

# Data Report NBP1208

**National Science Foundation**

**Seismic Test Cruise**

**Tim McGovern – Ocean Projects Manager, NSF**

**Amy Leventer – Project Chief Scientist**

**Sean Gulick – Lead Seismic PI UTIG**

**August 31, 2012 – September 5, 2012**



**RVIB Nathaniel B. Palmer**

**United States Antarctic Program**

**Antarctic Support Contractor**

**Prepared by Sean Drabant, Joe Tarnow**

## Table of Contents

<b>INTRODUCTION</b>	<b>4</b>
<b>DISTRIBUTION CONTENTS AT A GLANCE</b>	<b>5</b>
EXTRACTING DATA .....	6
<b>DISTRIBUTION CONTENTS</b>	<b>7</b>
CRUISE INFORMATION .....	7
<i>Cruise Track</i>	7
<i>Satellite Images</i>	7
NBP DATA PRODUCTS .....	7
<i>JGOFS</i>	8
<i>MGD77</i>	9
SCIENCE OF OPPORTUNITY .....	10
<i>ADCP</i>	10
<i>pCO<sub>2</sub></i>	10
CRUISE SCIENCE .....	11
<i>XBT</i>	11
RVDAS .....	11
<i>Sensors and Instruments</i>	11
Underway Sensors	12
Meteorology and Radiometry	12
Geophysics	12
Oceanography	12
Navigational Instruments	13
<i>Data</i>	13
Underway Data /rvdas/uw	14
Sound Velocity Probe (svp1)	14
Meteorology (mw1)	14
MET string	14
PUS string	15
SUS string	15
Knudsen (knud)	15
Fluorometer (flr1)	15
pCO <sub>2</sub> (pco2)	17
Micro-TSG (mtsg)	17
Micro-TSG #2 (gen1)	17
Gravimeter (grv1)	18
Engineering (eng1)	19
Hydro-DAS (hdas)	20
GUV Data (pguv)	20
Remote Temperature (rtmp)	20
Oxygen Data (oxyg)	21
Navigational Data /rvdas/nav	22
Seapath GPS (seap)	22
Trimble (P-Code) GPS (PCOD)	25
Gyro Compass (gyr1)	26
ADCP Course (adcp)	26
Processed Data /process/	27
pCO <sub>2</sub> -merged	27
Calculations	28
PAR .....	28
PSP .....	28
PIR .....	29
<b>ACQUISITION PROBLEMS AND EVENTS</b>	<b>30</b>
<b>APPENDIX: SENSORS AND CALIBRATIONS</b>	<b>31</b>
NBP1208 SHIPBOARD SENSORS .....	31
<i>Gravity Tie</i>	33

---

<i>Bridge Anemometer</i>	34
<i>Mast Barometer</i>	35
<i>Mast Humidity Sensor</i>	36
<i>Mast Temperature Sensor</i>	37
<i>Mast PIR</i>	38
<i>Mast PSP</i>	39
<i>Mast PAR</i>	40
<i>Mast GUV</i>	41
<i>CTD Conductivity (Primary)</i>	42
<i>CTD Conductivity (Secondary)</i>	43
<i>CTD Fish and Pressure Sensor</i>	44
<i>CTD Temperature (Primary - A)</i>	45
<i>CTD Temperature (Primary - B)</i>	46
<i>CTD Temperature (Secondary)</i>	47
<i>Fluorometer</i>	48
<i>Transmissometer</i>	49
<i>Underway TSG Conductivity</i>	50
<i>Underway TSG Temperature</i>	51
<i>Underway Remote Temperature</i>	52
<i>Oxygen Sensor</i>	53

## 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 UDF format. It is readable by most modern computer platforms.

All the data has been compressed using Unix “gzip,” identified by the “.gz” 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, use Stuffit Expander with DropStuff. On Windows operating systems use WinZip.

MultiBeam, EK60 data, Yo-yo camera data, 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: NBP1208

File	Description
/	Root level directory
NBP1208.trk	Text file of cruise track (lat,lon)
NBP1208.mgd	Full Cruise MGD77 data file
NBP1208.gmt	GMT binary file of MGD77 data
INSTCOEF.TXT	Instrument Coefficient File
1208DATA.doc	Data Report NBP1208 (MS Word)
1208DATA.pd	Data Report NBP1208 (PDF format)
/plots	Cruise track plots
nbp1208-track.ps	Cruise track plot (PostScript format)
nbp1208-track.jpg	Cruise track plot (JPEG format)
nbp1208-track.pdf	Cruise track plot (PDF format)
/process	Processed data
1208JGOF.tar	JGOFS format data files
1208QC.tar	Daily RVDAS QC postscript plots
1208PCO2.tar	Merged pCO2 data files
1208MGD.tar	MGD Data
1208PROC.tar	Other processed data
/rvdas/nav	Navigation data
1208adcp.tar	ADCP Data Sets
1208gyr1.tar	Gyro raw data
1208PCOD.tar	Trimble P-code raw data
1208seap.tar	Seapath data
/rvdas/uw	Underway data
1208bwnc.tar	Baltic Winch data
1208ctdd.tar	CTD Depth data
1208cwnc.tar	Waterfall Winch data
1208eng1.tar	Engineering data
1208grv1.tar	Gravimeter raw data
1208hdas.tar	HydroDAS raw data
1208knud.tar	Knudsen raw data
1208mbdp.tar	Multibeam depth data
1208mwx1.tar	Meteorology raw data
1208oxyg.tar	Oxygen sensor
1208pco2.tar	pCO2 raw data
1208pguv.tar	GUV raw data
1208rtmp.tar	Remote temperature data
1208svp1.tar	Sound velocity probe (in ADCP well)
1208tsg1.tar	Micro TSG data
1208tsg2.tar	2 <sup>nd</sup> Micro TSG data
1208twnc.tar	Winch data
/Imagery	Satellite Imagery
1208Imagery.tar	
/ocean	Ocean data
1208ctd.tar	CTD Data
1208xht.tar	XBT 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 were created using the command,

```
tar -cvf 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 “.gz” extension on the filename. These files can be decompressed after de-archiving, using the Unix command,

