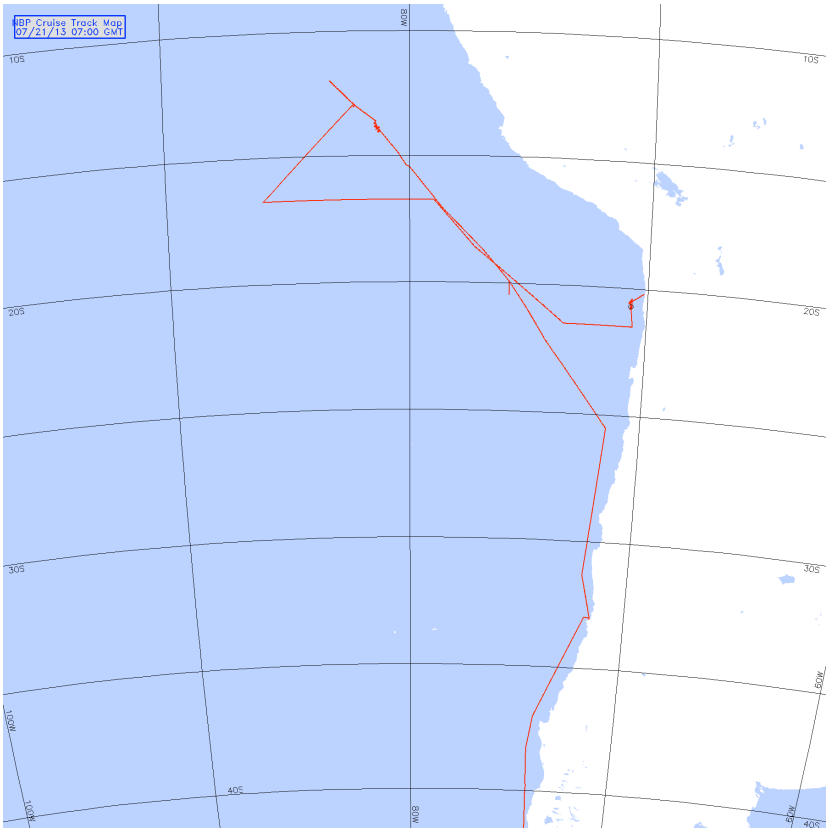
# Data Report NBP1305
# Ocean Sciences

**Dr. Devol**

**June 24, 2013 – July 22, 2013**

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# 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 DVD-R written in written in UDF format. It is readable by most modern computer platforms.

All the data has been compressed using Unix “gzip,” identified by the “.tz” extension. It has been copied to the distribution media in the Unix tar archive format, “.tar” extension. Tools are available on all platforms for uncompressing and de-archiving these formats: On Macintosh, one can use Stuffit Expander with DropStuff. On Windows operating systems, one can use WinZip.

MultiBeam and raw ADCP data 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: NBP1305**

| File | | Description |
|---|---|---|
| / | | Root level directory |
| | NBP1305.trk | Text file of cruise track (lat,lon) |
| | NBP1305.mgd | Full Cruise MGD77 data file |
| | NBP1305.gmt | GMT binary file of MGD77 data |
| | INSTCOEF.TXT | Instrument Coefficient File |
| | 1305DATA.doc | Data Report NBP1305 (MS Word) |
| | 1305DATA.pdf | Data Report NBP1305 (PDF format) |
| /cal-sheets | | Cruise track plots |
| | NBP1305-Sensors.doc | Sensor Calibration Sheet Reference |
| | NBP1305-CalSheets.zip | Sensor Calibration Sheet files |
| /plots | | Cruise track plots |
| | NBP1305-track.jpg | Cruise track plot (JPEG format) |
| | NBP1305-track.png | Cruise track plot (PNG format) |
| /process | | Processed data |
| | 1305JGOF.tz | JGOFS format data files |
| | 1305QC.tz | Daily RVDAS QC postcript plots |
| | 1305PCO2.tz | Merged pCO2 data files |
| | 1305MGD.tz | MGD Data |
| | 1305PROC.tz | Other processed data |
| /rvdas/nav | | Navigation data |
| | 1305adcp.tz | ADCP Data Sets |
| | 1305gyr1.tz | Gyro raw data |
| | 1305PCOD.tz | Trimble P-code raw data |
| | 1305seap.tz | Seapath data |
| | 1305sp1b.tz | Seapath 1b data |
| | 1305sp2a.tz | Seapath 2a data |
| /rvdas/uw | | Underway data |
| | 1305bwnc.tz | Baltic Winch data |
| | 1403ctdd.tz | CTD Winch data |
| | 1305cwnc.tz | Waterfall Winch data |
| | 1305eng1.tz | Engineering data |
| | 1305grv1.tz | Gravimeter raw data |
| | 1305hdas.tz | HydroDAS raw data |
| | 1305knud.tz | Knudsen raw data |
| | 1305mbdp.tz | Multibeam depth data |
| | 1305mwx1.tz | Meteorology raw data |
| | 1305oxyg.tz | Oxygen sensor |
| | 1305pco2.tz | pCO2 raw data |
| | 1305pguv.tz | GUV raw data |
| | 1305rtmp.tz | Remote temperature data |
| | 1305svp1.tz | Sound velocity probe (in ADCP well) |
| | 1305tsg1.tz | Micro TSG data |
| | 1305tsg2.tz | 2nd Micro TSG data |
| | 1305twnc.tz | Winch data |
| /Imagery | | Satellite Imagery |
| | 1305Imagery.tz | Collection of Imagery Files |

| | | |
|---|---|---|
| /ocean | | Ocean data |
| | 1305xbt.tz | XBT Data |
| | 1305ctd.tz | CTD Data |

## Extracting Data

The Unix tar command has many options. It is often useful to know exactly how an archive was produced when expanding its contents. All archives are gzipped tar files and were created using the command,

```
tar -czvf archive_filename files_to_archive
```

To create a list of the files in the archive, use the Unix command,

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

where `contents.list` is the name of the file to create

To extract the files from the archive:

```
tar -xvf  archive_filename file(s)_to_extract
```

G-zipped files will have a ".tz" extension on the filename. These files can be decompressed after de-archiving, using the Unix command,

```
gunzip filename.tz
```

# Distribution Contents

## Cruise Information

NBP1305 departed

Data logging was started at ~06:00 GMT on June 24, 2013

Data logging was stopped at ~04:00: GMT on July 22, 2013

### *Cruise Track*

The distribution DVD includes a GMT cruise track file (NBP1305.trk). It contains the longitude and latitude of the ship's position at one-minute intervals extracted from the NBP1305.gmt file.

PNG and PDF cruise track files have been produced and placed in the /plots directory.

### *Satellite Images*

Satellite Images received for this cruise can be found in the file called /Imagery/1305Imagery.tar. Each type of image is contained in a .tz file within that file.

## NBP Data Products

The IT staff on the NBP creates two processed data products for every 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 /process/1305proc.tar. These files are not intended to be end-products. 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/1305jgof.tar. The archive contains one file produced for each day named jgDDD.dat.tz, where DDD is the year-day the data was acquired. The ".tz" 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" 9999 in the JGOFS data.

| Field | Data | Units |
|---|---|---|
| 01 | GMT date | dd/mm/yy |
| 02 | GMT 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 | $\mu$Einsteins/meter$^2$ sec |
| 10 | Sea surface temperature (remote) | °C |
| 11 | Sea surface conductivity (TSG1) | siemens/meter |
| 12 | Sea surface salinity (TSG1) | PSU |
| 13 | Sea depth<br>(uncorrected, calc. sw sound 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 | $\mu$g/l (mg/m$^3$) |
| 20 | Transmissometer | % |
| 21 | PSP | W/m$^2$ |
| 22 | PIR | W/m$^2$ |

## *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 NBP1305.mgd. The file NBP1305.gmt is created from the MGD77 dataset using the “mgd77togmt” utility. NBP1305.gmt can be used with the GMT plotting package.

The data used to produce the NBP1305.mgd file can be found on the distribution media in the file /process/1305proc.tar. 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 characters 13-27) to GMT when added; 0 = GMT |
| 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 | + = North<br>- = South. (–9000000 to 9000000) |
| 36-44 | 9 | real | Longitude x 100000 | + = East<br>- = West. (–18000000 to 18000000) |
| 45 | 1 | int | Position type code | 1=Observed fix<br>3=Interpolated<br>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 | Bathymetry, 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<br>3 = Interpolated (Header Seq. 12)<br>9 = Unspecified |
| 61-66 | 6 | real | Magnetics total field, $1^{ST}$ sensor | In tenths of nanoteslas (gammas) |
| 67-72 | 6 | real | Magnetics total field, $2^{ND}$ 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 |

| Col | Len | Type | Contents | Description, Possible Values, Notes |
|---|---|---|---|---|
| 79 | 1 | int | Sensor for residual field | 1 = 1st or leading sensor<br>2 = 2nd or trailing sensor<br>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 residuals are assumed to have been already corrected. |
| 85-90 | 6 | F6.0 | Depth or altitude of magnetics sensor | (In meters)<br>+ = Below sea level<br>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.<br>E = 7.5 V cos phi sin alpha + 0.0042 V*V |
| 104-108 | 5 | real | Free-air anomaly | In 10th of mgals<br>G = observed<br>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<br>6=Suspected, by the data center<br>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.

A data feed is sent from the ADCP system to RVDAS whenever a reference layer is acquired. This feed contains east and north vectors for ship's speed, relative to the reference layer, and ship's heading. Collected files (one per day) are archived in 1305adcp.tar in the directory /rvdas/nav.

**Note**: **ADCP data collection was halted mid-cruise to perform a software configuration change. As such, this cruise's ADCP data is split into two data sets.**

### *$pCO_2$*

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 1305pco2.tar 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

### *XBT*

During the cruise, eXpendable BathyThermographs were used to obtain water column temperature profiles, providing corrections to the sound velocity profile for the multibeam system. The data files from these launches are included as 1305xbt.tar 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: `NBP1305mwx1.d025`

- The CruiseID is the numeric name of the cruise, in this case, NBP1305.
- 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 | Channel ID | Collect. Status | Rate | Instrument |
|---|---|---|---|---|
| Air Temperature | mwx1 | continuous | 1 sec | R.M. Young 41372LC |
| Relative Humidity | mwx1 | continuous | 1 sec | R.M. Young 41372LC |
| Wind Speed/Direction | mwx1 | continuous | 1 sec | Gill 1390-PK-062/R |
| Barometer | mwx1 | continuous | 1 sec | R.M. Young 61201 |
| PIR (LW radiation) | mwx1 | continuous | 1 sec | Eppley PIR |
| PSP (SW radiation) | mwx1 | continuous | 1 sec | Eppley PSP |
| PAR | mwx1 | continuous | 1 sec | BSI QSR-240 |
| GUV | pguv | continuous | 2 sec | BSI PUV-2511 |
| PUV | pguv | not collected | | BSI PUG-2500 |

### Geophysics

| Measurement | Channel ID | Collect. Status | Rate | Instrument |
|---|---|---|---|---|
| Gravimeter | grv1 | continuous | 10 sec* | LaCoste & Romberg |
| Magnetometer | mag1 | not collected | 15 sec | EG&G G-866 |
| Bathymetry | knud | continuous | Varies | Knudsen 320B/R |

*Data is output every second but it only changes every 10 seconds.

### Oceanography

| Measurement | Channel ID | Collect. Status | Rate | Instrument |
|---|---|---|---|---|
| Conductivity | mtsg | Continuous | 6 sec | SeaBird SBE-45 |
| Salinity | mtsg | Continuous | 6 sec | Calc. from pri. temp |
| Sea Surface Temp | mtsg | Continuous | 6 sec | SeaBird SBE 38 |
| Fluorometry | hdas | Continuous | 2 sec | WET Lab AFL |
| Transmissometry | hdas | Continuous | 2 sec | WET Lab C-Star |
| $pCO_2$ | pco2 | Continuous | 70 sec | (LDEO) |
| ADCP | adcp | Continuous | varies | RD Instruments |
| Oxygen | oxyg | Continuous | 10 sec | Oxygen Optode 3835 |

## Navigational Instruments

| Measurement | Channel ID | Collect. Status | Rate | Instrument |
|---|---|---|---|---|
| Trimble GPS | PCOD | Continuous | 1 sec | Trimble 20636-00SM |
| Gyro | gyr1 | Continuous | 0.2 sec | Yokogawa Gyro |
| SeaPath | seap | Continuous | 1 sec | SeaPath 200 |

### *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.

## Underway Data /rvdas/uw

Each section below 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 directory on the distribution disc.

