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# **LMG09-07**

**Garbage Barge**

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## **Cruise Data Report**

W. Kevin Pedigo



**04 July – 27 July, 2009**

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## Introduction

The LMG data acquisition systems continuously log data from a suite of instrumentation throughout the cruise. This document describes the format of that data and its location on the distribution CDs. It also contains important information that may affect how this data is processed such as instrument failures or other known problems with acquisition.

The data collected during this cruise is distributed on a CD-ROM written in ISO9660 level-1 format. This data format has very strict requirements on filenames and organization. However, it is readable by virtually every computing platform.

All of the data has been archived with the Unix "tar" command and/or compressed using Unix "gzip" compression. Tar files have a ".tar" extension and Gzipped files have a ".gz" extension. Tools are available on all platforms for uncompressing and de-archiving these formats. On Macintosh, Stuffit Expander with DropStuff will open a tar archive and uncompress gzipped and Unix compressed files. For Windows, WinZip, a shareware utility included on this CD (remember, it is shareware) will open these files.

In some cases to adhere to the ISO9660 format the .tar extension was removed. When we tarred the files then gzip the tar archive the name of the file became *File.tgz*. This name does not follow the 8.3 naming convention of the ISO9660 format. On Windows and Mac Platforms Winzip and Stuffit Expander handles this just fine. When they expand the *File.gz* the expanded file becomes *File.tar*, which both software packages can handle. On Unix platforms gunzip expands *File.tgz* but it does not append the .tar extension. So you may not recognize the file as a tar archive, but OS does recognize it as a tar archive. If you use the file command it will return saying it is a tar file. The below tar command will un-archive the file just fine.

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

## Archive Data Extraction

It is often useful to know exactly how an archive was produced when expanding its contents. Tar files were created using the following commands:

```
tar cvf archive-file files-to-be-archived
```

To create a list of the files in the archive:

```
tar tvf archive-file > contents.list
```

To extract the files from the archive:

```
tar xvf archive-file file(s)-to-extract
```

G-zipped files will have a “.gz” extension on the filename. These files can be decompressed after de-archiving, using:

```
gunzip filename.gz
```

## CD Directory Structure

<p>ADCP: ADCP.tar</p> <p>Cal: InstCoef.txt</p> <p>CTD: ctd.tar</p> <p>Imagery: Imag.tar</p> <p>Maps: (various)</p> <p>Process: JGOF.tar PCO2.tar PROC.tar QC.tar</p> <p>Report: Report.doc</p> <p>RVDAS: lmgnav.tar lmguw.tar</p>	<p>Salts:</p> <p>Science:</p> <p>TCO2:</p> <p>Utility: Acrobat Winzip</p>	
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## Distribution Contents

### ADCP

/Adcp/

This directory contains a tar file of gentoo's proc directory, which contains a database of the averaged ping data, Matlab m-files used in processing the data, and daily graphs of the currents. For more information contact Teri Chereskin at [tchereskin@ucsd.edu](mailto:tchereskin@ucsd.edu). Processed data is usually available shortly after the cruise at <http://currents.soest.hawaii.edu>

### Calibration

/Cal/

The tar files in the Cal directory contain images of calibration sheets for each of the following systems: Sound Velocity Probe (SVP\_CALS.TAR), Meteorological System (MET\_CALS.TAR), Underway System (UW\_CALS.TAR), and CTD\_CALS.pdf.

Refer to the InstCoef.txt file along with the specific instrument calibration sheets, both located in this directory, for information on how the RVDAS data was collected and processed.

### CTD

CTD/

CTD/Scripts/

This directory contains the control files used for preliminary processing of the data. Processing performed by the vessel technicians is for *quality control purposes only*, as a check that the instruments are performing correctly.

CTD//raw

Contains the raw data from the instrument.

CTD/process

Contains the files generated as a result of the preliminary post processing. For more details, refer to the SBE Data Processing documentation available on the SeaBird website (<http://www.seabird.com>).

### Ice Images

/ICE\_IMAGE/

This directory contains .jpg files of Terrascan ice imagery sent to the ship from Palmer station to aid in navigation of the ship and science.

### Isobar Charts

/Isobars/

This directory contains GIF image files. These file are an analysis of mean sea level pressure from the National Center for Environmental Prediction's Medium Range Forecast Model. They are updated every 6 hours. Naming the convention is as follows yyjjj.hh.gif where yy is the year, jjj is the day number, and hh is the hour.

## Data and Science Report

/Report/

Copies of this report in MS Word, HTML, and text formats.

## Sitrep

/Sitrep/

If this directory exists, it contains copies of the vessels Daily Situation Report.

## XBT

/XBT/

If this directory exists, it contains data from Expendable Bathythermographic (XBT) "Deep Blue" probes were used to obtain water column temperature profiles. The dataset includes the following files:

dat.zip	The probe drop schedule and other configuration files.
efiles.zip	The edited data files.
log.zip	The log files for drop and GPS positioning.
nav.zip	The navigation files.
sfiles.zip	The raw data files.
*.pdf	Scanned images of the paper log sheets.

## XCTD

/XCTD/

If this directory exists, it contains data from Expendable Conductivity, Temperature, and Depth (XCTD) digital probes were used to obtain water column temperature and Salinity profiles. Two files are created for each drop .RDF files contain the raw data, and the .EDF contain the exported ascii data.

## TCO2

/TCO2/

This directory contains the log sheet for the TCO2 sample during the Drake Transect Sampling. For further information on this data, contact Tim Newberger at [tnewberg@ldeo.columbia.edu](mailto:tnewberg@ldeo.columbia.edu)

## Salts

/SALT/

If this directory exists, it contains the log sheet for the Salt sample take during the Drake Transect Sampling, also a spreadsheet containing the Salt sample and TSG comparison. These samples are normally analyzed with a Guildline Autosalinometer.

## Drifters

/DRIFTERS/



This directory contains the log sheet for the drifter buoys released during the Drake Transect.

## Science

/Science/

If this directory is populated, it will contain various files, data, digital photos, and/or other information collected by the individual scientists.

## Maps

/Maps/

If this directory is present, it contains maps generated by vessel staff or provided by the science party. Maps may be in any number of formats, some of which may be proprietary or vendor specific. Maps generated by the Marine Electronics and Instrument Specialists are typically JPEG images.

## WAYPOINTS

/WAYPTS/

If this directory is present, it contains files in CSV format detailing various navigation waypoints.

## QC Plots

/QC\_PLOTS/

Postscript files of data stored each day on RVDAS for quality control analysis during the cruise. There are 3 types of files, named metXXX.ps, navXXX.ps, and oceanXXX.ps, where XXX represents the Julian day. Met files are a summary of the data from the meteorological instruments, Nav files are a summary of navigational data, and Ocean files are a summary of the underway seawater and bathymetry data.

