# Data Report
# NBP0207

**United States Antarctic Program**

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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, “.tar” extension. Tools are available on all platforms for uncompressing and de-archiving these formats: On Macintosh, use Stuffit Expander with DropStuff. On Windows operating systems use WinZip.

*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 | |
|---|---|
| 0207data.doc (this report)<br><br>NBP0207.trk<br>NBP0207.mgd<br>NBP0207.gmt<br><br>rvdas/uw 0207bat.tar<br>0207eng.tar<br>0207flr.tar<br>0207grv.tar<br>0207mag.tar<br>0207mbdp.tar<br>0207met.tar<br>0207pco2.tar<br>0207svp.tar<br>0207syn.tar<br>0207tsg.tar<br><br>rvdas/nav 0207adcp.tar<br>0207adu1.tar<br>0207gp02.tar<br>0207gyr1.tar<br>0207ngl.tar<br>0207PCOD.tar<br>0207seap.tar<br>0207trax.tar | geopdata/ 0207jgof.tar<br>0207mgd.tar<br>0207proc.tar<br>0207qcps.tar<br><br>ocean/ 0207xbt.tar<br><br>inst.cof<br>the instrument coefficients file entered into the computer at the beginning of the cruise<br><br>other/ 0207adcp.zip<br>0207batw.zip |

## 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 (NBP0207.trk). It contains the longitude and latitude at one-minute intervals extracted from the NBP0207.gmt file.

PostScript cruise tracks can be produced from this file

### *Satellite Images*

N/A

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*

N/A

## NBP Data Products

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) |
| 08 | Course made good | Degrees (azimuth) |
| 09 | Mast PAR | μEinsteins/meters$^2$ sec |
| 10 | Sea surface temperature | °C |
| 11 | Sea surface conductivity | Siemens/meter |

| Field | Data | Units |
|---|---|---|
| 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 NBP 0207.mgd. Also at the root level, NBP 0207.gmt is the output of the mgd77togmt utility using NBP 0207.mgd as input. The NBP 0207.gmt file can be used by GMT plotting software.

The data used to produce the NBP 0207.mgd file can be found on the distribution media in the file /geopdata/NBP 0207proc.tar. The data files in the PROC directory of the archive contain a day's data and follow the naming convention Dddd.fnl.gz, where ddd is the year-day. These files follow a space-delimited columnar format that may be more accessible for some purposes. They contain data at one-second intervals rather than one minute and are individually "gzipped" to save space. Below is a detailed description of the MGD77 data set format. The other directories in the archive contina interim processing files and are included to simplify possible reprocssing of the data using the RVDAS NBP processing scripts.

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

| Col | Len | Type | Contents | Description, Possible Values, Notes |
|---|---|---|---|---|
| 1 | 1 | Int | Data record type | Set to "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<br>- = South. (–9000000 to 9000000) |
| 36-44 | 9 | real | Longitude x 100000 | + = East<br>- = West. (–18000000 to 18000000) |
| 45 | 1 | int | Position type code | 1=Observed fix<br>3=Interpolated<br>9=Unspecified |
| 46-51 | 6 | real | Bathymetry, 2- way travel time | In 10,000th of seconds. Corrected for transducer depth and other such corrections |
| 52-57 | 6 | real | Bathymetry, corrected | In tenths of meters. |

| Col | Len | Type | Contents | Description, Possible Values, Notes |
|---|---|---|---|---|
| | | | depth | |
| 58-59 | 2 | int | Bathymetric correction code | This code details the procedure used for determining the sound velocity correction to depth |
| 60 | 1 | int | Bathymetric type code | 1 = Observed<br>3 = Interpolated (Header Seq. 12)<br>9 = Unspecified |
| 61-66 | 6 | real | Magnetics total field, $1^{ST}$ sensor | In tenths of nanoteslas (gammas) |
| 67-72 | 6 | real | Magnetics total field, $2^{ND}$ sensor | In tenths of nanoteslas (gammas), for trailing sensor |
| 73-78 | 6 | real | Magnetics residual field | In tenths of nanoteslas (gammas). The reference field used is in Header Seq. 13 |
| 79 | 1 | int | Sensor for residual field | 1 = $1^{st}$ or leading sensor<br>2 = $2^{nd}$ or trailing sensor<br>9 = Unspecified |
| 80-84 | 5 | real | Magnetics diurnal correction | In tenths of nanoteslas (gammas). (In nanoteslas) if 9-filled (i.e., set to "+9999"), total and residual fields are assumed to be uncorrected; if used, total and residuals are assumed to have been already corrected. |
| 85-90 | 6 | F6.0 | Depth or altitude of magnetics sensor | (In meters)<br>+ = Below sea level<br>3 = Above sea level |
| 91-97 | 7 | real | Observed gravity | In $10^{th}$ of mgals. Corrected for Eotvos, drift, tares |
| 98-103 | 6 | real | EOTVOS correction | In tenths of mgals.<br>E = 7.5 V cos phi sin alpha + 0.0042 V*V |
| 104-108 | 5 | real | Free-air anomaly | In tenths of milligals<br>G = observed<br>G = theoretical |
| 109-113 | 5 | char | Seismic line number | Cross-reference for seismic data |
| 114-119 | 6 | char | Seismic shot-point number | |
| 120 | 1 | int | Quality code for navigation | 5=Suspected, by the originating institution<br>6=Suspected, by the data center<br>9=No identifiable problem found |

## Science of Opportunity

### *ADCP*

The shipboard ADCP system measures currents in 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 file coadcp.zip. 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 `0207adcp.tar` in the file /other/0207adcp.zip

### *$PCO_2$*

The NBP carries 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. The $pCO_2$ data is transmitted and archived on RVDAS. You will find it in a file named `0207pco2.tar` in the /rvdas/uw directory, which contains the $pCO_2$ instrument's data merged with GPS, meteorological and other oceanographic measurements. For more information contact Colm Sweeney (csweeney@ldeo.columbia.edu) for additional information.

## Cruise Science

### *CTD*

No CTDs this cruise.

