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Introduction

The NBP data acquisition systems continuously logs 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 CD-ROM written in ISO9660 level-1 format. It is readable by virtually every computing platform.

All the data has been compressed using Unix “gzip,” identifiable by the “.gz” extension. It has been copied to the distribution media in the Unix tar archive format. 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. A shareware version of WinZip is included on this CD.

SeaBeam and bathyw data, if present, is 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

adcp/ 0107adcp.tar

geopdata/ 0107jgof.tar
0107mgd.tar
interim process files

imagery/ TeraScan satellite images

nbp0107.trk
nbp0107.mgd
nbpP0107.gmt

ocean/ 0107ctd.tar
0107pco2.tar
0107tsgf.tar
0107xbt.tar

plots/ *Cruise Plots*

report/ *Data Report*
instrument.coeff

scirep/ *Weekly Cruise Reports*

utility/ WinZip

Volume 2

rvdas/nav/ 01073df.tar
0107adcp.tar
0107gyr.tar
0107ngl1.tar
0107PCOD.tar

rvdas/uw/ 0107bat1.tar
0107flr.tar
0107grv.tar
0107knud.tar
0107met.tar
0107pco2.tar
0107sim.tar
0107svp.tar
0107tsg.tar

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

Cruise Track

The distribution CD includes a GMT cruise track file (NBP0107.trk). It contains the longitude and latitude at one-minute intervals extracted from the NBP0107.gmt file.

Two PostScript cruise track files have been produced and placed in the /plots directory: trk_lrg.ps is poster-size (~36" x 40") and trk_sml.ps is standard letter size (8.5" x 11").

Satellite Images

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

ID = image type (is = ice ssmi, iv = ice visible, cw = seawifs, wx = weather)
DDD = year-day
YY = year
A = allows for multiple images of one type for one day

Science Report

The weekly science reports are stored in the directory /scirep.

Standard Datasets

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

JGOFS

The JGOFS data set consists of a single file produced 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. The daily file consists of 22 columnar fields in text format described in the table below. The JGOFS data set is obtained primarily by applying calibrations to raw data and decimating to whole 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 by the NGL software package. During the cruise, the JGOFS data set produces the daily data plots. Note: Null, unused, or unknown fields are indicated as "NAN" in the JGOFS data.

Field	Data	Units
01	GMT date	dd/mm/yy
02	GMT time	hh:mm:ss
03	NGL latitude (negative is South)	tt.tttt
04	NGL longitude (negative is West)	ggg.gggg
05	Speed over ground	Knots
06	GPS HDOP	-
07	Gyro Heading	Degrees (azimuth)

Field	Data	Units
08	Course made good	Degrees (azimuth)
09	Mast PAR	Einsteins/meters^2 sec
10	Sea surface temperature	°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 (port windbird)	meters/sec
15	True wind direction (port windbird)	degrees (azimuth)
16	Ambient air temperature	°C
17	Relative humidity	%
18	Barometric pressure	mBars
19	Sea surface fluorometry	volts (0-5 FSO)
20	Not used	-
21	PSP	W/m^2
22	PIR	W/m^2

MGD77

The MGD77 data set is contained in a single file for the entire cruise. It can be found in the top level of the distribution data structure as NBP0107.mgd. Also at the root level, NBP0107.gmt is the output of the mgd77togmt utility using NBP0107.mgd as input. The NBP0107.gmt file can be used by GMT plotting software.

The data used to produce the NBP0107.mgd file can be found on the distribution media in the directory /geopdata/PROC. Each file contains a day's data and follows 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.

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 "3" for data record
2-9	8	Char	Survey identifier	
10-14	5	int	Time zone correction	In hundredths of hours. Corrects time (in characters 13-27) to GMT when added; 0 = GMT
15-16	2	int	Year	2 digit year
17-18	2	int	Month	2 digit month
19-20	2	int	Day	
21-22	2	int	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

Col	Len	Type	Contents	Description, Possible Values, Notes
				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, 1ST sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2ND sensor	In tenths of nanoteslas (gammas), for trailing sensor
73-78	6	real	Magnetics residual field	In tenths of nanoteslas (gammas). The reference field used is in Header Seq. 13
79	1	int	Sensor for residual field	1 = 1st or leading sensor 2 = 2nd or trailing sensor 9 = Unspecified
80-84	5	real	Magnetics diurnal correction	In tenths of nanoteslas (gammas). (In nanoteslas) if 9-filled (i.e., set to "+9999"), total and residual fields are assumed to be uncorrected; if used, total and 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 10th of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In tenths of mgals. E = 7.5 V cos phi sin alpha + 0.0042 V*V
104-108	5	real	Free-air anomaly	In tenths of milligals 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 the depth range from about 30 to 300 m -- in good weather. In bad weather or in ice, the range is less, and sometimes no valid measurements are made. It is the USAP-funded project of Eric Firing (University of Hawaii) and Teri Chereskin (Scripps Institution of Oceanography). ADCP data collection occurs on the both LMG and the NBP for the benefit of the scientists on individual cruises, and for the long-term goal of building a climatology of current structure in the Southern Ocean.

The ADCP data set collected during this cruise has been placed in the directory /adcp. Each file represents 24 hours of data collection. The files are named `pingdata.xxx` where `xxx` is a day number that is NOT a year-day. For the date, use the file's creation date.

Some ADCP data is also transmitted to RVDAS. East and north vectors for ship's speed relative to the reference layer and ship's heading are archived as `0107adcp.tar` in the directory, `/rvdas/nav`.

PCO_2

The NBP caries Lamont-Doherty Earth Observatory's (LDEO) pCO_2 system and RPSC staff maintains it. Data is sent to LDEO at the end of each cruise. Some pCO_2 data is also transmitted to RVDAS. You will find it in a file named `0107pco2.tar` in the `ocean/` directory.

Cruise Science

CTD

The ctd data have been placed in the tar file `ocean/0107ctd.tar`. The archive contains tar files `0107proc.tar` (processed data), `0107raw.tar` (raw data), and `0107grph.tar` (plots).

xbt

During the cruise Expendable Bathythermographs were used to obtain water column temperature profiles. These were used to adjust the sound velocity profile for the SeaBeam system. The data files from these launches are included as 0107`xbt.tar` in the `/ocean` directory.

RVDAS

Daily data processing of the RVDAS (Research Vessel Data Acquisition System) data is performed to convert values into useable units and as a check of the proper operation of the DAS. Both raw and processed data sets from RVDAS are included in the data distribution. The tables below provide detailed information on the 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 two broad categories, u*nderway and* n*avigation*. They can be found on the distribution media as subdirectories under the top level rvdas directory: `/rvdas/uw`, and `/rvdas/nav`. Oceanographic data is in the top level directory, /ocean. 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: `NBP0107.met1.d317`

- The CruiseID is the numeric name of the cruise, in this case, NBP0107.
- The Channel ID is a 4-character code representing the system being logged. An example is "met1," the designation for meteorology.
- DDD is the year-day the data was collected

Underway Sensors

Meteorology and Light

Measurement	Channel ID	Collect. Status	Rate	Instrument
Air Temperature	met1	Continuous	1 sec	R. M. Young 41372LC/LF
Relative Humidity	met1	Continuous	1 sec	
Wind Speed/Direction	met1	Continuous	1 sec	R.M. Young 05106
Barometer	met1	Continuous	1 sec	R.M. Young 61201
PIR (LW radiation)	met1	Continuous	1 sec	Eppley PIR
PSP (SW radiation)	met1	Continuous	1 sec	Eppley PSP
PhotoActive Radiation	met1	Continuous	1 sec	BSI QSR-240
GUV	guv	Not collected		BSI PUV-511
PUV	puv	Not collected		BSI PUG-500

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	bat1	Continuous	Varies	ODEC Bathy 2000
Bathymetry	knu1	First 3 days only	Varies	Knudsen 320B/R
Bathymetry	sim1	Depth < 2500 m	Varies	Simrad EK500 Sonar

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

Oceanography

Measurement	Channel ID	Collect. Status	Rate	Instrument
Conductivity	tsg1	Continuous	6 sec	SeaBird 21
Salinity	tsgfl	Continuous	6 sec	calculated from primary temp
Sea Surface Temp	tsg1	Continuous	6 sec	SeaBird 3-01/S
Fluorometry	flr1 tsg1	Continuous Continuous	1 second 6 sec	Turner 10-AU-005
Transmissometry	tsg1	Continuous	6 sec	WET Lab C-Star
pCO_2	pco2	Continuous	70 sec	(LDEO)
ADCP	adcp	Continuous	varies	RD Instruments

Navigational Instruments

Measurement	Channel ID	Collect. Status	Rate	Instrument
Attitude GPS	3df1	Continuous	1 sec	Ashtech ADU2
P-Code GPS	PCOD	Continuous	1 sec	Trimble 20636-00SM
Gyro	gyr1	Continuous	0.2 sec	Yokogawa Gyro
NGL Processed Nav Data	ngl1	Continuous	1 sec	NGL

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 = year-day
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

Meteorology (met1)

`01+322:00:03:27.306 04.5 292 010 05.7 294 010 0959.6 000.2 093 - 000.1537 0001.0886 0012.8248`

Field	Data	Units
1	RVDAS time tag	
2	Port anemometer speed (relative)	m/s
3	Port anemometer direction (relative)	deg
4	Port anemometer standard deviation	deg
5	Starboard anemometer speed (relative)	m/s
6	Starboard anemometer direction (relative)	deg
7	Starboard anemometer standard deviation	deg
8	Barometer	mBar
9	Air temperature	°C
10	Relative humidity	%
11	PSP (short wave radiation)*	mV
12	PIR (long wave radiation)*	mV
13	PAR (photosynthetically available radiation)*	mV

*See page 21 for calculations.