### Sound Velocity Probe (svp1)

```
08+330:00:00:49.011  1519.35
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS Time tag | |
| 2 | Sound velocity in ADCP sonar well | m/s |

### Meteorology (mwx1)

```
There are 3 different data strings in the mwx1 data file:

MET

08+330:23:59:57.725 MET,12.1,-54,6.64,88.7,111.3374,0.02414567,-
0.4827508,282.9581,281.8823,1005.119

PUS

08+330:23:59:58.546 PUS,A,020,008.53,M,+337.12,+009.00,00,0F

SUS

08+330:23:59:58.779 SUS,A,017,008.76,M,+335.53,+006.35,00,02
```

#### MET string

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | MET (string flag) | |
| 3 | Power Supply Voltage | V |
| 4 | Enclosure Relative Humidity (not currently implemented) | % |
| 5 | Air temperature | °C |
| 6 | Air Relative Humidity | % |
| 7 | PAR (photosynthetically available radiation)* | mV |
| 8 | PSP (short wave radiation)* | mV |
| 9 | PIR Thermopile (long wave radiation)* | mV |
| 10 | PIR Case Temperature | °Kelvin |
| 11 | PIR Dome Temperature | °Kelvin |
| 12 | Barometer | mBar |

*See page 21 for calculations.

### PUS string

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | PUS (string flag) | |
| 3 | A (unit identification) | |
| 4 | Port Wind direction relative | deg |
| 5 | Port Wind speed relative | m/s |
| 6 | Units | |
| 7 | Sound Speed | m/s |
| 8 | Sonic Temperature | °C |
| 9 | Unit Status (00 or 60 are good, any other value indicates fault) | |
| 10 | Check Sum | |

### SUS string

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | SUS (string flag) | |
| 3 | A (unit identification) | |
| 4 | Starboard Wind direction relative | deg |
| 5 | Starboard Wind speed relative | m/s |
| 6 | Units | |
| 7 | Sound Speed | m/s |
| 8 | Sonic Temperature | °C |
| 9 | Unit Status (00 or 60 are good, any other value indicates fault) | |
| 10 | Check Sum | |

## Knudsen (knud)

```
99+099:00:18:19.775 HF,305.2,LF,304.3
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | HF = High frequency flag (12 kHz) | |
| 3 | High frequency depth | meters |
| 4 | LF = Low frequency flag (3.5 kHz) | |
| 5 | Low frequency depth | meters |

## Fluorometer (flr1)

This Fluorometer is not in use. The current Fluorometer goes to the hdas string.

```
00+019:23:59:58.061 0  0818 ::  1/19/00 17:23:17 = 0.983  (RAW)   1.2 (C)
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | Marker 0 to 8 | |
| 3 | 4-digit index | |
| 4 | Date | mm/dd/yy |
| 5 | Time | hh:mm:ss |
| 6 | Signal | |
| 7 | Signal units of measurement | |
| 8 | Cell temperature (if temperature compensation package is installed) | |

| Field | Data | Units |
|---|---|---|
| 9 | Temperature units (if temperature compensation package is installed) | |

## $pCO_2$ (pco2)

```
00+021:23:59:43.190 2000021.99920 2382.4 984.2 30.73 50.8 345.9 334.1 -1.70
-68.046 -144.446 Equil
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $pCO_2$ time tag (decimal is fractional time of day) | yyyyddd.ttt |
| 3 | Raw voltage (IR) | mV |
| 4 | Cell temperature | °C |
| 5 | Barometer | MBar |
| 6 | Concentration | ppm |
| 7 | Equilibrated temperature | °C |
| 8 | $pCO_2$ pressure | microAtm |
| 9 | Flow rate | ml / min |
| 10 | Source ID # | 1 or 2 digits |
| 11 | Valve position | 1 or 2 digits |
| 12 | Flow source (Equil = $pCO_2$ measurement) | text |

## Micro-TSG (tsg1)

```
08+330:23:59:40.894   5.9322,  3.34685,  34.0550, 1473.281
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | Internal Temperature | °C |
| 3 | Conductivity | s/m |
| 4 | Salinity | PSU |
| 5 | Sound velocity | m/s |

## Micro-TSG #2 (tsg2)

```
08+330:23:59:40.894   5.9322,  3.34685,  34.0550, 1473.281
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | Internal Temperature | °C |
| 3 | Conductivity | s/m |
| 4 | Salinity | PSU |
| 5 | Sound velocity | m/s |

## Gravimeter (grv1)

There are now two sets of fields output by the gravity meter. The data record is output once per second, and identified by “$DAT” in the id field. A summary of sensor environmental data is output every ten seconds, identified by “%ENV” in the id field.

**Data record ($DAT):**

05+194:00:00:27.995 $DAT,2005/ 7/13, 0: 7: 7.36,194, 9050.37, 9050.06, 5410.86, -0.00, -0.01, -0.02, 0.00, 0.00, 0.70, 0.19, -0.12, -0.25, 0.00, -69.45711315, -54.32181487, 0.000, 285.200,

| Field | Data | Conversion | Units |
|---|---|---|---|
| 1 | RVDAS time tag | | |
| 2 | Text string (id field) | $DAT for data record | |
| 3 | Date | YYYY/MM/DD | |
| 4 | Time | HH:MM:SS.SS | |
| 5 | Day of Year | DDD | |
| 6 | Gravity count | mgal = count x 1.0046 + offset | count |
| 7 | Spring Tension | | CU |
| 8 | Beam Position | Volts x 750,000 | |
| 9 | VCC | | |
| 10 | AL | | |
| 11 | AX | | |
| 12 | VE | | |
| 13 | AX2 | | |
| 14 | XACC2 | | |
| 15 | LACC2 | | |
| 16 | CROSS ACCEL | | GAL |
| 17 | LONG ACCEL | | GAL |
| 18 | EOTVOS CORR | | MGAL |
| 19 | LONGITUDE | | Degrees |
| 20 | LATITUDE | | Degrees |
| 21 | HEADING | | Degrees |
| 22 | VELOCITY | | Knots |

**Environmental record ($ENV)**

```
05+183:19:13:10.945 %ENV,2005/ 7/ 2,19:19:52.16,183,S-036/V1.5,    3.34,
47.19,   20.34,1.111840E-1,-0.57700,-0.10591, 0.40180, 2.55260, 0.43000,   1,
300
```

| Field | Data | Conversion | Units |
|---|---|---|---|
| 1 | RVDAS time tag | | |
| 2 | Text string (id field) | $ENV for environmental record | |
| 3 | Date | YYYY/MM/DD | |
| 4 | Time | HH:MM:SS.SS | |
| 5 | Day of Year | DDD | |
| 6 | Meter ID | | |
| 7 | Meter Pressure | | inch-Hg |
| 8 | Meter temp | | °C |
| 9 | Ambient temp | | °C |
| 10 | K-Factor | | |
| 11 | VCC Coeff | | |
| 12 | AL Coeff | | |
| 13 | AX Coeff | | |
| 14 | VE Coeff | | |
| 15 | AX2 Coeff | | |
| 16 | Serial Filter Length | | Seconds |
| 17 | QC Filter Length | | Seconds |

## Engineering (eng1)

```
13+079:10:22:16.035 12.26 19.68 507.4  0.3 173.3 -751.9 0 0 NAN NAN
43.2 85.7
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | Power Supply Voltage | V |
| 3 | Internal Case Temperature | °C |
| 4 | Pump #1 flow rate (aquarium room) | L/min |
| 5 | Pump #2 flow rate (helo deck) | L/min |
| 6 | Pump #3 flow rate (hydro-lab) | L/min |
| 7 | Seismic air pressure | Lbs/sq-in |
| 8 | PIR case resistance (not currently hooked up, data is irrelevant) | Kohm |
| 9 | PIR case ratiometric output (not currently hooked up, data is irrelevant) | mV |
| 10 | Freezer #1 temperature | °C |
| 11 | Freezer #2 temperature | °C |
| 12 | Altimeter, OIS benthic (yoyo) camera; distance from the seafloor | m |
| 13 | Transmissometer, OIS benthic (yoyo) camera | % |

*See page 24 for PIR calculations.

## Hydro-DAS (hdas)

```
08+330:23:59:41.877 12.15836 14.22853 368.9655 4060.69 -1 65.5 65.5 80
57
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | Supply voltage | V |
| 3 | Panel temperature | °C |
| 4 | Fluorometer | mV |
| 5 | Transmissometer | mV |
| 6 | Sea Water Valve (-1 = stern thruster valve, 0 = moon pool valve) | |
| 7 | Flow meter 1 frequency | Hz |
| 8 | Flow meter 2 frequency | Hz |
| 9 | Flow meter 3 frequency | Hz |
| 10 | Flow meter 4 frequency | Hz |

## GUV Data (pguv)

```
08+330:23:59:40.328 112508 235940 .000197 1.856E-1 1.116E0 4.987E-2 -
1.959E-4 1.637E0 4.153E-3 1.76E0 42.296 17.844
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | Date | mmddyy |
| 3 | Time (UTC) | hhmmss |
| 4 | Ed0Gnd | V |
| 5 | Ed0320 | uW (cm^2 nm) |
| 6 | Ed0340 | uW (cm^2 nm) |
| 7 | Ed0313 | uW (cm^2 nm) |
| 8 | Ed0305 | uW (cm^2 nm) |
| 9 | Ed0380 | uW (cm^2 nm) |
| 10 | Ed0PAR | uE (cm^2 nm) |
| 11 | Ed0395 | uW (cm^2 nm) |
| 12 | Ed0Temp | °C |
| 13 | Ed0Vin | V |

## Remote Temperature (rtmp)

```
07+272:00:00:15.960 -1.7870
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | Temperature at seawater intake | °C |

## Oxygen Data (oxyg)

**Internal reference salinity is set to 34 ppt. For further information on this data, contact Sharon Stammerjohn, sstammer@ucsc.edu.**

11+011:00:21:48.109 MEASUREMENT 3835 1424 Oxygen: 334.01
Saturation: 90.71 Temperature: -0.78 DPhase: 37.65
BPhase: 35.95 RPhase: 0.00 BAmp: 212.13 BPot:
30.00 RAmp: 0.00 RawTem.: 788.05

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2-4 | Measurement ID, Model Number, Serial Number | alphanumeric |
| 5 | Oxygen heading | text |
| 6 | Oxygen Reading | $\mu$M |
| 7 | Saturation heading | text |
| 8 | Saturation Reading | % |
| 9 | Temperature heading | text |
| 10 | Water Temperature | °C |
| 11 | Dphase heading | text |
| 12 | Dphase | Raw numeric |
| 13 | Rphase heading | Text |
| 14 | Rphase | Raw numeric |
| 15 | Bamp heading | Text |
| 16 | Bamp | Raw numeric |
| 17 | Bpot heading | Text |
| 18 | Bpot | Raw numeric |
| 19 | Ramp heading | Text |
| 20 | Ramp | Raw numeric |
| 21 | RawTem heading | Text |
| 22 | RawTemp | V |

## Winch Data (bwnc, twnc, cwnc)

```
13+157:04:20:20.976 ^^^A03RD,2013-06-06T04:20:29.352,BALTIC,00000236,-
00000.0,-00009.3,3306
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | alphanumeric |
| 2 | LAN ID | alphanumeric |
| 3 | LCI-90i Date and Time | alphanumeric |
| 4 | Winch Name | alphanumeric |
| 5 | Tension | lbs |
| 6 | Speed | m/min |
| 7 | Pay-out | m |
| 8 | Checksum | numeric |

## Navigational Data /rvdas/nav

### Seapath GPS (seap)

The Seapath GPS outputs the following data strings, four in NMEA format and two in proprietary PSXN format:

- GPZDA
- GPGGA
- GPVTG
- GPHDT
- PSXN, 20
- PSXN, 22
- PSXN, 23

#### GPZDA

```
02+253:00:00:00.772 $GPZDA,235947.70,09,09,2002,,*7F
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $GPZDA | |
| 3 | time | hhmmss.ss |
| 4 | Day | dd |
| 5 | Month | mm |
| 6 | Year | yyyy |
| 7 | (empty field) | |
| 8 | Checksum | |

#### GPGGA

```
02+253:00:00:00.938
GPGGA,235947.70,6629.239059,S,06827.668899,W,1,07,1.0,11.81,M,,M,,*6F
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $GPGGA | |
| 3 | time | hhmmss.ss |
| 4 | Latitude | ddmm.mmmmmm |
| 5 | N or S for north or south latitude | |
| 6 | Longitude | ddmm.mmmmmm |
| 7 | E or W for east or west longitude | |
| 8 | GPS quality indicator, 0=invalid, 1=GPS SPS, 2=DGPS, 3=PPS, 4=RTK, 5=float RTK, 6=dead reckoning | |
| 9 | number of satellites in use (00-99) | |
| 10 | HDOP | x.x |
| 9 | height above ellipsoid in meters | m.mm |
| 11 | M | |
| 12 | (empty field) | |
| 13 | M | |
| 14 | age of DGPS corrections in seconds | s.s |
| 15 | DGPS reference station ID (0000-1023) | |
| 16 | Checksum | |

## GPVTG

```
02+253:00:00:00.940 $INVTG,19.96,T,,M,4.9,N,,K,A*39
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $GPVTG | |
| 3 | course over ground, degrees true | d.dd |
| 4 | T | |
| 5 | , | |
| 6 | M | |
| 7 | speed over ground in knots | k.k |
| 8 | N | |
| 9 | , | |
| 10 | K | |
| 11 | Mode | |
| 12 | Checksum | |

## GPHDT

```
02+253:00:00:00.941 $GPHDT,20.62,T*23
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $GPHDT | |
| 3 | Heading, degrees true | d.dd |
| 4 | T | |
| 5 | Checksum | |

## PSXN,20

```
02+253:00:00:00.942 $PSXN,20,0.43,0.43*39
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $PSXN | |
| 3 | 20 | |
| 4 | Horizontal position & velocity quality: 0=normal, 1=reduced performance, 2=invalid data | |
| 5 | Height & vertical velocity quality: 0=normal, 1=reduced performance, 2=invalid data | |
| 6 | Heading quality: 0=normal, 1=reduced performance, 2=invalid data | |
| 7 | Roll & pitch quality: 0=normal, 1=reduced performance, 2=invalid data | |
| 8 | Checksum | |

## PSXN,22

```
02+253:00:00:00.942 $PSXN,22,0.43,0.43*39
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $PSXN | |
| 3 | 22 | |
| 4 | gyro calibration value since system start-up in degrees | d.dd |
| 5 | short term gyro offset in degrees | d.dd |
| 6 | Checksum | |

### PSXN,23

```
02+253:00:00:02.933 $PSXN,23,0.47,0.57,20.62,0.03*0C
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $PSXN | |
| 3 | 23 | |
| 4 | roll in degrees, positive with port side up | d.dd |
| 5 | pitch in degrees, positive with bow up | d.dd |
| 6 | Heading, degrees true | d.dd |
| 7 | heave in meters, positive down | m.mm |
| 8 | Checksum | |