### *XBT, XCTD*

During the cruise Expendable Bathythermographs and Expendable CTDs were used to obtain water column temperature profiles. The data files from these launches are included in the file /ocean/0207xbt.tar

## RVDAS

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

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 general categories, *underway and navigation*. They can be found on the distribution media as /rvdas/uw and /rvdas/nav. Processed oceanographic data is in /geopdata. 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, NBP 02-07.
- The Channel ID is a 4-character code representing the system being logged. An example is "met1," the designation for meteorology.
- DDD is the day of year the data was collected

## Underway Sensors

### Meteorology and Radiometry

| Measurement | Channel ID | Collect. Status | Rate | Instrument |
|---|---|---|---|---|
| Air Temperature | met1 | Continuous | 1 sec | R. M. Young 41372LC |
| 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 |
| PAR | met1 | Continuous | 1 sec | BSI QSR-240 |
| GUV | guv | Continuous | | 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 | Collected | Varies | ODEC Bathy 2000 |
| Bathymetry | knu1 | Not collected | Varies | Knudsen 320B/R |
| Bathymetry | sim1 | Not Collected | 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 | Calc. From pri. temp |
| Sea Surface Temp | tsg1 | Continuous | 6 sec | SeaBird 3-01/S |
| Fluorometry | flr1 | Continuous | 1 sec | Turner 10-AU-005 |
| Fluorometry | flr1 & tsg1 | Continuous | 6 sec | |
| 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 | ngl1 | Continuous | 1 sec | NGL Processed Data |

### *Data*

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

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

where

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

All times are reported in UTC.

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

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

## Underway Data

### 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 18 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 strength | not used | |
| 6 | Signed heave data | SHHHH | cm |
| 7 | Date | mm/dd/yy | |
| 8 | Time | hh:mm:ss | |
| 9 | Transmit pulse window type | PW1=Rectangular<br>PW2=Hamming<br>PW3=Cosine<br>PW4=Blackman | |
| 10 | Primary transmit frequency | PF1=3.5 kHz<br>PF2=12.0 kHz | kHz |
| 11 | Parametric mode secondary frequency | SF1=3.5 kHz<br>SF2=12.0 kHz | kHz |
| 12 | Pulse length | PL1=200usec<br>PL2=500usec<br>PL3=1msec<br>PL4=2msec<br>PL5=5msec<br>PL6=10msec<br>PL7=25msec<br>If transmit mode is FM:<br>PL1=25msec<br>PL2=50msec<br>PL3=100msec | |
| 13 | Operating mode | MO1=CW parametric<br>MO2=CW<br>MO3=FM parametric<br>MO4=FM | |
| 14 | Frequency sweep bandwidth | SB1=1 kHz<br>SB2=2 kHz<br>SB3=5 kHz | kHz |
| 15 | Power level | PO1 = 0dB<br>PO2 = -6dB<br>PO3 = -12dB<br>PO4 = -18dB<br>PO5 = -24dB<br>PO6 = -30dB<br>PO6 = -30 dB<br>PO7 = -36dB<br>PO8 = -42dB | |
| 16 | Transmit mode | TX1=single ping active<br>TX2=pinger listen<br>TX3=multipinging TR<br>TX4=multipinging TR<br>TX5=multipinging TTRR<br>TX6=multipinging TTTTRRRR<br>TX7=multipinging TTTTTRRRRR | |
| 17 | Transmit Rate | TR3 = 4Hz<br>TR4 = 2Hz | Hz |

| Field | Data | Format / Possible Values | Units |
|---|---|---|---|
| | | TR5 = 1Hz<br>TR6 = .5Hz<br>TR7 = .33Hz<br>TR8 = .25Hz<br>TR9 = .20Hz<br>TR: = .10Hz<br>TR; = .05Hz | |
| 18 | System gain mode | GM0=hydrographic AGC<br>GM1 to GM9=hydrographic +3db to + 27db manual.<br>GMA to GMD=hydrographic + 30db through + 60db manual<br>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 |

## Thermosalinograph (tsg1)

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

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | Seabird hex string (see page 18 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 fractional time of day) | yyyddd.ttt |

| Field | Data | Units |
|---|---|---|
| 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 (not collected) | |
| 11 | Longitude (not collected) | |
| 10 | Flow source (Equil = $pCO_2$ measurement) | |

## Navigational Data

## Seapath GPS (seap)

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

- INZDA
- INGGA
- INVTG
- INHDT
- PSXN, 22
- PSXN, 23

### INZDA

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

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

### INGGA

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

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $INGGA | |
| 3 | time | hhmmss.ss |
| 4 | Latitude | ddmm.mmmmmm |
| 5 | N or S for north or south latitude | |
| 6 | Longitude | ddmm.mmmmmm |

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

## INVTG

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

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

## INHDT

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

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $INHDT | |
| 3 | Heading | |
| 4 | T | |
| 5 | Checksum | |

## PSXN,22

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

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

## PSXN,23

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

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

## 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 Position: ECEF X | meters |
| 6 | Station Position: ECEF Y | meters |
| 7 | Station Position: ECEF Z | meters |
| 8 | Latitude ( - = South ) | deg:min |
| 9 | Longitude ( - = West ) | deg:min |
| 10 | Altitude | meters |
| 11 | Velocity8 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 |

| Field | Data | Units |
|---|---|---|
| 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:<br>0 = Fix not available or invalid | |

| Field | Data | Units |
|---|---|---|
| | 1 = GPS, SPS mode, fix valid<br>2 = DGPS (differential GPS), SPS mode, fix valid<br>3 = P-CODE PPS mode, fix valid | |
| 9 | Number of GPS satellites used | |
| 10 | HDOP (horizontal dilution of precision) | |
| 11 | Antenna height | meters |
| 12 | M for meters | |
| 13 | Geoidal height | meters |
| 14 | M for meters | |
| 15 | Age of differential GPS data (no data in the sample string) | |
| 16 | Differential reference station ID (no data in the sample string) | |
| 17 | Checksum (no delimiter before this field) | |