Gravimeter (grv1)

`99+099:00:18:19.775 your_line#1999 99 01818 9735.4`

Field	Data	Conversion	Units
1	RVDAS time tag		
2	Text string		
3	Gravity device date	yyyydddhhmmss	
4	Gravity count	mgal = count x 1.0047 + offset	count

Bathy 2000 (bat1)

`00+019:23:59:53.901 ;I04485.3ME -23.0, I00000.0,-99.9,0000@01/11/00, 23:59:52.08 PW2 PF1 SF1 PL3 MO4 SB3 PO0 TX1 TR: GM5 1500 06.7 -72.1`

Field	Data	Format / Possible Values	Units
1	RVDAS time tag		
2	Flagged low frequency chn. depth w/ units	;FDDDDD.Dun where F = flag (V for valid, I for invalid), D=depth, un = units	meters
3	Low Frequency echo strength	EEE.EE	DB
4	Flagged high freq. chn. depth	not used	
5	High frequency echo	not used	

Field	Data	Format / Possible Values	Units
	strength		
6	Signed heave data	SHHHH	Cm
7	Date	mm/dd/yy	
8	Time	hh:mm:ss	
9	Transmit pulse window type	PW1=Rectangular PW2=Hamming PW3=Cosine PW4=Blackman	
10	Primary transmit frequency	PF1=3.5 kHz PF2=12.0 kHz	KHz
11	Parametric mode secondary frequency	SF1=3.5 kHz SF2=12.0 kHz	KHz
12	Pulse length	PL1=200usec PL2=500usec PL3=1msec PL4=2msec PL5=5msec PL6=10msec PL7=25msec If transmit mode is FM: PL1=25msec PL2=50msec PL3=100msec	
13	Operating mode	MO1=CW parametric MO2=CW MO3=FM parametric MO4=FM	
14	Frequency sweep bandwidth	SB1=1 kHz SB2=2 kHz SB3=5 kHz	KHz
15	Power level	PO1 = 0dB PO2 = -6dB PO3 = -12dB PO4 = -18dB PO5 = -24dB PO6 = -30dB PO6 = -30 dB PO7 = -36dB PO8 = -42dB	
16	Transmit mode	TX1=single ping active TX2=pinger listen TX3=multipinging TR TX4=multipinging TR TX5=multipinging TTRR TX6=multipinging TTTTRRRR TX7=multipinging TTTTTRRRRR	
17	Transmit Rate	TR3 = 4Hz TR4 = 2Hz TR5 = 1Hz TR6 = .5Hz TR7 = .33Hz TR8 = .25Hz	Hz

Field	Data	Format / Possible Values	Units
		TR9 = .20Hz TR: = .10Hz TR; = .05Hz	
18	System gain mode	GM0=hydrographic AGC GM1 to GM9=hydrographic +3db to + 27db manual. GMA to GMD=hydrographic + 30db through + 60db manual GME to GMK=sub-bottom 1 through sub-bottom 7	
19	Speed of sound		m/sec
20	Depth of sonar window below sea-level		Meters
21	Background noise level in fixed point reference		DB/V

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

Simrad (sim1)

`00+005:00:00:52.388 D1,23583509,1479.6, 17, 1, 0`

Field	Data	Units
1	RVDAS time tag	
2	Header	
3	Time tag	hhmmss.sss
4	Depth	m
5	Bottom surface backscattering strength	dBar
6	Transducer number (1 = 38 kHz)	
7		

Thermosalinograph (tsg1)

`00+019:23:59:46.976 15A16CFC163F8C2C100`

Field	Data	Units
1	RVDAS time tag	
2	Seabird hex string (see page 21 for conversion to real units)	

Fluorometer (flr1)

```
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	
9	Temperature units	

pCO_2

```
00+021:23:59:43.190 2000021.9992 2382.4 984.2 30.73 50.8 345.9 334.1
-1.70
-68.046 -144.446 Equil
```

Field	Data	Units
1	RVDAS time tag	
2	pCO_2 time tag (decimal is time of day)	yyyddd.ttt
3	Raw voltage	MV
4	Barometer	MBar
5	Cell temperature	°C
6	Flow rate	cm^3/min
7	Concentration	Ppm
8	pCO_2 pressure	microAtm
9	Equilibrated temperature	°C
10	Latitude	degrees
11	Longitude	degrees
12	Flow source (Equil = pCO_2 measurement)	

Navigational Data

Ashtech GPS (3df1)

The Ashtech GPS outputs three NMEA standard data strings:

- Measurement data (PBN)
- Attitude data (ATT)
- GPS position fix (GGA)

Measurement data (PBN)

01+324:00:00:00.064 $PASHR,PBN,172812.00,2129908.6,-1869076.7,-5694992.4,
-063:41.9477,-041:16.0918,00066.2,000.16,002.85,-000.90,08,????,02,01,01,
01*3A

Field	Data	Units
1	RVDAS time tag	
2	$PASHR	
3	PBN	
4	GPS Time sec. of the week	seconds
5	Station Postion: ECEF X	meters
6	Station Postion: ECEF Y	meters
7	Station Postion: ECEF Z	meters
8	Latitude (- = South)	deg:min
9	Longitude (- = West)	deg:min
10	Altitude	meters
11	Velocity in ECEF X	m/sec
12	Velocity in ECEF Y	m/sec
13	Velocity in ECEF Z	m/sec
14	Number of satellites used	
15	Site name	
16	PDOP	
17	HDOP	
18	VDOP	
19	TDOP	

GPS Position Fix – Geoid/Ellipsoid (GGA)

01+324:00:00:00.323

$GPGGA,235959.00,6341.9477,S,04116.0918,W,1,08,00.9,

+00066,M,,M,,*77

Field	Data	Units
1	RVDAS time tag	
2	$GPGGA	
3	UTC time at position	hhmmss.ss
4	Latitude	ddmm.mmm
5	North (N) or South (S)	
6	Longitude	ddmm.mmm
7	East (E) or West (W)	
8	GPS quality: 1 = GPS 2 = DGPS	
9	Number of GPS satellites used	
10	HDOP	
11	Antenna height	meters
12	M for Meters	
13	Geoidal height (no data in the sample string)	meters
14	M for meters	
15	Age of diff. 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)	

Attitude Data (ATT)

01+324:00:00:00.845 $PASHR,ATT,172813.0,137.88,+000.52,-

001.41,0.0029,

0.0254,0*2F

Field	Data	Units
1	RVDAS Time tag	
2	$PASHR	
3	ATT	
4	GPS Time sec. Of the week	seconds
5	Heading (rel. to true North)	degrees
6	Pitch	degrees
7	Roll	degrees
8	Measurement RMS error	meters
9	Baseline RMS error	meters
10	Attitude reset flag	

Trimble P-Code GPS (PCOD)

The PCode GPS 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)	

Field	Data	Units
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 $HEHRC25034,-020*73
```

Field	Data	Units
1	RVDAS time tag	
2	$HEHRC	
3	Heading XXXXX = ddd.dd	degrees
4	Rate of change SYYY S = +/-, YYY = r.rr	
5	Checksum	

Furuno GPS (gp02)

The Furuno GPS outputs four data strings:

- Latitude / longitude (GLL)
- GPS position fix (GGA)
- Track and ground speed (VTG)
- Waypoint Arrival Alarm (AAM)

GLL, Latitude / Longitude

```
01+353:00:00:00.115 $GPGLL,6459.545,S,06325.223,W
```

Field	Data	Units
1	RVDAS Time tag	
2	$GPGLL	
3	Latitude	degrees

Field	Data	Units
4	North or South	
5	Longitude	degrees
6	East or West	

GGA, GPS Position Fix

01+353:00:00:00.248 $GPGGA,000000,6459.545,S,06325.223,W,1,3,001,000033,M,0012,M

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)	

VTG, Track and Ground Speed

01+353:00:00:00.340 $GPVTG,230.5,T,,M,005.2,N,009.7,K

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	

AAM, Waypoint Arrival Alarm

```
01+353:00:00:00.407 $GPAAM,V,V,0.00,N,11
```

Field	Data	Units
1	RVDAS time tag	
2	$AAM	
3	Status: A = Arrival circle entered V = Arrival circle not entered	
4	Status: A = Perpendicular passed at waypoint V = Perpendicular not passed	
5	Arrival circle radius	
6	Units of radius, N = nautical miles	
7	Waypoint ID	

NGL System (ngl1)

```
00+019:23:59:59.857 -68.82822,-
137.21416,1.10,279.27,251.10,0.00,0.00,
0,18.2587,1,1146973
```

Field	Data	Units
1	RVDAS time tag	
2	Latitude (south is negative)	degrees
3	Longitude (west is negative)	degrees
4	Ship speed	knots
5	Course made good	degrees
6	Gyro heading	degrees
7	PDOP	
8	HDOP	
9	Quality	
10	GPS up	
11	Fix Number	
12		

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	kn
5	Ship Speed relative to reference layer, north vector	kn
6	Ship heading	degrres

Sound Velocity Probe (svp1)

00+348:01:59:52.128 1539.40

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

Ocean

pCO2-merged

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

Field	Data	Units
1	RVDAS time tag	
2	PCO_2 time tag (decimal is time of day)	yyyddd.ttt
3	Raw voltage	mV
4	Barometer	mB
5	Cell temperature	°C
6	Flow rate	cm^3/min
7	Concentration	ppm
8	PCO_2 pressure	microAtm
9	Equilibrated temperature	°C
10	Flow Source (Equil = pCO_2 measurement)	
11	RVDAS latitude	degrees
12	RVDAS longitude	degrees
13	TSG external temperature	°C
14	TSG salinity	PSU
15	TSG fluorometry	V
16	RVDAS true wind speed	m/s
17	RVDAS true wind direction	degrees
18	Barometric Pressure	MBars

Field	Data	Units
19	Uncontaminated seawater pump flow rate	l/min
20	Speed over ground	Knots
21	Course made good	Degrees

tsgfl

00+075:00:00:04.467 -01.488 -01.720 02.6783 33.63748 1.002442 0.002442

Field	Data	Units
1	RVDAS time tag	
2	Internal water temperature	°C
3	Sea Surface Temperature	°C
4	Conductivity	Siemens
5	Salinity	PSU
6	Fluorometry	V
7	Unused	

Calculations

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

TSG

Raw TSG data is stored as a 20 byte (character) long hex string

Bytes	Data
1-4	Sensor Temperature
5-8	Conductivity
9-14	Remote Temperature
15-17	Fluorometer voltage
18-20	Transmissometer voltage

The coefficients for temperature and conductivity sensors can be found the `instrument.coeff` file and on the calibrations sheets in the appendix.

