
H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OXYGEN (ml/l)	BATH TEMPERATURE (° C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.17	12.00	0.00	0.785	1.16	-0.00
1.17	20.00	0.00	0.847	1.17	-0.00
1.17	6.00	0.00	0.742	1.17	0.00
1.17	2.00	0.00	0.713	1.17	-0.00
1.18	26.00	0.00	0.896	1.18	0.00
1.18	30.00	0.00	0.929	1.18	-0.00
3.92	12.00	0.00	1.488	3.93	0.00
3.93	6.00	0.00	1.339	3.93	0.00
3.93	2.00	0.00	1.243	3.93	0.00
3.93	25.99	0.00	1.851	3.93	0.00
3.93	20.00	0.00	1.695	3.94	0.00
3.94	30.00	0.00	1.961	3.94	-0.00
6.71	2.00	0.00	1.776	6.71	0.00
6.71	6.00	0.00	1.942	6.71	-0.00
6.74	12.00	0.00	2.205	6.74	0.00
6.74	30.00	0.00	3.010	6.74	0.00
6.75	19.92	0.00	2.554	6.75	-0.00
6.77	25.91	0.00	2.830	6.77	-0.00

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)
Oxsol(T,S) = oxygen saturation (ml/l); P = pressure (dbar)
$Oxygen\ (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * Oxsol(T,S) * \exp(E * P / K)$
Residual (ml/l) = instrument oxygen - bath oxygen



1

Dissolved Oxygen (secondary)

SECONDARY

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13431 NE 20th Street
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www.seabird.com

SENSOR SERIAL NUMBER: 3170
CALIBRATION DATE: 13-Aug-22

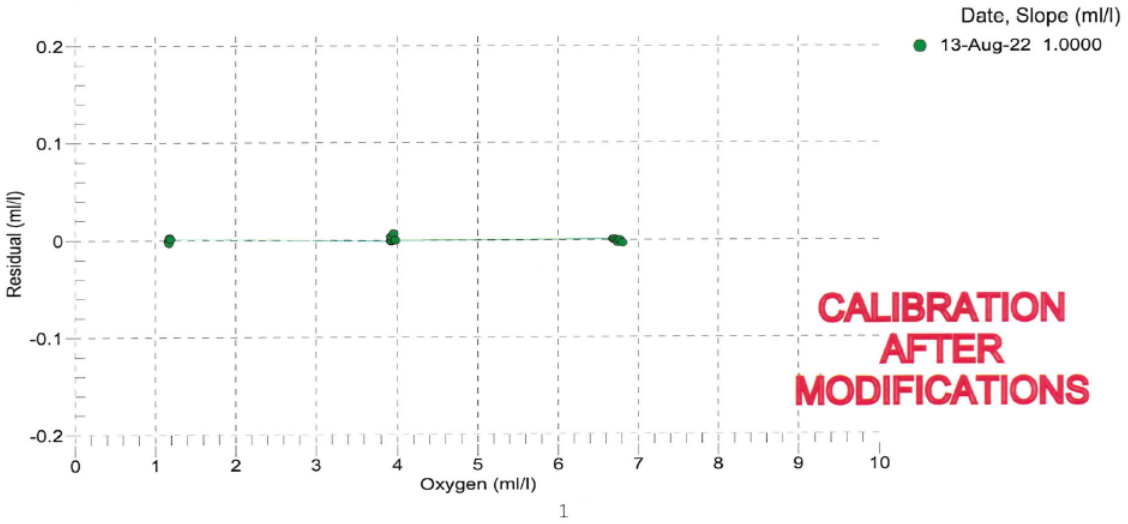
SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:
Soc = 0.3757
Voffset = -0.4876
Tau20 = 1.02
A = -4.8801e-003
B = 1.8525e-004
C = -2.0833e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4
D2 = -4.64803e-2
H1 = -3.300000e-2
H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OXYGEN (ml/l)	BATH TEMPERATURE (° C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.17	12.00	0.00	0.914	1.17	-0.00
1.17	6.00	0.00	0.853	1.17	-0.00
1.17	20.00	0.00	0.998	1.17	-0.00
1.18	2.00	0.00	0.813	1.17	-0.00
1.18	26.00	0.00	1.064	1.18	0.00
1.19	30.00	0.00	1.108	1.19	0.00
3.92	6.00	0.00	1.714	3.92	-0.00
3.93	20.00	0.00	2.200	3.93	0.00
3.93	2.00	0.00	1.577	3.93	-0.00
3.93	12.00	0.00	1.926	3.93	0.00
3.95	26.00	0.00	2.417	3.96	0.01
3.98	30.00	0.00	2.563	3.98	-0.00
6.69	2.00	0.00	2.345	6.69	0.00
6.70	6.00	0.00	2.583	6.70	0.00
6.73	12.00	0.00	2.949	6.73	-0.00
6.75	20.00	0.00	3.428	6.75	-0.00
6.77	30.00	0.00	4.019	6.77	-0.00
6.80	26.00	0.00	3.803	6.80	-0.00