### GLL: GPS Latitude/Longitude

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

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

### VTG: GPS Track and Ground Speed

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

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

## Gyro Compass (gyr1)

```
00+019:23:59:59.952 $HEHRC 25034,-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 | |

## 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 | degrees |

## 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 |

| Field | Data | Units |
|---|---|---|
| 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 |
| 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 | μSiemens |
| 5 | Salinity | PSU |
| 6 | Fluorometry | V |
| 7 | Unused | |

# Calculations

The file *inst.cof* located in the /directory contains the calibration factors for shipboard instruments. This was the file 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 rvdascal.txt 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); $\delta$ = Ctcor; $\varepsilon$ = 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/(μEinstiens/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= μEinstiens/$m^2$sec
or
(*data* mV – 0.3 mV) x 1.65 (μEinstiens/$m^2$sec)/mV = μEinstiens/$m^2$sec

## 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 yy+ddd:hh:mm (yy is 2-digit year, ddd is year-day, hh is hour, and mm is minute). Times are reported in GMT.

| Start | End | Description |
|---|---|---|
| 02+314:18:00(lt) | | Start data collection. |
| 02+315:17:05 | 02+317:00:02 | Enter Mexican waters |
| 02+315:17:21 | | Alarm L176: the following program should always run, but is still not running<br>SimRad said to reboot |
| 02+316:13:22 | | Reboot MB |
| 02+316:13:37 | | SimRad locked on bottom no error messages |
| 02+317:00:02 | | Leave Mexican waters at Lat 27:30 long 121:49 |
| 02+317:22:03 | 02+317:22:30 | Complete power loss to all computer systems |
| 02+317:22:30 | | Reboot system appears ok |
| 02+319:19:45 | | Put in new SVProfile. Missing data ~ 10minutes |
| 02+322:03:15 | | First noticed navigation errors. Ship track and sonar track do not match (seapath?) Forced system to find depth and it seemed to help |
| 02+322:15:22 | | Ship track askew to sonar again. Forced depth |
| 02+323:07:30 | | Ship track askew to sonar again. Forced depth |
| 02+323:10:15 | | Ship track askew to sonar again. Forced depth |
| 02+323:22:20 | | Put in new SVProfile. Missing data ~ 10minutes |
| 02+324:07:40 | | Ship track askew to sonar again. Forced depth (paper copy has lat and long) |
| 02+324:15:32 | | Ship track askew to sonar again. Forced depth (paper copy has lat and long) |
| 02+324:16:30 | | Ship track askew to sonar again. Forced depth (paper copy has lat and long) |
| 02+324:16:57 | | Ship track askew to sonar again. Forced depth (paper copy has lat and long) |
| 02+325:19:45 | | Pulled out a data sample to transmit to office for analysis of navigational errors |
| 02+326:15:31 | | Crossed into Kiribati waters |
| 02+326:19:34 | | Ship made turns in the form of a “Z” in an attempt to force Seapath system to resolve ship track errors |
| 02+326:21:05 | | Turn done back on course |
| 02+326:22:12 | | Ship track askew to sonar again. Forced depth (paper copy has lat and long) |
| 02+326:23:13 | | Slowed to 5kts (file 233, 234) |

| | | |
|---|---|---|
| 02+327:00:40 | | Resume speed 11kts |
| 02+327:19:27 | | Ship made full circle (360') turn in an attempt to force Seapath system to resolve ship track errors (file 254) |
| 02+327:19:50 | | Turn completed |
| 02+327:20:50 | | Ship track askew to sonar again. Forced depth (paper copy has lat and long) |
| 02+327:22:34 | | Slowed to 5 kts (ping 257) |
| 02+328:00:22 | | Leave Kiribati. Enter Cook Islands. |
| 02+330:01:10 | | Slowed to 5kts (line 309) |
| 02+330:19:30 | | PCO2 pump stopped working |
| 02+331:09:04 | | Leave Cook Islands waters / Enter Niue |
| 02+333:13:12 | | Leave Niue |
| 02+333:1616 | | Turned on filter "Aeration" to help get rid of smiles. (line 374) |