```
gunzip filename.gz
```

## Distribution Contents

### Cruise Information

NBP1208 departed Punta Arenas, Chile on August 31, 2012

Data logging was started at 1100GMT on Aug 31, 2012

Data logging was stopped at 1340GMT on September 5, 2012

### *Cruise Track*

The distribution DVD includes a GMT cruise track file (NBP1208.trk). It contains the longitude and latitude of the ship's position at one-minute intervals extracted from the NBP1208.gmt file.

JPEG 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/1208Imagery.tar. Each type of image is contained in a .tar.gz 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/1208proc.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](mailto:itvessel@usap.gov).

**JGOFS**

The JGOFS data set can be found on the distribution media in the file /process/1208jgof.tar. The archive contains one file produced for each day named jgDDD.dat.gz, where DDD is the year-day the data was acquired. The “.gz” extension indicates that the individual files are compressed before archiving. Each daily file consists of 22 columnar fields in text format as described in the table below. The JGOFS data set is created from calibrated data decimated at one-minute intervals. Several fields are derived measurements from more than a single raw input. For example, Course Made Good (CMG) and Speed Over Ground (SOG) are calculated from gyro and GPS inputs. Daily plots during the cruise are produced from the JGOFS data set. Note: Null, unused, or unknown fields are indicated as “NAN” 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	$\mu\text{Einsteins/meter}^2 \text{ sec}$
10	Sea surface temperature	$^{\circ}\text{C}$
11	Sea surface conductivity	siemens/meter
12	Sea surface salinity	PSU
13	Sea depth (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	$^{\circ}\text{C}$
17	Relative humidity	%
18	Barometric pressure	mBars
19	Sea surface fluorometry	$\mu\text{g/l (mg/m}^3\text{)}$
20	Transmissometry	%
21	PSP	$\text{W/m}^2$
22	PIR	$\text{W/m}^2$

## 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 NBP1208.mgd. The file NBP1208.gmt is created from the MGD77 dataset using the “mgd77togmt” utility. NBP1208.gmt can be used with the GMT plotting package.

The data used to produce the NBP1208.mgd file can be found on the distribution media in the file /process/1208proc.tar. The data files in the archive contain a day's data and follow the naming convention Dddd.fnl.gz, 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 - = South. (–9000000 to 9000000)
36-44	9	real	Longitude x 100000	+ = East - = West. (–18000000 to 18000000)
45	1	int	Position type code	1=Observed fix 3=Interpolated 9=Unspecified
46-51	6	real	Bathymetry, 2- way travel time	In 10,000th of seconds. Corrected for transducer depth and other such corrections
52-57	6	real	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 3 = Interpolated (Header Seq. 12) 9 = Unspecified
61-66	6	real	Magnetics total field, 1 <sup>ST</sup> sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2 <sup>ND</sup> sensor	In tenths of nanoteslas (gammas), for trailing sensor
73-78	6	real	Magnetics residual field	In tenths of nanoteslas (gammas). The reference field used is in Header Seq. 13
79	1	int	Sensor for residual	1 = 1 <sup>st</sup> or leading sensor

Col	Len	Type	Contents	Description, Possible Values, Notes
			field	2 = 2 <sup>nd</sup> or trailing sensor 9 = Unspecified
80-84	5	real	Magnetics diurnal correction	In tenths of nanoteslas (gammas). (In nanoteslas) if 9-filled (i.e., set to "+9999"), total and residual fields are assumed to be uncorrected; if used, total and residuals are assumed to have been already corrected.
85-90	6	F6.0	Depth or altitude of magnetics sensor	(In meters) + = Below sea level 3 = Above sea level
91-97	7	real	Observed gravity	In 10 <sup>th</sup> of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In 10 <sup>th</sup> of mgals. $E = 7.5 V \cos \phi \sin \alpha + 0.0042 V^*V$
104-108	5	real	Free-air anomaly	In 10 <sup>th</sup> of mgals G = observed G = theoretical
109-113	5	char	Seismic line number	Cross-reference for seismic data
114-119	6	char	Seismic shot-point number	
120	1	int	Quality code for navigation	5= Suspected, by the originating institution 6= Suspected, by the data center 9= No identifiable problem found

## Science of Opportunity

### ADCP

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

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 1208adcp.tar in the directory /rvdas/nav.

### pCO<sub>2</sub>

The NBP carries a pCO<sub>2</sub> measurement system from Lamont-Doherty Earth Observatory (LDEO). pCO<sub>2</sub> data is recorded by RVDAS and transmitted to LDEO at the end of each cruise. You will find pCO<sub>2</sub> data in a file named 1208pco2.tar in the /process directory, which contains the pCO<sub>2</sub> 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 1208xbt.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:     NBP1208.mwx1.d330