## JGOFS Data Set

/JGOF/

The JGOFS data set consists of a single file produced each day named jg<julian\_day>.dat.gz where <julian\_day> is the day the data was acquired. The “.gz” extension indicates that the individual files are compressed before archiving. The daily file consists of 22 separate columnar fields in text format, which are described below. The JGOFS data set is obtained primarily by applying calibrations to raw data and decimating to whole minute intervals. However, several fields are derived measurements from more than a single raw input. *Note: Null, unused, or unknown fields are filled with 9's in the JGOFS data.*

Additionally, 3 separate QC plots are generated daily by the ET using the JGOFS data set. These plots include TSG and Bathymetry data, meteorological data, and navigation data. The files are called ocean<julian\_day>.ps, met<julian\_day>.ps, and nav<julian\_day>.ps respectively.

Field	Data	Units
01	GMT date	dd/mm/yy
02	GMT time	hh:mm:ss
03	PCOD latitude (negative is South)	Ddd.dddd
04	PCOD longitude (negative is West)	Ddd.dddd
05	Ships speed	Knots
06	GPS HDOP	-
07	Gyro Heading	Degrees (azimuth)
08	Course over ground	Degrees (azimuth)
09	Mast PAR	$\mu\text{Einsteins/meters}^2 \text{ sec}$
10	Sea surface temperature	$^{\circ}\text{C}$
11	Conductivity	S/m
12	Sea surface salinity	PSU
13	Sea depth (uncorrected, calc. sw sound vel. 1500 m/s)	meters
14	True wind speed (port windbird)	meters/sec
15	True wind direction (port windbird)	degrees (azimuth)
16	Ambient air temperature	$^{\circ}\text{C}$
17	Relative humidity	%
18	Barometric pressure	mBars
19	Sea surface fluorometry	$\mu\text{g/l}$
20	Transmissometer	Vols (0-5 FSO)
21	PSP	$\text{W/m}^2$
22	PIR	$\text{W/m}^2$

## RVDAS

/RVDAS/

RVDAS (Research Vessel Data Acquisition System) was developed at Lamont-Doherty Earth Observatory of Columbia University and has been used on the R/V Maurice Ewing for several years. It was adapted for use on the Nathaniel B. Palmer and her sister ship, the R/V Laurence M. Gould.

Below you will find detailed information on the data included. Be sure to read the "Significant Acquisition Events" section below for important information about data acquisition during this cruise.

### *Meteorological and Light Data*

Measurement	File ID	Collect. Status	Rate	Instrument
Air Temperature	lmwx	continuous	1 sec	R. M. young 41372VC
Relative Humidity	lmwx	continuous	1 sec	R. M. young 41372VC
Wind Speed/Direction	lmwx	continuous	1 sec	R. M. young 5106
PAR, (Photosynthetically-Available Radiation)	lmwx	continuous	1 sec	BSI QSR-240
Barometer	lmwx	continuous	1 sec	R. M. young 61201
GUV & PUV	lguv	continuous	1 sec	GUV2511 & PUV2510
PIR (LW radiation)	lmwx	continuous	1 sec	Eppler PIR
PSP (SW radiation)	lmwx	continuous	1 sec	Eppler PSP
Port Ultrasonic Wind Speed/Direction	lmwx	continuous	1 sec	Gill Wind Observer II

### *Navigational Data*

Measurement	File ID	Collect. Status	Rate	Instrument
Attitude GPS	lash	continuous	1 sec	Ashtec ADU-2
Trimble GPS	tgps	civilian mode	1 sec	Trimble 20636-00SM
Gyro	lgyr	continuous	0.2 sec	Anschutz Gyro
Garmin GPS	lgar	continuous	1 sec	Garmin 17

### *Geophysical Data*

Measurement	File ID	Collect. Status	Rate	Instrument
Bathymetry	lknu	variable	Varies	Knudsen 320B/R
Net Depth Sensor	lnds	variable	~1/3 sec	Omega PX-605
DUSH 11 Winch	lwn1	variable	varies	Markey DUSH 11
DUSH 5 Winch	lwn1	variable	varies	Markey DUSH 5
DUSH 4 Winch	lwn1	variable	varies	Markey DUSH 4

### *Oceanographic Data*

Measurement	File ID	Collect. Status	Rate	Instrument
Salinity	utsg	continuous	1 sec	SeaBird 45
Sea Surface Temperature	lrtm	continuous	1 sec	SeaBird 38
Fluorometry (digital)	lflr	continuous	1 sec	Turner 10-AU-005
Fluorometry (digital)	ldfl	continuous	1 sec	Wetlab ECO
ADCP, Speed Log	ladc	continuous	1 sec	RD Instruments
Oxygen	loxy	continuous	1 sec	
PCO2	lpcO2	continuous	2.5 min	

## Data File Names and Structures

RVDAS data is divided into two broad categories, **Underway** and **Navigation**. The groups are abbreviated “uw” and “nav”. Thus, these two tar files, lmguw.tar and lmgnav.tar exist under the top-level rvdas directory. The instruments are broken down as shown. Each data file is g-zipped to save space on the distribution. Not all data types are collected everyday or on every cruise.

RVDAS data files are named following the convention: LMG[FileID].dDDD.

- The FileID is a 4-character code representing the system being logged, for example: lmet (for meteorology)
- DDD is the Julian day of the data collection

Underway Data	File ID	Navigation Data	File ID
Meteorological - Cambell	lmwx	Gyro Compass	lgyr
Knudsen	lknu	P-CODE GPS	tgps
microTSG	utsg	Ashtech ADU2 GPS	lash
Digital Remote Temperature	lrtm	Garmin 17 GPS	lgar
Fluorometer - Turner	lflr		
Fluorometer – Wetlab ECO	ldfl		
ADCP	ladc		
Sound Velocity Probe	lsvp		
GUV & PUV	lguv		
PCO2 System	lpco		
Oxygen	loxy		
Wet Wall Flows	lsea		
Winches: Dush4,5,&11	lwn1		
Net Depth Sensor	lnds		

Data is received by the RVDAS system via RS-232 serial connections. The data files that comprise the rvdas data set are described below. A time tag is added to each line of data received and the data is written to disk.

YY+DDD:HH:MM:SS.SSS [data stream from instrument]

Where, YY: two-digit year, DDD: Julian Day, HH: 2 digit hours, MM: 2 digit minutes SS.SSS: seconds. All times are UTC.

The delimiters used to separate fields in the raw data files are usually spaces and commas, but other delimiters are used (:, =, @) and occasionally there is no delimiter. Care should be taken when reprocessing the data that the field separations are clearly understood. An example data string is provided with each instrument section for your convenience, however it is always best to refer directly to the raw data.