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)
Oxsol(T,S) = oxygen saturation (ml/l); P = pressure (dbar)
$Oxygen\ (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * Oxsol(T,S) * \exp(E * P / K)$
Residual (ml/l) = instrument oxygen - bath oxygen



1

Fluorometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

(541) 929-5650
Fax (541) 929-5277
www.wetlabs.com

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 3/9/2021 S/N: FLRTD-397

Chlorophyll concentration expressed in µg/l can be derived using the equation:

CHL (µg/l) = Scale Factor * (Output - Dark Counts)

	Analog Range 1	Analog Range 2	Analog Range 4 (default)		Digital	
Dark Counts	0.113	0.069	0.047	V	70	counts
Scale Factor (SF)	6	12	23	µg/l/V	0.0071	µg/l/count
Maximum Output	4.98	4.98	4.98	V	16380	counts
Resolution	0.7	0.7	0.7	mV	1.0	counts

Ambient temperature during characterization 21.0 °C

Analog Range: 1 (most sensitive, 0–4,000 counts), 2 (midrange, 0–8,000 counts), 4 (entire range, 0–16,000 counts).

Dark Counts: Signal output of the meter in clean water with black tape over detector.

SF: Determined using the following equation: SF = x ÷ (output - dark counts), where x is the concentration of the solution used during instrument characterization. SF is used to derive instrument output concentration from the raw signal output of the fluorometer.

Maximum Output: Maximum signal output the fluorometer is capable of.

Resolution: Standard deviation of 1 minute of collected data.

The relationship between fluorescence and chlorophyll-a concentrations *in-situ* is highly variable. The scale factor listed on this document was determined using a mono-culture of phytoplankton (*Thalassiosira weissflogii*). The population was assumed to be reasonably healthy and the concentration was determined by using the absorption method. To accurately determine chlorophyll concentration using a fluorometer, you must perform secondary measurements on the populations of interest. This is typically done using extraction-based measurement techniques on discrete samples. For additional information on determining chlorophyll concentration see "Standard Methods for the Examination of Water and Wastewater" part 10200 H, published jointly by the American Public Health Association, American Water Works Association, and the Water Environment Federation.

FLRTD-397 Revision J 3/17/08

PAR

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 06/04/19 Job No.: R13636
Model Number: QSP200L4S
Serial Number: 4361
Operator: TPC
Standard Lamp: V-039(1/3/19)
Operating Voltage Range: 6 to 15 VDC (+)

Note: The QSP200L4S uses a log amplifier to measure the detector signal current with V = log I (Amps) / IRef
To calculate irradiance, use this formula:

Irradiance = Calibration factor * (10^Light Signal Voltage - 10^Dark Voltage)

With the appropriate (solar corrected) Irradiance Calibration Factor:

Dry Calibration Factor:	**1.49E+13**	**quanta/cm²·sec per volt**	**2.47E-05**	**µEinsteins/cm²·sec per volt**
Wet Calibration Factor:	**2.62E+13**	**quanta/cm²·sec per volt**	**4.36E-05**	**µEinsteins/cm²·sec per volt**