| 02+333:17:03 | | Tsg alarm started showing again on screen. Data seems to be coming in on device setup. Raw input |
| 02+333:20:08 | | Changed out tsg, changed instrument coeff and restarted das |
| 02+333:21:30 | | Line 377/378 turned off Aeration filter |
| 02+334:19:32 | | Change out tsg again. Errors with MB system. Set sound speed at transducer to manual 1520 m/sec |
| 02+334:20:26 | | Crossed 200mi limit into NZ waters |
| 02+334:21:30 | 02+334:22:00 | Rebooted fram and restarted rv-das on eltanin the new tsg coeff were put back into the system |
| 02+ | | Em120 line 427 si 4 hours long. Reason unknown. Stopped and restarted logging in order to get lines into 1hr sync again |
| 02+335:02:30 | | Line 431 added new svp (xbt T5-00196) |
| 02+336:18:35 | | Line 467 of MB exchanged out new svp (xbt T5-00196) |
| 02+337:13:15 | | Em120 crashed cause unknown. Reboot at line 486 |
| 02+337:13:20 | | During reboot said could not bring up BIST test |
| 02+337: | | Restarted operator station then ran test on BIST. TX power took a long time (4 to 5 mins) S18: No reply to current BIST test. Sensors went red then in 2 mins came back to green. Noise = 63.0db / Hz. Ch1 – 61 av 63.0. Ch1 showed low=57.6 and high=66.4 vs Ch61 showed low=61.4 high=61.5<br>On active warning launchpad: logfile size 0.31 reset is recommended. Turned active – no pinging (shows active but no pings) |
| 02+337:13:49 | | P421 communication problems between SPRX and BSP Merlin signal 10 received<br>Low voltage power failure. Run BIST for more details<br>P406 DC Offset problem on some receiver channels |

| | | |
|---|---|---|
| | | Error in communication<br>++++++++++++++++++<br>P464 Error in communication with TRU<br>P421 Communications problems between SPRX and BSP (3 error:)<br>P464 (see above error P464)<br>P406 Low voltage power supply failure<br>Echo sounder,<br>P406 DC Offset problem on some receiver channels: Action run BIST (RX-Channels) for more details<br>Merlin signal 10 received<br>+++++ Then repeted the last 7 errors |
| 02+ | | Survey window keeps closing<br>warning launchpad: logfile size 0.31 reset is recommended<br>Merlin signal 11 received |
| 02+ | | Went to main file and reset logfile.<br>Survey window still continues to close<br>“echo sounder is ready”<br>TSG giving bad signals all night<br>Sound speed at transducer set manually |
| | | |
| | | End log |
| | | |
| | | |
| | | |

# Appendix: Sensors and Calibrations

## NBP 0207 Sensors:

### *Shipboard Sensors*

| Sensor | Description | Serial # | Last Calibration Date | Status |
|---|---|---|---|---|
| **Meteorology & Radiometers** | | | | |
| Port Anemometer | RM Young 5106 | WM46834 | 03/15/02 | Collect |
| Stbd Anemometer | RM Young 5106 | WM46263 | 03/15/02 | 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 | 06/11/02 | Collect |
| PSP (Pyranometer) | Eppley PSP | 33090F3 | 12/06/01 | Collect |
| Mast PAR | BSI QSR-240 | 6356 | 02/15/01 | Collect |
| GUV | | | | Not used |
| PUV | | | | Not used |
| **Underway** | | | | |
| TSG | SeaBird SBE21 | 0857 | 07/12/02 | Collect |
| TSG Remote Temp | SeaBird 3-01/S | 034071 | 04/16/02 | 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-422PR | 12/20/01 | 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 |

### *NBP 0207 CTD Sensors:*

| Sensor | Description | Serial # | Last Calibration Date | Status |
|---|---|---|---|---|
| CTD Fish | SeaBird model SBE 9+ | N/A | | Collect |
| CTD Fish Pressure | Paroscientific model 410K-105 pressure sensor | N/A | | Collect |
| CTD Deck Unit | SeaBird model SBE 11+ | N/A | | Collect |
| Primary Temperature Sensor | SeaBird model 3-02/F | N/A | | Collect |
| Secondary Temperature Sensor | SeaBird model 3-02/F | N/A | | Collect |
| Primary Conductivity Sensor | SeaBird model 4-02/0 | N/A | | Collect |
| Secondary Conductivity Sensor | SeaBird model 4C | N/A | | Collect |
| Dissolved Oxygen Sensor | SeaBird model 13-02-B | N/A | | Collect |
| PAR Sensor | Biospherical Instruments QSR-240 | N/A | | Collect |
| PAR Sensor | Biospherical Instruments QSR-240 | N/A | | Collect |
| Transmissometer | WET Labs CST-423PR, C-Star | N/A | | Collect |