- The CruiseID is the numeric name of the cruise, in this case, NBP1208.
- 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-007
Barometer	mwx1	continuous	1 sec	R.M. Young 61208
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 3-01/S
Fluorometry	hdas	Continuous	2 sec	WET Lab AFL
Transmissometry	hdas	Continuous	2 sec	WET Lab C-Star
pCO <sub>2</sub>	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 (mw1)

There are 3 different data strings in the mw1 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	%
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<sub>2</sub> (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 <sub>2</sub> 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 <sub>2</sub> 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 <sub>2</sub> 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)**

08+330:23:59:50.899 12.25684 23.89813 0.4029922 0.2541656 233.4218 -  
 751.9 -8145.28 -1.386184 23.37653 23.37653 NAN

Field	Data	Units
1	RVDAS time tag	
2	Power Supply Voltage	V
3	Internal Case Temperature	°C
4	Pump #1 flow rate	L/min
5	Pump #2 flow rate	L/min
6	Pump #3 flow rate	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	Freezer #3 temperature	°C

\*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 <sup>2</sup> nm)
6	Ed0340	uW (cm <sup>2</sup> nm)
7	Ed0313	uW (cm <sup>2</sup> nm)
8	Ed0305	uW (cm <sup>2</sup> nm)
9	Ed0380	uW (cm <sup>2</sup> nm)
10	Ed0PAR	uE (cm <sup>2</sup> nm)
11	Ed0395	uW (cm <sup>2</sup> 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, [ssammer@ucsc.edu](mailto:ssammer@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	μM
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

## **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: 0 = Fix not available or invalid 1 = GPS, SPS mode, fix valid 2 = DGPS (differential GPS), SPS mode, fix valid 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
6	Ship heading	degrees

**Processed Data** /process/**pCO<sub>2</sub>-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 <sub>2</sub> 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 <sub>2</sub> pressure	microAtm
9	Equilibrated temperature	°C
10	Sea Water Temp	1 or 2 digits
11	Valve position	°C
12	Flow source (Equil = pCO <sub>2</sub> measurement)	text
13	RVDAS latitude	degrees
14	RVDAS longitude	degrees
15	TSG external temperature	°C
16	TSG salinity	PSU
17	TSG fluorometry	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	Input Source	-1 stem Thurston; 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 “mw1” 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 “mw1” 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 “`mw1`” 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
1100 Aug 31, 2012		Started Logging
	1340 Sep 5, 2012	Stopped Logging

## Appendix: Sensors and Calibrations

### NBP1208 Shipboard Sensors

<i>Sensor</i>	<i>Serial Number</i>	<i>Last Calibration</i>	<i>Comments</i>
<b>Meteorology &amp; Radiometers</b>			
Bridge Anemometer (RMV)	WM 115659	10/27/2011	Installed 11/18/2011.
Stbd Anemometer (Gill Ultrasonic)	847014	9/29/2010	Installed 11/17/2010 No calibration-sheet.
Port Anemometer (Gill Ultrasonic)	924057	11/18/2009	Installed 3/5/2010 No calibration-sheet.
Barometer	00872	3/9/2010	Installed 11/16/2011
Humidity/Wet Temp	06135	12/03/2010	Installed 5/5/2011
PIR	32845F3	4/12/2011	Installed 6/17/2011
PSP	32850F3	4/11/2011	Installed 6/17/2011
Mast PAR	6357	7/8/2010	Installed 5/5/2011
GUV (Mast)	25110203114	6/30/2010	Installed 5/5/2011
<b>CTD</b>			
Altimeter	49432		Installed 11/15/2011 No calibration sheet.
Conductivity (Secondary)	041431	9/8/2010	Installed 11/15/2011
Conductivity (Primary)	040926	8/24/2010	Installed 11/15/2011
CTD Fish	09P49179-0919	9/23/2010	Installed 11/15/2011
CTD Pressure Sensor	110538	9/23/2010	Installed 11/15/2011
CTD Pump (Primary)	050889 3.0K	8/18/2010	Installed 11/15/2011 No calibration sheet.
CTD Pump (Secondary)	051265 3.0K	8/18/2010	Installed 11/15/2011 No calibration sheet.
Temperature (Primary-A)	03P2308	9/10/2010	Installed 11/15/2011
Temperature (Primary-B)	03P2299	3/3/2011	Installed 11/30/2011
Temperature (Secondary)	03P2367	9/10/2010	Installed 11/15/2011
<b>Underway</b>			
Fluorometer	AFLT-011	10/6/2010	Installed 9/5/2011
Transmissometer	CST-831DR	03/18/2010	Installed 11/30/2010
TSG	4550449-0242	8/19/2010	Installed 9/5/2011
Remote Temp (Primary)	3846730-0323	5/18/2010	Installed 11/16/2011

---

Oxygen Optode 3835	1424	10/21/2010	Installed 12/30/2010
--------------------	------	------------	----------------------

**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: **3/7/2012**  
 Location: **Punta Arenas, Chile**  