## Trimble (P-Code) GPS (PCOD)

The Trimble GPS, which formerly output Precise Position (*P-Code*) strings, but now only outputs Standard Position (*Civilian*) strings, outputs three NMEA standard data strings:

- Position fix (GGA)
- Latitude / longitude (GLL),
- Track and ground speed (VTG)

### GGA: GPS Position Fix – Geoid/Ellipsoid

```
01+319:00:04:11.193 $GPGGA,000410.312,6227.8068,S,06043.6738,W,1,06,1.0,
031.9,M,-017.4,M,,*49
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS Time tag | |
| 2 | $GPGGA | |
| 3 | UTC time at position | hhmmss.sss |
| 4 | Latitude | ddmm.mmm |
| 5 | North (N) or South (S) | |
| 6 | Longitude | ddmm.mmm |
| 7 | East (E) or West (W) | |
| 8 | GPS quality:<br>0 = Fix not available or invalid<br>1 = GPS, SPS mode, fix valid<br>2 = DGPS (differential GPS), SPS mode, fix valid<br>3 = P-CODE PPS mode, fix valid | |
| 9 | Number of GPS satellites used | |
| 10 | HDOP (horizontal dilution of precision) | |
| 11 | Antenna height | meters |
| 12 | M for meters | |
| 13 | Geoidal height | meters |
| 14 | M for meters | |
| 15 | Age of differential GPS data (no data in the sample string) | |
| 16 | Differential reference station ID (no data in the sample string) | |
| 17 | Checksum (no delimiter before this field) | |

## GLL: GPS Latitude/Longitude

```
01+319:00:04:11.272 $GPGLL,6227.8068,S,06043.6738,W,000410.312,A*32
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS Time tag | |
| 2 | $GPGLL | |
| 3 | Latitude | degrees |
| 4 | North or South | |
| 5 | Longitude | degrees |
| 6 | East or West | |
| 7 | UTC of position | hhmmss.sss |
| 8 | Status of data (A = valid) | |
| 9 | Checksum | |

## VTG: GPS Track and Ground Speed

```
01+319:00:04:11.273 $GPVTG,138.8,T,126.0,M,000.0,N,000.0,K*49
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $GPVTG | |
| 3 | Heading | degrees |
| 4 | Degrees true (T) | |
| 5 | Heading | degrees |
| 6 | Degrees magnetic (M) | |
| 7 | Ship speed | knots |
| 8 | N = knots | |
| 9 | Speed | km/hr |
| 10 | K = km per hour | |
| 11 | Checksum | |

## Gyro Compass (gyr1)

```
00+019:23:59:59.952 $HEHDT 25034,-020*73
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $HEHDT | |
| 3 | Heading, Degrees True | degrees |
| 5 | Checksum | |

## ADCP Course (adcp)

```
00+019:23:59:59.099 $PUHAW,UVH,-1.48,-0.51,250.6
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $PUHAW | |
| 3 | UVH (E-W, N-S, Heading) | |
| 4 | Ship Speed relative to reference layer, east vector | knots |
| 5 | Ship Speed relative to reference layer, north vector | knots |

| Field | Data | Units |
|---|---|---|
| 6 | Ship heading | degrees |

## Processed Data /process/

### pCO2-merged

```
00+346:23:58:20.672 2000346.9991 2398.4 1008.4 0.01 45.4 350.3 342.6 15.77
Equil -43.6826 173.1997 15.51 33.90 0.33 5.28 9.05 1007.57 40.0 14.87 182.44 -1
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $pCO_2$ time tag (decimal is fractional time of day) | yyyyddd.ttt |
| 3 | Raw voltage (IR) | mV |
| 4 | Cell temperature | °C |
| 5 | Barometer | MBar |
| 6 | Flow rate | ml / min |
| 7 | Concentration | ppm |
| 8 | $pCO_2$ pressure | microAtm |
| 9 | Equilibrated temperature | °C |
| 10 | Sea Water Temp | 1 or 2 digits |
| 11 | Valve position | °C |
| 12 | Flow source (Equil = $pCO_2$ measurement) | text |
| 13 | RVDAS latitude | degrees |
| 14 | RVDAS longitude | degrees |
| 15 | TSG external temperature | °C |
| 16 | TSG 1 salinity | PSU |
| 17 | Fluorometer | V |
| 18 | RVDAS true wind speed | m/s |
| 19 | RVDAS true wind direction | degrees |
| 20 | Barometric Pressure | mBars |
| 21 | Uncontaminated seawater pump flow rate | l/min |
| 22 | Speed over ground | knots |
| 23 | Course made good | degrees |
| 24 | Oxygen | $\mu$M |
| 25 | TSG 2 internal temperature | °C |
| 26 | TSG 2 salinity | PSU |
| 27 | TSG 1 internal temperature | °C |
| 28 | H2O Input Source | -1 stern thrustor<br>0 moonpool |

## Calculations

The file `instrument.coeff` located in the `/` directory contains the calibration factors for shipboard instruments. This was the file used by the RVDAS processing software.

## 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 GMT.

| Start | End | Description |
|---|---|---|
| ~06:00 June 24, 2013 | | Data collection started |
| ~19:00 June 26,2013 | ~02:00 June 27, 2013 | Permit questions |
| ~08:00 July 15, 2013 | ~17:00 July 15, 2013 | Within 12 miles of coast |
| | ~04:00 July 22, 2013 | Stop Data collection |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

# Appendix: Sensors and Calibrations

| *Sensor* | *Serial Number* | *Last Cal.* | *Comments* |
|---|---|---|---|
| **Meteorology & Radiometers** | | | |
| Stbd Anemometer (Gill US) | 847014 | 9/29/2010 | Installed 11/17/2010 |
| Port Anemometer (Gill US) | 924057 | 11/18/09 | Installed 3/5/2010 |
| Barometer | 01706 | 2/12/2010 | Installed 5/9/2013 |
| Humidity/Wet Temp | 06733 | 7/20/2011 | Installed 5/9/2013 |
| PIR | 33023F3 | 7/20/2011 | Installed 4/7/2013 |
| PSP | 33090F3 | 7/19/2011 | Installed 4/7/2013 |
| Mast PAR | 6356 | 8/4/2011 | Installed 7/30/2012 |
| GUV (Mast) | 25110203113 | 7/29/2011 | Installed 7/31/2012 |
| **Underway** | | | |
| Micro-TSG #1 | 4546167-0242 | 12/29/2012 | Installled 5/9/2013 |
| Micro-TSG #2 | 4566350-0389 | 10/20/2011 | Installled 9/7/2012 |
| Digital Remote Temp (Primary) | 3846730-0178 | 9/21/2012 | Installed 5/9/2013 |
| Oxygen Optode | 3835-1424 | 10/21/2010 | Installed12/30/2010 |
| Fluorometer | AFLD-009 | 9/12/2011 | Installed 12/24/2012 |
| Transmissometer | CST-1316DR | 12/6/2012 | Installed 5/13/2011 |
| **CTD** | | | |
| CTD Fish | 1130 | 12/11/2012 | Installed 5/13/2013 |
| CTD Fish Pressure | 120089 | 12/11/2012 | Installed 5/13/2013 |
| CTD Deck Unit | 11P19858-0490 | N/A | Installed11/8/2007 |
| Slip-Ring Assembly | 1.406 | N/A | Installed 3/27/04 |
| Carousel Water Sampler | 3214153-0140 | N/A | Installed 5/13/2013 |
| Pump (primary) | 055643 3.0K | 11/28/2010 | Installed 5/13/2013 |
| Pump (secondary) | 055641 3.0K | 11/28/2010 | Installed 5/13/2013 |
| Temperature (primary) | 03P5730 | 11/13/2012 | Installed 5/13/2013 |
| Temperature (secondary) | 03P2438 | 8/22/2012 | Installed 5/13/2013 |
| Conductivity (primary) | 043503 | 6/17/2011 | Installed 5/13/2013 |
| Conductivity (secondary) | 043505 | 6/17/2011 | Installed 5/13/2013 |
| Dissolved Oxygen (primary) | 430082 | 8/21/2012 | Installed 5/13/2013 |
| Dissolved Oxygen (secondary) | 430139 | 8/17/2012 | Installed 5/13/2013 |
| Fluorometer | FLRTD-397 | 11/15/2012 | Installed 5/13/2013 |
| Transmissometer | CST-892DR | 12/5/2012 | Installed 5/13/2013 |
| PAR | 4721 | 10/26/2012 | Installed 5/13/2013 |
| Altimeter | 42434 | N/A | Installed 5/13/2013 |
| Bottom Contact Switch | #3 | N/A | Installed 5/13/2013 |
| **Mocness** | | | |
| Pressure Sensor | 178 | 11/18/2010 | Installed 5/15/2013 |
| Temperature | 031541 | 2/27/13 | Installed 5/15/2013 |
| Conductivity | 041431 | 7/25/12 | Installed 5/15/2013 |

## *Gravity Tie*

# Gravity Tie Spreadsheet

**The fields outlined in BOLD MUST BE FILLED IN for this spreadsheet to operate properly. The automatically calculated values show up in the shaded fields.**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Date:** | **11/5/2013** | | | Reference Code Numbers: | | |
| **Location:** | **Punta Arenas, Chile** | | | Station no. | 9337-50 | |
| Station: | Harbour Admin. Bldg. | | | ISGN no. | 51230N | |
| Latitude: | 53 09 S | | | | | |
| Longitude: | 070 55 W | | | | | |
| Elevation: | | | | | | |
| Gravity: | 981320.82 | | | | | |
| | | **Value** | **Time (GMT)** | | | |
| | Ship's meter before gravity tie ( Gravity (cu) ) | 8778.5 | 19:14 | | | |
| | Ship's meter after gravity tie ( Gravity (cu) ) | 8778.6 | 20:42 | | | |
| | Average | 8778.6 | | | | |
| | Ship Gravimeter's Calibration Constant | 1.0046 | | | | |
| | **Corrected ship's meter** ( QC Grav (mgal) ) | 8818.9 | | | | |
| | | **Value** | **Time (GMT)** | | | |
| | Ship's meter before gravity tie (serial, RVDAS) | 8777.5 | 19:15 | | | |
| | Ship's meter after gravity tie (serial, RVDAS) | 8777.9 | 20:42 | | | |
| | Average (for comparison check only) | 8777.7 | | | | |
| | Portable Gravimeter Interval Factor | 1.01007 | From Table 1 of Model G #807 Meter | | | |
| | **Station** | **Value** | **Time (GMT)** | **Temp** | **Date** | |
| | Pier measurement 1 | 4918.35 | 19:26 | 54 | November 5, 2013 | OBS mgal, averaged |
| | Pier measurement 2 | 4918.44 | 19:29 | 54 | November 5, 2013 | 4967.93 |
| | Pier measurement 3 | 4918.41 | 19:32 | 54 | November 5, 2013 | |
| | Average | 4918.40 | | | | |
| | Station measurement 1 | 4919.07 | 19:43 | 54 | November 5, 2013 | OBS mgal, averaged |
| | Station measurement 2 | 4919.09 | 19:45 | 54 | November 5, 2013 | 4968.64 |
| | Station measurement 3 | 4919.16 | 19:47 | 54 | November 5, 2013 | |
| | Average | 4919.11 | | | | |
| | Pier measurement 4 | 4918.33 | 20:36 | 54 | November 5, 2013 | OBS mgal, averaged |
| | Pier measurement 5 | 4918.54 | 20:38 | 54 | November 5, 2013 | 4967.98 |
| | Pier measurement 6 | 4918.48 | 20:40 | 54 | November 5, 2013 | |
| | Average | 4918.45 | | | | |
| | | | | **Gravity offset from last tie** | | 972504.56 |
| | | | | **Drift since last tie** | | -3.37 |
| | **OBS Differences** | | **Comments** | | | |
| | Station to Pier (1, 2, & 3 averaged) | -0.71 | Tie performed by George Aukon and Barry Bjork. Conditions average. | | | |
| | Station to Pier (4, 5, & 6 averaged) | -0.66 | | | | |
| | Averaged Differences | -0.69 | | | | |
| | **Gravity at pier** | 981320.13 | | | | |
| | Elevation of pier above gravimeter, meters | 0.0 | | | | |
| | Earth differential gravity, mgal/meter | 0.3 | | | | |
| | Gravity at ship's gravimeter | 981320.12 | | | | |
| | Gravity Offset (for RVDAS) | 972501.19 | | | | |

**Note about Elevation of Pier:** *If pier is below the ship's gravimeter, this value is negative. If above, positive.*

## *Bridge Anemometer*

### RM Young Anemometer Calibration, Model 05106

**S/N:** 45835 **Date:** 27-Sep-04 **Cal'd By:** W. Gallagher

| Clockwise Cal Motor RPM | Calculated Windspeed m/s | Measured Windspeed m/s | Delta m/s | Knots |
|---|---|---|---|---|
| 0 | 0.00 | 0.0 | 0.0 | 0.0 |
| 200 | 0.98 | 0.9 | 0.1 | 1.9 |
| 500 | 2.45 | 2.3 | 0.2 | 4.8 |
| 1000 | 4.90 | 4.8 | 0.1 | 9.5 |
| 1500 | 7.35 | 7.3 | 0.0 | 14.3 |
| 2000 | 9.80 | 9.7 | 0.1 | 19.0 |
| 3000 | 14.70 | 14.7 | 0.0 | 28.6 |
| 4000 | 19.60 | 19.7 | -0.1 | 38.1 |
| 5000 | 24.50 | 24.6 | -0.1 | 47.6 |
| 6000 | 29.40 | 29.7 | -0.3 | 57.1 |
| 7000 | 34.30 | 34.7 | -0.4 | 66.6 |
| 8000 | 39.20 | 39.7 | -0.5 | 76.2 |
| 9000 | 44.10 | 44.7 | -0.6 | 85.7 |
| 10000 | 49.00 | 49.6 | -0.6 | 95.2 |
| 12000 | 58.80 | 59.6 | -0.8 | 114.2 |

| Direction | Measured Direction | Delta Direction |
|---|---|---|
| 0 | 0 | 0 |
| 30 | 28 | 2 |
| 60 | 59 | 1 |
| 90 | 89 | 1 |
| 120 | 119 | 1 |
| 150 | 150 | 0 |
| 180 | 180 | 0 |
| 210 | 210 | 0 |
| 240 | 240 | 0 |
| 270 | 270 | 0 |
| 300 | 300 | 0 |
| 330 | 330 | 0 |
| 0 | 0 | 0 |