## Calibrations

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:** 11/9/02
**Location:** Port Hueneme, California
Station: Ventura County Airport
Latitude: 034 12 N
Longitude: 119 12 W
Elevation: 13.1m
Gravity: 979608.813

Reference Code Numbers:
Station no. 5617-1
ISGN no. 12049J

| | Value | Time (GMT) |
|---|---|---|
| Ship's meter before gravity tie (Digital Gravity) | 7244.6 | 21:45 |
| Ship's meter after gravity tie (Digital Gravity) | 7246.8 | 0:31 |
| Average | 7245.7 | |
| Ship Gravimeter's Calibration Constant | 1.0046 | |
| Corrected ship's meter (Digital Gravity) | 7279.0 | |

| | Value | Time (GMT) |
|---|---|---|
| Ship's meter before gravity tie (serial, RVDAS) | 7278.6 | 21:46 |
| Ship's meter after gravity tie (serial, RVDAS) | 7281.0 | 0:32 |
| Average (for comparison check only) | 7279.8 | |

Portable Gravimeter Correction Divisor 1.007937

| Station | Value | Time (GMT) | Temp | Date | OBS mgal, averaged |
|---|---|---|---|---|---|
| Pier measurement 1 | 3223.70 | 23:02 | 54 | Nov. 09, 2002 | |
| Pier measurement 2 | 3223.69 | 23:05 | 53 | Nov. 09, 2002 | 3198.30 |
| Pier measurement 3 | 3223.66 | 23:07 | 53 | Nov. 09, 2002 | |
| Average | 3223.68 | | | | |

| | | | | | OBS mgal, averaged |
|---|---|---|---|---|---|
| Station measurement 1 | 3207.03 | 23:06 | 53 | Nov. 09, 2002 | |
| Station measurement 2 | 3207.01 | 23:45 | 54 | Nov. 09, 2002 | 3181.77 |
| Station measurement 3 | 3207.04 | 23:51 | 54 | Nov. 09, 2002 | |
| Average | 3207.03 | | | | |

| | | | | | OBS mgal, averaged |
|---|---|---|---|---|---|
| Pier measurement 4 | 3223.87 | 0:22 | 54 | Nov. 10, 2002 | |
| Pier measurement 5 | 3223.90 | 0:23 | 54 | Nov. 10, 2002 | 3198.50 |
| Pier measurement 6 | 3223.90 | 0:25 | 54 | Nov. 10, 2002 | |
| Average | 3223.89 | | | | |

Gravity offset from last tie 972348.79
Drift since last tie -2.23

| OBS Differences | |
|---|---|
| Station to Pier (1, 2, & 3 averaged) | 16.53 |
| Station to Pier (4, 5, & 6 averaged) | 16.73 |
| Averaged Differences | 16.63 |
| Gravity at pier | 979625.44 |
| Elevation of pier above gravimeter, meters | 0.5 |
| Earth differential gravity, mgal/meter | 0.3 |
| Gravity at ship's gravimeter | 979625.59 |
| Gravity Offset | 972346.56 |

**Comments**

Gravity Tie done by Floyd Trujillo and Sheldon Blackman

# Meteorology System

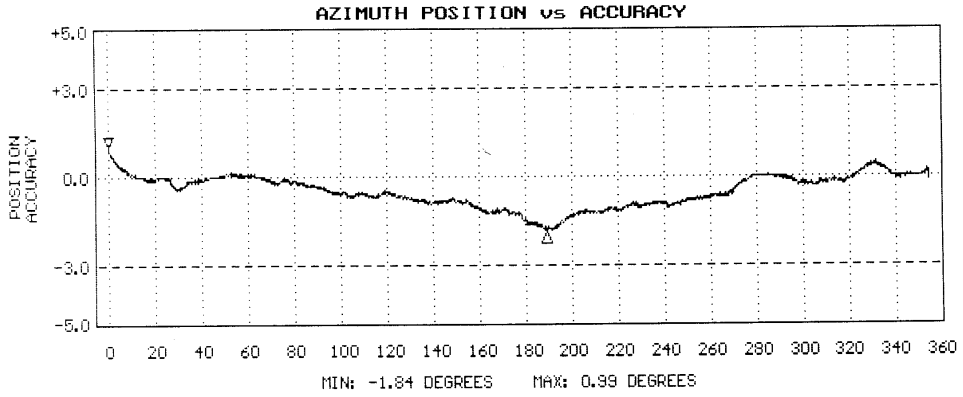
## *Anemometer (Port)*

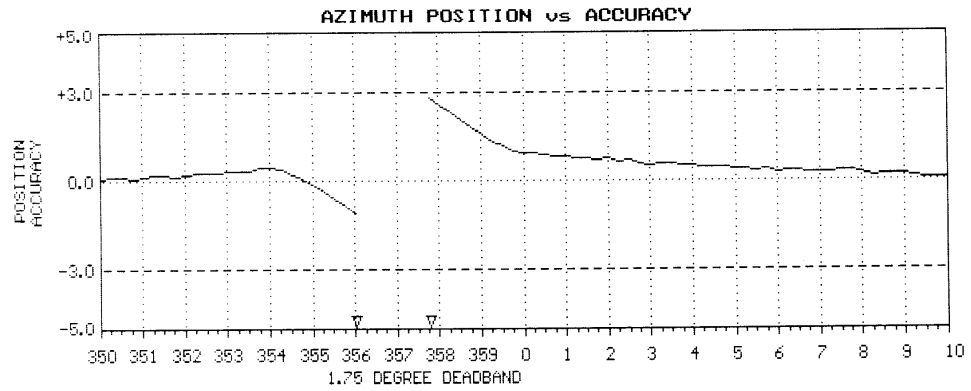
---

**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:**



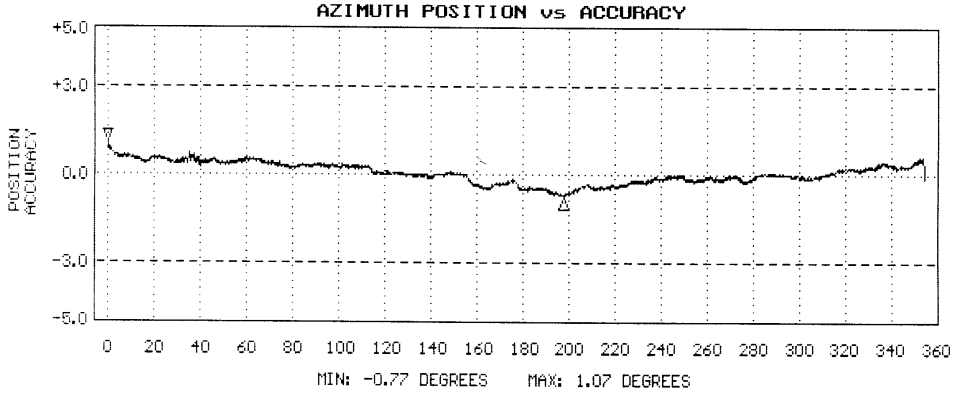



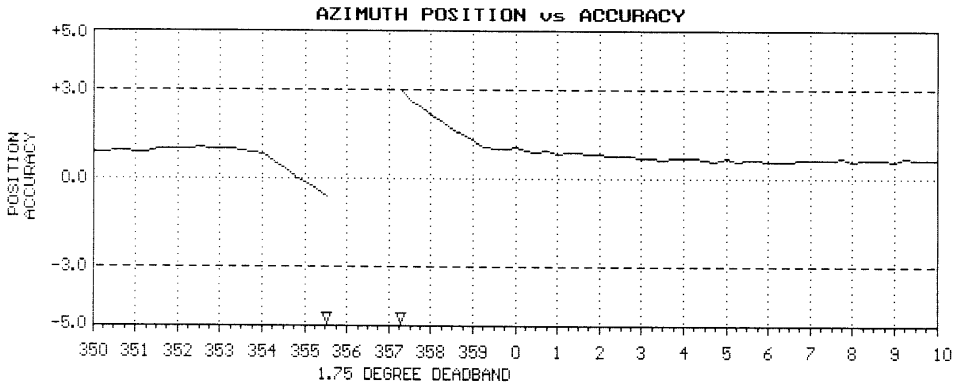

NOTE: Azimuth Position vs Accuracy graphs are accurate to within 0.5 degrees. The accuracy shown in the potentiometer deadband region between 355 and 0 degrees is the result of no resistance change while position changes. The gap represents the actual deadband (open circuit).

## *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 (Mast)***

**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

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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 23 °C.

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

$$4.13 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 700 watts meter$^{-2}$. 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 Hueneme, CA

S.O. Number: 59011
Date: June 19, 2002

Date of Test: June 11, 2002

In Charge of Test: R T Foreman

Reviewed by: Thomas D Kuk

Remarks:

***PSP (Mast)***

**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 SPECTRAL PYRANOMETER Model PSP

Serial Number: 33090F3

Resistance: 699 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:

8.19 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 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 Ninth International Pyrheliometric Comparisons (IPC IX) at Davos, Switzerland in September-October 2000.

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 Scientific Foundation
Port Hueneme, CA

S.O. Number: 58775
Date: December 13, 2001

Date of Test: December 6, 2001

In Charge of Test: R. T. Eppley

Reviewed by: Thomas D Kuhr

Remarks:

## *GUV (Mast)*

Calibration Certificate

**Biospherical Instruments Inc.**

### Calibration Certificate for GUV & PUV Radiometers

**Serial Number: 9266** Instrument Model: PUV-511 Date Solar Data Processed: 12/14/01
**Solar Calibration Dates: 11/01/01 to 11/03/01** Solar Reference GUV(s): 9250
**Lamp Calibration Date: 10/16/01** Solar Ref Cal Factor Version: 1
**Owner of Instrument: RAYTHEON** Solar Calibration at: San Diego, CA (BSI)
**Data Analyst(s): JSR** General Comments: Original Calibration

A note to the end-user. Instrument calibration is easily as important as instrument deployment, but it is often overlooked. This document has been prepared to help explain the conditions under which the different sensors in your instrument have been calibrated. Please read this information carefully and completely. If you do not understand a calibration factor, please feel free to contact the factory for a more detailed explanation.

GUV and GTR radiometers are precision, temperature-controlled filter radiometers designed for long term monitoring. PUV-510 Reference Ultraviolet Radiometers are designed to provide the above-water counterpart to the PUV-500 providing fast and accurate measurements of solar UV in the water column. Both of these series of instruments are calibrated in two different ways: "lamp calibrations" and "solar calibrations." The more familiar lamp calibration is performed in our laboratory using a NIST-traceable 1000 Watt FEL-type Standard of Spectral Irradiance and the methods described in National Bureau of Standards (US) publications 594-13 and 250-20. This standardized procedure gives good accuracy when calibrating the PAR visible channel and is useful in indicating if channel sensitivities have changed over time. Lamp calibrations are problematic for solar UV measurements because the solar spectrum is radically different from the lamp spectrum and changes greatly as a function of wavelength. Solar calibrations are achieved through direct comparison with "reference" GUVs (RGUVs) using the sun as the source of irradiance. These RGUVs are, in turn, calibrated through continuous intercomparison with a high resolution scanning spectroradiometer in San Diego (SUV-100) that is part of a world-wide UV monitoring network.

As a result of our calibration research, we have now standardized on solar calibrations for the UV channels while retaining the traditional lamp-based calibration for PAR. It is important to note that the solar calibration procedure automatically takes into account the spectral bandwidth of the detectors and therefore report the irradiance as a 1nm wide triangular bandpass centered on the nominal wavelength.

**Caveats.** The reference instruments used at Biospherical are "GUV" model radiometers that are temperature controlled and equipped with cosine collectors optimized for use in air. Years of GUV solar calibration experience have shown the procedure to be robust, accurate and reproducible for generalized GUV calibrations. PUVs are not temperature stabilized, a factor adding uncertainty to GUV/PUV calibration transfers. We are recommending that researchers use the solar calibration constants. Generally, these effects are well below the 10% uncertainty level. For a more detailed discussion, see Booth et al. (1994) Errors in reporting of solar irradiance using moderate bandwidth radiometers: an experimental investigation. SPIE Vol. 2258 Ocean Optics XII: 654-663.

*Note: These calibration documents also apply to the "GTR" variant of the GUV instruments.*

UV Irradiance Channels Calibrated Using Solar Intercomparison

| ROM Tag Number | Chs | Nominal Wavelength (nm) | Initial Offset (Volts) | Scale Factor in Air | Resulting Units |
|---|---|---|---|---|---|
| N/A | 2 | 305 | -0.00022 | 0.51767 | μW/(cm²·nm) |
| N/A | 4 | 320 | 0.00018 | -0.10711 | μW/(cm²·nm) |
| N/A | 5 | 340 | -0.0001 | -0.11218 | μW/(cm²·nm) |
| N/A | 6 | 380 | -0.0022 | -0.04364 | μW/(cm²·nm) |

*Note: Units for the Scale Factors are Volts/(μW/(cm² ·nm)). The initial offsets shown above resulted from our rooftop intercomparisons and they should be redetermined after the instrument is in its final installation, since the offset at 305nm is known to shift somewhat during shipping.*