 Station: **Harbour Admin. Bldg.**  
 Latitude: **53 09 S**  
 Longitude: **070 55 W**  
 Elevation:  
 Gravity: **981320.82**

Reference Code Numbers:  
 Station no. **9337-50**  
 ISGN no. **51230N**

	Value	Time (GMT)
Ship's meter before gravity tie ( Gravity (cu) )	8974.9	17:01
Ship's meter after gravity tie ( Gravity (cu) )	8974.9	18:01
Average	8974.9	
Ship Gravimeter's Calibration Constant	1.0046	
Corrected ship's meter ( QC Grav (mgal) )	8946.2	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	8974.9	17:03
Ship's meter after gravity tie (serial, RVDAS)	8974.9	18:02
Average (for comparison check only)	8974.9	

Portable Gravimeter Interval Factor **1.01007** From Table 1 of Model G #807 Meter

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	4917.64	17:23	54	March 7, 2012	
Pier measurement 2	4917.62	17:24	54	March 7, 2012	4962.15
Pier measurement 3	4917.63	17:25	54	March 7, 2012	
Average	4917.63				
Station measurement 1	4918.43	17:36	54	March 7, 2012	
Station measurement 2	4918.41	17:37	54	March 7, 2012	4962.54
Station measurement 3	4918.39	17:38	54	March 7, 2012	
Average	4918.41				
Pier measurement 4	4917.70	17:36	54	March 7, 2012	
Pier measurement 5	4917.63	17:52	54	March 7, 2012	4962.19
Pier measurement 6	4917.67	17:55	54	March 7, 2012	
Average	4917.67				

Gravity offset from last tie **972302.62**  
 Drift since last tie **-3.29**

**OBS Differences**

Station to Pier (1, 2, & 3 averaged) **0.79**  
 Station to Pier (4, 5, & 6 averaged) **0.79**  
 Averaged Differences **0.77**  
 Gravity at pier **981221.38**  
 Elevation of pier above gravimeter, meters **0.0**  
 Earth differential gravity, mgal/meter **0.3**  
 Gravity at ship's gravimeter **981220.05**  
 Gravity Offset (for RVDAS) **972302.62**

**Comments**

Tie done by Sheldon Blackman prior to NBP1203. Very stable conditions on pier. Pier elevation exactly even with ship's gravimeter.

**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?   
 Wind Direction Threshold < 30 gm?

**Additional Comments**

Installed new housing assy. and wind direction coupling. Adjusted clearance 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



**CALIBRATION REPORT**  
**Barometric Pressure Sensor**

Customer: *Raytheon Technical Services Company LLC*

Test Number: 1510-01B  
Test Date: 10 May 2011

Customer PO: RR57542-01  
Sales Order: 1906

<u>Test Sensor:</u>	
Model: 61201	Serial Number: BP01705
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  $\pm 1.0$  hPa.

Reference Pressure (hPa)	Voltage Output (millivolts)	Indicated (1) Pressure (hPa)
800.0	0	800.0
875.0	1251	875.1
950.0	2501	950.1
1025.0	3749	1024.9
1100.0	4997	1099.8

(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  
Druck Pressure Controller Model DPI515  
Fluke Multimeter Model 8060A

Serial # NIST Test Reference  
51500497 UKAS Lab 0221  
4865407 234027

Tested By: EChanning

M E T E O R O L O G I C A L I N S T R U M E N T S  
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

**CALIBRATION REPORT**  
**Relative Humidity Sensor**

Customer: *Raytheon Technical Services Company LLC*

Test Number: 1623-01R  
Test Date: 23 June 2011

Customer PO: RR59338-01  
Sales Order: 1983

<u>Test Sensor:</u>	
Model: 41372LC	Serial Number: TS06134
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  $\pm 2.0$  %.

Reference Humidity (%)	Current Output (milliamps)	Indicated (1) Humidity (%)
10.4	5.9	11.9
30.3	8.9	30.4
50.3	12.2	51.3
70.4	15.3	70.4
89.6	17.9	86.9

(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  
Vaisala Humidity Sensor Model 35AC  
Fluke Multimeter Model 8060A

Serial #	NIST Test Reference
N475040	TN 266152
4865407	234027

Tested By: EChenney

M E T E O R O L O G I C A L I N S T R U M E N T S  
Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: youngusa.com



**Mast Temperature Sensor**

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

**CALIBRATION REPORT**  
**Temperature Sensor**

Customer: *Raytheon Technical Services Company LLC*

Test Number: 1623-01T  
Test Date: 23 June 2011

Customer PO: RR59338-01  
Sales Order: 1983

<u>Test Sensor:</u>	
Model: 41372LC	Serial Number: TS06134
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  $\pm 0.1^\circ$  Celsius.

Bath Temperature (degrees C)	Current Output (milliamps)	Indicated (1) Temperature (degrees C)
-49.81	4.031	-49.81
0.03	12.003	0.02
50.29	20.046	50.29
(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.

<u>Reference Instrument</u>	<u>Serial #</u>	<u>NIST Test Reference</u>
Brooklyn Thermometer Model 43-FC	8006-118	204365
Brooklyn Thermometer Model 22332-D5-FC	25071	249763
Brooklyn Thermometer Model 2X400-D7-FC	77532	228060
Keithley Multimeter Model 191	15232	234027

Tested By: EChenning

M E T E O R O L O G I C A L I N S T R U M E N T S  
Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: youngusa.com  
ISO 9001:2008 CERTIFIED

**Mast PIR****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: 32845F3

Resistance: 713  $\Omega$  at 23°C

Temperature Compensation Range: -20° to +40°C

This pyrgometer has been compared against Eppley's Blackbody Calibration System under radiation intensities of approximately 200 watts meter<sup>-2</sup> and an average ambient temperature of 22°C as measured by Standard Omega Temperature Probe, RTD#1.

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

$$4.11 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

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<sup>-2</sup>. This radiometer is linear to within  $\pm 1.0\%$  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

Date of Test: April 12, 2011

S.O. Number: 62959

Date: April 14, 2011

In Charge of Test:

*Daniel L. Gentry*

Reviewed by:

*Thomas D. Kirk*

Remarks:

**Mast PSP****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 SPECTRAL PYRANOMETER  
Model PSP**

Serial Number: 32850F3

Resistance: 706  $\Omega$  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<sup>-2</sup> (roughly one half a solar constant).

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

$$7.87 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 1400 watts meter<sup>-2</sup>. This radiometer is linear to within  $\pm 0.5\%$  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 (TPC 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<sup>-2</sup> min<sup>-1</sup> = 697.3 watts meter<sup>-2</sup>  
1 BTU/ft<sup>2</sup>-hr<sup>-1</sup> = 3.153 watts meter<sup>-2</sup>

Shipped to: Raytheon Polar Services NSF  
Port Hueneme, CA

S.O. Number: 62958  
Date: April 14, 2011

Remarks:

Date of Test: April 11, 2011

In Charge of Test:

Reviewed by:

*Debra L. Shultz*  
*Thomas J. Kerk*

**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  $\mu$ C 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/cm<sup>2</sup>sec  
0.01544  $\mu$ E/cm<sup>2</sup>sec

Calibration Scale Factor:

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

Dry: 1.0436E-17 V/(quanta/cm<sup>2</sup>sec)  
6.2847E+00 V/( $\mu$ E/cm<sup>2</sup>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



**Mast GUV**

Biospherical Instruments Inc.

**GU-2511 Calibration Certificate**

System Serial Number 25110203114 Date of Calibration 6/30/10  
 Calibration database 25110203114v6.mdb Date of Certificate 8/30/2010  
 DASSN 0089 Standard of Spectral Irradiance GS101918/2808  
 Microprocessor Tag Number 4 Operator TC

Monochromator Channels	Wavelength Address	Responsivity [amps per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$ ]	ScaleSmall [Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$ ]	ScaleMedium [Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$ ]	ScaleLarge [Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$ ]	OffsetSmall [Volts]	OffsetMedium [m [Volts]	OffsetLarge [Volts]	Measurement Units	
ED0320	2	2.40E-10	2.40E-05	7.1712E-03	2.2834E+00	5.6000E-06	6.7000E-06	5.7000E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$	
ED0340	6	1.8655E-10	1.8634E-05	6.8485E-03	1.9277E+00	8.8000E-05	1.0000E-04	9.6100E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$	
ED0313	8	2.1902E-10	2.2272E-05	8.5382E-03	2.2644E+00	9.1600E-04	9.0900E-04	-1.4750E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$	
ED0305	10	1.1300E-11	1.1477E-06	3.5530E-04	1.1025E-01	3.9600E-04	3.9600E-04	1.2480E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$	
ED0380	12	8.2707E-11	8.4361E-06	2.4947E-03	7.9062E-01	3.0400E-04	2.8900E-04	-1.1200E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$	
ED0305	18	2.9427E-10	3.0016E-05	8.7395E-03	2.7720E+00	4.0100E-04	4.0700E-04	1.6210E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$	
Broadband Channels	Wavelength Address	Responsivity [amps per $\mu\text{E}/(\text{cm}^2\cdot\text{s})$ ]	ScaleSmall [Volts per $\mu\text{E}/(\text{cm}^2\cdot\text{s})$ ]	ScaleMedium [Volts per $\mu\text{E}/(\text{cm}^2\cdot\text{s})$ ]	ScaleLarge [Volts per $\mu\text{E}/(\text{cm}^2\cdot\text{s})$ ]	OffsetSmall [Volts]	OffsetMedium [m [Volts] <td>OffsetLarge [Volts]</td> <td>Measurement Units</td>	OffsetLarge [Volts]	Measurement Units	
ED0PAR	13	1.7323E-05	1.7695E+00	5.1021E+02	1.0244E+05	5.9300E-04	5.8500E-04	-6.9400E-04	$\mu\text{E}/(\text{cm}^2\cdot\text{s})$	
Auxiliary Channels	Address	Wavelength	Responsivity	ScaleS	ScaleM	ScaleL	OffsetS	OffsetM	OffsetL	Measurement Units
ED0Temp	22	0	1.0000E+00	1.0000E-02	1.0000E-02	1.0000E-02	0.0000E+00	0.0000E+00	0.0000E+00	C
ED0Vln	27	0	1.0000E+00	-2.5000E-01	-2.5000E-01	-2.5000E-01	0.0000E+00	0.0000E+00	0.0000E+00	V

© Biospherical Instruments Inc., 5340 Riley Street, San Diego, California 92110 USA. Contact [support@biospherical.com](mailto:support@biospherical.com) for more information.