### Iknu – Knudsen Sonar

08+024:07:36:36.245 HF,00.00, 000,0,LF,448.9,-026,1

Field	Data	Units
1	RVDAS Time Tag	
2	HF – high frequency header (12 kHz)	
3	HF - depth to surface	meters
4	HF - Echo Strength	
5	HF – Depth Valid Flag	
6	LF – low frequency header (3.5 kHz)	
7	LF - depth to surface	meters
8	LF - Echo Strength	

Field	Data	Units
9	LF – Depth Valid Flag	

## Inds – Net Depth Sensor

99+099:00:18:19.775 V01 00199.8

Field	Data	Units
1	RVDAS Time Tag	
2	V01 – Sensor 1	label
3	Depth	meters

## lwn1 - Winches

08+033:11:27:50.673 RD,DUSH-5,00111.63,00000000,-0000012,1938

Field	Data	Units
1	RVDAS Time Tag	
2	Record Identifier, RD=Remote Data	
3	Winch Identifier, DUSH-X where X is 4, 5, or 11	
4	Tension	lbs
5	Speed	Meters/minute
6	Payout	meters
7	Checksum	

## Imwx - Campbell Meteorological DAS

08+034:13:52:14.216 SUS,A,356,002.15,M,+332.28,+000.97,60,08

Field	Data	Units
1	RVDAS Time Tag	
2	SUS tag – Starboard UltraSonic Anemometer	
3	Unit Identification, A-Z	
4	Port Wind Direction, degrees relative to Bow	deg
5	Port Wind Speed	m/s
6	Units, M=meters per second	
7	Sound Speed	m/s
8	Sonic Temperature	°C
9	Status, 0=ok, 60=Heating Enabled & ok, Other value mean a fault	
10	Check Sum	

08+034:13:52:14.216 PUS,A,356,002.15,M,+332.28,+000.97,60,08

-- Derived from RMYoung Anemometer

Field	Data	Units
1	RVDAS Time Tag	
2	PUS tag – Port Anemometer	
3	Unit Identification, A-Z	
4	Port Wind Direction, degrees relative to Bow	deg
5	Port Wind Speed	m/s
6	Units, M=meters per second	
7	Sound Speed	meaningless
8	Sonic Temperature	meaningless
9	Status, 0=ok, 60=Heating Enabled & ok, Other value mean a fault	meaningless
10	Check Sum	meaningless

08+034:13:52:14.454 MET,12.22322,44.25706,-75,-25,-363.6365,2.332982,-0.08215196,278.6845,279.2192,854.6198

Field	Data	Units
1	RVDAS Time Tag	
2	MET tag	
3	Power Supply Voltage	Volts
4	Enclosure Relative Humidity	%
5	Air Temp	°C
6	Air Relative Humidity	%
7	PAR	mVolts
8	PSP Thermopile	mVolts
9	PIR Thermopile	mVolts
10	PIR Case Temperature	°K
11	PIR Dome Temperature	°K
12	Barometer	mBars

### utsg – microTSG, Thermosalinograph

For further information on this data, check on [www.seabird.com](http://www.seabird.com) on SBE 45 MicroTSG Thermosalinograph

08+037:13:45:57.596 2.6470, 3.03853, 33.8129, 1459.351

Field	Data	Units
1	RVDAS Time Tag	
2	Internal water temperature	°C
3	Conductivity	S/m
4	Salinity	psu
5	Sound Velocity	m/s

### Irtm – digital Remote Temperature

For further information on this data, check on [www.seabird.com](http://www.seabird.com) on SBE38 Digital Thermometer

08+037:13:47:17.841 2.2527

Field	Data	Units
1	RVDAS Time Tag	
2	External water temperature	°C

### Ifir – Fluorometer, Turner

04+107:16:48:02.342 0 5450 :: 4/16/04 09:44:17 = 0.632 (RAW)

Field	Data	Units
1	RVDAS Time Tag	
2	Zero Field	numeric
3	Sample Number	numeric
4	Fluorometer Date	mm/dd/yy
5	Fluorometer Time	hh:mm:ss
6	Digital output of fluorometer	Volts
7	(RAW)	

**Idfl – Fluorometer, Wetlab ECO**

08+037:13:55:08.434 99/99/99 99:99:99 0.00 2585 73 543

Field	Data	Units
1	RVDAS Time Tag	
2	Fluorometer Date	mm/dd/yy
3	Fluorometer Time	hh:mm:ss
4	Chlorophyll Signal	µg/l
5	Reference	λq
6	Counts – Chlorophyll Signal	Count
7	Thermistor	

**loxy - Oxygen**For further information on this data, contact Tim Newberger at [tnewberg@ldeo.columbia.edu](mailto:tnewberg@ldeo.columbia.edu)

04+117:23:57:23.504 MEASUREMENT 3830 380 Oxygen: 309.95 Saturation:  
83.48 Temperature: -1.35 DPhase: 33.41 BPhase: 32.22  
RPhase: 0.00 BAmp: 262.09 BPot: 163.00 RAmp:  
0.00 RawTem.: 694.92

Field	Data	Units
1	RVDAS Time Tag	
2-4	Measurement ID, Model Number, Serial Number	alphanumeric
5	Oxygen heading	text
6	Oxygen Reading	Raw numeric
7	Saturation heading	text
8	Saturation Reading	Raw numeric
9	Temperature heading	text
10	Water Temperature	°C
11	Dphase heading	text
12	Dphase	Raw numeric
13	Bphase heading	text
14	BPhase	Raw numeric
15	Rphase heading	text
16	Rphase	Raw numeric
17	Bamp heading	text
18	Bamp	Raw numeric
19	Bpot heading	text
20	Bpot	Raw numeric
21	Ramp heading	text
22	Ramp	Raw numeric
23	RawTem heading	text
24	RawTemp	Raw numeric

## IpcO – PCO<sub>2</sub> system

For further information on this data, contact Tim Newberger at [tnewberg@ldeo.columbia.edu](mailto:tnewberg@ldeo.columbia.edu)

02+319:23:59:13.748 2002319.99851 7154.27 26.49 1033.6 325.79 6.74 329.3  
53.76 0 Equil

Field	Data	Units
1	RVDAS Time Tag	
2	Julian date file string	Julian
3	IR voltage reading	mV
4	Cell temperature	°C
5	Barometer	millibars
6	VCO <sub>2</sub>	mL
7	Equilibrator temperature	°C
8	PCO <sub>2</sub>	millibars
9	Gas flow	mL/min
10	Solenoid position ID	number
11	Valve Position ID	number
12	Measured gas	name

## Iguv – Biospherical GUV

08+037:14:17:59.211 020608 141758 -.000099 1.307E0 7.24E0 1.316E1 2.609E1 3.285E1 3.505E1 8.075E-  
2 38.993 17.985

GUV only

Field	Data	Units
1	RVDAS Time Tag	
2	GUV Computer Date	mmddyy
3	GUV Computer Time	hhmmss
4	Ed0Gnd - GUV	Volts
5	Ed0305 - GUV	μW/cm <sup>2</sup> nm
6	Ed0313 - GUV	μW/cm <sup>2</sup> nm
7	Ed0320 - GUV	μW/cm <sup>2</sup> nm
8	Ed0340 - GUV	μW/cm <sup>2</sup> nm
9	Ed0380 - GUV	μW/cm <sup>2</sup> nm
10	Ed0395 - GUV	μW/cm <sup>2</sup> nm
11	Ed0PAR - GUV	μE/cm <sup>2</sup> sec
12	Ed0Temp - GUV	°C
13	Ed0VIn	Volts