**Note:** Delta direction should not exceed + or - 3 degrees.

| Counter Clockwise Cal Motor RPM | Calculated Windspeed m/s | Measured Windspeed m/s | Delta m/s |
|---|---|---|---|
| 0 | 0.00 | 0.0 | 0.0 |
| 200 | 0.98 | 0.9 | 0.1 |
| 500 | 2.45 | 2.3 | 0.2 |
| 1000 | 4.90 | 4.9 | 0.0 |
| 1500 | 7.35 | 7.3 | 0.0 |
| 2000 | 9.80 | 9.8 | 0.0 |
| 3000 | 14.70 | 14.7 | 0.0 |
| 4000 | 19.60 | 19.8 | -0.2 |
| 5000 | 24.50 | 24.7 | -0.2 |
| 6000 | 29.40 | 29.8 | -0.4 |
| 7000 | 34.30 | 34.7 | -0.4 |
| 8000 | 39.20 | 39.7 | -0.5 |
| 9000 | 44.10 | 44.7 | -0.6 |
| 10000 | 49.00 | 49.7 | -0.7 |
| 12000 | 58.80 | 59.6 | -0.8 |

Caution: Do Not exceed 12000 rpm during Wind Speed test.

| | |
|---|---|
| Wind Speed Threshold < 2.9 gm? | yes |
| Wind Direction Threshold < 30 gm? | yes |

| Additional Comments |
|---|
| Installed new housing assy.and wind direction coupling. Adjusted clearence on wind direction potentiometer thumbwheel. |

**Note:** Delta Windspeed should not exceed + or - 0.3 m/s for 0 - 5000 rpm

## *Mast Barometer*

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

# CALIBRATION REPORT
## Barometric Pressure

Customer: *Raytheon Technical Services Company LLC*

Test Number: 2126-01B
Test Date: 26 January 2012
Customer PO: RR64145-01
Sales Order: 2430

Test Sensor:
Model: 61201
Serial Number: *BP01706*
Description: Barometric Pressure Sensor

Report of calibration comparison of test barometric pressure sensor with National Institute of Standards and Technology traceable standard pressure calibrator at five pressures in the R.M. Young Company controlled pressure facility. Calibration accuracy ± 1.0 hPa.

| Reference Pressure (hPa) | Voltage Output (millivolts) | Indicated (1) Pressure (hPa) |
|---|---|---|
| 800.0 | 0 | 800.0 |
| 875.0 | 1251 | 875.0 |
| 950.0 | 2501 | 950.1 |
| 1025.0 | 3750 | 1025.0 |
| 1100.0 | 4998 | 1099.9 |

(1) Calculated from voltage output

All reference equipment used in this calibration procedure have been tested by comparison to traceable standards certified by the National Institute of Standards and Technology.

| Reference Instrument | Serial # | NIST Test Reference |
|---|---|---|
| Druck Pressure Controller Model DPI515 | 51500497 | UKAS Lab 0221 |
| Fluke Multimeter Model 8060A | 4865407 | 234027 |

Tested By: E Chenuney

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

## *Mast Humidity Sensor*

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

YOUNG

# CALIBRATION REPORT
## Relative Humidity

Customer: *Raytheon Technical Services Company LLC*

Test Number: 1721-01R
Test Date: 21 July 2011

Customer PO: RR59934-01
Sales Order: 2040

Test Sensor:
Model: 41372LC
Serial Number: *TS06733*
Description: Temperature/Relative Humidity Sensor

Report of calibration comparison of test relative humidity sensor with National Institute of Standards and Technology traceable standard relative humidity sensor at five humidity levels in the R.M. Young Company controlled humidity chamber facility. Calibration accuracy ± 2.0 %.

| Reference Humidity (%) | Current Output (milliamps) | Indicated (1) Humidity (%) |
|---|---|---|
| 10.1 | 5.9 | 11.7 |
| 30.1 | 8.8 | 30.1 |
| 50.0 | 12.2 | 51.0 |
| 70.1 | 15.3 | 70.5 |
| 90.0 | 18.1 | 87.9 |

(1) Calculated from voltage output

All reference equipment used in this calibration procedure have been tested by comparison to traceable standards certified by the National Institute of Standards and Technology.

| Reference Instrument | Serial # | NIST Test Reference |
|---|---|---|
| Vaisala Humidity Sensor Model 35AC | N475040 | TN 266152 |
| Fluke Multimeter Model 8060A | 4865407 | 234027 |

Tested By: E. Chenney

METEOROLOGICAL INSTRUMENTS
Tel: 231-943-3980 Fax: 231-943-4772 Email: metsales@youngusa.com Website: youngusa.com
ISO 9001:2008 CERTIFIED

## *Mast Temperature Sensor*

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

YOUNG

# CALIBRATION REPORT
## Temperature

Customer: *Raytheon Technical Services Company LLC*

Test Number: 1720-09T
Test Date: 20 July 2011

Customer PO: RR59934-01
Sales Order: 2040

Test Sensor:
Model: 41372LC
Serial Number: TS06733
Description: Temperature/Relative Humidity Sensor

Report of calibration comparison of test temperature sensor with National Institute of Standards and Technology traceable standard thermometers at three temperatures in the R.M. Young Company controlled temperature calibration bath facilities. Calibration accuracy ± 0.1° Celsius.

| Bath Temperature (degrees C) | Current Output (milliamps) | Indicated (1) Temperature (degrees C) |
|---|---|---|
| -49.91 | 4.009 | -49.94 |
| 0.03 | 12.007 | 0.04 |
| 50.08 | 20.013 | 50.06 |

(1) Calculated from current output.

All reference equipment used in this calibration procedure have been tested by comparison to traceable standards certified by the National Institute of Standards and Technology.

| Reference Instrument | Serial # | NIST Test Reference |
|---|---|---|
| Brooklyn Thermometer Model 43-FC | 8006-118 | 204365 |
| Brooklyn Thermometer Model 22332-D5-FC | 26071 | 249783 |
| Brooklyn Thermometer Model 2X400-D7-FC | 77532 | 228050 |
| Keithley Multimeter Model 191 | 15232 | 234027 |

Tested By: E. Chenney

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

***Mast 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

## STANDARDIZATION OF EPPLEY PRECISION INFRARED RADIOMETER Model PIR

Serial Number: 33023F3

Resistance: 739 Ω at 23°C
Temperature Compensation Range: -20° to +40°C

This pyrgeometer has been compared against Eppley's Blackbody Calibration System under radiation intensities of approximately 200 watts meter$^{-2}$ and an average ambient temperature of 25°C as measured by Standard Omega Temperature Probe, RTD51.

As a result of a series of comparisons, it has been found to have a sensitivity of:

$$3.85 \times 10^{-9} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 700 watts meter$^{-2}$. This radiometer is linear to within ±1.0% up to this intensity.

The calibration of this instrument is traceable to the International Practical Temperature Scale (IPTS) through a precision low-temperature blackbody.

Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy. Unless otherwise stated in the remarks section below or on the Sales Order, the results are "AS FOUND / AS LEFT".

Shipped to: Raytheon Polar Services NSF
Port Hueneme, CA

S.O. Number: 63090
Date: July 28, 2011

Date of Test: July 20, 2011

In Charge of Test: Debra L. Murphy

Reviewed by: Thomas D. Kirk

Remarks:

# THE EPPLEY LABORATORY, INC.

12 Sheffield Avenue, PO Box 419, Newport, Rhode Island USA 02840
Phone: 401.847.1020 Fax: 401.847.1021 Email: info@eppleylab.com

## STANDARDIZATION OF EPPLEY PRECISION SPECTRAL PYRANOMETER Model PSP

Serial Number: 33090F3

Resistance: 700 Ω at 23°C
Temperature Compensation Range: -20° to +40°C

This radiometer has been compared with Standard Precision Spectral Pyranometer, Serial Number 21231F3 in Eppley's Integrating Hemisphere under radiation intensities of approximately 700 watts meter$^{-2}$ (roughly one half a solar constant).

As a result of a series of comparisons, it has been found to have a sensitivity of:

$8.03 \times 10^{-6}$ volts/watts meter$^{-2}$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 1400 watts meter$^{-2}$. This radiometer is linear to within ± 0.5% up to this intensity.

The calibration of this instrument is traceable to standard self-calibrating cavity pyrheliometers in terms of the Systems Internationale des Unites (SI units), which participated in the Tenth International Pyrheliometric Comparisons (IPC X) at Davos, Switzerland in September-October 2005.

Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy. Unless otherwise stated in the remarks section below or on the Sales Order, the results are "AS FOUND / AS LEFT".

Useful conversion facts: 1 cal cm$^{-2}$ min$^{-1}$ = 697.3 watts meter$^{-2}$
1 BTU/ft$^2$-hr$^{-1}$ = 3.153 watts meter$^{-2}$

Shipped to: Raytheon Polar Services NSF
Port Hueneme, CA

S.O. Number: 63091
Date: July 28, 2011

Date of Test: July 19, 2011

In Charge of Test: Debra L. Brighty

Reviewed by: Thomas D. Kirk

Remarks:

## *Mast PAR*

PAR for Mast

**Biospherical Instruments Inc.**

CALIBRATION CERTIFICATE

| | |
|---|---|
| Calibration Date | 8/4/2011 |
| Model Number | QSR-240 |
| Serial Number | 6356 |
| Operator | TPC |
| Standard Lamp | GS-1024(7/22/11) |
| Probe Excitation Voltage Range: | 6 to 18 VDC(+) |
| Output Polarity: | Positive |

Probe Conditions at Calibration(in air):

| | | |
|---|---|---|
| Calibration Voltage: | 6 | VDC(+) |
| Probe Current: | 1.2 | mA |

Probe Output Voltage:

| | | |
|---|---|---|
| Probe Illuminated | 97.2 | mV |
| Probe Dark | 0.1 | mV |
| Probe Net Response | 97.0 | mV |
| RG780 | 0.3 | mV |

Corrected Lamp Output:

Output In Air (same condition as calibration):

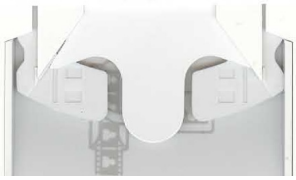
| | |
|---|---|
| 9.298E+15 | quanta/cm²sec |
| 0.01544 | uE/cm$^2$sec |

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

| | | |
|---|---|---|
| Dry: | 1.0436E-17 | V/(quanta/cm²sec) |
| | 6.2847E+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



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 25110203113**

**Optical Calibrations:**

**NIST Traceability.** For wavelengths longer than 313 nm, the specific instruments cited here were calibrated using a 1000W FEL #GS-1024 (7/22/11) following procedures and standards traceable to NIST Standard of Spectral Irradiance **F473**. 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 **25110203113v6.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 | 25110203113 | Date of Calibration | 7/29/2011 |
| Calibration database | 25110203113.mdb | Date of Certificate | 8/1/2011 |
| DASSN | 0068 | Standard of Spectral Irradiance | GS1024(7/22/11) |
| Microprocessor Tag Number | 2 | 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 | 2.5711E-10 | 2.6225E-05 | 7.6619E-03 | 2.7126E+00 | -5.8115E-06 | -9.1758E-06 | 1.7218E-04 | µW/(cm²nm) |
| Ed0340 | 6 | 340 | 2.0927E-10 | 2.1346E-05 | 6.2363E-03 | 2.1989E+00 | 3.0451E-04 | 3.0474E-04 | 1.1770E-03 | µW/(cm²nm) |
| Ed0313 | 8 | 313 | 2.1800E-10 | 2.2286E-05 | 6.5111E-03 | 2.3245E+00 | 6.3074E-05 | 6.4994E-05 | 7.6713E-04 | µW/(cm²nm) |
| Ed0305 | 10 | 305 | 1.6400E-11 | 1.6687E-06 | 4.8753E-04 | 1.5082E-01 | 3.4984E-04 | 3.3908E-04 | -2.2555E-03 | µW/(cm²nm) |
| Ed0380 | 12 | 380 | 6.6055E-11 | 6.7376E-06 | 1.9684E-03 | 6.5646E-01 | 1.0888E-03 | 1.0755E-03 | -1.4791E-03 | µW/(cm²nm) |
| Ed0PAR | 13 | 0 | 1.8677E-05 | 1.9051E+00 | 5.5658E+02 | 1.9817E+05 | 8.5258E-04 | 8.4359E-04 | -1.3226E-03 | µE/(cm²sec) |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| Ed0395 | 18 | 400-700 | 3.3639E-10 | 3.4312E-05 | 1.0024E-02 | 3.2744E+00 | 6.7600E-05 | 6.2557E-05 | 2.1591E-04 | µW/(cm²nm) |

| Auxiliary Channels | Address | Wavelength | Responsivity | ScaleS | ScaleM | ScaleL | OffsetS | OffsetM | OffsetL | Measurement Units |
|---|---|---|---|---|---|---|---|---|---|---|
| Ed0Gnd | 0 | 0 | 1 | 1.00 | 1.00 | 1.00 | 0 | 0 | 0 | V |
| Ed0Temp | 22 | 0 | 1 | 0.01 | 0.01 | 0.01 | 0 | 0 | 0 | C |
| Ed0Vin | 27 | 0 | 1 | -0.25000 | -0.25000 | -0.25000 | 0.0000 | 0.0000 | 0.0000 | V |