Calibration Data - Do Not Destroy

page 2 of 2

**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: 0926  
CALIBRATION DATE: 11-Mar-11SBE4 CONDUCTIVITY CALIBRATION DATA  
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter**GHJ COEFFICIENTS**

$g = -4.06382038e+000$   
 $h = 5.32057497e-001$   
 $i = -5.05861065e-004$   
 $j = 5.40281567e-005$   
 $CPcor = -9.5700e-008$  (nominal)  
 $CTcor = 3.2500e-006$  (nominal)

**ABCDM COEFFICIENTS**

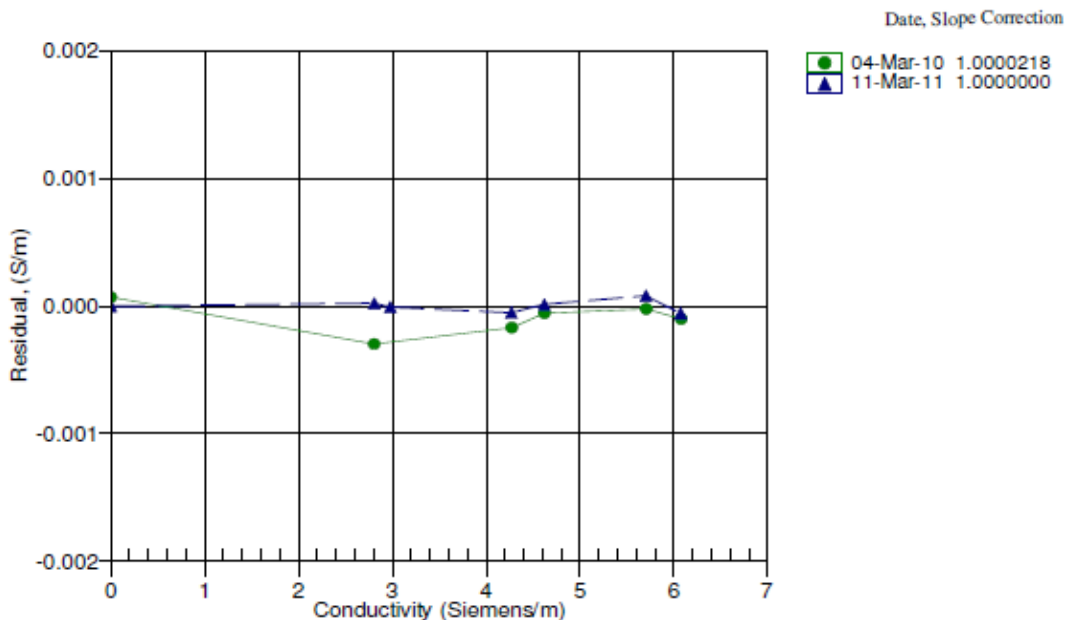
$a = 1.91126098e-006$   
 $b = 5.30423399e-001$   
 $c = -4.05921976e+000$   
 $d = -9.00459698e-005$   
 $m = 5.0$   
 $CPcor = -9.5700e-008$  (nominal)

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	2.76624	0.00000	0.00000
-1.0000	34.8036	2.80365	7.77229	2.80367	0.00002
0.9999	34.8040	2.97501	7.97650	2.97500	-0.00001
15.0000	34.8039	4.27025	9.37545	4.27020	-0.00005
18.5000	34.8029	4.61678	9.71508	4.61680	0.00001
29.0000	34.8012	5.70012	10.70588	5.70020	0.00008
32.4999	34.7947	6.07264	11.02532	6.07258	-0.00006

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

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

$$t = \text{temperature}[^\circ\text{C}]; p = \text{pressure}[\text{decibars}]; \delta = CTcor; \epsilon = CPcor;$$

$$\text{Residual} = (\text{instrument conductivity} - \text{bath conductivity}) \text{ using } g, h, i, j \text{ coefficients}$$


**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: 1431  
CALIBRATION DATE: 08-Sep-10SBE4 CONDUCTIVITY CALIBRATION DATA  
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

## GHJ COEFFICIENTS

$g = -4.25166884e+000$   
 $h = 5.51885639e-001$   
 $i = -2.09157770e-004$   
 $j = 4.06408584e-005$   
 $CP_{cor} = -9.5700e-008$  (nominal)  
 $CT_{cor} = 3.2500e-006$  (nominal)

## ABCDM COEFFICIENTS

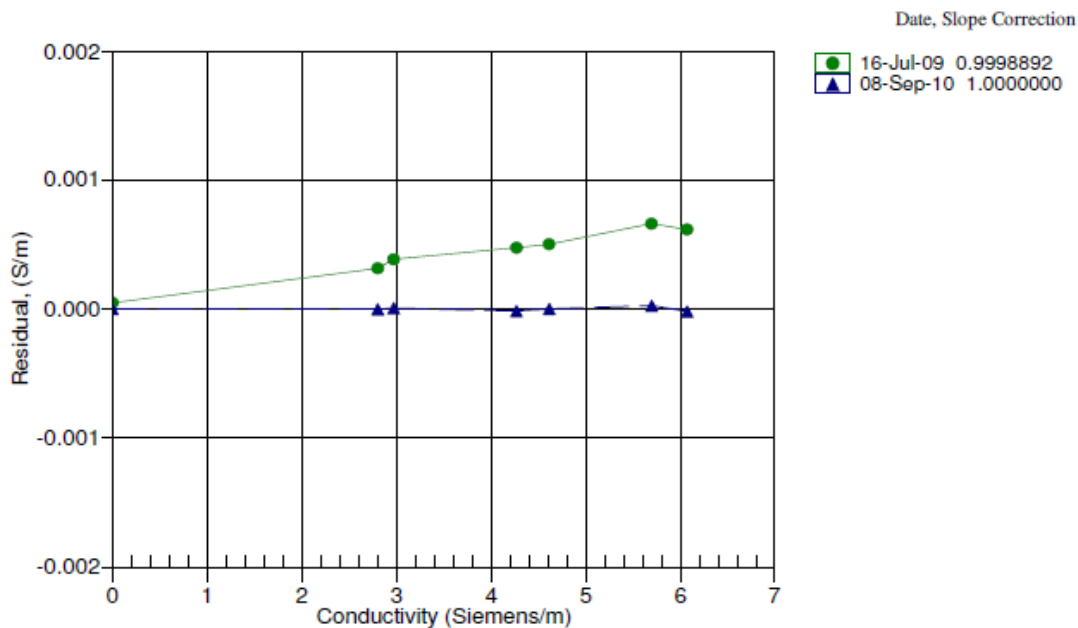
$a = 1.29306337e-005$   
 $b = 5.51237389e-001$   
 $c = -4.24961895e+000$   
 $d = -7.97813651e-005$   
 $m = 4.3$   
 $CP_{cor} = -9.5700e-008$  (nominal)

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	2.77626	0.00000	0.00000
-1.0000	34.7751	2.80157	7.64103	2.80157	-0.00000
1.0000	34.7761	2.97286	7.84065	2.97286	0.00001
15.0000	34.7777	4.26738	9.20855	4.26736	-0.00001
18.5000	34.7778	4.61381	9.54090	4.61381	0.00000
29.0000	34.7773	5.69665	10.51080	5.69668	0.00003
32.5000	34.7716	6.06908	10.82381	6.06906	-0.00002

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

$$\text{Conductivity} = (af^m + bf^2 + c + dt) / [10(1 + \epsilon p)] \text{ Siemens/meter}$$
 $t = \text{temperature}[^{\circ}\text{C}]; p = \text{pressure}[\text{decibars}]; \delta = CT_{cor}; \epsilon = CP_{cor};$ 

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





**CTD Fish and Pressure Sensor****SEA-BIRD ELECTRONICS, INC.**

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0919  
CALIBRATION DATE: 23-Sep-10SBE9plus PRESSURE CALIBRATION DATA  
10000 psia S/N 110538

## DIGIQUARTZ COEFFICIENTS:

C1 = -4.555149e+004  
 C2 = 1.898470e-001  
 C3 = 1.479120e-002  
 D1 = 3.202800e-002  
 D2 = 0.000000e+000  
 T1 = 2.996325e+001  
 T2 = -2.339450e-004  
 T3 = 4.373540e-006  
 T4 = 2.520670e-009  
 T5 = 0.000000e+000

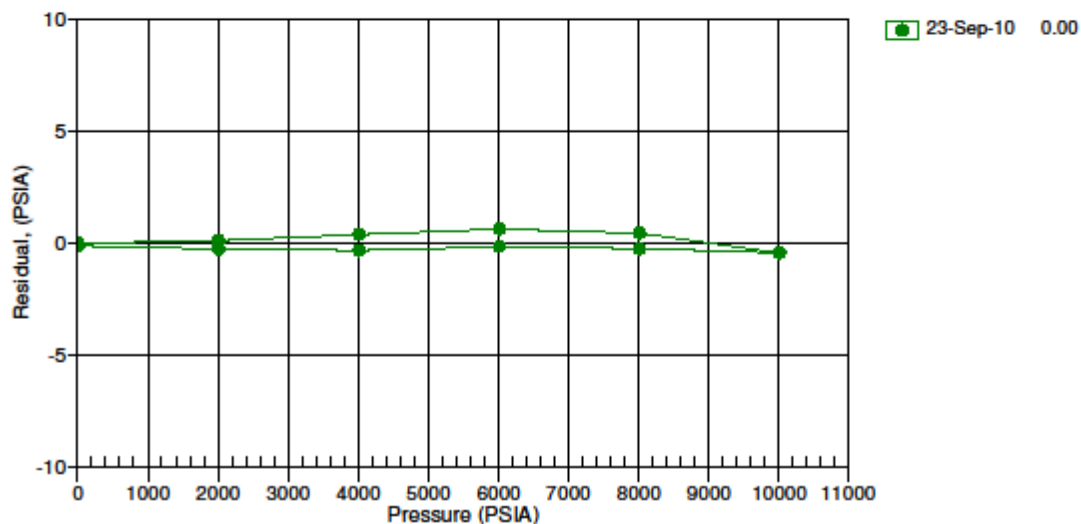
## AD590M, AD590B, SLOPE AND OFFSET:

AD590M = 1.28040e-002  
 AD590B = -8.97842e+000  
 Slope = 1.00008  
 Offset = -2.2397 (dbars)

PRESSURE (PSIA)	INST OUTPUT(Hz)	INST TEMP(C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.583	33383.99	20.8	17.701	14.453	-0.130
2014.793	34107.83	20.9	2017.610	2014.531	-0.262
4014.932	34814.68	21.0	4017.509	4014.599	-0.334
6014.946	35505.58	21.0	6017.526	6014.785	-0.161
8014.801	36181.31	21.1	8017.133	8014.561	-0.240
10014.824	36842.86	21.1	10016.794	10014.391	-0.433
8014.802	36181.55	21.2	8017.821	8015.249	0.446
6014.724	35505.79	21.2	6018.092	6015.352	0.628
4014.787	34814.90	21.3	4018.080	4015.170	0.383
2014.844	34108.01	21.3	2018.032	2014.953	0.109
14.584	33384.07	21.4	17.829	14.581	-0.003

Residual = corrected instrument pressure - reference pressure

Date, Avg Offset (psia)





**CTD Temperature (Primary - A)**

This unit failed and was replaced on 11/30/2011.

**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: 2308  
CALIBRATION DATE: 11-Mar-11

SBE3 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

**ITS-90 COEFFICIENTS**

g = 4.34508815e-003  
h = 6.44608878e-004  
i = 2.32504116e-005  
j = 2.17287909e-006  
f0 = 1000.0

**IPTS-68 COEFFICIENTS**

a = 3.68121082e-003  
b = 6.02564639e-004  
c = 1.63235823e-005  
d = 2.17443851e-006  
f0 = 2906.238

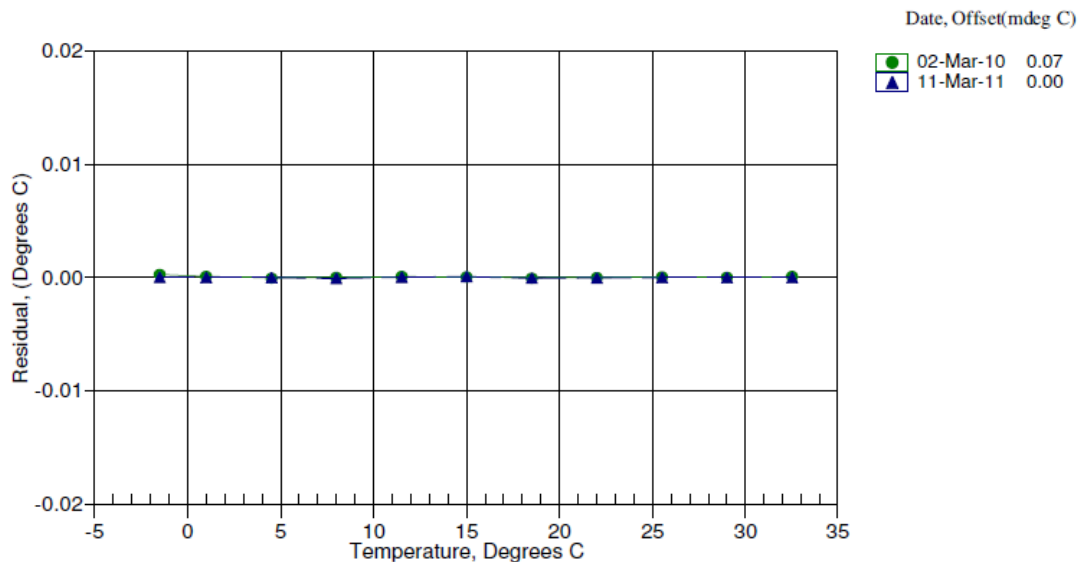
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4999	2906.238	-1.4999	0.00001
1.0001	3073.039	1.0001	-0.00000
4.5001	3318.052	4.5001	-0.00000