Calculating Temperature – ITS-90

T = decimal equivalent of bytes 1-4
Temperature Frequency: f = T/19 +2100
Temperature = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\}$ - 273.15 (°C)

Calculating Conductivity – ITS-90

C = decimal equivalent of bytes 5-8
Conductivity Frequency f = sqrt(C*2100+6250000)
Conductivity = $(g + hf^2 + if^3 + jf^4)/[10(1 + \delta t + \varepsilon p)]$ (siemens/meter)
t = temperature (°C); p = pressure (decibars); δ = Ctcor; ε = CPcor

Calculating Fluorometry Voltage

f = decimal equivalent of bytes 15-17
Fluorometry Voltage = f/819

Calculating Transmittance

V_{dark} = 0.058 V
V_{ref} = 4.765 V
t = decimal equivalent of bytes 18 – 20
Transmissometer Voltage (V_{signal}) = t/819
% Transmittance = $(V_{signal} - V_{dark}) / (V_{ref} - V_{dark})$

PAR

raw data = mV
calibration scale = 6.08 V/(Einstiens/cm ^{2}sec)
offset (V_{dark}) = 0.3 mV
(*raw* mV - V_{dark})/scale x 10^4 cm^2/m^2 x 10^{-3} V/mV= Einstiens/m^2sec
or
(*data* mV – 0.3 mV) x 1.65 (Einstiens/m^2sec)/mV = Einstiens/m^2sec

PIR

raw data = mV

calibration scale = 4.13 x 10^{-6} V/(W/m^2)
data mV / (scale x 10^3 mV/V) = W/m^2
or
data mV x 242.1(W/m^2)/mV = W/m^2

PSP

raw data = mV
calibration scale = 8.28 x 10^{-6} V/(W/m^2)
data mV / (scale x 10^3 mV/V) = W/m^2
or
data mV x 120.7 (W/m^2)/V = W/m^2

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
340:13:00		**Reached 68º W.** Turned on loggers for ADCP, tsg1 (fluorometer off), and svp.
340:16:00	341:17:00	Port/stbd Windbirds wind speed and direction not matching
341:13:15		Disabled tsg logging to replace with spare due to repeated lockups
341:13:40		Enabled tsg, S/N 857, Calibrations not updated
341:17:09		Entered tsg calibration coefficients
341:17:15		**Reached 200 mile limit**
342:21:54	End of cruise	Turned off Knudsen
344:12:20	344:13:00	Fluorometer maintenance. Cleaned flow well and checked dessicant
347:13:06	347:13:13	Fluorometer off to replace dessicant
351:16:004	351:18:00	Seawater system pump tripped off
352:20:30	352:21:30	Seawater system pump tripped off
353:12:22		Ashtech locked up. Reset and re-initialized
354:01:00	354:01:30	Seawater system pump tripped off.
357:08:25	357:08:55	Seawater system pump tripped off.
358:06:30	358:06:37	Seawater system pump tripped off.
359:12:02		Ashtech reinitialized.
360:12:28		PCO2 computer rebooted.
360:19:50	19:55	PCO2 & gas flow spike.
360:18:45	360:20:10	NGL system crashed.
361:05:30	361:05:45	Seawater system off during brown-out & fire alarm.
001:00:00	001:01:00	No NGL data.
001:22:14	001:22:16	Fluorometer down for cleaning.
003:11:37		Red Ashtech warning light. Problem corrected itself
011:19:04		**REACHED 200-MILE LIMIT.**

Appendix: Sensors and Calibrations

NBP0107 Sensors:

Shipboard Sensors

Sensor	Description	Serial #	Last Calibration Date	Status
Meteorology & Radiometers				
Port Anemometer	RM Young 5106	WM46834	04/11/01	Collect
Stbd Anemometer	RM Young 5106	WM46263	04/11/01	Collect
Barometer	RM Young 61201	01705	06/01/01	Collect
Air Temp/Rel. Hum.	RM Young 41372LC	06134	06/01/01	
Mast PRR	BSI PRR-610			Not used
UW PRR	BSI PRR-600			Not used
PIR (Pyrgeometer)	Eppley PIR	32845F3	02/22/01	Collect
PSP (Pyranometer)	Eppley PSP	33850F3	02/09/01	Collect
Mast PAR	BSI QSR-240	6356	2/15/01	Collect
GUV				Not used
PUV				Not used
Underway				
TSG	SeaBird SBE21	857	02/07/01	Collect
TSG Remote Temp	SeaBird 3-01/S	1267	01/12/01	Collect
Fluorometer	Turner 10-AU-005 Lamp: daylight 10-045; ref. filter: 10-052, em. filter: 10-051, ex. filter: 10-050	5651 FRTD	N/A	Collect
Transmissometer	WET Labs C-Star	CST-423PR	01/02/01	Collect
Magnetometer	EG&G G-866			Not used
Gravimeter	LaCoste & Romberg Gravity Meter			Collect
Bathymetry	Simrad EK500	3001	11/1/95	Collect
Bathymetry	Knudsen 320B/R			Collect
Bathymetry	Bathy 2000			Collect
Other				
P-Code GPS	Trimble 20636-00 (SM)	0220035116	Key expires 07/10/02	Collect
Attitude GPS	Ashtech 12	700273F2114 FW 7B13-D1-C21	N/A	Collect

NBP0107 CTD Sensors:

Sensor	Description	Serial #	Last Calibration Date	Status
CTD Fish	SeaBird model SBE 9+	09P10716-0377	07/13/01	Collect
CTD Fish Pressure	Paroscientific model 410K-105 pressure sensor	58949	07/13/01	Collect
CTD Deck Unit	SeaBird model SBE 11+	11P7536-0317		Collect
Primary Temperature Sensor	SeaBird model 3-02/F	1457	07/12/01	Collect
Secondary Temperature Sensor	SeaBird model 3-02/F	1649	07/12/01	Collect
Primary Conductivity Sensor	SeaBird model 4-02/0	1431	07/13/01	Collect
Secondary Conductivity Sensor	SeaBird model 4C	2069	07/12/01	Collect
Dissolved Oxygen Sensor	SeaBird model 13-02-B	130243	07/13/01	Collect
PAR Sensor	Biospherical Instruments QSR-240	4471	06/27/01	Collect
PAR Sensor	Biospherical Instruments QSR-240	4469	06/27/01	Collect
Transmissometer	WET Labs CST-423PR, C-Star	259	11/15/01	Collect

Calibrations

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

The following pages are replicas of current calibration sheets for the sensors used during this cruise.

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: 12/5/01
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 (Digital Gravity)	8942.3	10:06
Ship's meter after gravity tie (Digital Gravity)	8947.7	11:10
Average	8945.0	
Ship Gravimeter's Calibration Constant	1.0046	
Corrected ship's meter (Digital Gravity)	8986.1	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	8983.6	10:06
Ship's meter after gravity tie (serial, RVDAS)	8983.8	11:10
Average (for comparison check only)	8983.7	

Portable Gravimeter Correction Divisor 1.007937

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	4902.13	10:20	53.4	December 5, 2001	
Pier measurement 2	4902.13	10:22	53.4	December 5, 2001	4863.53
Pier measurement 3	4902.14	10:25	53.4	December 5, 2001	
Average	4902.13				
Station measurement 1	4902.75	10:40	53.5	December 5, 2001	
Station measurement 2	4902.75	10:45	53.5	December 5, 2001	4864.15
Station measurement 3	4902.76	10:48	53.5	December 5, 2001	
Average	4902.75				
Pier measurement 4	4902.10	10:58	53.5	December 5, 2001	
Pier measurement 5	4902.09	11:02	53.5	December 5, 2001	4863.50
Pier measurement 6	4902.10	11:06	53.5	December 5, 2001	
Average	4902.10				

Gravity offset from last tie 972336.98
Drift since last tie -2.84

OBS Differences	
Station to Pier (1, 2, & 3 averaged)	-0.62
Station to Pier (4, 5, & 6 averaged)	-0.65
Averaged Differences	-0.63
Gravity at pier	981320.19
Elevation of pier above gravimeter, meters	0.0
Earth differential gravity, mgal/meter	0.3
Gravity at ship's gravimeter	981320.19
Gravity Offset	972334.04

Comments

Gravity tie done by Fred Stuart and Jeff Otten

CTD

Pressure Sensor

Pressure Calibration Check 13 July 2001

pressure sensor model: Digiquartz 410K-105
sensor serial number: 58949
installed in: CTD 09P10716-0377

This pressure calibration is a check of the 'test' sensor against a stable reference pressure sensor. The reference pressure sensor is itself checked several times per year against a NIST-traceable pressure standard maintained at Paroscientific, Inc.. The circumstances of this pressure check introduce no more than 1.5 psia total error in 10,000 psi (0.015 %) in addition to the error resident in the Paroscientific site standard. The check offers a very high level certification of the health and proper operation of the 'test' sensor.