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Calibration Data – Do Not Destroy

page 2 of 2

## *Underway Oxygen Sensor*

AANDERAA DATA INSTRUMENTS

# CALIBRATION CERTIFICATE

Form No. 622, Dec 2005
Page 1 of 2

**Sensing Foil Batch No: 5009**
**Certificate No:**

**Product: Oxygen Optode 3835**
**Serial No: 1424**
**Calibration Date: 21 October 2010**

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

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

**Parameter: Internal Temperature:**

**Calibration points and readings:**

| | | | | |
|---|---|---|---|---|
| Temperature (°C) | 1.17 | 12.12 | 24.11 | 36.08 |
| Reading (mV) | 730.09 | 383.95 | -11.29 | -379.10 |

**Giving these coefficients**

| | | | | |
|---|---|---|---|---|
| Index | 0 | 1 | 2 | 3 |
| TempCoef | 2.37613E01 | -3.08128E-02 | 2.84735E-06 | -4.15311E-09 |

**Parameter: Oxygen:**

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

**Calibration points and readings[2]:**

| | Air Saturated Water | Zero Solution ($Na_2SO_3$) |
|---|---|---|
| Phase reading (°) | 3.27669E+01 | 6.65595E+01 |
| Temperature reading (°C) | 9.90918E+00 | 2.04774E+01 |
| Air Pressure (hPa) | 9.76884E+02 | |

**Giving these coefficients**

| | | | | |
|---|---|---|---|---|
| Index | 0 | 1 | 2 | 3 |
| PhaseCoef | -4.44928E00 | 1.17131E00 | 0.00000E00 | 0.00000E00 |

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

AANDERAA DATA INSTRUMENTS AS

5851 BERGEN, NORWAY Tel. +47 55 60 48 00 Fax. +47 55 60 48 01 E-mail: info@aadi.no Web: http://www.aadi.no

AANDERAA DATA INSTRUMENTS

# CALIBRATION CERTIFICATE

Form No. 622, Dec 2005
Page 2 of 2

**Sensing Foil Batch No: 5009**
**Certificate No:**

**Product: Oxygen Optode 3835**
**Serial No: 1424**
**Calibration Date: 21 October 2010**

**SR10 Scaling Coefficients:**

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

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

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

Date: 22 October 2010

Sign:

Tor Ove Kvalvåg

Tor Ove Kvalvåg, Calibration Engineer

AANDERAA DATA INSTRUMENTS AS

5851 BERGEN, NORWAY Tel. +47 55 60 48 00 Fax. +47 55 60 48 01 E-mail: info@aadi.no Web: http://www.aadi.no

### *Underway Micro-TSG number 1*

**Sea-Bird Electronics, Inc.**
13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0242
CALIBRATION DATE: 29-Dec-12

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

COEFFICIENTS:

```
g = -9.992296e-001
h =  1.524743e-001
i = -4.722991e-004
j =  6.065458e-005

CPcor = -9.5700e-008
CTcor =  3.2500e-006
WBOTC = -0.0000e+000
```

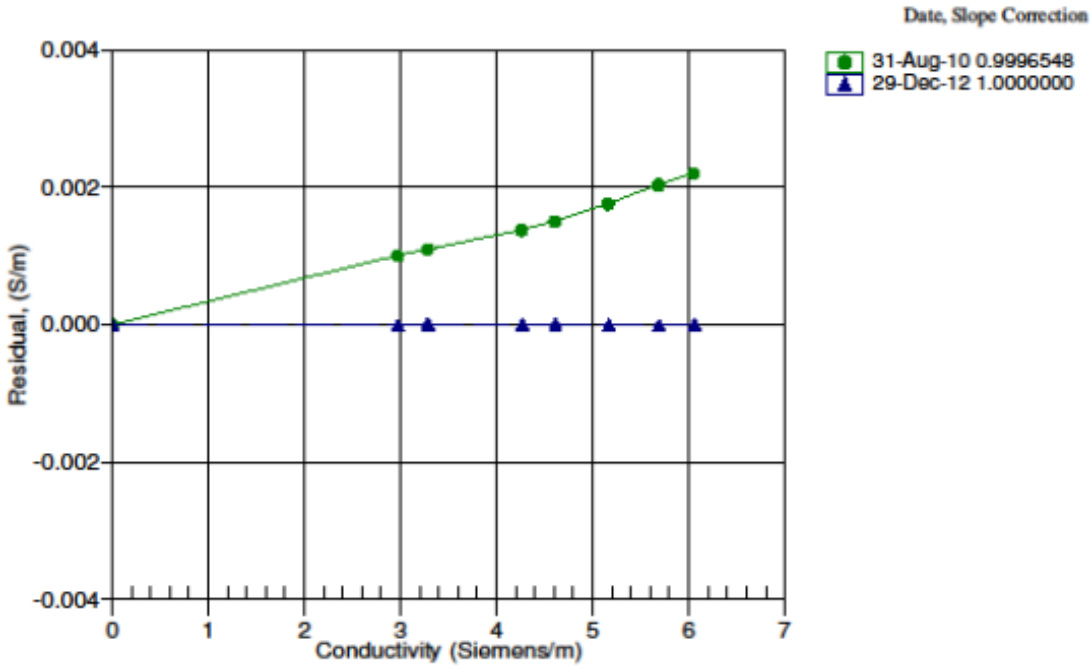
| BATH TEMP (ITS-90) | BATH SAL (PSU) | BATH COND (Siemens/m) | INST FREQ (Hz) | INST COND (Siemens/m) | RESIDUAL (Siemens/m) |
|---|---|---|---|---|---|
| 22.0000 | 0.0000 | 0.00000 | 2566.82 | 0.00000 | 0.00000 |
| 1.0000 | 34.8118 | 2.97562 | 5119.70 | 2.97561 | -0.00001 |
| 4.5000 | 34.7917 | 3.28263 | 5313.24 | 3.28264 | 0.00001 |
| 15.0000 | 34.7487 | 4.26420 | 5888.60 | 4.26420 | 0.00000 |
| 18.5000 | 34.7394 | 4.60927 | 6077.64 | 4.60927 | 0.00001 |
| 24.0000 | 34.7293 | 5.16711 | 6371.04 | 5.16711 | -0.00001 |
| 29.0000 | 34.7238 | 5.68887 | 6633.34 | 5.68886 | -0.00001 |
| 32.5000 | 34.7207 | 6.06120 | 6814.13 | 6.06121 | 0.00001 |

f = INST FREQ * sqrt(1.0 + WBOTC * t / 1000.0)

Conductivity = $(g + hf^2 + if^3 + jf^4) / (1 + \delta t + \varepsilon p)$ Siemens/meter

t = temperature[°C]; p = pressure[decibars]; $\delta$ = CTcor; $\varepsilon$ = CPcor;

Residual = instrument conductivity - bath conductivity



**Sea-Bird Electronics, Inc.**
13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0242
CALIBRATION DATE: 29-Dec-12

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

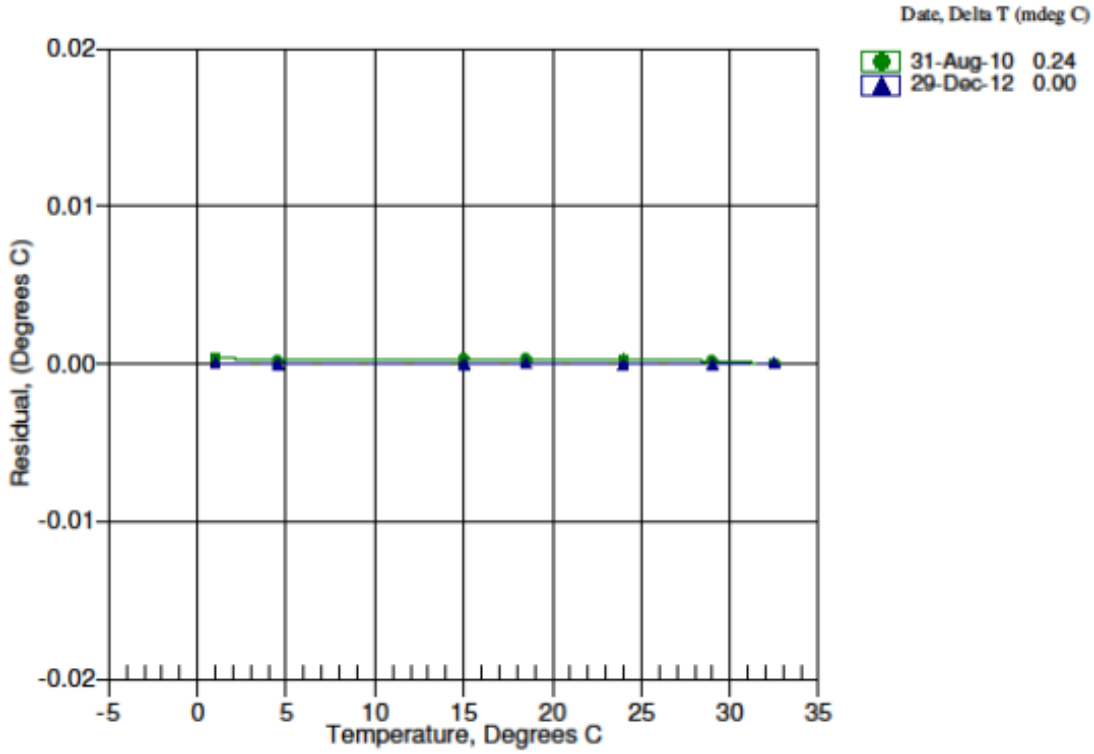
ITS-90 COEFFICIENTS

```
a0 =  4.555848e-005
a1 =  2.733778e-004
a2 = -2.324224e-006
a3 =  1.499077e-007
```

| BATH TEMP (ITS-90) | INSTRUMENT OUTPUT | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| 1.0000 | 649816.0 | 1.0000 | 0.0000 |
| 4.5000 | 554883.5 | 4.5000 | -0.0000 |
| 15.0000 | 352327.7 | 15.0000 | -0.0000 |
| 18.5000 | 304717.7 | 18.5000 | 0.0000 |
| 24.0000 | 244011.0 | 24.0000 | 0.0000 |
| 29.0000 | 200602.2 | 29.0000 | -0.0000 |
| 32.5000 | 175478.8 | 32.5000 | 0.0000 |

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

Residual = instrument temperature - bath temperature



## *Underway Micro-TSG number 2*

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# Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

Micro TSG

SENSOR SERIAL NUMBER: 0389
CALIBRATION DATE: 20-Oct-11

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

COEFFICIENTS:

g = -9.860311e-001
h = 1.453869e-001
i = -4.022911e-004
j = 5.189313e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 1.9700e-007

| BATH TEMP (ITS-90) | BATH SAL (PSU) | BATH COND (Siemens/m) | INST FREQ (Hz) | INST COND (Siemens/m) | RESIDUAL (Siemens/m) |
|---|---|---|---|---|---|
| 23.3000 | 0.0000 | 0.00000 | 2024.51 | 0.00000 | 0.00000 |
| 1.3000 | 34.9210 | 2.98600 | 5244.92 | 2.98436 | 0.00000 |
| 4.3000 | 34.9005 | 3.29188 | 5443.39 | 3.29188 | -0.00000 |
| 14.3999 | 34.8564 | 4.27003 | 6036.41 | 4.27031 | 0.00001 |
| 18.4999 | 34.8467 | 4.62156 | 6227.28 | 4.62180 | -0.00000 |
| 24.3000 | 34.8204 | 5.18113 | 6528.21 | 5.18115 | -0.00000 |
| 29.3000 | 34.8217 | 5.70357 | 6795.97 | 5.70357 | -0.00000 |
| 32.3000 | 34.8211 | 6.07673 | 6962.21 | 6.07673 | 0.00000 |

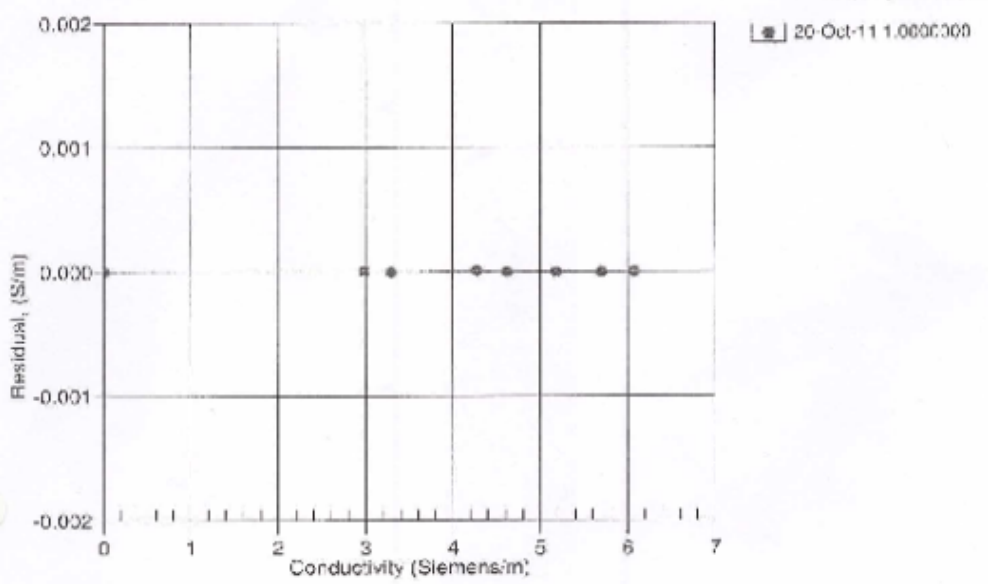
f = INST FREQ * sqrt(10.0) + WBOTC * t) / 1000.0