Sensor Test Data and Results[4)]

Sensor Supply Current (Dark):	75.4	mA			
Supply Voltage:	6	Volts			
Lamp Integrated PAR Irradiance:	8.90E+15	quanta/cm²·sec	0.01478	µEinsteins/cm²sec	
SC3 Immersion Coefficient:	0.5664	Scalar Correction:	1	PAR Solar Correction:	1.0000

Nominal Filter OD	Calibrated Trans.	Sensor Voltage	Measured Trans.	Measured Signal (Amps)	Estimated Signal (Amps)	Calc. Output (Volts)	Error (Volts)	Error (%)	Test Irrad. (quanta/cm²·sec)
No Filter	100.00%	2.779	100.00%	6.01E-08	6.01E-08	2.780	0.001	0.0	8.90E+15
0.3	36.10%	2.338	36.05%	2.17E-08	2.17E-08	2.339	0.002	0.1	3.21E+15
0.5	27.60%	2.224	27.68%	1.66E-08	1.66E-08	2.224	0.000	-0.3	2.46E+15
1	9.27%	1.758	9.31%	5.59E-09	5.57E-09	1.757	-0.001	-0.4	8.28E+14
2	1.11%	0.911	1.10%	6.63E-10	6.67E-10	0.914	0.003	0.6	9.83E+13
3	0.05%	0.295	0.07%	4.37E-11	3.21E-11	0.268	-0.026	-26.6	6.48E+12

Dark Before: 0.186 Volts
Light - No Filter Hldr.: 2.779 Volts
Dark After - NFH: 0.186 Volts
Average Dark 0.186 Volts

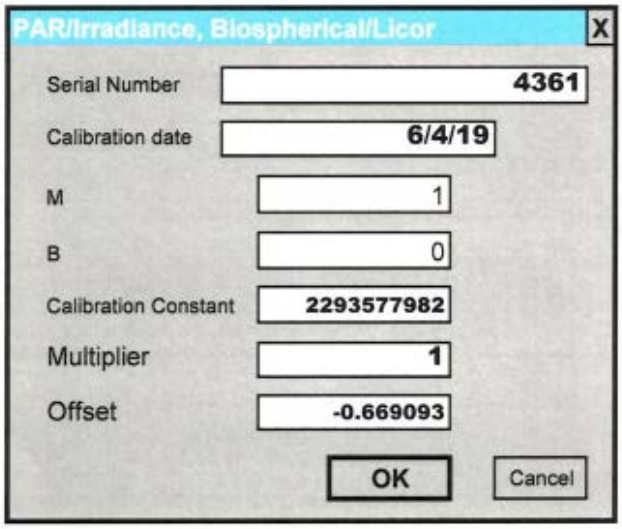
I_{Ref} = 1.00E-10 Amps
I_{Dark} = 1.53E-10 Amps
10^{VDark} = 1.534087

RG780 **0.219**

Notes:
1. Annual calibration is recommended.
2. The collector should be cleaned frequently with alcohol.
4) This section is for internal use and for more advanced analysis.

QSP200L-QSP2300 (4-2013-).xls

See Seabird Application Note 11 QSP L



Information from Cal Sheet:

Serial Number	4361
Cal Date	6/4/2019
Wet Cal Factor	4.36E-05
Average Dark	0.186

Pressure Sensor

Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 1130
CALIBRATION DATE: 22-Mar-21

SBE 9plus PRESSURE CALIBRATION DATA
10000 psia S/N 120089

DIGIQUARTZ COEFFICIENTS:

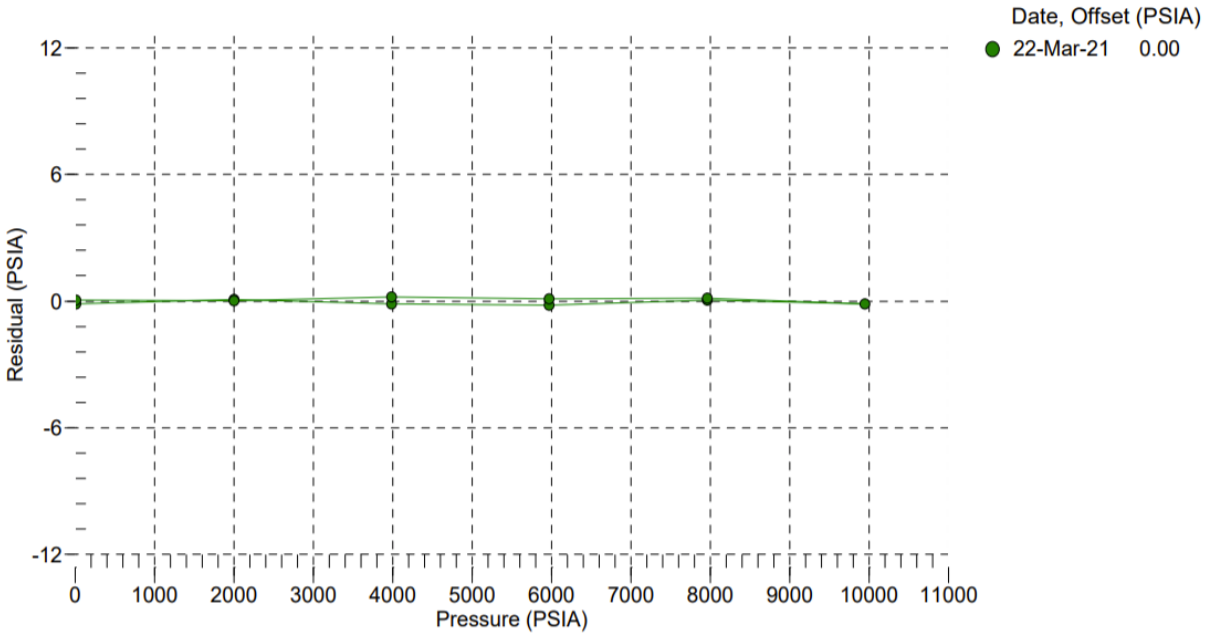
C1 =	-4.230776e+004
C2 =	1.490078e-001
C3 =	1.507500e-002
D1 =	3.473000e-002
D2 =	0.000000e+000
T1 =	3.002251e+001
T2 =	-2.774200e-004
T3 =	4.796030e-006
T4 =	1.754420e-009
T5 =	0.000000e+000

AD590M, AD590B, SLOPE AND OFFSET:

AD590M =	1.28100e-002
AD590B =	-8.83931e+000
Slope =	0.99999
Offset =	1.2528 (dbars)

PRESSURE (PSIA)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT TEMPERATURE (°C)	INSTRUMENT PRESSURE (PSIA)	CORRECTED PRESSURE (PSIA)	RESIDUAL (PSIA)
14.531	33317.40	21.1	12.581	14.398	-0.133
2000.754	34089.30	21.3	1999.023	2000.816	0.062
3988.219	34842.00	21.3	3986.325	3988.093	-0.126
5975.739	35576.50	21.3	5973.808	5975.552	-0.187
7963.340	36294.00	21.3	7961.673	7963.393	0.053
9951.154	36995.30	21.4	9949.321	9951.017	-0.137
7963.255	36294.00	21.4	7961.662	7963.382	0.127
5975.681	35576.60	21.4	5974.051	5975.795	0.114
3988.143	34842.10	21.4	3986.557	3988.325	0.182
2000.761	34089.30	21.4	1998.977	2000.770	0.009
14.539	33317.50	21.5	12.757	14.575	0.036

Residual (PSIA) = corrected instrument pressure - reference pressure



1

Pump (primary)

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13431 NE 20th Street
Bellevue, WA 98005
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seabird@seabird.com
www.seabird.com

Pressure Test Certificate

Test Date: **2020-07-01**

Description: **SBE-5T Submersible Pump**

Sensor Information:

Replaced the main piston "O"-Rings.