Input Pressure* [psia]	Sensor Output [hz]	Sensor Temperature [deg C]	Pressure Factory Coef [psia]	Pressure Corrected [psia]	Error [psia]
14.700	33360.59	23.2	14.668	14.986	0.286
2014.689	34041.54	23.2	2014.473	2014.776	0.087
4014.348	34706.93	23.3	4014.163	4014.452	0.104
6013.814	35357.64	23.3	6013.643	6013.918	0.104
8013.175	35994.51	23.3	8013.027	8013.288	0.113
10012.889	36618.31	23.3	10012.365	10012.612	-0.277
8013.257	35994.54	23.3	8013.101	8013.362	0.105
6013.753	35357.61	23.3	6013.535	6013.811	0.058
4014.262	34706.87	23.4	4013.938	4014.227	-0.035
2014.600	34041.43	23.4	2014.097	2014.400	-0.200
14.670	33360.38	23.4	14.007	14.325	-0.345

Input pressure is generated with a Ruska model 5201 dead-weight tester, serial number 23330/380, and is determined by measurement with reference pressure sensor model Digiquartz 410K-000, serial number 73292.

Sensor Temperature: pressure sensor internal temperature.

Pressure Corrected: pressure computed with original factory coefficients and then corrected with a slope and offset to give the best linear agreement with the 'reference' Input pressure.

Error: Corrected pressure - Input pressure

A linear fit of this calibration data, between sensor pressure computed with factory coefficients and the Input pressure, yields correction coefficients:
Corrected pressure = psi_slope * Factory pressure + psi_offset [psia]
psi_slope = 0.99999 and psi_offset = +0.32 [psia]

These are converted to Slope and Offset in decibars for use in the SEASOFT programs by: Slope = psi_slope = 0.99999
Offset = C * (psi_offset - 14.7 * (1 - psi_slope)) = +0.2188 [dbars]
C = 0.689476 [dbar/psi]

Slope and Offset coefficients are entered into the pressure sensor calibration coefficient section of the <>.CON file using the program SEACON.

Digiquartz Coefficients:

C1 = -4.840395e+04
C2 = -2.017057e-03
C3 = 1.464810e-02
D1 = 3.990600e-02
D2 = 0.000000e+00
T1 = 2.998386e+01
T2 = -2.560542e-04
T3 = 3.869120e-06
T4 = 2.452640e-09

AD590 Pressure Temperature Coefficients:

AD590M = 0.01146
AD590B = -8.45734

Calibration Correction:

Slope = 0.99999
Offset = +0.2188

Primary Temperature Sensor

SEA-BIRD ELECTRONICS, INC.
1808 136th Place N.E., Bellevue, Washington 98005 USA
Phone: (425) 643 - 9866 Fax: (425) 643 - 9954 Internet: seabird@seabird.com

SENSOR SERIAL NUMBER = 1457
CALIBRATION DATE: 12-Jul-01s

TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.82786164e-03
h = 6.69713186e-04
i = 2.48873621e-05
j = 1.92657896e-06
f_0 = 1000.000

IPTS-68 COEFFICIENTS

a = 3.68120978e-03
b = 5.98480381e-04
c = 1.44086221e-05
d = 1.92795113e-06
f_0 = 6157.445

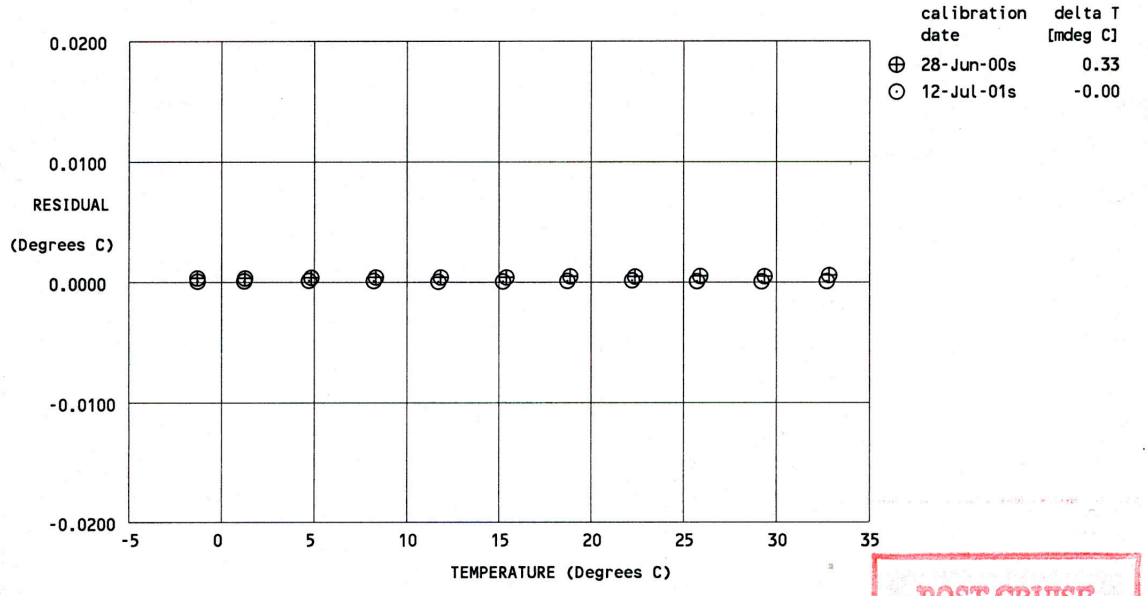
BATH TEMP (ITS-90 °C)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90 °C)	RESIDUAL (ITS-90 °C)
-1.4998	6157.445	-1.4998	-0.00001
1.0002	6513.271	1.0002	-0.00000
4.5002	7035.975	4.5002	0.00004
8.0002	7588.022	8.0002	0.00002
11.5002	8170.190	11.5001	-0.00006
15.0002	8783.260	15.0002	-0.00004
18.5002	9427.957	18.5002	0.00002
22.0002	10104.975	22.0002	0.00005
25.5002	10814.985	25.5002	0.00001
29.0002	11558.658	29.0002	-0.00002
32.5002	12336.625	32.5002	-0.00000

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

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



POST CRUISE CALIBRATION

Secondary Temperature Sensor

SEA-BIRD ELECTRONICS, INC.
1808 136th Place N.E., Bellevue, Washington 98005 USA
Phone: (425) 643 - 9866 Fax: (425) 643 - 9954 Internet: seabird@seabird.com

SENSOR SERIAL NUMBER = 1649
CALIBRATION DATE: 12-Jul-01s

TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.80597217e-03
h = 6.63603508e-04
i = 2.11665244e-05
j = 1.37355149e-06
f_0 = 1000.000

IPTS-68 COEFFICIENTS

a = 3.68120347e-03
b = 6.01320158e-04
c = 1.38390288e-05
d = 1.37481715e-06
f_0 = 5958.298

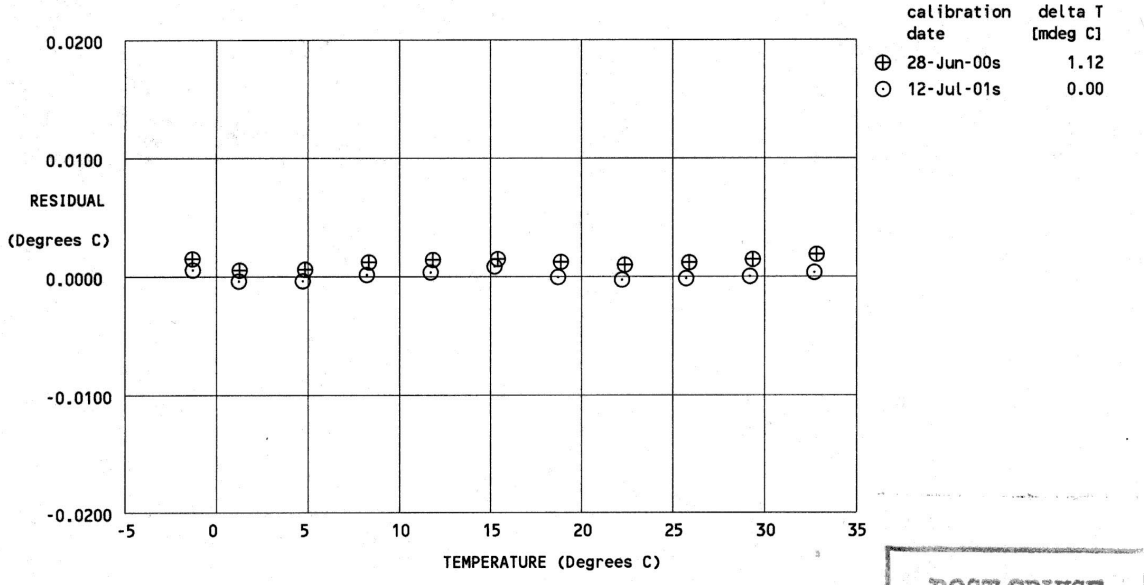
BATH TEMP (ITS-90 °C)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90 °C)	RESIDUAL (ITS-90 °C)
-1.4998	5958.298	-1.4993	0.00045
1.0002	6300.791	0.9997	-0.00046
4.5002	6803.857	4.4998	-0.00044
8.0002	7334.981	8.0003	0.00005
11.5002	7894.787	11.5005	0.00025
15.0002	8484.090	15.0009	0.00074
18.5002	9103.294	18.5001	-0.00015
22.0002	9753.434	21.9999	-0.00035
25.5002	10435.105	25.4999	-0.00027
29.0002	11148.909	29.0001	-0.00008
32.5002	11895.472	32.5005	0.00026

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

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



POST CRUISE CALIBRATION

Sea-Bird Electronics, Inc. FAX: (425) 643-9954
1808 136th Place NE, Bellevue, Washington 98005 USA Tel:(425)643-9866
Website: http://www.seabird.com Email: seabird@seabird.com

DISSOLVED OXYGEN SENSOR CALIBRATION: S/N 130243 13 July 2001

Sensor type:
Beckman, Module S/N 7-11-37

Sensor Current

m = 2.4594 E-7
b = -8.6078 E-10

The use of these constants in a linear equation of the form

$$I = mV + b$$

will yield DO sensor membrane current as a function of sensor output voltage.