8.0001	3576.809	8.0000	-0.00007
11.5001	3849.699	11.5001	0.00005
15.0001	4137.062	15.0002	0.00009
18.5001	4439.237	18.5000	-0.00005
22.0001	4756.592	22.0001	-0.00002
25.5001	5089.436	25.5001	-0.00001
29.0001	5438.084	29.0001	0.00000
32.5001	5802.835	32.5001	0.00001

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



**CTD Temperature (Primary - B)**

This is the replacement for the failed unit.

**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: 2299  
CALIBRATION DATE: 03-Mar-11

SBE3 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

**ITS-90 COEFFICIENTS**

g = 4.33171857e-003  
h = 6.43346549e-004  
i = 2.33071967e-005  
j = 2.23959680e-006  
f0 = 1000.0

**IPTS-68 COEFFICIENTS**

a = 3.68121062e-003  
b = 6.02057486e-004  
c = 1.63012418e-005  
d = 2.24116315e-006  
f0 = 2848.656

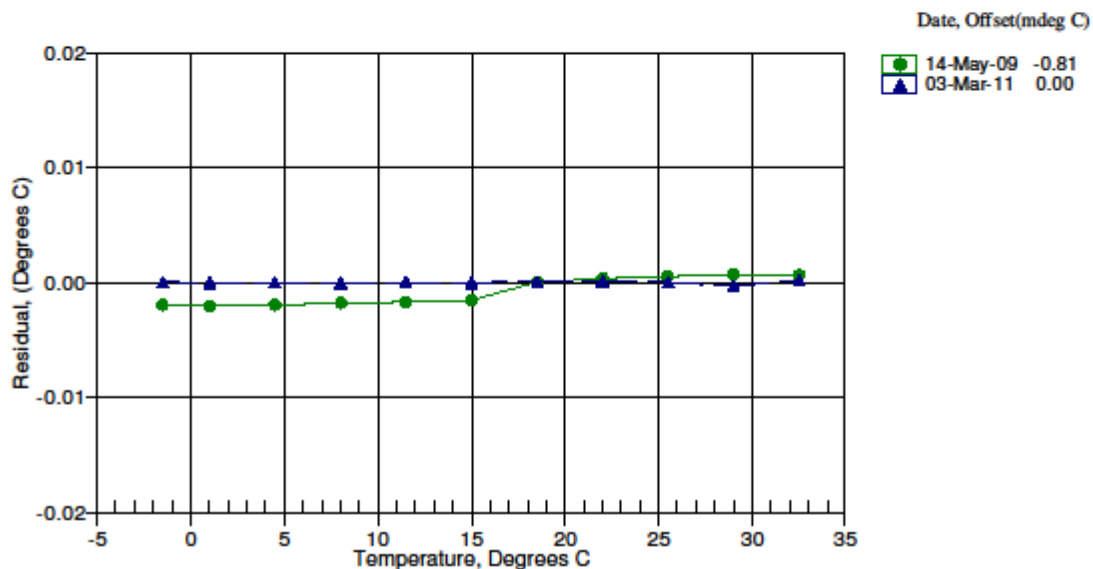
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4999	2848.656	-1.4999	0.00002
1.0001	3012.292	1.0001	-0.00001
4.5001	3252.672	4.5001	-0.00001
8.0002	3506.559	8.0001	-0.00005
11.5002	3774.314	11.5002	0.00001
15.0002	4056.280	15.0002	-0.00002
18.5002	4352.818	18.5003	0.00006
22.0002	4664.247	22.0003	0.00014
25.5001	4990.858	25.5001	0.00001
29.0002	5332.982	28.9999	-0.00034
32.5001	5690.983	32.5003	0.00019

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



**CTD Temperature (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: 2367  
CALIBRATION DATE: 03-Mar-11SBE3 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

## ITS-90 COEFFICIENTS

$g = 4.37164144e-003$   
 $h = 6.45520397e-004$   
 $i = 2.31501409e-005$   
 $j = 2.11802230e-006$   
 $f_0 = 1000.0$

## IPITS-68 COEFFICIENTS

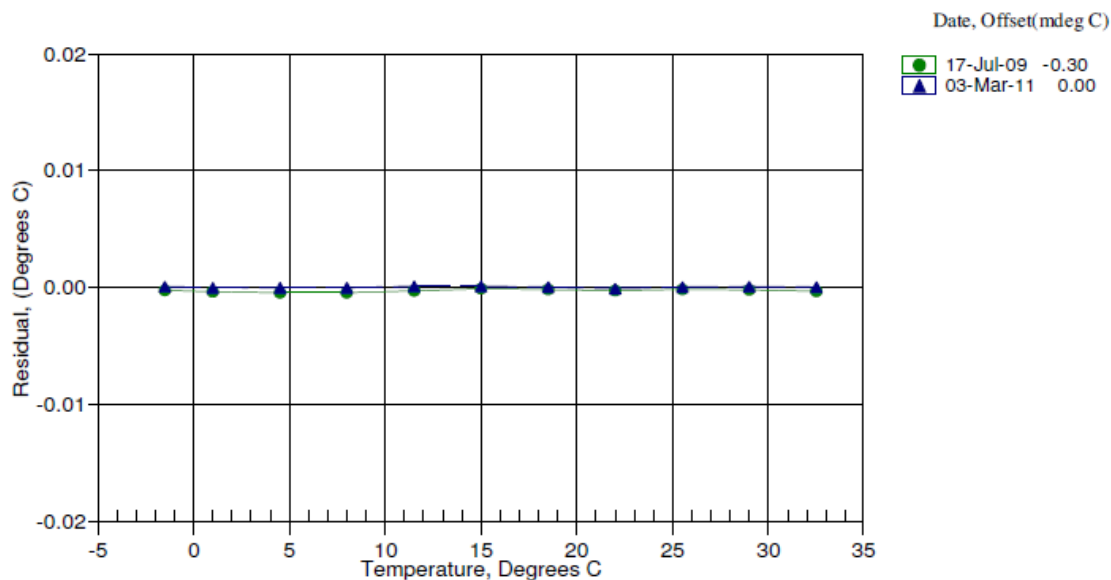
$a = 3.68121056e-003$   
 $b = 6.02126873e-004$   
 $c = 1.61295995e-005$   
 $d = 2.11955857e-006$   
 $f_0 = 3032.014$

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4999	3032.014	-1.4999	0.00003
1.0001	3206.158	1.0001	-0.00003
4.5001	3461.964	4.5001	-0.00003
8.0002	3732.135	8.0002	-0.00004
11.5002	4017.051	11.5003	0.00006
15.0002	4317.080	15.0003	0.00007
18.5002	4632.586	18.5002	-0.00000
22.0002	4963.926	22.0001	-0.00010
25.5001	5311.454	25.5001	0.00001
29.0002	5675.500	29.0002	0.00004
32.5001	6056.335	32.5001	-0.00001

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

$$\text{Temperature IPITS-68} = 1/\{a + b[\ln(f_0/f)] + c[\ln^2(f_0/f)] + d[\ln^3(f_0/f)]\} - 273.15 \text{ (}^\circ\text{C)}$$
Following the recommendation of JPOTS:  $T_{68}$  is assumed to be  $1.00024 * T_{90}$  (-2 to 35  $^\circ\text{C}$ )

Residual = instrument temperature - bath temperature



**Fluorometer**

PO Box 518  
620 Applegate St.  
Philomath OR 97370



(541) 929-6650  
Fax (541) 929-6277  
<http://www.wetlabs.com>

**Chlorophyll Fluorometer Characterization .**

**Date:** 10/06/10  
**Serial #:** AFLD-011  
**Job#:** 0011007  
**Tech:** SML

**Dark Counts** 0.0701 volts  
**CEV** 2.065 volts  
**SF** 11.0782

**FSV** 5.36 volts

**Linearity:** 0.999 R<sup>2</sup> (0–1.5 volts)  
0.995 R<sup>2</sup> (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 determined by using the following equation:  
SF = (22.1) / (CEV – dark) e.g. (22.1 / (2.065 – 0.0701) = 9.516)

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

Chlorophyll concentration expressed in µg/l (mg/m<sup>3</sup>) can be derived by using the following equation: (µg/l) = (V<sub>measured</sub> – dark) \* SF

The relationship between fluorescence and chlorophyll-*a* concentrations in-situ is highly 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.

**Transmissometer**

PO Box 518  
620 Applegate St.  
Philomath, OR 97370



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

**C-Star Calibration**

Date **June 28, 2010** S/N# **CST-831DR** Pathlength **25 cm**

	Analog meter
$V_d$	<b>0.059 V</b>
$V_{air}$	<b>4.804 V</b>
$V_{ref}$	<b>4.728 V</b>

Temperature of calibration water	<b>24.2 °C</b>
Ambient temperature during calibration	<b>22.1 °C</b>

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.

**Underway TSG Conductivity****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: 0242  
CALIBRATION DATE: 19-Aug-10SBE 45 CONDUCTIVITY CALIBRATION DATA  
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

## COEFFICIENTS:

g = -9.989330e-001  
h = 1.523009e-001  
i = -4.020682e-004  
j = 5.518631e-005CPcor = -9.5700e-008  
CTcor = 3.2500e-006  
WBOTC = 0.0000e+000

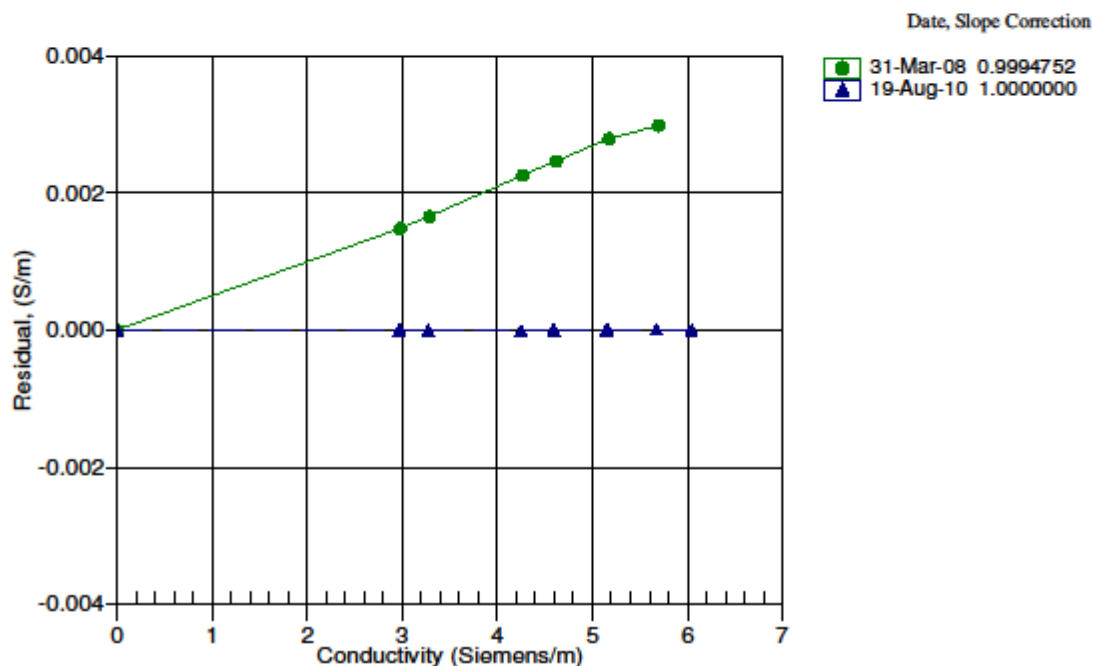
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2566.68	0.00000	0.00000
1.0000	34.6826	2.96562	5112.38	2.96563	0.00000
4.5000	34.6626	3.27165	5305.46	3.27165	-0.00000
15.0000	34.6197	4.25004	5879.57	4.25003	-0.00001
18.5000	34.6104	4.59399	6068.22	4.59399	0.00000
24.0000	34.6001	5.15001	6361.02	5.15002	0.00001
29.0000	34.5937	5.66995	6622.76	5.66996	0.00001