12/15/2001 9266solarcal12-01.xls

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## *GUV (Mast)*

**Standard Lamp Calibrated Channels (PAR)** Serial Number: 9266

| ROM Tag Number | Ch# | Nominal Wavelength (nm) | Initial Offset (Volts) | Scale Factor in Air | Resulting Units |
|---|---|---|---|---|---|
| N/A | 8 | PAR | 0.0002 | -8.563 | µE/(cm²·sec) |
| *Lamp Reference* | | 91773 (04/12/01) | | | Units for the Scale Factors are Volts/(µEinsteins/(cm²·sec)) |

Photosynthetically Active (or Available) Radiation (PAR). In our instruments, PAR is measured over the spectral region from 400 to 700 nm using sensors with a constant quantum response (responds equally to all wavelengths). Instruments are available from Biospherical with one of two different irradiance measurement geometries. The PAR channel in the PUV measures (plane) downwelling irradiance, "Ed (PAR)", which is the downward irradiance incident on a flat surface of unit area. The measurement in a PUV-500 is made with a "cosine" collector optimized for use underwater. The GUV and PUV-510 also uses cosine collectors, but optimized for use in air. For this reason, direct comparisons of PUV-500 with PUV-510 or GUV-511 instruments are difficult.

Ed(PAR) is often confused with scalar irradiance, Eo (PAR), which is a measure of the radiance flux integrated from all directions incident on a point in space, as used by the PNF-300 Natural Fluorometer. Downwelling PAR irradiance will always be less than the scalar PAR under natural aquatic conditions.

Please note that the PUV is calibrated in µE/(cm²·sec). This is different from the PNF (cm⁻², not m⁻²).

This channel is calibrated by a standard lamp.

**Instrument Diagnostic Channels**

| ROM Tag Number | Ch# | Variable | Offset | Scale Factor | Original Value | Resulting Units |
|---|---|---|---|---|---|---|
| N/A | 7 | Diode Array Gnd. | 0 | 1 | 0.000038 | Volts |

*Note: These channels are not normally used in data analysis, but are available for monitoring instrument performance, and for monitoring long term changes in the electronics. The offsets in these channels are normally entered with Offset as 0 and Scale as 1. Ground channels track the potential at several locations in the instrument, and the reference voltage is used to monitor the performance of the analog to digital converter. The voltages shown are not calibration factors, but they are the values at the time of this calibration and are included for reference.*

**Temperature**

| ROM Tag Number | Ch# | Function | Offset | Scale Factor | Resulting Units |
|---|---|---|---|---|---|
| N/A | 1 | Detector Array Temperature | 0 | 0.01 | °C |
| N/A | 3 | Electronics Temperature | 0 | 0.01 | °C |

*Note: "Detector Array Temperature records the temperature of the detector/filter array. It is possible to use data from this to compensate for the residual temperature sensitivity in the PUV, but this compensation is not supported in our software.*

2 12/15/2001 9266solarcal12-01.xls

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## *PAR (mast)*

**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/cm²sec |

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/cm²sec) ✓ |

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.

SR240R 05/24/95

## TSG Calibration Files

### *Underway Conductivity (Wet Lab)*

**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

TSG Conductivity

SENSOR SERIAL NUMBER = 1390
CALIBRATION DATE: 26-Feb-02

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

GHIJ COEFFICIENTS

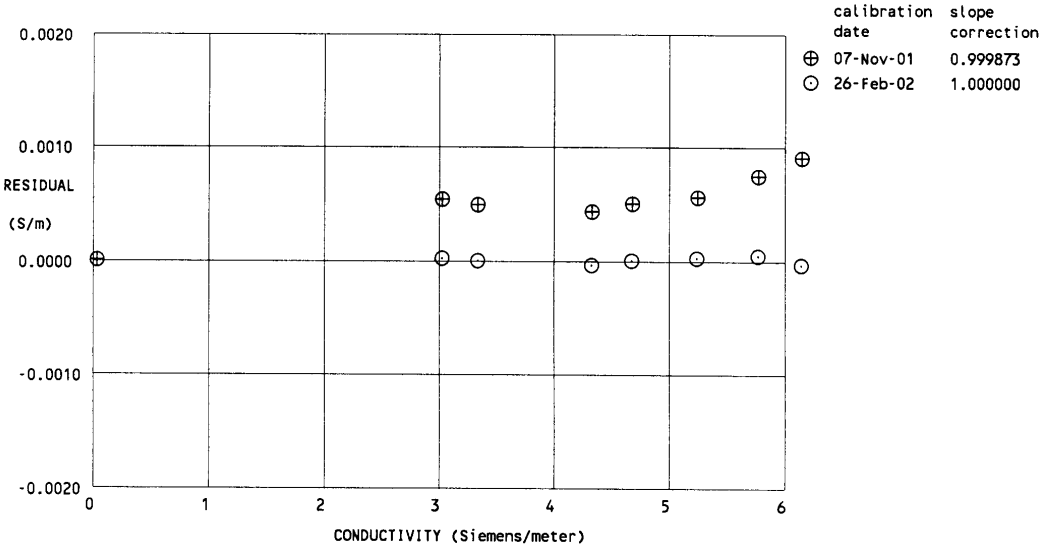
g = -3.93721982e+00
h = 4.71760725e-01
i = 3.91210505e-04
j = 2.24390213e-06
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)

ABCDM COEFFICIENTS

a = 4.34273451e-04
b = 4.71515703e-01
c = -3.93435367e+00
d = -8.27365845e-05
m = 3.0
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 | 2.88540 | -0.00000 | -0.00000 |
| 0.9999 | 35.0470 | 2.99379 | 8.44293 | 2.99381 | 0.00002 |