Sensor Compensation Temperature

k = 8.9623
c = -6.9422

The use of these constants in a linear equation of the form

$$T = kV + c$$

will yield membrane temperature as a function of temperature channel voltage with a maximum error of about 0.5 deg C. The correction to dissolved oxygen resulting from the use of this calibration should be sufficient to achieve the precision of which the sensor is capable.

SEASOFT Coefficients based on Oxfit Calibration Results

Soc	2.4121	
Boc	-0.0226	
tcor	-0.033	(nominal)
pcor	1.50e-4	(nominal)
tau	2.0	(for profiling applications only)
tau	0.0	(for moored applications only)
wt	0.67	(for Beckman type sensors)
wt	0.85	(for YSI type sensors)

barometer	=	1016.045	mB
Twater	=	5.816	deg C
Tcomp	=	5.434	deg C
Isat	=	0.513	uA
Iair	=	0.636	uA
Izero	=	0.010	uA

PAR (1)

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 06/27/01 **Job No.:** R7756
Model Number: QSP200L
Serial Number: 4471
Operator: TPC
Standard Lamp: 94532 (03/13/98)
Operating Voltage Range: 6 to 15 VDC (+)

Note: The QSP-200L uses a log amplifier to measure the detector signal current with V = log I (Amps) / IRef
To calculate irradiance, use this formula:

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

With the appropriate (solar corrected) Irradiance Calibration Factor:

Dry Calibration Factor:	**4.54E+12**	**quanta/cm² sec/"amps"**	**7.55E-06**	**µEinsteins/cm² sec/"amps"**
Wet Calibration Factor:	**7.65E+12**	**quanta/cm² sec/"amps"**	**1.27E-05**	**µEinsteins/cm² sec/"amps"**

Sensor Test Data and Results[4)]

Sensor Supply Current (Dark):	71.1	mA			
Supply Voltage:	6	Volts			
Lamp Integrated PAR Irradiance:	8.55E+15	quanta/cm² sec	0.01420	µEinsteins/cm²sec	
SC3 Immersion Coefficient:	0.594	Scalar Correction:	1	PAR Solar Correction:	1.0000

Nominal Filter OD	Calibrated Trans.	Sensor Voltage	Measured Trans.		Measured Signal (Amps)	Estimated Signal (Amps)	Calc. Output (Volts)	Error (Volts)	Error (%)	Test Irrad. (quanta/ cm² sec)
No Filter	100.00%	3.275	100.00%		1.88E-07	1.88E-07	3.275	0.000	0.0	8.55E+15
0.3	36.10%	2.827	35.59%		6.70E-08	6.80E-08	2.833	0.006	1.4	3.04E+15
0.5	27.60%	2.716	27.55%		5.19E-08	5.20E-08	2.717	0.001	0.2	2.36E+15
1	9.27%	2.251	9.39%		1.77E-08	1.75E-08	2.246	-0.005	-1.3	8.03E+14
2	1.11%	1.362	1.14%		2.16E-09	2.09E-09	1.350	-0.012	-3.0	9.79E+13
3	0.05%	0.469	0.08%		1.47E-10	1.01E-10	0.394	-0.075	-31.6	6.68E+12

Dark Before: 0.166 Volts
Light - No Filter Hldr.: 3.275 Volts
Dark After - NFH: 0.171 Volts
Average Dark 0.1685 Volts

I_{Ref} = 1.00E-10 Amps
I_{Dark} = 1.47E-10 Amps
10^{VDark} = 1.474009 Amps

Seaspace cal constant = 10^5 / wet calfactor = 10^5 / 1.27 E^-5 = 7.87 e^9

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

PAR (2)

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 06/27/01 **Job No.:** R7755
Model Number: QSP200L
Serial Number: 4469
Operator: TPC
Standard Lamp: 94532 (03/13/98)
Operating Voltage Range: 6 to 15 VDC (+)

Note: The QSP-200L uses a log amplifier to measure the detector signal current with V = log I (Amps) / IRef
To calculate irradiance, use this formula:

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

With the appropriate (solar corrected) Irradiance Calibration Factor:

Dry Calibration Factor:	**6.27E+12**	**quanta/cm² sec/"amps"**	**1.04E-05**	**µEinsteins/cm² sec/"amps"**
Wet Calibration Factor:	**1.06E+13**	**quanta/cm² sec/"amps"**	**1.75E-05**	**µEinsteins/cm² sec/"amps"**

Sensor Test Data and Results[4)]

Sensor Supply Current (Dark):	63.7	mA			
Supply Voltage:	6	Volts			
Lamp Integrated PAR Irradiance:	8.55E+15	quanta/cm² sec	0.01420	µEinsteins/cm²sec	
SC3 Immersion Coefficient:	0.594	Scalar Correction:	1	PAR Solar Correction:	1.0000

Nominal Filter OD	Calibrated Trans.	Sensor Voltage	Measured Trans.	Measured Signal (Amps)	Estimated Signal (Amps)	Calc. Output (Volts)	Error (Volts)	Error (%)	Test Irrad. (quanta/ cm² sec)
No Filter	100.00%	3.135	100.00%	1.36E-07	1.36E-07	3.135	0.000	0.0	8.55E+15
0.3	36.10%	2.691	35.89%	4.90E-08	4.93E-08	2.694	0.003	0.6	3.07E+15
0.5	27.60%	2.581	27.85%	3.80E-08	3.77E-08	2.577	-0.004	-0.9	2.38E+15
1	9.27%	2.118	9.53%	1.30E-08	1.26E-08	2.107	-0.011	-2.7	8.15E+14
2	1.11%	1.235	1.16%	1.58E-09	1.51E-09	1.218	-0.017	-4.3	9.92E+13
3	0.05%	0.388	0.08%	1.07E-10	7.29E-11	0.322	-0.066	-32.1	6.72E+12

Dark Before: 0.137 Volts
Light - No Filter Hldr.: 3.132 Volts
Dark After - NFH: 0.138 Volts
Average Dark 0.1373 Volts

I_{Ref} = 1.00E-10 Amps
I_{Dark} = 1.37E-10 Amps
10^{VDark} = 1.371829 Amps

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

Transmissometer

Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com

FAX: (425) 643-9954
Tel: (425) 643-9866
Email: seabird@seabird.com

TRANSMISSOMETER CALIBRATIONS: S/N 259 Date 15-November-2001

A0	=	4.746	(air calibration voltage from Sea Tech)
Y0	=	-0.002	(blocked path voltage from Sea Tech)
A1	=	4.775	(current air voltage)
Y1	=	0.008	(current blocked path voltage)
Tw	=	96.4	(percentage transmission in pure water – see application note 7)
W0	=	4.820	(voltage output in pure water from Sea Tech)

M = (Tw/W0) * (A0 - Y0) / (A1 - Y1)

= (96.4/4.820) * (4.746 +0.002) / (4.775 – 0.008)

M = 19.9203

B = -M * Y1

B = -0.1594

These values of M and B should be entered into the transmissometer calibration section of the file SEASOFT.CFG using the program SEACON.

Primary Conductivity Sensor

SEA-BIRD ELECTRONICS, INC.
1808 136th Place N.E., Bellevue, Washington 98005 USA
Phone: (425) 643 - 9866 Fax: (425) 643 - 9954 Internet: seabird@seabird.com

SENSOR SERIAL NUMBER = 1431
CALIBRATION DATE: 13-Jul-01s

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

GHIJ COEFFICIENTS

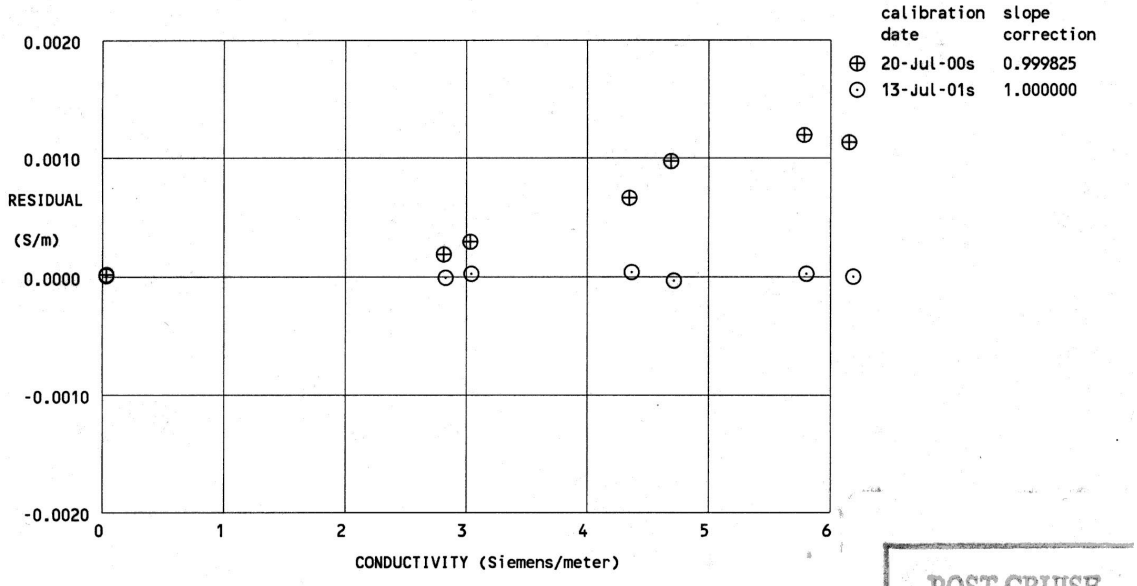
g = -4.24814601e+00
h = 5.51209690e-01
i = -1.06532071e-04
j = 3.47295936e-05
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)