Conductivity = (g + hf$^2$ + if$^3$ + jf$^4$) / (1 + δt + εp) Siemens/meter

t = temperature[°C]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = instrument conductivity - bath conductivity

Data: Slope Correction



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# Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

Micro TSG

SENSOR SERIAL NUMBER: 0589
CALIBRATION DATE: 20 Oct. 11

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

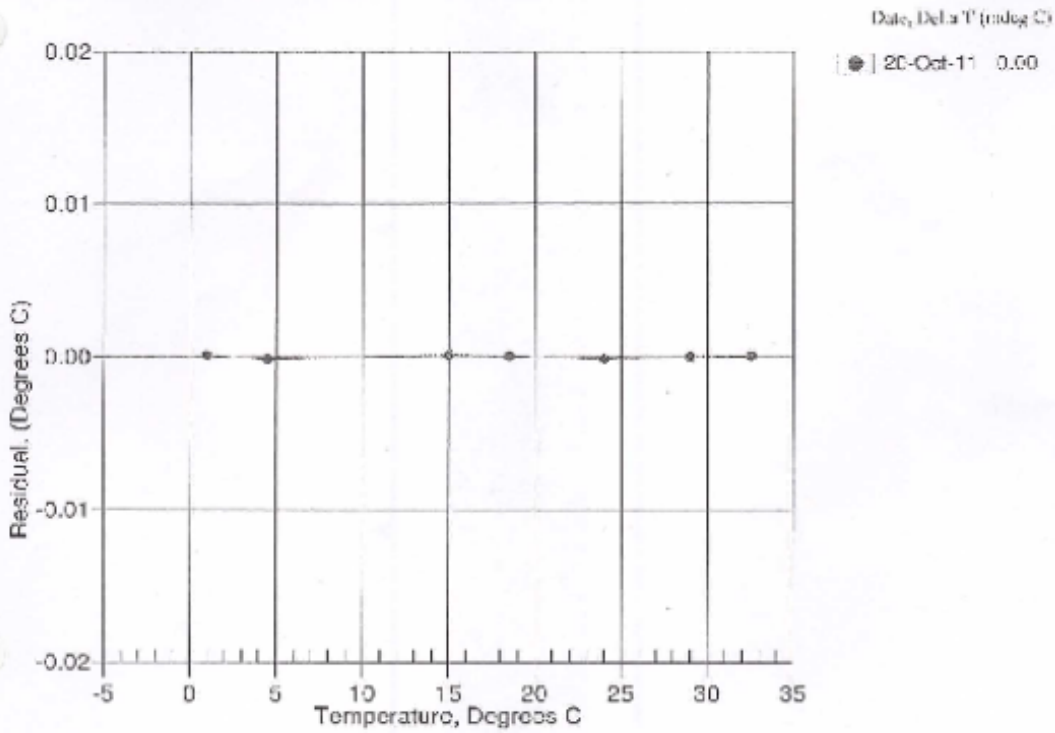
ITS-90 COEFFICIENTS

a0 = 3.173883e-003
a1 = 2.836177e-004
a2 = -1.828637e-006
a3 = 1.327174e-007

| BATH TEMP (ITS-90) | INSTRUMENT OUTPUT | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| 1.0000 | 828514.5 | 1.0001 | 0.0001 |
| 4.5000 | 706709.4 | 4.4998 | -0.0002 |
| 14.9999 | 449335.5 | 15.0000 | 0.0001 |
| 18.4999 | 386307.8 | 18.5000 | 0.0001 |
| 24.0000 | 305342.6 | 23.9999 | -0.0001 |
| 26.0000 | 253727.3 | 29.0000 | -0.0000 |
| 32.0000 | 221749.5 | 32.0000 | 0.0000 |

Temperature ITS-90 = 1/{a0 + a1[ln(n)] + a2[ln²(n)] + a3[ln³(n)]} - 273.15 (°C)

Residual = instrument temperature - bath temperature



**Sea-Bird Electronics, Inc.**
13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0178
CALIBRATION DATE: 21-Sep-12

SBE 38 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

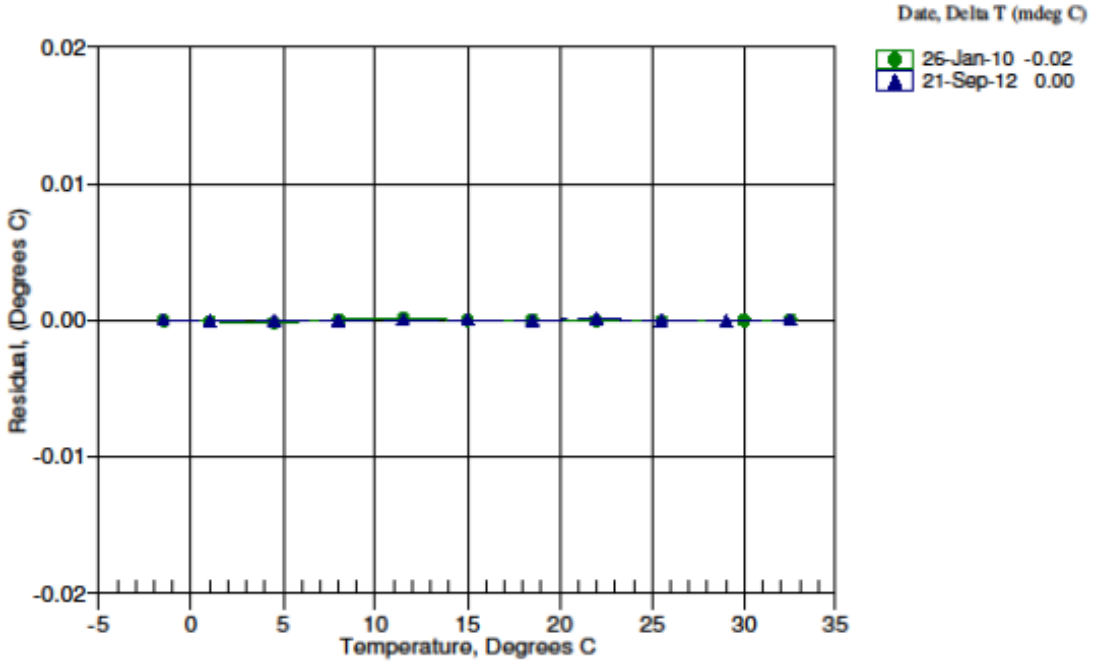
ITS-90 COEFFICIENTS

```
a0 = -4.740793e-005
a1 =  2.820902e-004
a2 = -2.754939e-006
a3 =  1.681819e-007
```

| BATH TEMP (ITS-90) | INSTRUMENT OUTPUT | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| -1.50000 | 750879.8 | -1.49997 | 0.00003 |
| 1.00000 | 671250.6 | 0.99996 | -0.00004 |
| 4.50000 | 575382.9 | 4.49998 | -0.00002 |
| 8.00000 | 494802.5 | 7.99999 | -0.00001 |
| 11.50000 | 426843.9 | 11.50002 | 0.00002 |
| 15.00000 | 369343.4 | 15.00002 | 0.00002 |
| 18.50000 | 320537.2 | 18.49998 | -0.00002 |
| 21.99990 | 278981.8 | 21.99999 | 0.00009 |
| 25.50000 | 243494.9 | 25.49993 | -0.00007 |
| 28.99990 | 213101.3 | 28.99982 | -0.00008 |
| 32.49990 | 186993.9 | 32.49996 | 0.00006 |

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

Residual = instrument temperature - bath temperature



PO Box 518
620 Applegate St.
Philomath OR 97370

WET Labs

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

**Chlorophyll Fluorometer Characterization, New Proxy .**

| | |
|---|---|
| **Date:** | **09/12/2011** |
| **Serial #:** | AFLT-009 |
| **Job#:** | 006066 |
| **Tech:** | SML |

| | |
|---|---|
| **Dark Counts** | **0.193 volts** |
| **CEV** | **1.429 volts** |
| **SF** | **19.29** |
| **FSV** | **5.36 volts** |
| **Linearity:** | **0.999 $R^2$ (0–1.5 volts)** |
| | **0.995 $R^2$ (0– 5.45 volts)** |

Notes:

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

**CEV** is the chlorophyll equivalent voltage. This value is the signal output of the fluorometer when using a fluorescent proxy that has been determined to be approximately equivalent to **24.63 µg/l** of a *Thalassiosira weissflogii* phytoplankton culture.

**SF** is the scale factor used to derive chlorophyll concentration from the signal voltage output of the fluorometer. The scale factor is determine by using the following equation: SF = (24.63) / (CEV – dark) e.g.(24.63 / (1.429 – 0.193) = 19.29)

**FSV** is the maximum signal voltage output that the fluorometer is capable of.

Chlorophyll concentration expressed in µg/l (mg/$m^3$) can be derived by using the following equation: (µg/l) = (Vmeasured -dark) * SF

The relationship between fluorescence and chlorophyll-*a* concentrations in-situ is high variable. The scale factor listed on this document was determined by 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 determination of chlorophyll concentration see [ Standard Methods For The Examination Of Water And Wastewater] part 10200 H published jointly by: American Public Health Association, American Water Works Association and Water Environment Federation.

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WET Labs

(541) 929-5650
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http://www.wetlabs.com

**Chlorophyll Fluorometer Pre-Characterization, Old Proxy .**

| | |
|---|---|
| **Date:** | **09/12/2011** |
| **Serial #:** | AFLT-009 |
| **Job#:** | 006066 |
| **Tech:** | SML |

| | |
|---|---|
| **Dark Counts** | **0.193 volts** |
| **CEV** | **2.372 volts** |
| **SF** | **10.142** |
| **FSV** | **5.36 volts** |
| **Linearity:** | **0.999 $R^2$ (0–1.5 volts)** |
| | **0.995 $R^2$ (0– 5.45 volts)** |

Notes:

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

**CEV** is the chlorophyll equivalent voltage. This value is the signal output of the fluorometer when using a fluorescent proxy that has been determined to be approximately equivalent to **22.1 µg/l** of a *Thalassiosira weissflogii* phytoplankton culture.

**SF** is the scale factor used to derive chlorophyll concentration from the signal voltage output of the fluorometer. The scale factor is determine by using the following equation: SF = (22.1) / (CEV – dark) e.g.(22.1 / (2.372 – 0.193) = 9.516)

**FSV** is the maximum signal voltage output that the fluorometer is capable of.

Chlorophyll concentration expressed in µg/l (mg/m$^3$) can be derived by using the following equation: (µg/l) = (Vmeasured -dark) * SF

The relationship between fluorescence and chlorophyll-*a* concentrations in-situ is high variable. The scale factor listed on this document was determined by 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 determination of chlorophyll concentration see [ Standard Methods For The Examination Of Water And Wastewater] part 10200 H published jointly by: American Public Health Association, American Water Works Association and Water Environment Federation.

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WETLabs

## C-Star Calibration

Date December 6, 2012 S/N# CST-1316DR Pathlength 25 cm

| | Analog output | Digital output |
|---|---|---|
| $V_d$ | 0.008 V | 0 counts |
| $V_{air}$ | 4.804 V | 15733 counts |
| $V_{ref}$ | 4.705 V | 15405 counts |

| | |
|---|---|
| Temperature of calibration water | 20.0 °C |
| Ambient temperature during calibration | 20.8 °C |

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

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

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

$V_d$ 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 Fish and Pressure Sensor*

13

**SEA-BIRD ELECTRONICS, INC.**
13431 NE 20th St, Bellevue Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 Email: seabird@seabird.com

**Digiquartz Pressure Calibration dP/dT Corrected Coefficients**
*(Changed coefficients are posted in italics)*

Pressure Transducer Serial Number: 120089
Original Calibration Date: 2011-01-28
Date of Correction: 2012-12-11
Installed in: SBE 9Plus S/N 1130

**PRESSURE COEFFICIENTS**

| | | |
|---|---|---|
| *C1* | *-42307.76* | *psia* |
| *C2* | *1.4900785e-01* | *psia/deg C* |
| C3 | 1.5073e-02 | psia/deg $C^2$ |
| D1 | 0.03473 | |
| D2 | 0.0 | |
| *T1* | *30.0225* | *µsec* |
| *T2* | *-2.774198e-04* | *µsec/deg C* |
| T3 | 4.796e-06 | µsec/deg $C^2$ |
| T4 | 1.75442e-09 | µsec/deg $C^3$ |
| T5 | 0e+00 | |

AD590M = 0.01281
AD590B = -8.819139
Slope = 1.0
Offset = 0.0

Corrected at Sea-Bird Electronics as per Paroscientific Calibration and Sea-Bird Electronics dP/dT tests. The original calibration from Paroscientific assumes an operating temperature range of 0 to 125 degrees C. dP/dT correction adjusts this operating range to a nominal range of 0 to 22 degrees C. This increases the accuracy of the transducer in this temperature range.

NOTE: Original coefficients from Paroscientific are attached to this form for informational purposes and should not be used.