GUV and PUV

Field	Data	Units
1	RVDAS Time Tag	
2	GUV Computer Date	mmddyy
3	GUV Computer Time	hhmmss
4	EdZGnd -PUV	Volts
5	EdZ305 -PUV	μW/cm <sup>2</sup> nm
6	EdZ313 -PUV	μW/cm <sup>2</sup> nm
7	EdZ320 -PUV	μW/cm <sup>2</sup> nm
8	EdZ395 -PUV	μW/cm <sup>2</sup> nm
9	EdZ340 -PUV	μW/cm <sup>2</sup> nm
10	EdZPAR -PUV	μE/cm <sup>2</sup> sec
11	LuZChl -PUV	μE/srm <sup>2</sup> sec
12	EdZ380 -PUV	μW/cm <sup>2</sup> nm
13	WTemp -PUV	°C
14	Depth -PUV	m
15	EdZTemp -PUV	°C
16	LuZTemp -PUV	°C
17	Tilt -PUV	Degrees
18	Roll -PUV	Degrees
19	Ed0Gnd - GUV	Volts
20	Ed0305 - GUV	μW/cm <sup>2</sup> nm
21	Ed0313 - GUV	μW/cm <sup>2</sup> nm
22	Ed0320 - GUV	μW/cm <sup>2</sup> nm
23	Ed0340 - GUV	μW/cm <sup>2</sup> nm
24	Ed0380 - GUV	μW/cm <sup>2</sup> nm
25	Ed0395 - GUV	μW/cm <sup>2</sup> nm
26	Ed0PAR - GUV	μE/cm <sup>2</sup> sec



27	Ed0Temp - GUV	°C
28	Ed0VIn	Volts

## Isvp - Sound Velocity Probe in ADCP Transducer Well

00+348:01:59:52.128 1539.40

Field	Data	Units
1	RVDAS Time Tag	
2	Sound velocity	m/s

## ladc – ADCP Speed Log

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 <sup>1</sup> velocity <sup>2</sup> , East vector	knots
5	Ship Speed relative to reference layer <sup>1</sup> velocity <sup>2</sup> , North vector	knots
6	Ship heading	degrees

<sup>1</sup>The reference layer is an average velocity measured in a number of depth “bins”. On the LMG, the bins are eight meters deep and bins 3-10 define the reference layer. Hence, the reference layer is the water column from 16-80 meters beneath the ship.

<sup>2</sup>The speed output is water velocity relative to the ship’s hull and is therefore opposite of the actual movement of the ship. For example, if the ship’s heading is due north, the North/South reference layer velocity is likely to be negative (southerly).

## lash – Ashtech GPS

ATTD: Attitude Data

01+081:00:00:00.806 \$PASHR,ATT,345605.0,165.03,+001.86,-01.96,0.0018,0.0173,0\*22

Field	Data	Units
1	RVDAS Time Tag \$PASHR	
2	ATT	
3	GPS Time sec. of the week	seconds
4	heading (rel. to true North)	degrees
5	pitch	degrees
6	roll	degrees
7	Measurement RMS error	meters
8	Baseline RMS error	meters
9	attitude reset flag	

01+081:00:00:00.966 \$GPGGA,235952.00,6051.7937,S,06030.2175,W,1,08,01.0,+00068,M,,M,,\*79

Field	Data	Units
1	RVDAS Time Tag \$GPGGA	
2	UTC time at position	hhmmss.ss
3	Latitude	ddmm.mmm

Field	Data	Units
4	North (N) or South (S)	
5	Longitude	ddmm.mmm
6	East (E) or West (W)	
7	GPS quality (1=GPS 2=DGPS)	
8	Number of GPS satellites used	
9	HDOP	
10	Antenna Height	meters
11	M for Meters	
12	Geoidal height	meters
13	M for meters	
14	age of diff. GPS data	sss
15	differential reference station ID	aaaa

### Igyr - Gyro

02+315:23:59:58.194 \$PASVW,00.1,A\*1D

02+315:23:59:58.414 \$IIVHW,287.7,T,,M,,N,,K\*71

02+315:23:59:58.616 \$HEHDT,287.7,T\*25

02+315:23:59:58.821 \$HEROT,001.6,A\*2C

02+315:23:59:58.984 \$HCHDT,,T\*07

### HDT: True Heading

01+083:00:00:02.893 \$HEHDT,246.3,T\*2C

Field	Data	Units
1	RVDAS Time Tag \$HEHDT	
2	Heading XXXXX = ddd.d	degrees
3	T flag for true heading, checksum	

### ROT: Rate of Turn

01+083:00:00:03.093 \$HEROT,-006.3,A\*03

Field	Data	Units
1	RVDAS Time Tag \$HEROT	
2	Rate of turn	degrees/min
3	Status: A = data valid, checksum	

### Igar - Garmin GPS

#### GGA: Global Positioning Fix Data

08+034:12:26:06.131 \$GPGGA,122607,6446.4733,S,06403.4455,W,1,11,0.9,-193.4,M,9.7,M,,\*5A

Field	Data	Units
1	RVDAS Time Tag	
2	\$GPGGA Tag	
3	UTC of position	hhmmss.ss
4	Latitude in degrees with decimal minutes	ddmm.mmm
5	North (N) or South (S)	
6	Longitude in degrees with decimal minutes	ddmm.mmm
7	East (E) or West (W)	
8	GPS quality (1=GPS 2=DGPS)	

Field	Data	Units
9	Number of GPS satellites used	
10	Horizontal dilution of precision (HDOP)	
11	Antenna height above/below mean-sea-level (geoid)	meters
12	Units for antenna height (M = Meters)	
13	Geoidal Separation <sup>1</sup>	
14	Units for Geoidal Separation (M = Meters)	meters
15	Age of differential GPS data, number of seconds since last SC104 Type 1 or 9	
16	Differential reference station ID	

<sup>1</sup>Geoidal Separation: the difference between the WGS-84 earth ellipsoid and mean-sea-level (geoid). A negative value represents mean-sea-level below ellipsoid.