ABCDM COEFFICIENTS

a = 1.65810088e-05
b = 5.50966945e-01
c = -4.24784260e+00
d = -8.97552663e-05
m = 4.2
CPcor = -9.57e-08 (nominal)

BATH TEMP (IPTS-68 °C)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.77621	0.00000	0.00000
-1.4228	35.2266	2.79844	7.63853	2.79842	-0.00002
1.0381	35.2274	3.01104	7.88572	3.01106	0.00002
15.2043	35.2293	4.33673	9.27769	4.33676	0.00003
18.6850	35.2304	4.68561	9.60997	4.68557	-0.00004
29.1088	35.2305	5.77336	10.57813	5.77338	0.00002
32.6739	35.2273	6.15753	10.89905	6.15752	-0.00001

Conductivity = $(g + hf^2 + if^3 + jf^4) / [10(1 + \delta t + \epsilon p)]$ Siemens/meter
Conductivity = $(af^m + bf^2 + c + dt) / [10(1 + \epsilon p)]$ Siemens/meter
t = temperaure [deg C]; p = pressure [decibars]; δ = CTcor; ϵ = CPcor;
Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



POST CRUISE CALIBRATION

Secondary Conductivity Sensor

SEA-BIRD ELECTRONICS, INC.
1808 136th Place N.E., Bellevue, Washington 98005 USA
Phone: (425) 643 - 9866 Fax: (425) 643 - 9954 Internet: seabird@seabird.com

SENSOR SERIAL NUMBER = [redacted]
CALIBRATION DATE: [redacted]

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

GHIJ COEFFICIENTS

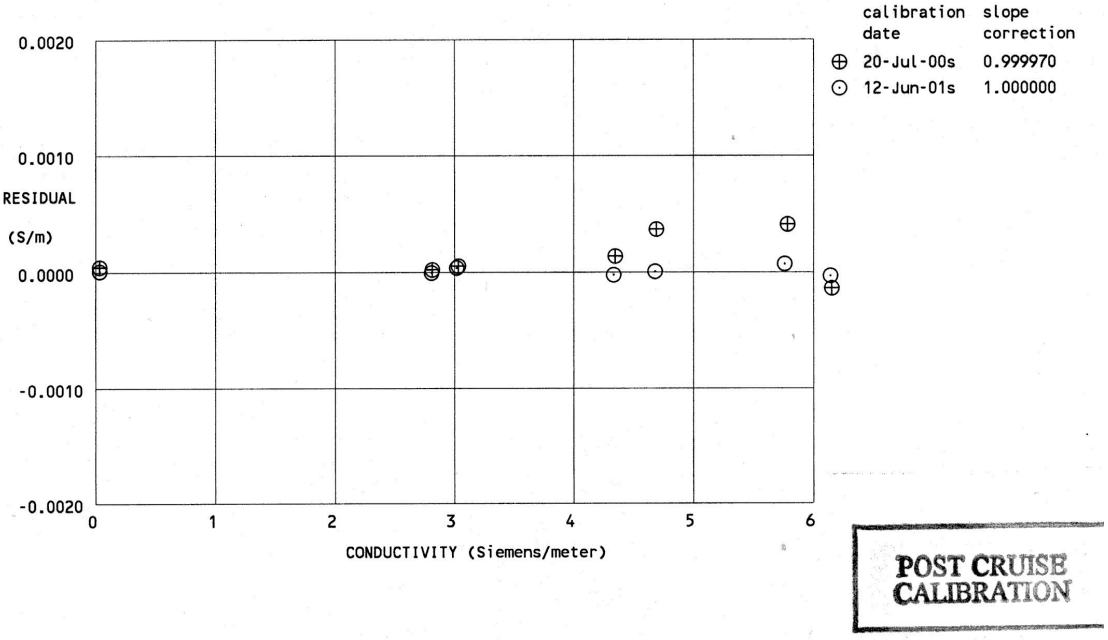
```
g = -1.03882978e+01
h =  1.45160286e+00
i = -4.68415158e-03
j =  4.15025489e-04
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)
```

ABCDM COEFFICIENTS

```
a =  7.50319225e-10
b =  1.43693792e+00
c = -1.03502558e+01
d = -5.55023876e-05
m =  9.4
CPcor = -9.57e-08 (nominal)
```

BATH TEMP (IPTS-68 °C)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.68402	-0.00000	-0.00000
-1.4245	34.9265	2.77667	5.15017	2.77666	-0.00001
1.0375	34.9266	2.98773	5.29083	2.98776	0.00003
15.2043	34.9280	4.30358	6.09432	4.30355	-0.00003
18.6852	34.9280	4.64976	6.28853	4.64976	-0.00000
29.1119	34.9283	5.72975	6.85864	5.72981	0.00006
32.6773	34.9266	6.11132	7.04879	6.11128	-0.00004

Conductivity = $(g + hf^2 + if^3 + jf^4) / [10(1 + \delta t + \epsilon p)]$ Siemens/meter
Conductivity = $(af^m + bf^2 + c + dt) / [10(1 + \epsilon p)]$ Siemens/meter
t = temperaure [deg C]; p = pressure [decibars]; δ = CTcor; ϵ = CPcor;
Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



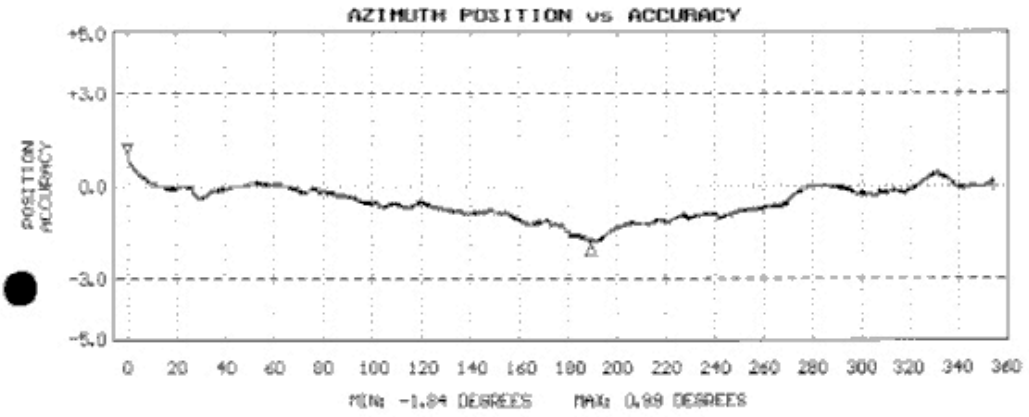
POST CRUISE CALIBRATION

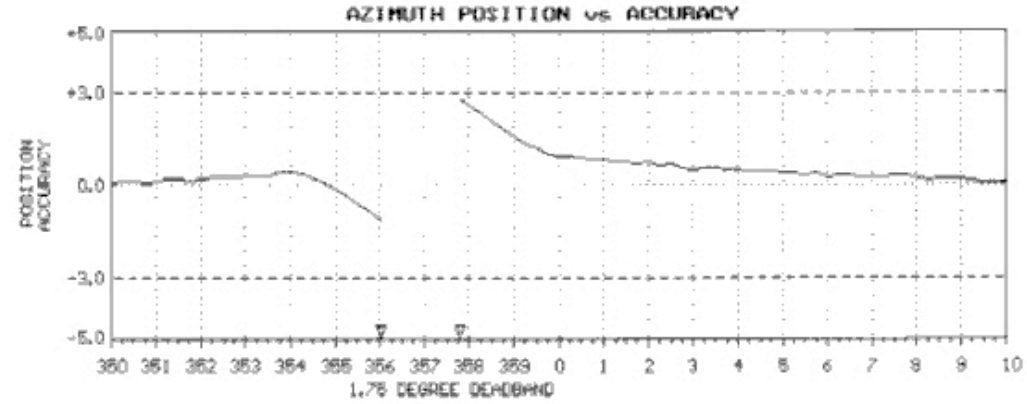
Meteorology System

Anemometer (Port)

R. M. YOUNG COMPANY WIND SENSOR CALIBRATION CERTIFICATE

SENSOR: 05106 WIND MONITOR-MA
SENSOR SERIAL NUMBER: WM45834
BEARINGS: SEALED/WATERPROOF GREASE
DATE: APR 6 2001
WIND SPEED THRESHOLD TEST: PASS
LOW WIND SPEED AMPLITUDE/FREQUENCY TEST: PASS
HIGH WIND SPEED AMPLITUDE/FREQUENCY TEST: PASS
VANE TORQUE TEST: PASS
SPECIAL NOTES:
SPECIAL NOTES:



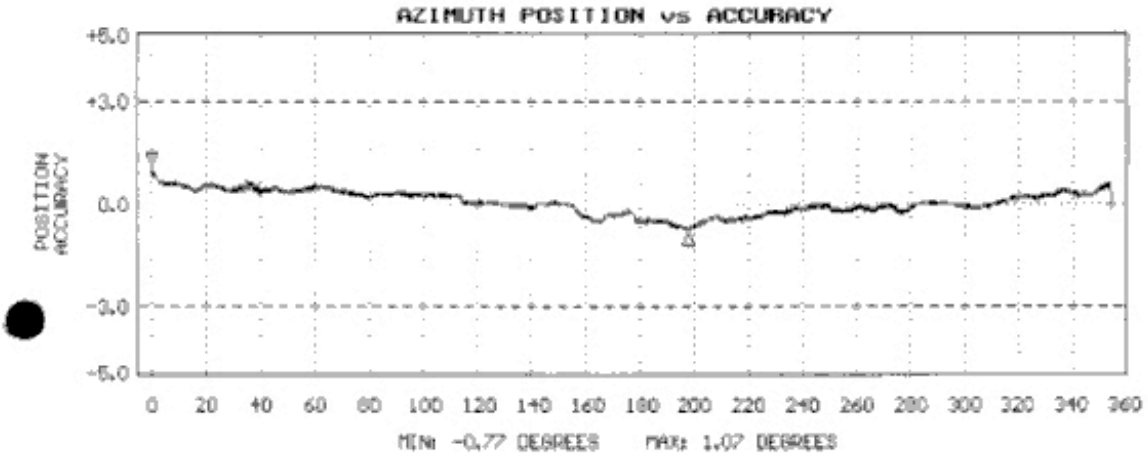


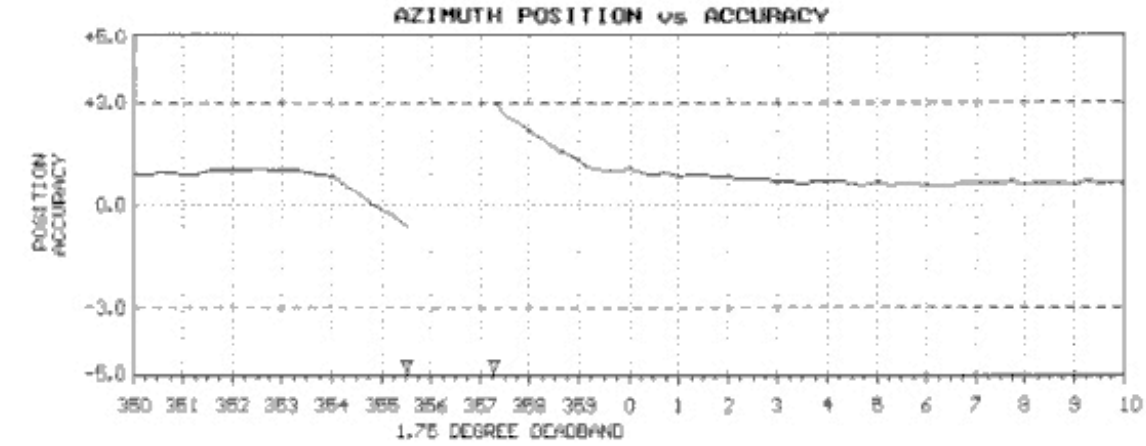
NOTE: Azimuth Position vs Accuracy graphs are accurate to within 0.5 degrees. The accuracy shown in the potentiometer deadband region between 355 and 0 degrees is the result of no resistance change while position changes. The gap represents the actual deadband (open circuit).

Anemometer (Starboard)

R. M. YOUNG COMPANY WIND SENSOR CALIBRATION CERTIFICATE

SENSOR: 05106 WIND MONITOR-MA
SENSOR SERIAL NUMBER: WM46263
BEARINGS: SEALED/WATERPROOF GREASE
DATE: APR 11 2001
WIND SPEED THRESHOLD TEST: PASS
LOW WIND SPEED AMPLITUDE/FREQUENCY TEST: PASS
HIGH WIND SPEED AMPLITUDE/FREQUENCY TEST: PASS
VANE TORQUE TEST: PASS
SPECIAL NOTES:
SPECIAL NOTES:





NOTE: Azimuth Position vs Accuracy graphs are accurate to within 0.5 degrees. The accuracy shown in the potentiometer deadband region between 355 and 0 degrees is the result of no resistance change while position changes. The gap represents the actual deadband (open circuit).

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: eplab@mail.bbsnet.com Internet: www.eppleylab.com

EPLAB
Scientific Instruments
for Precision Measurements
Since 1917

STANDARDIZATION OF EPPLEY PRECISION INFRARED RADIOMETER Model PIR

Serial Number: 32845F3

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

This pyrgeometer has been compared with Precision Infrared Radiometer, Serial Number 29326F3 in Eppley's Blackbody Calibration System under radiation intensities of approximately 200 watts meter^{-2} and an average ambient temperature of 24°C.

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

4.13 x 10^{-6} volts/watts meter^{-2}

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

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

Shipped to:
National Science Foundation
Port Heuneme, CA

Date of Test: February 22, 2001

In Charge of Test: R.T. Eppley

S.O. Number: 58376
Date: March 1, 2001

Reviewed by: Thomas D Kirk

Remarks:

PSP

THE EPPLEY LABORATORY, INC.
12 Sheffield Ave., P.O. Box 419, Newport, RI 02840 USA
Telephone: 401-847-1020 Fax: 401-847-1031

EPLAB
Scientific Instruments for Precision Measurements Since 1917

STANDARDIZATION OF EPPLEY PRECISION SPECTRAL PYRANOMETER Model PSP

Serial Number: 32850F3

Resistance: 706 Ω at 23 °C
Temperature Compensation Range: -20 to 40 °C

This radiometer has been compared with Standard Precision Spectral Pyranometer, Serial Number 21231F3 in Eppley's Integrating Hemisphere under radiation intensities of approximately 700 watts meter^{-2} (roughly one-half a solar constant). The adopted calibration temperature is 25 °C.

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

$$\frac{8.20}{5.72} \quad \times 10^{-6} \text{ volts/watts meter}^{-2} \text{ millivolts/cal cm}^{-2} \text{ min}^{-1} = 8.20 \times 10^{-3} \text{ mv/w}$$

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

The calibration of this instrument is traceable to standard self-calibrating cavity pyrheliometers in terms of the Systems Internationale des Unites (SI units), which participated in the Eighth International Pyrheliometric Comparisons (IPC VIII) at Davos, Switzerland in October 1995.

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

Shipped to:
National Science Foundation
Port Hueneme, CA

Date of Test: February 9, 2001

In Charge of Test: R.T. Eppman

S.O. Number: 58376
Date: March 1, 2001

Reviewed by: Thomas D Kuck

PAR

DO NOT DESTROY
Biospherical Instruments Inc.
CALIBRATION DATA

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	2/15/01
Model Number	QSR-240
Serial Number	6356
Operator	TPC
Standard Lamp	94532(03/13/98)
Probe Excitation Voltage Range:	5 to 18 VDC(+)
Output Polarity:	POSITIVE

Probe Conditions at Calibration(in air):

Calibration Voltage:	6	VDC(+)
Probe Current:	1.1	mA

Probe Output Voltage:

Probe Illuminated	86.6	mV
Probe Dark	0.3	mV
Probe Net Response	86.3	mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

8.55E+15	quanta/cm²sec
0.014	uE/cm^{2}sec

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

Dry:	1.01E-17	V/(quanta/cm²sec)
	6.08E+00	V/(uE/cm^{2}sec)

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

TSG Calibration Files

Underway Conductivity

SEA-BIRD ELECTRONICS, INC.
1808 136th Place N.E., Bellevue, Washington 98005 USA
Phone: (425) 643 - 9866 Fax: (425) 643 - 9954 Internet: seabird@seabird.com

SENSOR SERIAL NUMBER = 857
CALIBRATION DATE: 07-Feb-01

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

GHIJ COEFFICIENTS

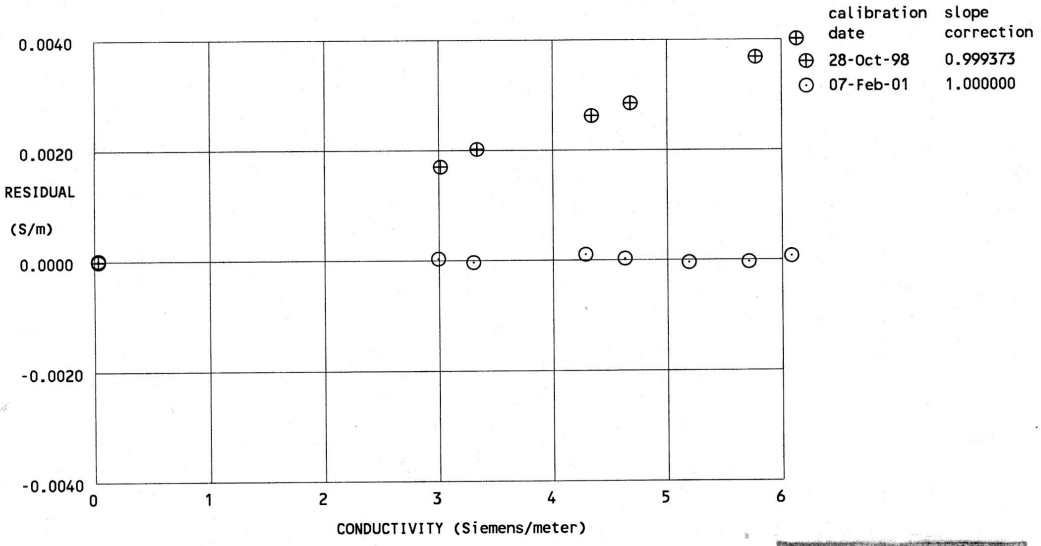
```
g = -4.05724357e+00
h =  4.84226382e-01
i =  1.14515552e-03
j = -2.84005419e-05
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)
```