Model Number: **SBE-5T**

Serial Number: **5643**

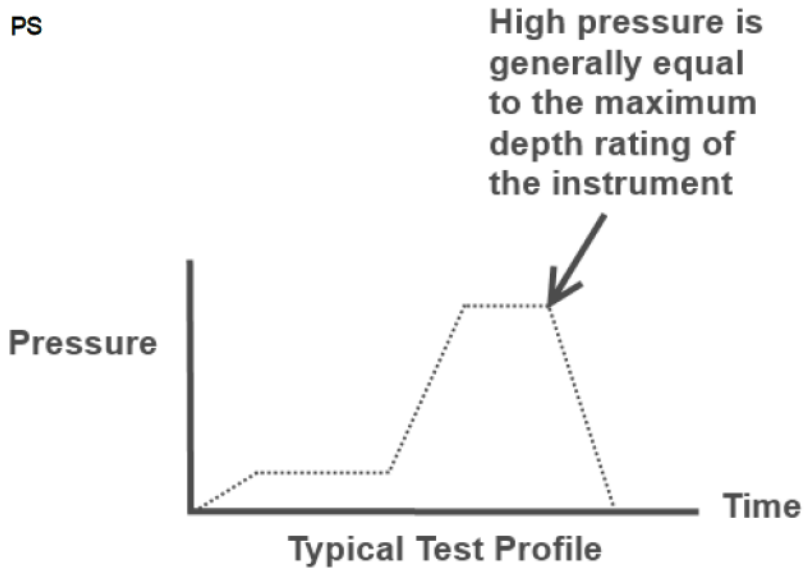
Pressure Test Protocol:

Low Pressure Test: **40** PSI Held For: **15** Minutes

High Pressure Test: **10000** PSI Held For: **30** Minutes

Passed Test: **True**

Tested By: **PS**



Pump (secondary)

Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

Pressure Test Certificate

Test Date: **2020-07-01**

Description: **SBE-5T Submersible Pump**

Sensor Information:

Replaced the main piston "O"-Rings.

Model Number: **SBE-5T**

Serial Number: **5641**

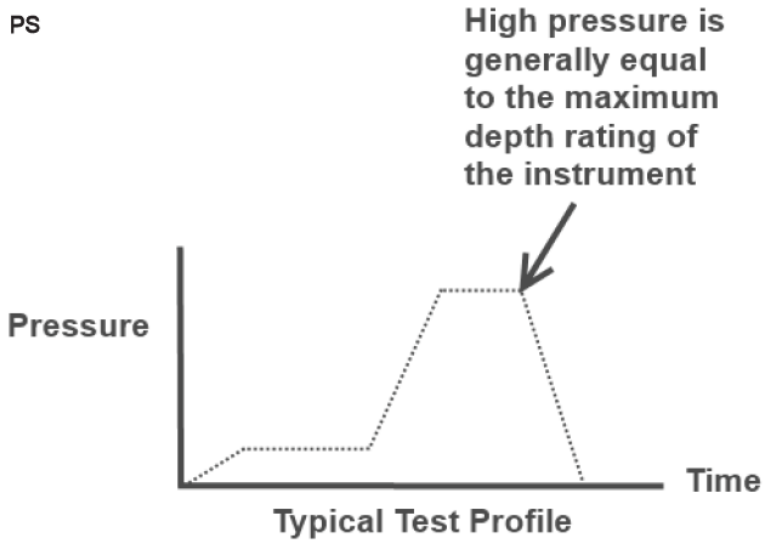
Pressure Test Protocol:

Low Pressure Test: **40** PSI Held For: **15** Minutes

High Pressure Test: **10000** PSI Held For: **30** Minutes

Passed Test: **True**

Tested By: **PS**



Temperature (primary)

Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 1457
CALIBRATION DATE: 13-Mar-21

SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

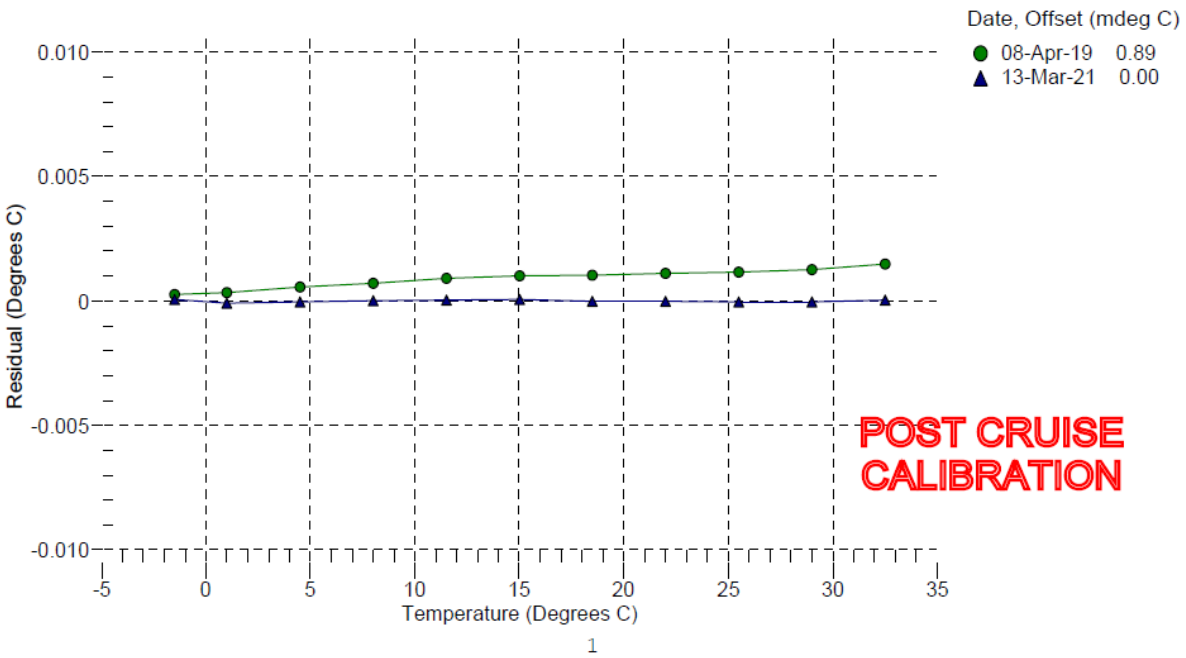
```
g =  4.82838388e-003
h =  6.70461000e-004
i =  2.51909719e-005
j =  1.96929563e-006
f0 =  1000.0
```

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5001	6156.484	-1.5000	0.00007
1.0000	6512.203	0.9999	-0.00009
4.5000	7034.769	4.5000	-0.00003
8.0000	7586.685	8.0000	0.00002
11.5000	8168.720	11.5000	0.00003
15.0000	8781.639	15.0001	0.00005
18.5000	9426.153	18.5000	-0.00001
22.0000	10102.997	22.0000	-0.00001
25.5000	10812.829	25.5000	-0.00004
29.0000	11556.316	29.0000	-0.00004
32.5000	12334.095	32.5000	0.00005

f = Instrument Output (Hz)

Temperature ITS-90 (°C) = $1/\{g + h[ln(f0 / f)] + i[ln^2(f0 / f)] + j[ln^3(f0 / f)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



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Temperature (Secondary)

SEA-BIRD SCIENTIFIC
Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 1238
CALIBRATION DATE: 10-Mar-21

SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

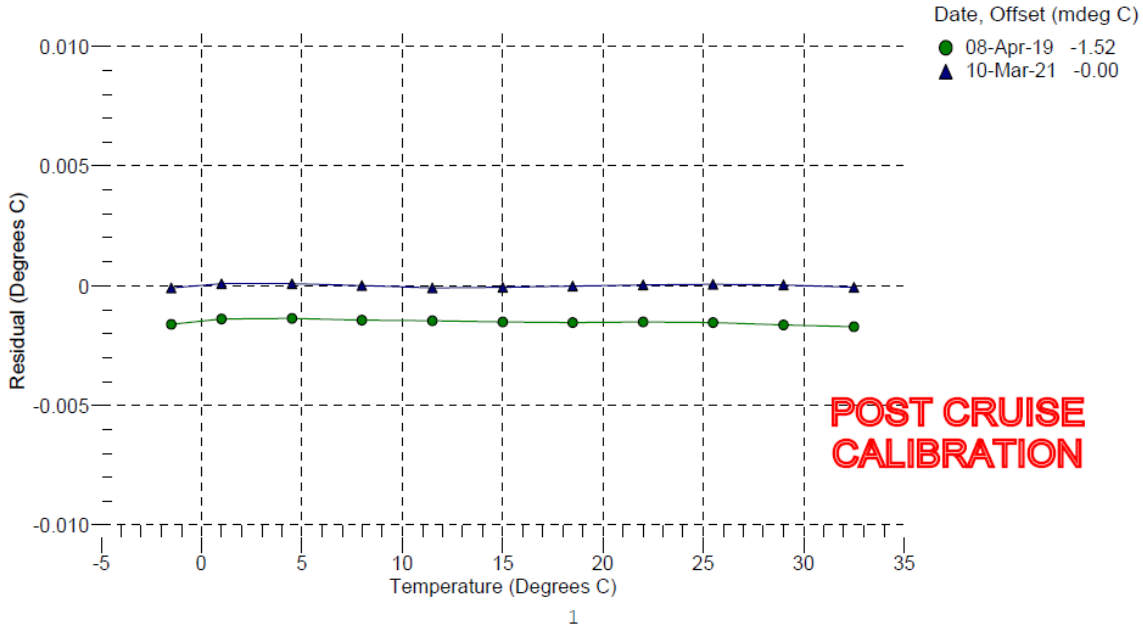
```
g =  4.78572276e-003
h =  6.54386618e-004
i =  2.20741994e-005
j =  1.49970925e-006
f0 =  1000.0
```

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	5941.808	-1.5001	-0.00008
1.0000	6290.187	1.0001	0.00008
4.5000	6802.417	4.5001	0.00008
8.0000	7344.019	8.0000	0.00001
11.5000	7915.831	11.4999	-0.00008
15.0000	8518.688	14.9999	-0.00006
18.5000	9153.370	18.5000	-0.00002
22.0000	9820.649	22.0000	0.00004
25.5000	10521.264	25.5001	0.00007
29.0000	11255.933	29.0000	0.00004
32.5000	12025.355	32.4999	-0.00006

f = Instrument Output (Hz)

Temperature ITS-90 (°C) = $1/\{g + h[ln(f0 / f)] + i[ln^2(f0 / f)] + j[ln^3(f0 / f)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



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Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

SEA-BIRD SCIENTIFIC

(541) 929-5650
Fax (541) 929-5277
www.sea-birdscientific.com

C-Star Calibration

Date May 17, 2022 S/N# CST-1316DR Pathlength 25cm

	Analog output	Digital output
V_d	0.021 V	0 counts
V_{air}	4.832 V	15778 counts
V_{ref}	4.699 V	15342 counts

Temperature of calibration water	22.5	°C
Ambient temperature during calibration	22.4	°C

Relationship of transmittance (Tr) to beam attenuation coefficient (c), and pathlength (x, in meters): $\mathbf{Tr = e^{-cx}}$

To determine beam transmittance: $\mathbf{Tr = (V_{sig} - V_{dark}) / (V_{ref} - V_{dark})}$

To determine beam attenuation coefficient: $\mathbf{c = -1/x * \ln (Tr)}$

V_d Meter output with the beam blocked. This is the offset.
V_{air} Meter output in air with a clear beam path.
V_{ref} Meter output with clean water in the path.
Temperature of calibration water: temperature of clean water used to obtain V_{ref}.
Ambient temperature: meter temperature in air during the calibration.
V_{sig} Measured signal output of meter.