#### GLL: Geographic Position – Latitude/Longitude

08+034:12:26:06.211 \$GPGLL,6446.4733,S,06403.4455,W,122607,A

Field	Data	Units
1	RVDAS Time Tag	
2	\$GPGLL Tag	
3	Latitude	ddmm.mmm
4	North (N) or South (S)	
5	Longitude	ddmm.mmm
6	East (E) or West (W)	
7	UTC of position	hhmmss.ss
8	Status: A = Data Valid, V = Data Not Valid	

#### VTG: Track Made Good and Speed over Ground

08+034:12:26:06.211 \$GPVTG,167,T,151,M,000.0,N,0000.0,K

Field	Data	Units
1	RVDAS Time Tag	
2	\$GPVTG Tag	
3	Track, degrees true	degrees
3	T flag for True	
4	Track, degrees magnetic	degrees
5	M flag for Magnetic	
6	Speed over Ground	knots
7	N flag for Knots	
8	Speed over Ground	kmhr
9	K flag for km/hr	

#### tgps – Trimble Centurion GPS

##### GGA: Global Positioning Fix Data

08+034:12:26:06.131 \$GPGGA,122607,6446.4733,S,06403.4455,W,1,11,0.9,-193.4,M,9.7,M,,\*5A

Field	Data	Units
1	RVDAS Time Tag	
2	\$GPGGA Tag	
3	UTC of position	hhmmss.ss
4	Latitude in degrees with decimal minutes	ddmm.mmm
5	North (N) or South (S)	

Field	Data	Units
6	Longitude in degrees with decimal minutes	ddmm.mmm
7	East (E) or West (W)	
8	GPS quality (1=GPS 2=DGPS)	
9	Number of GPS satellites used	
10	Horizontal dilution of precision (HDOP)	
11	Antenna height above/below mean-sea-level (geoid)	meters
12	Units for antenna height (M = Meters)	
13	Geoidal Separation <sup>1</sup>	
14	Units for Geoidal Separation (M = Meters)	meters
15	Age of differential GPS data, number of seconds since last SC104 Type 1 or 9	
16	Differential reference station ID	

<sup>1</sup>Geoidal Separation: the difference between the WGS-84 earth ellipsoid and mean-sea-level (geoid). A negative value represents mean-sea-level below ellipsoid.

#### GLL: Geographic Position – Latitude/Longitude

08+034:12:26:06.211 \$GPGLL,6446.4733,S,06403.4455,W,122607,A

Field	Data	Units
1	RVDAS Time Tag	
2	\$GPGLL Tag	
3	Latitude	ddmm.mmm
4	North (N) or South (S)	
5	Longitude	ddmm.mmm
6	East (E) or West (W)	
7	UTC of position	hhmmss.ss
8	Status: A = Data Valid, V = Data Not Valid	

#### VTG: Track Made Good and Speed over Ground

08+034:12:26:06.211 \$GPVTG,167,T,151,M,000.0,N,0000.0,K

Field	Data	Units
1	RVDAS Time Tag	
2	\$GPVTG Tag	
3	Track, degrees true	degrees
3	T flag for True	
4	Track, degrees magnetic	degrees
5	M flag for Magnetic	
6	Speed over Ground	knots
7	N flag for Knots	
8	Speed over Ground	kmhr
9	K flag for km/hr	

#### RMC: Recommended Minimum Specific GNSS Data

08+034:13:17:26.627 \$GPRMC,131726.605,A,6446.4820,S,06403.3075,W,000.0,094.4,030208,16.3,E

Field	Data	Units
1	RVDAS Time Tag	
2	\$GPRMC Tag	
3	UTC of position	hhmmss.ss

Field	Data	Units
4	Status A = Data Valid, V = Navigation Receiver Warning	
5	Latitude in degrees with decimal minutes	ddmm.mmm
6	North (N) or South (S)	
7	Longitude in degrees with decimal minutes	ddmm.mmm
8	East (E) or West (W)	
9	Speed Over Ground, knots	knots
10	Course Over Ground, degrees True	degrees
11	Date	ddmmyy
12	Magnetic Variation, degrees E/W	degrees
13	Mode Indicator E= Estimated Mode	

## LMG Sensors

### Shipboard Sensors

Sensor	Description	Serial #	Cal. Date	Status
Port Anemometer	Gill Ultrasonic Wind Observer II	840019		Collected
Starboard Anemometer	Gill Ultrasonic Wind Observer II	71738		Collected
Barometer	R.M. Young 61201	BP00873	10-Feb-2009	Collected
Humidity/Wet Temp	RM Young 41372LC	06719	10-Feb-2009	Collected/Replaced on 5/24/2009
Humidity/Wet Temp	RM Young 41372LC	06720	20-Feb-2007	Collected – installed due to S/N 06719 failure
PAR for Mast	Biosph. Inst. QSR-240P	6393	02 July, 2008	Collected
PIR	Eppley PIR	32031F3	22 May, 2008	Collected
PSP	Eppley PSP	31701F3	22 May, 2008	Collected
GUV (Mast)	Biosph. Inst. GUV-2511	25110805127	02-Dec-2008	Collected
Transmissometer	WET Labs C-Star 25 cm deep	CST-553DR	15-May-2008	Collected
Fluorometer	Turner 10AU-005-CE	6592 RTX		Collected
MicroTSG	Sea-Bird 45	227	12-Jan-2008	Collected
Digital Remote Temp	Sea-Bird 38	262	07-Jan-2008	Collected
Fluorometer	WET Labs ECO-FL	FLRTD-398	30-Oct-2007	Collected

### Sampling Sensors (CTD, MOC)

Sensor	Description	Serial #	Cal. Date	Status
CTD Fish	SeaBird 9+ CTD Fish w/ Pressure Sensor	0919	24-Nov-2008	Collected
CTD Conductivity Sensor	SeaBird 4-01/0 Conductivity Sensor	0350	01-Jul-2008	Collected
CTD Conductivity Sensor	SeaBird 4M Conductivity Sensor	2293	01-Jul-2008	Collected
MOC Conductivity Sensor	SeaBird 4C Conductivity Sensor	2047	20-Mar-2009	Collected
CTD Temperature Sensor	SeaBird 3-02/F Temperature Sensor	1529	18-Jun-2008	Collected
CTD Temperature Sensor	SeaBird 3+ Temperature Sensor	2658	03-Jul-2008	Collected
MOC Temperature Sensor	SeaBird 3-01/S Temperature Sensor	31620	14-Jun-2005	Collected
CTD Fluorometer	WetLabs ECO-FL	FLRTD-867	25-Sep-2008	Collected
MOC Fluorometer	WetLabs ECO-FL	AFLT-001	02-Jul-2008	Collected
CTD Dissolved Oxygen	SeaBird 43 DSO Sensor	430182	25-Jul-2008	Collected
CTD Dissolved Oxygen	SeaBird 43 DSO Sensor	430196	12-Sep-2008	Collected
PAR Sensor	Biospherical QSP-200L4S	4470	17-Jun-2008	Collected

## Underway Calibration Sheets

## Remote Temperature (SBE-38)

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**SEA-BIRD ELECTRONICS, INC.**

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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

SENSOR SERIAL NUMBER: 0262  
CALIBRATION DATE: 07-Jan-08SBE 38 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