ABCDM COEFFICIENTS

```
a =  4.78926301e-02
b =  4.32368827e-01
c = -4.04137716e+00
d = -1.12306086e-04
m =  2.1
CPcor = -9.57e-08 (nominal)
```

BATH TEMP (ITS-90 °C)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.88550	0.00000	0.00000
1.0001	34.6653	2.96429	8.27829	2.96430	0.00001
4.4999	34.6654	3.27188	8.64565	3.27183	-0.00005
14.9999	34.6641	4.25490	9.72645	4.25499	0.00009
18.5000	34.6631	4.60023	10.07823	4.60024	0.00001
24.0000	34.6604	5.15799	10.62162	5.15793	-0.00006
28.9999	34.6558	5.67898	11.10502	5.67893	-0.00005
32.4998	34.6481	6.04995	11.43675	6.05000	0.00005

Conductivity = $(g + hf^2 + if^3 + jf^4) / [10(1 + \delta t + \epsilon p)]$ Siemens/meter
Conductivity = $(af^m + bf^2 + c + dt) / [10(1 + \epsilon p)]$ Siemens/meter
t = temperaure [deg C]; p = pressure [decibars]; δ = CTcor; ϵ = CPcor;
Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



POST CRUISE CALIBRATION

Underway Temperature Sensor

SEA-BIRD ELECTRONICS, INC.
1808 136th Place N.E., Bellevue, Washington 98005 USA
Phone: (425) 643 - 9866 Fax: (425) 643 - 9954 Internet: seabird@seabird.com

SENSOR SERIAL NUMBER = 857
CALIBRATION DATE: 07-Feb-01

TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.24096327e-03
h = 5.99514049e-04
i = 4.88339043e-06
j = -1.67667318e-06
f_0 = 1000.000

IPTS-68 COEFFICIENTS

a = 3.64763319e-03
b = 5.84843916e-04
c = 9.94146384e-06
d = -1.67615257e-06
f_0 = 2720.016

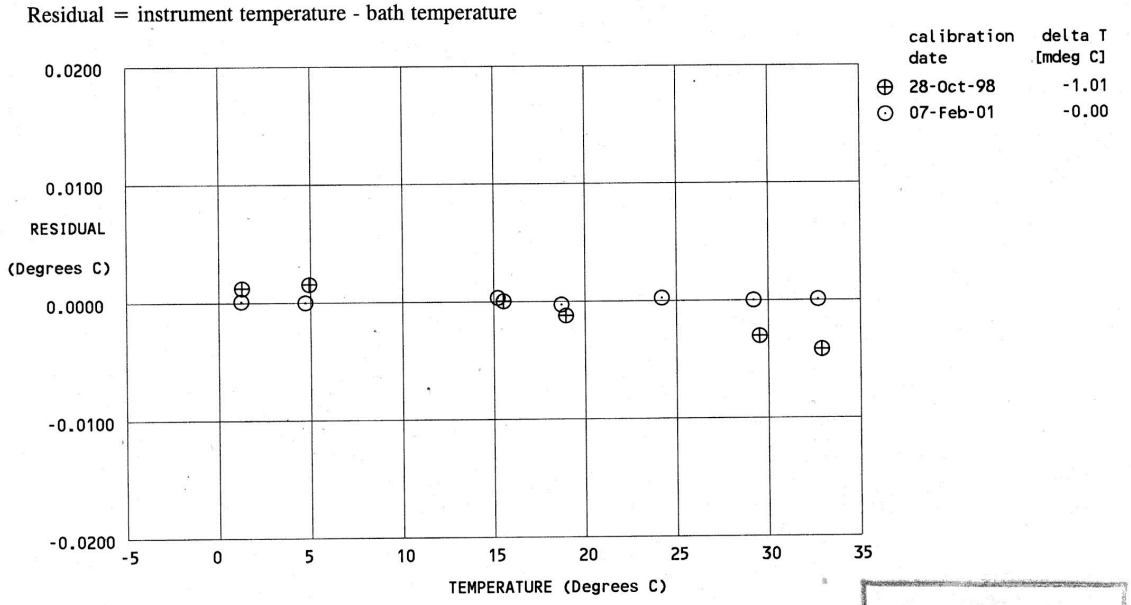
BATH TEMP (ITS-90 °C)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90 °C)	RESIDUAL (ITS-90 °C)
1.0001	2720.016	1.0001	0.00003
4.4999	2942.848	4.4998	-0.00007
14.9999	3689.140	15.0002	0.00025
18.5000	3965.047	18.4997	-0.00033
24.0000	4427.621	24.0002	0.00016
28.9999	4879.819	28.9998	-0.00006
32.4998	5214.974	32.4998	0.00002

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

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



POST CRUISE CALIBRATION

Underway Remote Temperature Sensor

SEA-BIRD ELECTRONICS, INC.
1808 136th Place N.E., Bellevue, Washington 98005 USA
Phone: (425) 643 - 9866 Fax: (425) 643 - 9954 Internet: seabird@seabird.com

SENSOR SERIAL NUMBER = [redacted]
CALIBRATION DATE: [redacted]

TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.76637285e-03
h = 6.64703922e-04
i = 2.05244583e-05
j = 2.64328920e-06
f_0 = 1000.000

IPTS-68 COEFFICIENTS

a = 3.67984422e-03
b = 5.89471142e-04
c = 1.47206122e-05
d = 2.64476073e-06
f_0 = 5720.436

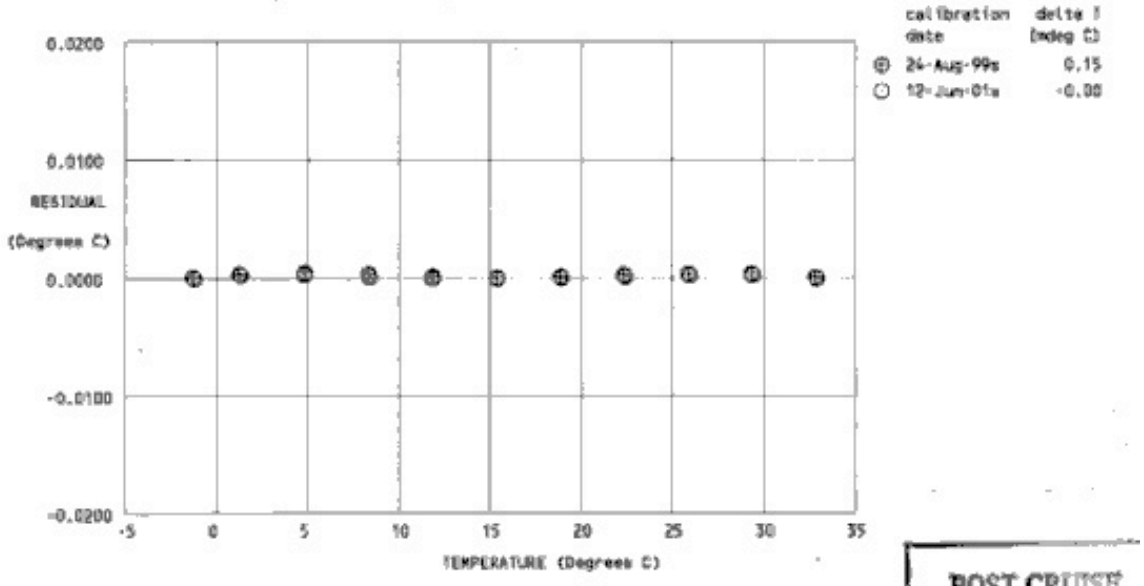
BATH TEMP (ITS-90 °C)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90 °C)	RESIDUAL (ITS-90 °C)
-1.3989	5720.436	-1.3990	-0.00016
1.1096	6057.177	1.1098	0.00015
4.6023	6549.634	4.6024	0.00018
8.2003	7086.466	8.2003	-0.00001
11.6341	7627.516	11.6340	-0.00011
15.1913	8218.360	15.1911	-0.00015
18.6957	8831.382	18.6956	-0.00007
22.1954	9474.904	22.1954	0.00004
25.7553	10162.291	25.7555	0.00015
29.1723	10853.790	29.1725	0.00016
32.7057	11602.038	32.7055	-0.00018

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



POST CRUISE CALIBRATION

C-Star Calibration Sheet

Date: [redacted]
Customer: National Science Foundation
Serial Number: [redacted]
Job Number: 0012016

V_d = V dark	0.059
V_{air} = V out in air	4.848
V_{ref} = V out in H_2O	4.818
Calibration Temp of H_2O	25.3
Ambient Temperature	25.1

% Transmission = $(V_{sig}-V_d)/(V_{ref}-V_d)$
$Tr = e^{-cx}$
To solve for the attenuation coefficient **c** in units of m^{-1} use the following equation.
$c = -1/x\ (\ln((V_{sig}-V_d)/(V_{ref}-V_d)))$
For further information on these calculations please see C Star Users Guide section 1.

Temperature Error: 0.02% F.S./°C

NOTES

- (V_d) is the analog output of the instrument with the beam blocked. This is an instrumental offset.
- (V_{air}) is the analog output voltage of the instrument with a cleared beam path.
- (V_{ref}) is the analog output voltage of the instrument with clean H_2O in the path.
- (**Calibration Temp of H_2O**) is the temperature of the clean H_2O used to obtain V_{ref}.
- (**Ambient Temperature**) is the temperature of the instrument during the calibration procedures.
- (V_{sig}) is the measured signal voltage of the C Star.