## *CTD Conductivity (Primary)*

# SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 3503
CALIBRATION DATE: 17-Jun-11

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -1.03262410e+001
h =  1.56275016e+000
i = -3.00997664e-003
j =  3.20040950e-004
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  1.71106814e-007
b =  1.55458632e+000
c = -1.03093231e+001
d = -8.08777604e-005
m =  6.9
CPcor = -9.5700e-008 (nominal)
```

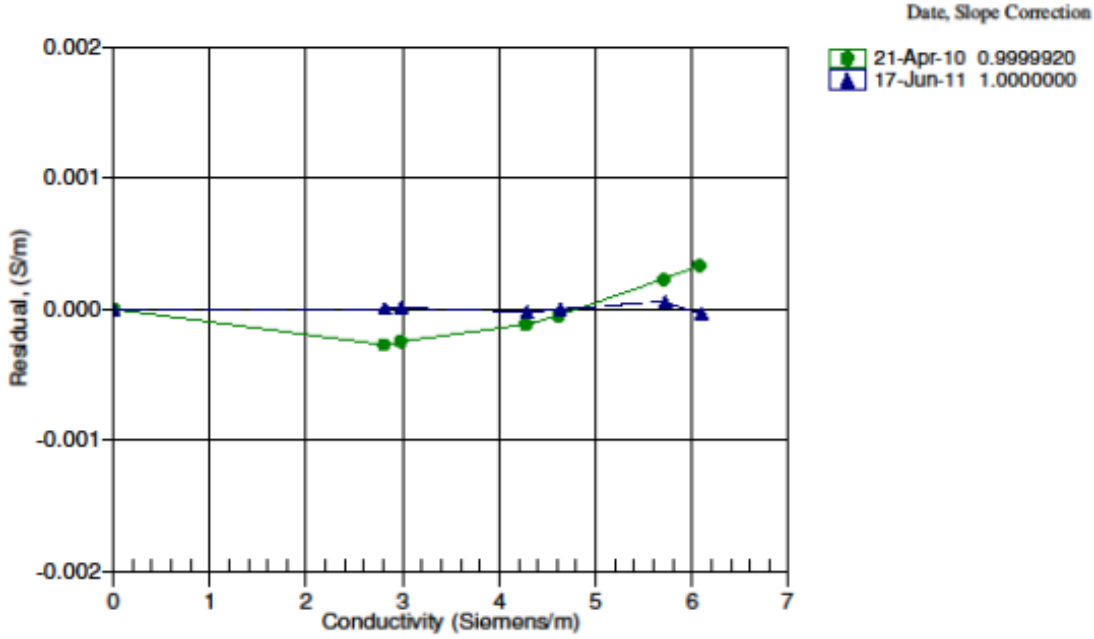
| BATH TEMP (ITS-90) | BATH SAL (PSU) | BATH COND (Siemens/m) | INST FREQ (kHz) | INST COND (Siemens/m) | RESIDUAL (Siemens/m) |
|---|---|---|---|---|---|
| 0.0000 | 0.0000 | 0.00000 | 2.57519 | 0.00000 | 0.00000 |
| -1.0000 | 34.9369 | 2.81338 | 4.97213 | 2.81338 | 0.00000 |
| 1.0000 | 34.9374 | 2.98533 | 5.08204 | 2.98534 | 0.00001 |
| 15.0000 | 34.9374 | 4.28489 | 5.84581 | 4.28487 | -0.00002 |
| 18.5000 | 34.9364 | 4.63258 | 6.03365 | 4.63257 | -0.00000 |
| 29.0000 | 34.9333 | 5.71932 | 6.58591 | 5.71937 | 0.00006 |
| 32.5001 | 34.9258 | 6.09293 | 6.76517 | 6.09289 | -0.00004 |

Conductivity = $(g + hf^2 + if^3 + jf^4)/10(1 + \delta t + \epsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt)/[10(1 + \epsilon p)$ Siemens/meter

t = temperature[°C]; p = pressure[decibars]; $\delta$ = CTcor; $\epsilon$ = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



## *CTD Conductivity (Secondary)*

# SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 3505
CALIBRATION DATE: 17-Jun-11

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -1.00495277e+001
h =  1.48833566e+000
i = -1.51676049e-003
j =  2.01820274e-004
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  3.64626762e-006
b =  1.48467285e+000
c = -1.00428577e+001
d = -8.59276632e-005
m =  5.4
CPcor = -9.5700e-008 (nominal)
```

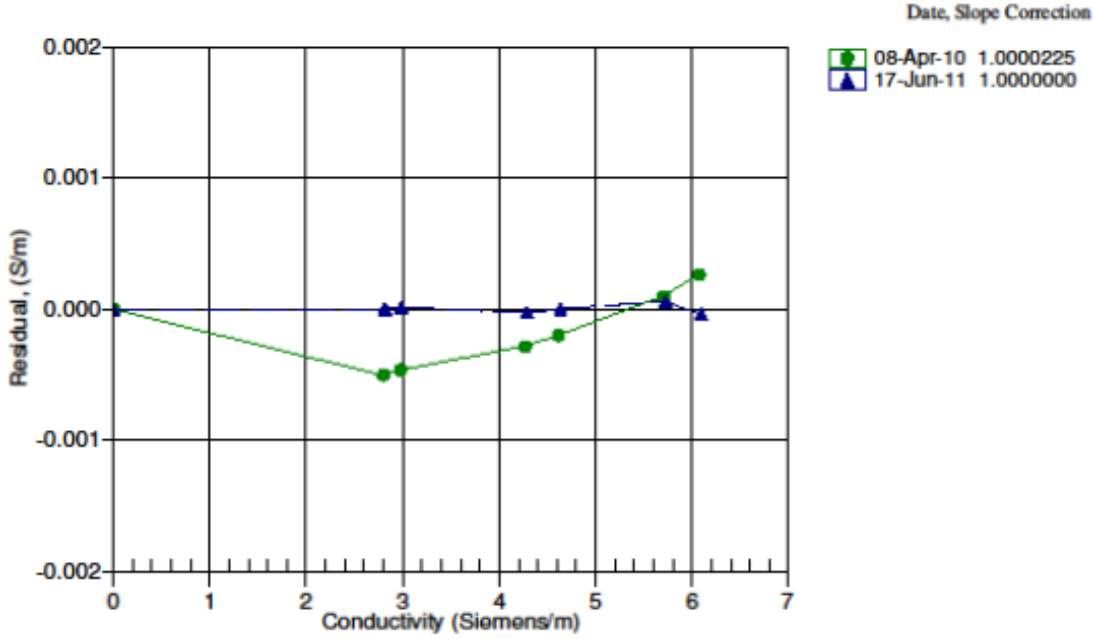
| BATH TEMP (ITS-90) | BATH SAL (PSU) | BATH COND (Siemens/m) | INST FREQ (kHz) | INST COND (Siemens/m) | RESIDUAL (Siemens/m) |
|---|---|---|---|---|---|
| 0.0000 | 0.0000 | 0.00000 | 2.60075 | 0.00000 | 0.00000 |
| -1.0000 | 34.9369 | 2.81338 | 5.06934 | 2.81338 | -0.00000 |
| 1.0000 | 34.9374 | 2.98533 | 5.18214 | 2.98534 | 0.00001 |
| 15.0000 | 34.9374 | 4.28489 | 5.96556 | 4.28486 | -0.00003 |
| 18.5000 | 34.9364 | 4.63258 | 6.15816 | 4.63258 | -0.00000 |
| 29.0000 | 34.9333 | 5.71932 | 6.72432 | 5.71938 | 0.00006 |
| 32.5001 | 34.9258 | 6.09293 | 6.90806 | 6.09289 | -0.00004 |

Conductivity = $(g + hf^2 + if^3 + jf^4)/10(1 + \delta t + \epsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt)/[10(1 + \epsilon p)$ Siemens/meter

t = temperature[°C]; p = pressure[decibars]; $\delta$ = CTcor; $\epsilon$ = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



## *CTD Temperature (Primary)*

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# Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 5730
CALIBRATION DATE: 13 Nov 12

SBE3 TEMPERATURE CALIBRATION DATA
ITS 90 TEMPERATURE SCALE

**ITS-90 COEFFICIENTS**

g = 4.35188740e-003
h = 6.29746782e-004
i = 1.97095106e-005
j = 1.42614274e-006
t0 = 1000.0

**IPTS-68 COEFFICIENTS**

a = 3.68121342e-003
b = 5.91711217e-004
c = 1.90304619e-005
d = 1.42742670e-006
t0 = 1000.000

| BATH TEMP (ITS 90) | INSTRUMENT FREQ (Hz) | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| 1.0000 | 3003.672 | -1.0001 | 0.00008 |
| 1.0000 | 3179.320 | 1.0001 | 0.00010 |
| 4.0000 | 3437.383 | 4.0000 | 0.00005 |
| 7.9999 | 3710.673 | 7.9998 | 0.00002 |
| 11.5000 | 3999.035 | 11.4999 | -0.00008 |
| 15.0000 | 4303.081 | 15.0005 | -0.00005 |
| 18.5000 | 4623.218 | 18.5000 | 0.00004 |
| 22.0000 | 4959.855 | 22.0000 | 0.00004 |
| 25.5000 | 5313.373 | 25.5001 | 0.00007 |
| 29.0000 | 5684.146 | 29.0000 | 0.00003 |
| 32.5000 | 6072.544 | 32.4999 | 0.00006 |

Temperature ITS-90 = $1/\{g + h[\ln(f_0/f)] + i[\ln^2(f_0/f)] + j[\ln^3(f_0/f)]\} - 273.15$ (°C)

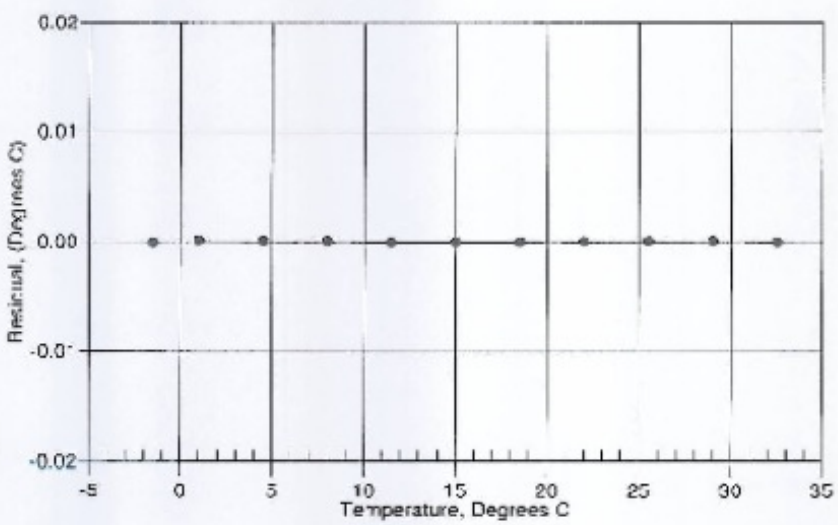
Temperature IPTS-68 = $1/\{a + b[\ln(f_0/f)] + c[\ln^2(f_0/f)] + d[\ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: $T_{68}$ is assumed to be 1.00024 * $T_{90}$ ( 2 to 35 °C)

Residual = instrument temperature - bath temperature

Date, Offset(deg C)

13-Nov-12 -0.00



## *CTD Temperature (Secondary)*

**Sea-Bird Electronics, Inc.**
13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2438
CALIBRATION DATE: 22-Aug-12

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

```
g =  4.31134824e-003
h =  6.41973049e-004
i =  2.30562159e-005
j =  2.19522017e-006
f0 = 1000.0
```

IPTS-68 COEFFICIENTS

```
a =  3.68121208e-003
b =  6.02099910e-004
c =  1.63994358e-005
d =  2.19678773e-006
f0 = 2759.345
```

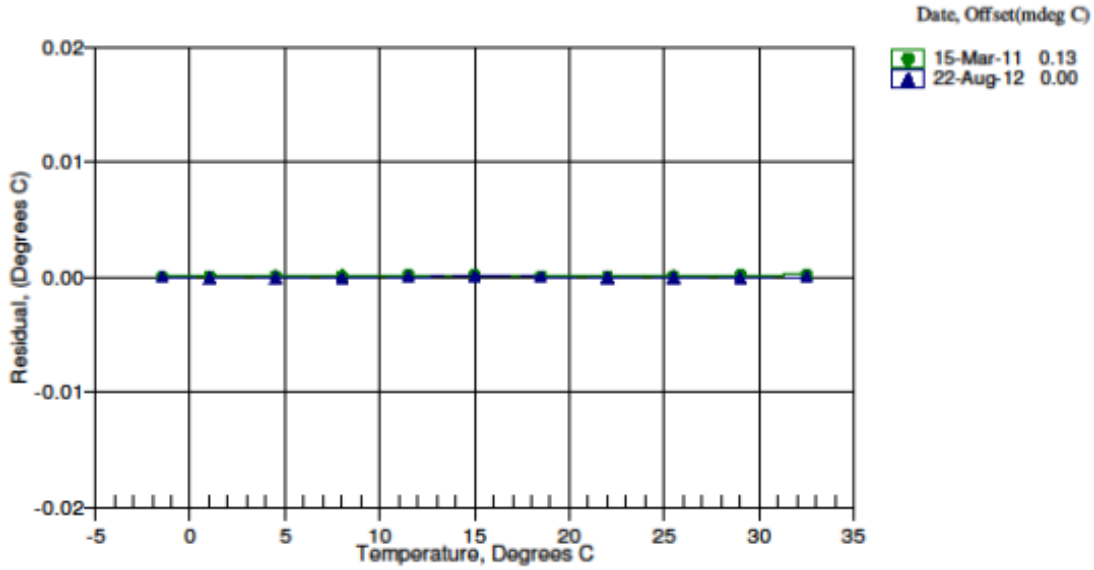
| BATH TEMP (ITS-90) | INSTRUMENT FREQ (Hz) | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| -1.5000 | 2759.345 | -1.5000 | 0.00002 |
| 1.0000 | 2917.842 | 1.0000 | -0.00000 |
| 4.5000 | 3150.675 | 4.5000 | -0.00001 |
| 8.0000 | 3396.590 | 7.9999 | -0.00007 |
| 11.5000 | 3655.956 | 11.5000 | 0.00001 |
| 14.9999 | 3929.098 | 15.0000 | 0.00010 |
| 18.4999 | 4216.353 | 18.4999 | 0.00003 |
| 22.0000 | 4518.054 | 21.9999 | -0.00005 |
| 25.5000 | 4834.507 | 25.5000 | -0.00003 |
| 29.0000 | 5166.008 | 29.0000 | -0.00004 |
| 32.5000 | 5512.855 | 32.5000 | 0.00004 |