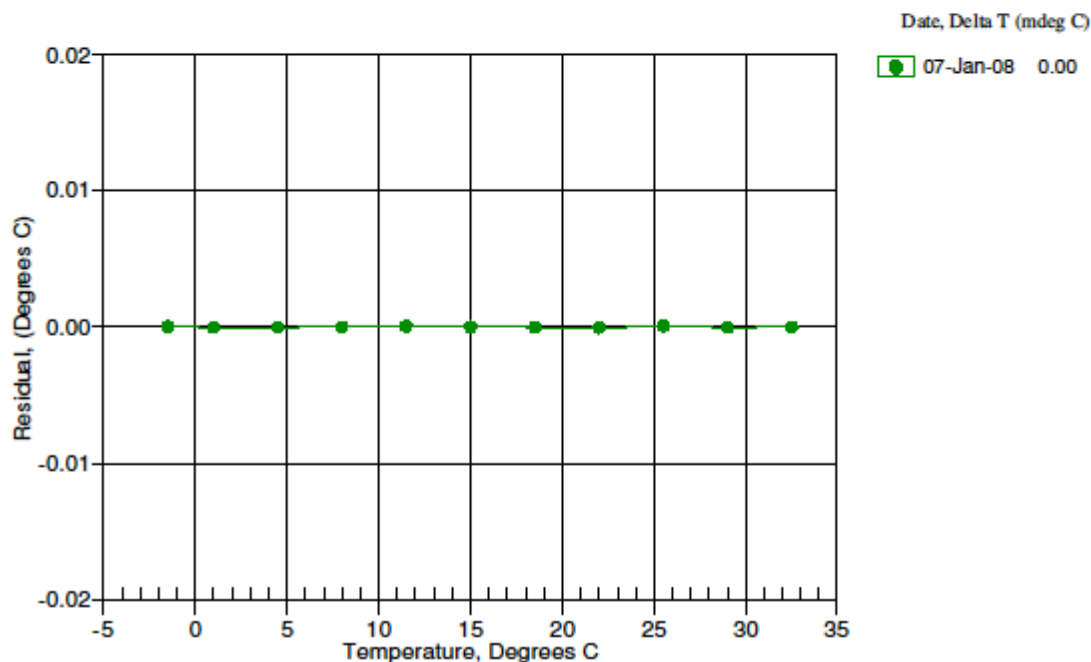
## ITS-90 COEFFICIENTS

$a_0 = -2.602085e-005$   
 $a_1 = 2.811337e-004$   
 $a_2 = -2.667958e-006$   
 $a_3 = 1.663429e-007$

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50010	702896.2	-1.50006	0.00004
0.99990	628320.9	0.99986	-0.00004
4.49990	538544.5	4.49988	-0.00002
7.99990	463090.7	7.99989	-0.00001
11.49990	399460.2	11.49997	0.00007
14.99990	345627.5	14.99992	0.00002
18.50000	299936.1	18.49998	-0.00002
22.00000	261037.3	21.99993	-0.00007
25.49990	227819.7	25.49997	0.00007
28.99990	199372.5	28.99986	-0.00004
32.49990	174939.0	32.49992	0.00002

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

Residual = instrument temperature - bath temperature



**Transmissometer (Wetlabs C-Star)**

PO Box 518  
620 Applegate St.  
Philomath, OR 97370



(541) 929-5850  
Fax (541) 929-5277  
[www.wetlabs.com](http://www.wetlabs.com)

**C-Star Calibration**

Date	May 15, 2008	S/N#	CST-553DR	Pathlength	25cm
------	--------------	------	-----------	------------	------

	<b>Analog meter</b>
$V_d$	0.059 V
$V_{air}$	4.794 V
$V_{ref}$	4.684 V

Temperature of calibration water	22.7 °C
Ambient temperature during calibration	26.7 °C

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

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 I

4/17/08



## Fluorometer (Wetlabs ECO-FL)

PO Box 518  
620 Applegate St.  
Philomath, OR 97370



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

### ECO Chlorophyll Fluorometer Characterization Sheet

Date: 10/30/2007

S/N: FLRTD-398

Chlorophyll concentration expressed in  $\mu\text{g/l}$  can be derived using the equation:

$$\text{CHL } (\mu\text{g/l}) = \text{Scale Factor} * (\text{Output} - \text{Dark Counts})$$

	Analog Range 1	Analog Range 2 (default)	Analog Range 4	Digital
Dark Counts	0.102	0.057	0.034 V	74 counts
Scale Factor (SF)	6	13	26 $\mu\text{g/l/V}$	0.0077 $\mu\text{g/l/count}$
Maximum Output	4.92	4.92	4.92 V	16331 counts
Resolution	0.5	0.5	0.5 mV	0.9 counts

Ambient temperature during characterization

21.5 °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:  $\text{SF} = x \div (\text{output} - \text{dark counts})$ , 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-398.xls

Revision I

10/2/07

**PSP (Eppley model PSP)****THE EPPLEY LABORATORY, INC.**

12 Sheffield Ave., P.O. Box 419, Newport, RI 02840 USA

Telephone: 401-847-1020

Fax: 401-847-1031

Email: info@eppleylab.com

Internet: www.eppleylab.com



Scientific Instruments  
for Precision Measurements  
Since 1917

## STANDARDIZATION OF EPPLEY PRECISION SPECTRAL PYRANOMETER Model PSP

Serial Number: 31701F3

Resistance: 674  $\Omega$  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:

$$8.40 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

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 (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<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: National Science Foundation  
Port Hueneme, CA

S.O. Number: 61623

Date: May 22, 2008

In Charge of Test:

Reviewed by:

Remarks:

**PIR (Eppley model PIR)****THE EPPLEY LABORATORY, INC.**

12 Sheffield Ave., P.O. Box 419, Newport, RI 02840 USA

Telephone: 401-847-1020

Fax: 401-847-1031

Email: info@eppleylab.com

Internet: www.eppleylab.com

Scientific Instruments  
for Precision Measurements  
Since 1917**STANDARDIZATION OF  
EPPLEY PRECISION INFRARED RADIOMETER  
Model PIR**

Serial Number: 32031F3

Resistance: 709  $\Omega$  at 23  $^{\circ}\text{C}$ Temperature Compensation Range: -20  $^{\circ}$  to +40  $^{\circ}\text{C}$ 

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 23  $^{\circ}\text{C}$  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:

$$3.88 \times 10^{-5} \text{ volts/watts meter}^{-2}$$

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: National Science Foundation  
Port Hueneme, CA

In Charge of Test:

S.O. Number: 61623

Date: May 22, 2008

Reviewed by:

Remarks:

**PAR (QSR-240P)****Biospherical Instruments Inc.**

## CALIBRATION CERTIFICATE

Calibration Date 2/16/2008  
 Model Number: QSR-240  
 Serial Number 5393  
 Operator TPC  
 Standard Lamp 91537/10/25/2005  
 Probe Excitation Voltage Range 6 to 18 VDC(+) 1000  
 Output Polarity Positive

Probe Conditions at Calibration (in air):