32.5000	34.5894	6.04088	6803.11	6.04087	-0.00001

$$f = \text{INST FREQ} * \sqrt{1.0 + \text{WBOTC} * t} / 1000.0$$

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

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

Residual = instrument conductivity - bath conductivity



**Underway TSG Temperature****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

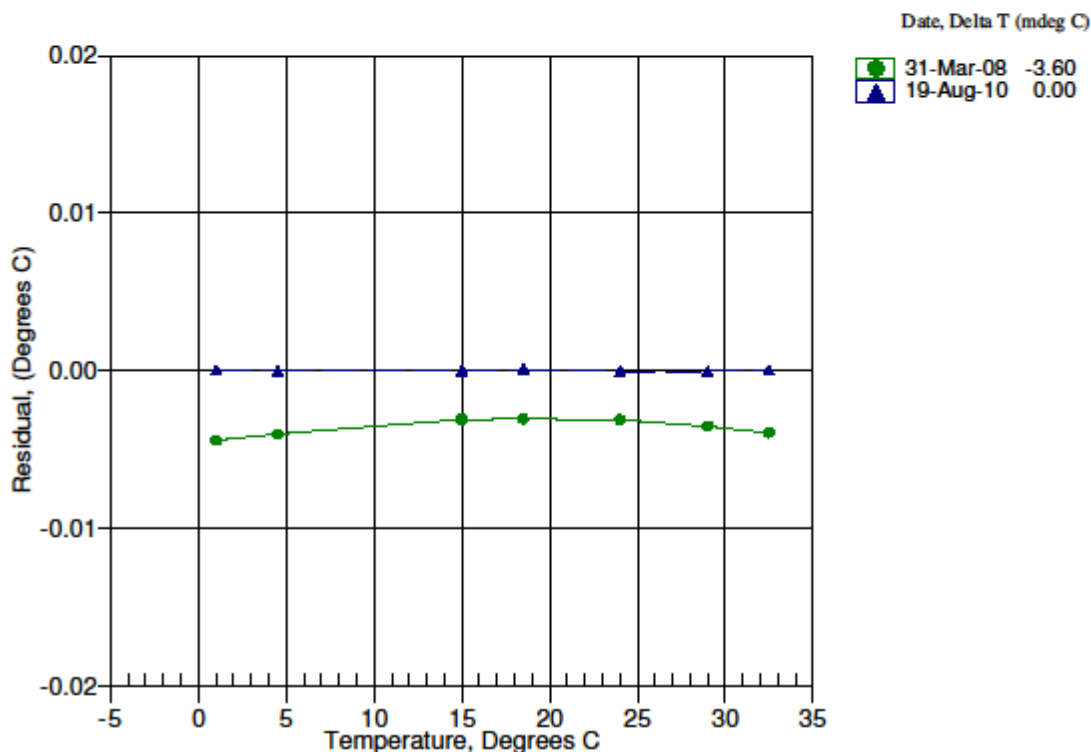
SENSOR SERIAL NUMBER: 0242  
CALIBRATION DATE: 19-Aug-10SBE 45 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE**ITS-90 COEFFICIENTS**

$a_0 = 1.627072e-005$   
 $a_1 = 2.803649e-004$   
 $a_2 = -2.880337e-006$   
 $a_3 = 1.646907e-007$

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	649700.0	1.0000	0.0000
4.5000	554797.1	4.5000	-0.0000
15.0000	352285.1	15.0000	-0.0000
18.5000	304682.3	18.5001	0.0001
24.0000	243986.2	24.0000	-0.0000
29.0000	200583.6	29.0000	-0.0000
32.5000	175464.1	32.5000	0.0000

$$\text{Temperature ITS-90} = 1/[a_0 + a_1[\ln(n)] + a_2[\ln^2(n)] + a_3[\ln^3(n)]] - 273.15 \text{ (}^\circ\text{C)}$$

Residual = instrument temperature - bath temperature



**Underway Remote Temperature****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

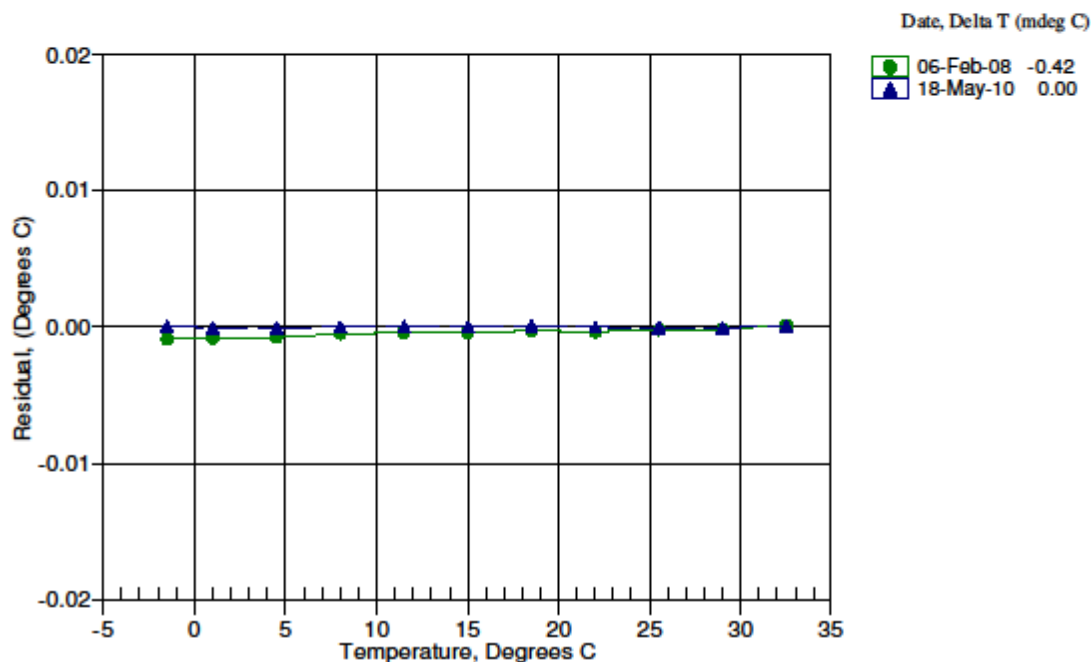
SENSOR SERIAL NUMBER: 0323  
CALIBRATION DATE: 18-May-10SBE 38 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE**ITS-90 COEFFICIENTS**

$a_0 = -7.978660 \times 10^{-6}$   
 $a_1 = 2.802838 \times 10^{-4}$   
 $a_2 = -2.734104 \times 10^{-6}$   
 $a_3 = 1.671396 \times 10^{-7}$

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50010	711080.8	-1.50004	0.00006
0.99990	635133.7	0.99984	-0.00006
4.49990	543787.8	4.49985	-0.00005
7.99990	467095.3	7.99991	0.00001
11.49990	402489.0	11.49995	0.00005
14.99990	347886.3	14.99991	0.00001
18.49990	301588.8	18.49993	0.00003
21.99990	262212.4	21.99990	-0.00000
25.49990	228620.9	25.49984	-0.00006
28.99990	199879.3	28.99986	-0.00004
32.49990	175217.1	32.49995	0.00005

$$\text{Temperature ITS-90} = 1/[a_0 + a_1[\ln(n)] + a_2[\ln^2(n)] + a_3[\ln^3(n)]] - 273.15 \text{ (}^\circ\text{C)}$$

Residual = instrument temperature - bath temperature





**Oxygen Sensor**

AANDERAA DATA INSTRUMENTS

**CALIBRATION CERTIFICATE**Form No. 622, Dec 2005  
Page 1 of 2Sensing 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  
ASL Digital Thermometer model F250321-1-40  
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 $\mu\text{M}$ <sup>1)</sup>	0 - 120%
Accuracy <sup>1)</sup> :	< $\pm 8\mu\text{M}$ or $\pm 5\%$ (whichever is greater)	$\pm 5\%$
Resolution:	< 1 $\mu\text{M}$	< 0.4%
Settling Time (63%):	< 25 seconds	

**Calibration points and readings <sup>2)</sup>:**

	Air Saturated Water	Zero Solution (Na <sub>2</sub> SO <sub>3</sub> )
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

<sup>1)</sup> Valid for 0 to 2000m (6562ft) depth, salinity 33 - 37ppt<sup>2)</sup> 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 2Sensing 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  $\mu\text{M}$  or air saturation in %. The setting of the internal property "Output"<sup>3)</sup>, 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 ( $\mu\text{M}$ ) = A + BN + CN2 + DN3	Oxygen (%) = A + BN + CN2 + DN3

<sup>3)</sup> The default output setting is set to -1

Date: 22 October 2010

Sign:

Tor-Ove Kvalvaag, Calibration Engineer

AANDERAA DATA INSTRUMENTS AS

5851 BERGEN, NORWAY    Tel. +47 55 60 48 00    Fax. +47 55 60 48 01    E-mail: [info@aadi.no](mailto:info@aadi.no)    Web: <http://www.aadi.no>



AANDERAA DATA INSTRUMENTS

# CALIBRATION CERTIFICATE

Form No. 621, Dec 2005

Certificate No: 3853\_5009\_40331  
Batch No: 5009

Product: O2 Sensing Foil PSt3 3853  
Calibration Date: 2 June 2010

## Calibration points and phase readings (degrees)

Temperature (°C)		3.97	10.93	20.15	29.32	38.39
Pressure (hPa)		977.00	977.00	977.00	977.00	977.00
O2 in % of O2+N2	0.00	73.18	72.63	71.62	70.72	69.77
	1.00	68.01	67.02	65.42	63.92	62.31
	2.00	64.39	63.16	61.20	59.44	57.57
	5.00	55.80	54.16	51.76	49.56	47.45
	10.00	46.27	44.47	41.97	39.75	37.69
	20.90	35.09	33.38	31.14	29.24	27.56
	30.00	29.85	28.30	26.31	24.64	23.19

## Giving these coefficients <sup>1)</sup>

Index	0	1	2	3
C0 Coefficient	4.53793E+03	-1.62595E+02	3.29574E+00	-2.79285E-02
C1 Coefficient	-2.50953E+02	8.02322E+00	-1.58398E-01	1.31141E-03
C2 Coefficient	5.66417E+00	-1.59647E-01	3.07910E-03	-2.46265E-05
C3 Coefficient	-5.99449E-02	1.48326E-03	-2.82110E-05	2.15156E-07
C4 Coefficient	2.43614E-04	-5.26759E-06	1.00064E-07	-7.14320E-10

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

Date: 11/4/2010

Sign:

Tor-Ove Kvalvaag, Calibration Engineer

AANDERAA DATA INSTRUMENTS AS

5851 BERGEN, NORWAY

Tel. +47 55 60 48 00

Fax. +47 55 60 48 01

E-mail: [info@aadi.no](mailto:info@aadi.no)Web: <http://www.aadi.no>