Temperature ITS-90 = $1/[g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]] - 273.15$ (°C)

Temperature IPTS-68 = $1/[a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]] - 273.15$ (°C)

Following the recommendation of JPOTS: $T_{68}$ is assumed to be 1.00024 * $T_{90}$ (-2 to 35 °C)

Residual = instrument temperature - bath temperature



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WET Labs

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# *ECO* Chlorophyll Fluorometer Characterization Sheet

Date: 11/15/2012 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** | 0.106 | 0.064 | 0.043 V | 68 counts |
| **Scale Factor (SF)** | 6 | 13 | 25 µg/l/V | 0.0077 µg/l/count |
| **Maximum Output** | 4.96 | 4.96 | 4.96 V | 16330 counts |
| **Resolution** | 0.6 | 0.6 | 0.6 mV | 1.0 counts |

Ambient temperature during characterization 22.3 °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.xls Revision J 3/17/08

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## C-Star Calibration

Date December 5, 2012 S/N# CST-892DR Pathlength 25

| | Analog output |
|---|---|
| $V_d$ | 0.060 V |
| $V_{air}$ | 4.802 V |
| $V_{ref}$ | 4.703 V |

| | |
|---|---|
| Temperature of calibration water | 19.9 °C |
| Ambient temperature during calibration | 21.8 °C |

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

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

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

$V_d$ 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 Dissolved Oxygen Sensor (Primary)*

**Sea-Bird Electronics, Inc.**
13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0082
CALIBRATION DATE: 21-Aug-12

SBE 43 OXYGEN CALIBRATION DATA

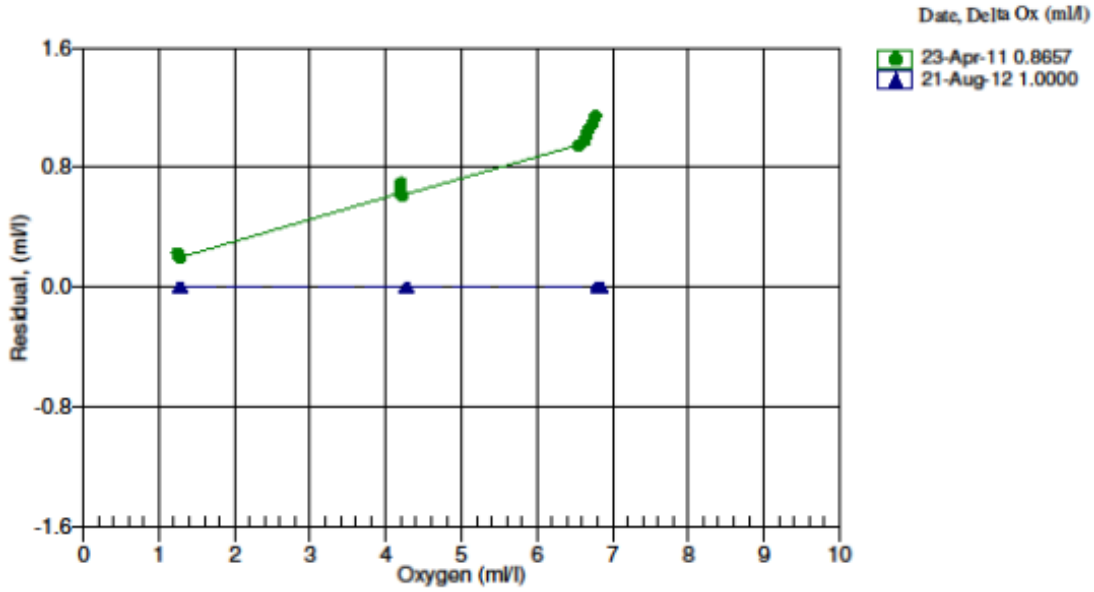
COEFFICIENTS
Soc = 0.4221
Voffset = -0.6822
Tau20 = 1.57

A = -2.9945e-003
B = 6.5601e-005
C = -1.4073e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4 H1 = -3.30000e-2
D2 = -4.64803e-2 H2 = 5.00000e+3
H3 = 1.45000e+3

| BATH OX (ml/l) | BATH TEMP ITS-90 | BATH SAL PSU | INSTRUMENT OUTPUT (VOLTS) | INSTRUMENT OXYGEN (ml/l) | RESIDUAL (ml/l) |
|---|---|---|---|---|---|
| 1.26 | 2.00 | 0.04 | 0.993 | 1.26 | -0.00 |
| 1.27 | 6.00 | 0.04 | 1.034 | 1.27 | -0.00 |
| 1.28 | 12.00 | 0.04 | 1.096 | 1.28 | -0.00 |
| 1.30 | 20.00 | 0.04 | 1.187 | 1.29 | -0.00 |
| 1.30 | 26.00 | 0.04 | 1.259 | 1.30 | 0.00 |
| 1.31 | 30.00 | 0.04 | 1.311 | 1.31 | 0.00 |
| 4.26 | 2.00 | 0.04 | 1.732 | 4.26 | 0.00 |
| 4.27 | 6.00 | 0.04 | 1.864 | 4.27 | 0.00 |
| 4.29 | 12.00 | 0.04 | 2.071 | 4.29 | 0.00 |
| 4.29 | 30.00 | 0.04 | 2.745 | 4.29 | -0.00 |
| 4.29 | 26.00 | 0.04 | 2.586 | 4.29 | 0.00 |
| 4.29 | 20.00 | 0.04 | 2.356 | 4.29 | -0.00 |
| 6.78 | 2.00 | 0.04 | 2.352 | 6.78 | -0.00 |
| 6.79 | 12.00 | 0.04 | 2.879 | 6.79 | 0.00 |
| 6.81 | 6.00 | 0.04 | 2.564 | 6.81 | -0.00 |
| 6.84 | 20.00 | 0.04 | 3.349 | 6.84 | -0.00 |
| 6.85 | 26.00 | 0.04 | 3.719 | 6.85 | 0.00 |
| 6.86 | 30.00 | 0.04 | 3.985 | 6.86 | 0.00 |

Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * $T^2$ + C * $T^3$) * OxSol(T,S) * exp(E * P / K)
V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU], K = temperature [Kelvin]
OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen



## *CTD Dissolved Oxygen Sensor (Secondary)*

**Sea-Bird Electronics, Inc.**
13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0139
CALIBRATION DATE: 17-Aug-12

SBE 43 OXYGEN CALIBRATION DATA

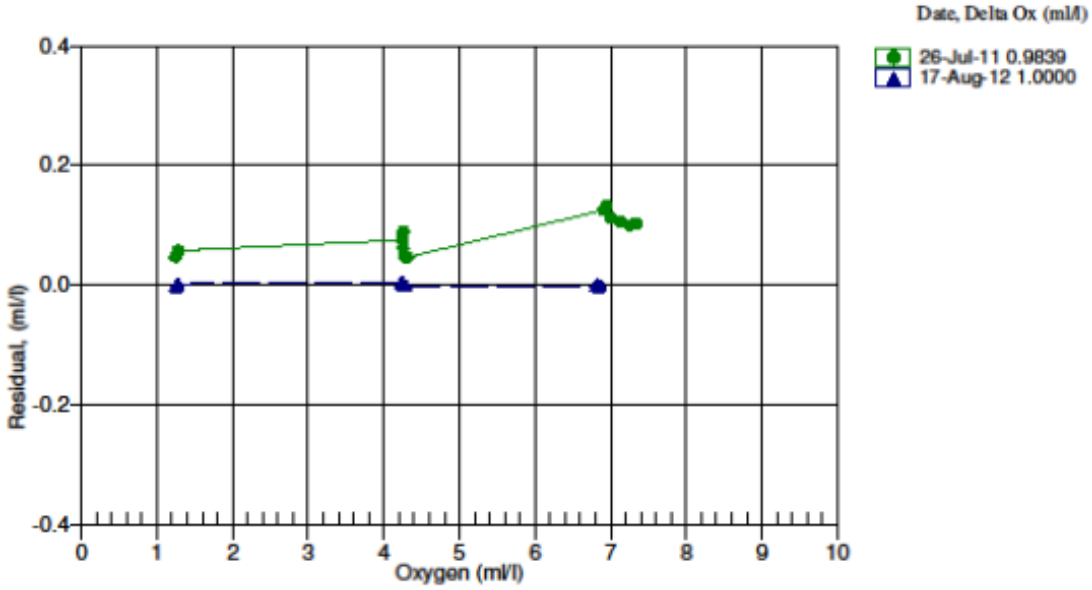
COEFFICIENTS
Soc = 0.3794
Voffset = -0.5881
Tau20 = 1.31

A = -2.6177e-003
B = 1.1822e-004
C = -1.9061e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4 H1 = -3.30000e-2
D2 = -4.64803e-2 H2 = 5.00000e+3
H3 = 1.45000e+3

| BATH OX (ml/l) | BATH TEMP ITS-90 | BATH SAL PSU | INSTRUMENT OUTPUT (VOLTS) | INSTRUMENT OXYGEN (ml/l) | RESIDUAL (ml/l) |
|---|---|---|---|---|---|
| 1.24 | 2.00 | 0.04 | 0.928 | 1.24 | -0.00 |
| 1.25 | 6.00 | 0.04 | 0.971 | 1.25 | -0.00 |
| 1.26 | 12.00 | 0.04 | 1.037 | 1.26 | -0.00 |
| 1.27 | 20.00 | 0.04 | 1.127 | 1.27 | -0.00 |
| 1.28 | 26.00 | 0.04 | 1.195 | 1.28 | 0.00 |
| 1.28 | 30.00 | 0.04 | 1.244 | 1.28 | 0.00 |
| 4.23 | 2.00 | 0.04 | 1.748 | 4.24 | 0.00 |
| 4.25 | 6.00 | 0.04 | 1.890 | 4.25 | 0.00 |
| 4.25 | 12.00 | 0.04 | 2.103 | 4.26 | 0.00 |
| 4.26 | 20.00 | 0.04 | 2.389 | 4.26 | -0.00 |
| 4.26 | 26.00 | 0.04 | 2.612 | 4.26 | 0.00 |
| 4.29 | 30.01 | 0.04 | 2.779 | 4.29 | -0.00 |
| 6.81 | 20.00 | 0.04 | 3.466 | 6.80 | -0.00 |
| 6.81 | 12.00 | 0.04 | 3.010 | 6.81 | -0.00 |
| 6.83 | 26.00 | 0.04 | 3.831 | 6.83 | 0.00 |
| 6.84 | 2.00 | 0.04 | 2.459 | 6.83 | -0.00 |
| 6.86 | 6.00 | 0.04 | 2.689 | 6.86 | -0.00 |
| 6.87 | 30.04 | 0.04 | 4.096 | 6.87 | -0.00 |

Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * $T^2$ + C * $T^3$) * OxSol(T,S) * exp(E * P / K)
V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU], K = temperature [Kelvin]
OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen



## *CTD Underwater PAR*

### Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

**Calibration Date:** 10/26/12 **Job No.:** R11453
**Model Number:** QSP2300
**Serial Number:** 4721
**Operator:** TPC
**Standard Lamp:** V-030(3/7/12)
**Operating Voltage Range:** 6 to 15 VDC (+)

Note: The QSP-200 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:** | **3.00E+13** | **quanta/cm²·sec/"amps"** | **4.99E-05** | **µEinsteins/cm²·sec/"amps"** |
| **Wet Calibration Factor:** | **5.30E+13** | **quanta/cm²·sec/"amps"** | **8.81E-05** | **µEinsteins/cm²·sec/"amps"** |

**Sensor Test Data and Results**[4]

| | | | | | |
|---|---|---|---|---|---|
| Sensor Supply Current (Dark): | 84.7 | mA | current dithers | | |
| Supply Voltage: | 6 | Volts | | | |
| Lamp Integrated PAR Irradiance: | 9.83E+15 | quanta/cm²·sec | 0.01632 | 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% | 2.517 | 100.00% | 3.29E-08 | 3.29E-08 | 2.519 | 0.002 | 0.0 | 9.83E+15 |
| 0.3 | 36.10% | 2.080 | 36.26% | 1.19E-08 | 1.19E-08 | 2.080 | 0.000 | -0.4 | 3.56E+15 |
| 0.5 | 27.60% | 1.967 | 27.86% | 9.16E-09 | 9.07E-09 | 1.965 | -0.002 | -0.9 | 2.74E+15 |
| 1 | 9.27% | 1.511 | 9.44% | 3.10E-09 | 3.05E-09 | 1.506 | -0.006 | -1.8 | 9.28E+14 |
| 2 | 1.11% | 0.720 | 1.14% | 3.74E-10 | 3.65E-10 | 0.714 | -0.006 | -2.3 | 1.12E+14 |
| 3 | 0.05% | 0.249 | 0.06% | 2.59E-11 | 1.76E-11 | 0.230 | -0.019 | -30.4 | 7.64E+12 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Dark Before: | 0.163 | Volts | | | | |
| Light - No Filter Hldr.: | 2.517 | Volts | $I_{sig}$ = 1.30E-10 | Amps | | |
| Dark After - NFH: | 0.163 | Volts | $I_{dark}$ = 1.52E-10 | Amps | R(G/80) | 0.2 |
| Average Dark | 0.163 | Volts | $10^{Vdark}$ = 1.5231/6 | Amps | | |

Notes:
1. Annual calibration is recommended.
2. There is increasing error associated with readings below zero.
3. The collector should be cleaned frequently with alcohol.
4) This section is for internal use and for more advanced analysis.

QSP-200L,QSP2300(2008- )