Calibration Voltage: 6 VDC(+) 1000  
 Probe Current: 1.3 mA

Probe Output Voltage:

Probe Illuminated 58.7 mV  
 Probe Dark 0.8 mV  
 Probe Net Response 87.9 mV  
 RGTBD 2.1 mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

9.80E-15 quanta/cm<sup>2</sup>sec  
0.01487 uE/cm<sup>2</sup>sec

Calibration Scale Factor:

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

Dry 9.04531E-18 V/(quanta/cm<sup>2</sup>sec)  
5.9897E+00 V/(uE/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

**Temperature/Relative Humidity (RMYoung model 41372LC)**

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

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

Customer: *Raytheon Technical Services Co LLC*

Test Number: 89914

Customer PO: RR41830-01

Test Date: 26 September 2008

Sales Order: 9970

**Test Sensor:**

Model: 41372LC

Serial Number: 6719

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)
-49.93	4.009	-49.94
0.03	12.003	0.02
49.83	19.972	49.83

(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**

Brooklyn Thermometer Model 43-FC  
Brooklyn Thermometer Model 22332-D5-FC  
Brooklyn Thermometer Model 2X400-D7-FC  
Keithley Multimeter Model 191

**Serial # NIST Test Reference**

8006-118 204365  
25071 249763  
77532 228060  
15232 234027

Tested By: *EChanning*

METEOROLOGICAL INSTRUMENTS

Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: www.youngusa.com



**Temperature/Relative Humidity (RMyoung model 41372LC)**

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

**Temperature Sensor Calibration Report**

Customer: *Raytheon Technical Services Company LLC*

Test Number: 72201  
Test Date: 20 February 2007

Customer PO: RM32323-50  
Sales Order: 8926

**Test Sensor:**

Model: 41372LC      Serial Number: 6720  
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)
-49.93	4.009	-49.94
0.02	12.001	0.01
50.21	20.028	50.18

(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	25071	249763
Brooklyn Thermometer Model 2X400-D7-FC	77532	228060
Keithley Multimeter Model 191	15232	234027

Tested By:

METEOROLOGICAL INSTRUMENTS

Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: www.youngusa.com

**Barometer (RMYoung model 61201)**

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

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

Customer: *Raytheon Technical Services Co LLC*

Test Number: 89101

Customer PO: RR42365-01

Test Date: 10 September 2008

Sales Order: 9955

<u>Test Sensor:</u>
Model: 61201      Serial Number: <i>BP00873</i>
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	1	800.1
875.0	1251	875.1
950.0	2500	950.0
1025.0	3748	1024.9
1100.0	4994	1099.6

(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:

*ECherny*

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: www.youngusa.com

## Micro TSG (Seabird SBE45 Conductivity)

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**SEA-BIRD ELECTRONICS, INC.**

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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

SENSOR SERIAL NUMBER: 0227  
CALIBRATION DATE: 12-Jan-08SBE45 CONDUCTIVITY CALIBRATION DATA  
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

## COEFFICIENTS:

g = -1.015905e+000

CPcor = -9.5700e-008

h = 1.574425e-001

CTcor = 3.2500e-006

i = -4.543106e-004

WBOTC = 1.0472e-006

j = 6.120110e-005

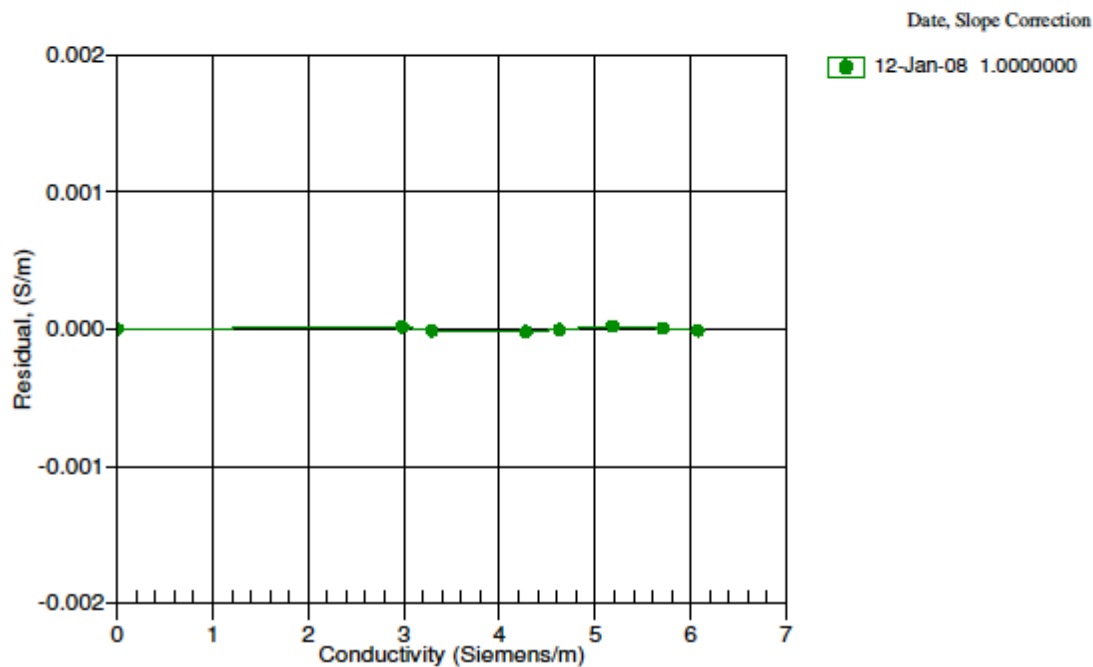
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2546.31	0.00000	0.00000
1.0000	34.9254	2.98440	5052.43	2.98442	0.00002
4.4999	34.9056	3.29231	5242.70	3.29230	-0.00001
15.0000	34.8618	4.27660	5808.54	4.27659	-0.00002
18.5000	34.8524	4.62264	5994.50	4.62264	-0.00000
24.0000	34.8419	5.18201	6283.14	5.18203	0.00002
29.0000	34.8360	5.70518	6541.20	5.70519	0.00001
32.5000	34.8334	6.07863	6719.12	6.07862	-0.00001

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

Conductivity = (g + hf<sup>2</sup> + if<sup>3</sup> + jf<sup>4</sup>) / (1 + δt + εp) Siemens/meter

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

Residual = instrument conductivity - bath conductivity





## Micro TSG (Seabird SBE45 Temperature)

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**SEA-BIRD ELECTRONICS, INC.**

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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

SENSOR SERIAL NUMBER: 0227  
CALIBRATION DATE: 12-Jan-08SBE45 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

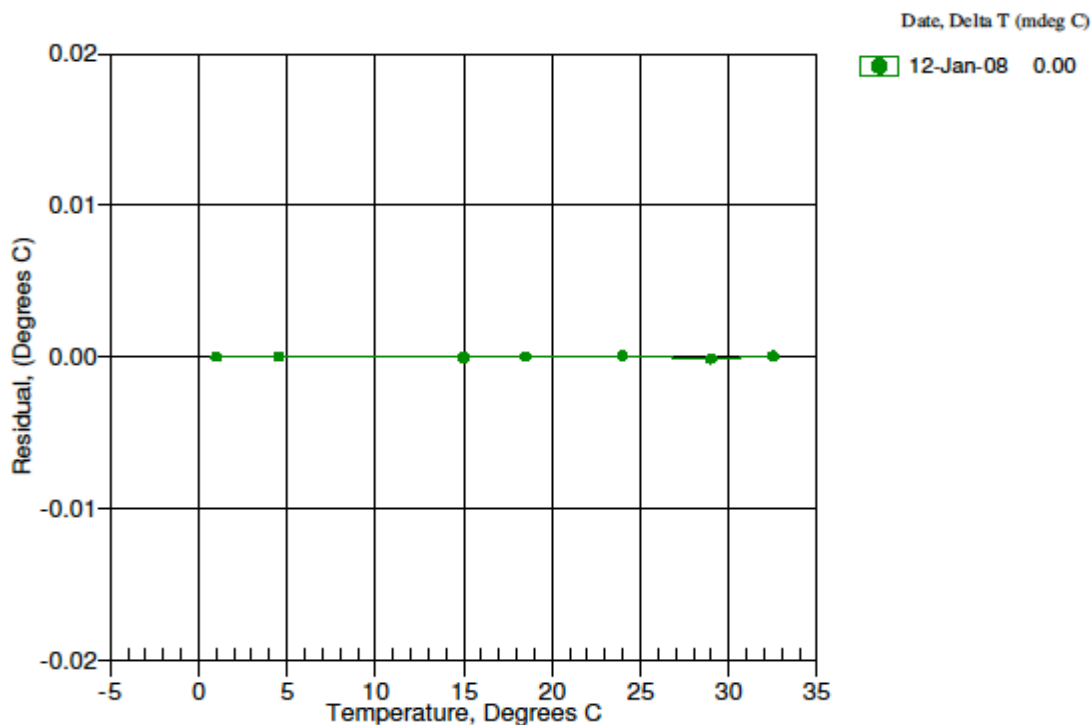
## ITS-90 COEFFICIENTS

$a_0 = 1.750051e-006$   
 $a_1 = 2.794345e-004$   
 $a_2 = -2.721644e-006$   
 $a_3 = 1.612953e-007$

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	664677.5	1.0000	0.0000
4.4999	568096.6	4.4999	-0.0000
15.0000	361662.4	15.0000	-0.0000
18.5000	313050.9	18.5000	0.0000
24.0000	251002.5	24.0001	0.0001
29.0000	206582.7	28.9999	-0.0001
32.5000	180847.8	32.5001	0.0001

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

Residual = instrument temperature - bath temperature



**GUV (Biospherical Instruments 2511)**

Biospherical Instruments Inc.

GUV-2511 Calibration Certificate										
System Serial Number		25110805127		Date of Calibration		12/2/08				
Calibration database		25110805127v3.mdb		Date of Certificate		12/4/2008				
DASSN		0111		Standard of Spectral Irradiance		91537(10/25/06)				
Microprocessor Tag Number		2		Operator		TC				
Monochromatic Channels	Address	Wavelength [nm]	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 [volts]	OffsetLarge [volts]	Measurement Units
Ed0305	2	305	3.8400E-11	3.9533E-06	1.1621E-03	3.5561E-01	-3.1100E-04	-3.1400E-04	-3.2200E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0313	6	313	1.7300E-10	1.7613E-05	5.1598E-03	1.8121E+00	2.4700E-04	2.5200E-04	1.3090E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0320	8	320	2.5643E-10	2.6108E-05	7.6668E-03	2.5121E+00	-1.6900E-04	-1.6900E-04	-3.6000E-05	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0340	10	340	1.9390E-10	1.9792E-05	5.7828E-03	2.0723E+00	1.7900E-04	1.9300E-04	1.2780E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0380	12	380	7.3738E-11	7.5266E-06	2.2042E-03	7.5742E-01	-1.5300E-04	-1.4600E-04	1.3300E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0395	13	395	3.1478E-10	3.2257E-05	9.4259E-03	3.2088E+00	-1.1700E-04	-1.1400E-04	-2.1000E-05	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Broadband Channels	Address	Wavelength [nm]	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 [volts]	OffsetLarge [volts]	Measurement Units
Ed0PAR	18	400-700	1.6951E-05	1.7283E+00	5.0613E+02	1.6683E+05	-2.0000E-06	0.0000E+00	7.9900E-04	$\mu\text{E}/(\text{cm}^2\cdot\text{sec})$
Auxiliary Channels	Address	Wavelength [nm]	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	$^{\circ}\text{C}$
Ed0Vin	27	0	1.0000E+00	-2.5000E-01	-2.5000E-01	-2.5000E-01	0.0000E+00	0.0000E+00	0.0000E+00	V

**CTD Fish (SBE-9+)**

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**CALIBRATION COEFFICIENTS**

PAROSCIENTIFIC  
PRESSURE TRANSDUCER

*Corrected coefficients for SBE-9plus, SN 0919.*

Serial No: **110538**

Original Cal Date: 6/17/2008

Corrected Cal Date: 11/24/2008

MODEL:  
410K-134

PRESSURE RANGE:  
0 to 10000 psia

TEMP. RANGE:  
0 to 125 deg C

PORT:  
oil filled

**PRESSURE COEFFICIENTS**

U = temperature (deg C)

T = pressure period (μsec)

$$C = C_1 + C_2U + C_3U^2$$

$$D = D_1 + D_2U$$

$$T_0 = T_1 + T_2U + T_3U^2 + T_4U^3 + T_5U^4$$

pressure: (psia)

$$P = C(1 - (T_0^2/T^2))(1 - D(1 - (T_0^2/T^2)))$$

<i>C1</i>	<i>-45551.68</i>	<i>psia</i>
<i>C2</i>	<i>2.193066E-01</i>	<i>psia/deg C</i>
<i>C3</i>	<i>1.4791E-02</i>	<i>psia/deg C<sup>2</sup></i>
<i>D1</i>	<i>0.032028</i>	
<i>D2</i>	<i>0</i>	
<i>T1</i>	<i>29.96319</i>	<i>μsec</i>
<i>T2</i>	<i>-2.248899E-04</i>	<i>μsec/deg C</i>
<i>T3</i>	<i>4.37354E-06</i>	<i>μsec /deg C<sup>2</sup></i>
<i>T4</i>	<i>2.52067E-09</i>	<i>μsec /deg C<sup>3</sup></i>
<i>T5</i>	<i>0</i>	

**Digiquartz Pressure Calibration Coefficients**

Corrected at Sea-Bird Electronics on **24-Nov-2008**

as per Paroscientific Calibration and SBE dP/dT tests.

*(Changed coefficients are posted in italics.)*