| 4.5000 | 35.0467 | 3.30431 | 8.81993 | 3.30431 | -0.00000 |
| 15.0000 | 35.0464 | 4.29683 | 9.92836 | 4.29679 | -0.00004 |
| 18.5000 | 35.0459 | 4.64552 | 10.28917 | 4.64552 | -0.00000 |
| 23.9998 | 35.0448 | 5.20882 | 10.84635 | 5.20884 | 0.00002 |
| 28.9999 | 35.0411 | 5.73496 | 11.34172 | 5.73500 | 0.00004 |
| 32.5001 | 35.0337 | 6.10960 | 11.68138 | 6.10956 | -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]; $\delta$ = CTcor; $\epsilon$ = CPcor;
Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



## *Underway Temperature Sensor (Wet Lab)*

**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 = 1390
CALIBRATION DATE: 26-Feb-02

TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.21133811e-03
h = 5.97506417e-04
i = 6.74711109e-06
j = -1.26911965e-06
$f_0$ = 1000.000

IPTS-68 COEFFICIENTS

a = 3.64763440e-03
b = 5.81273311e-04
c = 1.04100442e-05
d = -1.26850783e-06
$f_0$ = 2600.195

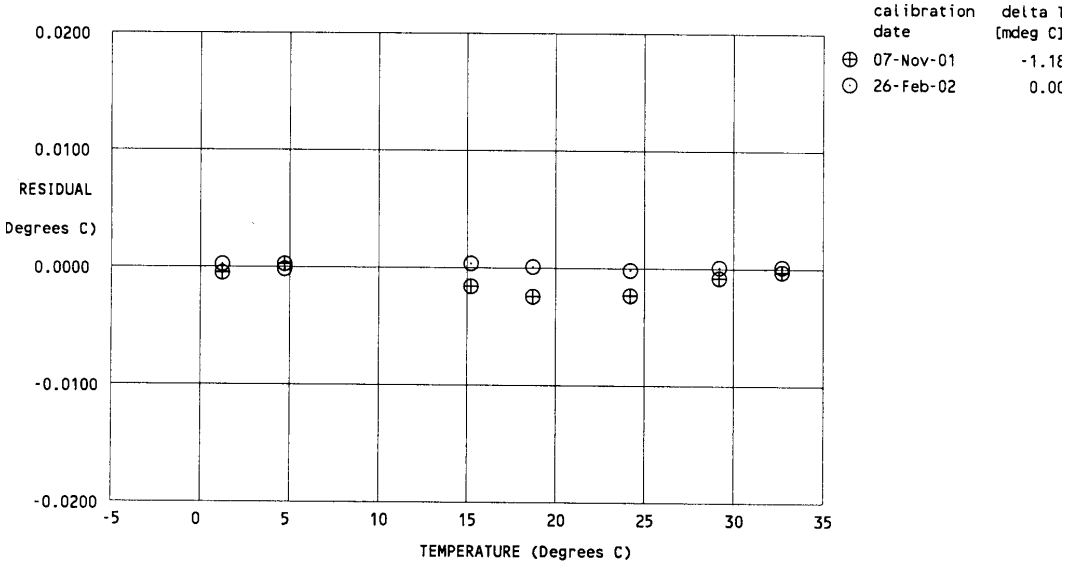
| BATH TEMP (ITS-90 °C) | INSTRUMENT FREQ (Hz) | INST TEMP (ITS-90 °C) | RESIDUAL (ITS-90 °C) |
|---|---|---|---|
| 0.9999 | 2600.195 | 1.0000 | 0.00014 |
| 4.5000 | 2814.589 | 4.4997 | -0.00027 |
| 15.0000 | 3533.526 | 15.0003 | 0.00027 |
| 18.5000 | 3799.626 | 18.5000 | 0.00001 |
| 23.9998 | 4245.947 | 23.9996 | -0.00023 |
| 28.9999 | 4682.700 | 28.9999 | 0.00002 |
| 32.5001 | 5006.561 | 32.5002 | 0.00005 |

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



## *Underway Remote Temperature Sensor (Wet Lab)*

**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

NBP 0204 Remote temp

SENSOR SERIAL NUMBER = 4071
CALIBRATION DATE: 16-Apr-02s

SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE
TSG in Wet Lab

ITS-90 COEFFICIENTS

g = 4.35876516e-03
h = 6.39863070e-04
i = 2.13393613e-05
j = 1.57577668e-06
$f_0$ = 1000.000

IPTS-68 COEFFICIENTS

a = 3.68121033e-03
b = 5.98920278e-04
c = 1.61869089e-05
d = 1.57723580e-06
$f_0$ = 2991.316

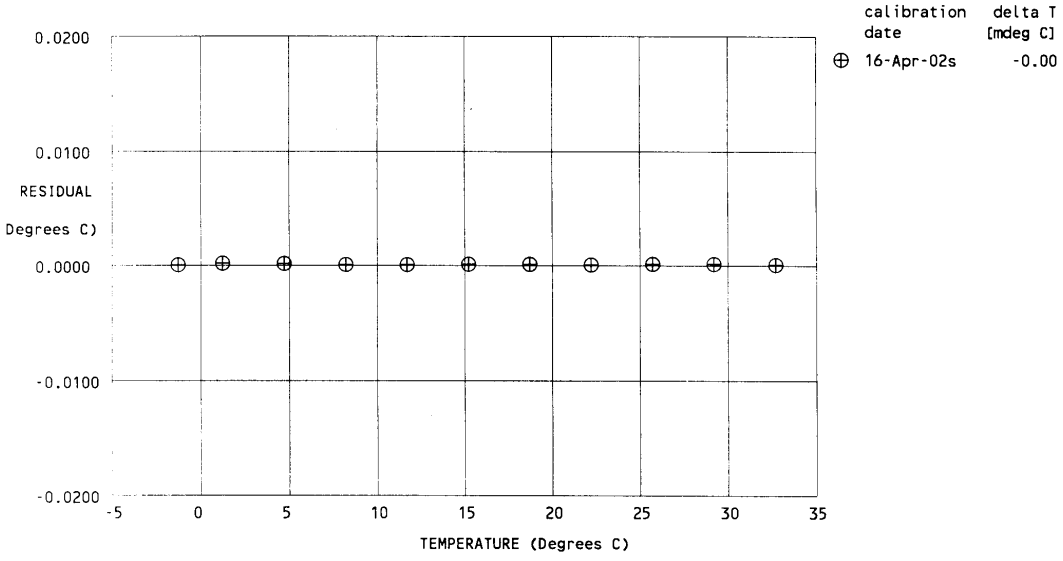
| BATH TEMP (ITS-90 °C) | INSTRUMENT FREQ (Hz) | INST TEMP (ITS-90 °C) | RESIDUAL (ITS-90 °C) |
|---|---|---|---|
| -1.4998 | 2991.316 | -1.4999 | -0.00005 |
| 1.0002 | 3164.085 | 1.0003 | 0.00007 |
| 4.5002 | 3417.963 | 4.5002 | 0.00005 |
| 8.0002 | 3686.226 | 8.0002 | -0.00005 |
| 11.5002 | 3969.295 | 11.5002 | -0.00004 |
| 15.0002 | 4267.566 | 15.0002 | 0.00001 |
| 18.5002 | 4581.420 | 18.5002 | 0.00001 |
| 22.0003 | 4911.248 | 22.0003 | -0.00002 |
| 25.5002 | 5257.401 | 25.5002 | 0.00003 |
| 29.0002 | 5620.254 | 29.0002 | 0.00003 |
| 32.5002 | 6000.144 | 32.5002 | -0.00003 |

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



## *Underway Transmissometer (Wet Lab)*

PO Box 518
620 Applegate St.
Philomath OR 97370

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

WET Labs
Western Environmental Technology Laboratories Inc.

Transmissometer - AT55

# C-Star Calibration Sheet

| | |
|---|---|
| **Date:** | **12/20/01** |
| **Customer:** | **National Science Foundation** |
| **Serial Number:** | **CST-422PR** |
| **Job Number:** | **0012016** |
| **Work Order:** | **003** |

| | |
|---|---|
| $V_d$ = V dark | **0.058** |
| $V_{air}$ = V out in air | **4.841** |
| $V_{ref}$ = V out in water | **4.733** |
| Calibration Temperature of water | **23.0** |
| Ambient Temperature | **21.8** |

% Transmission = $\mathbf{(V_{sig}-V_d)/(V_{ref}-V_d)}$
$\mathbf{Tr = e^{-cx}}$
To solve for the attenuation coefficient **c** in units of $\mathbf{m^{-1}}$ use the following equation.
$\mathbf{c = -1/x\ (ln(V_{sig}-V_d)/(V_{ref}-V_d))}$
For further information on these calculations please see C-Star User's Guide, Section 2.

**Temperature Error: 0.02% F.S./°C**

NOTES

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

## Pressure Sensor (CTD)

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 (CTD)*

T1

**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: 25-Feb-02s

TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.82804638e-03
h = 6.69948735e-04
i = 2.49743854e-05
j = 1.93704984e-06
$f_0$ = 1000.000

IPTS-68 COEFFICIENTS

a = 3.68121035e-03
b = 5.98504293e-04
c = 1.44387438e-05
d = 1.93842519e-06
$f_0$ = 6157.246

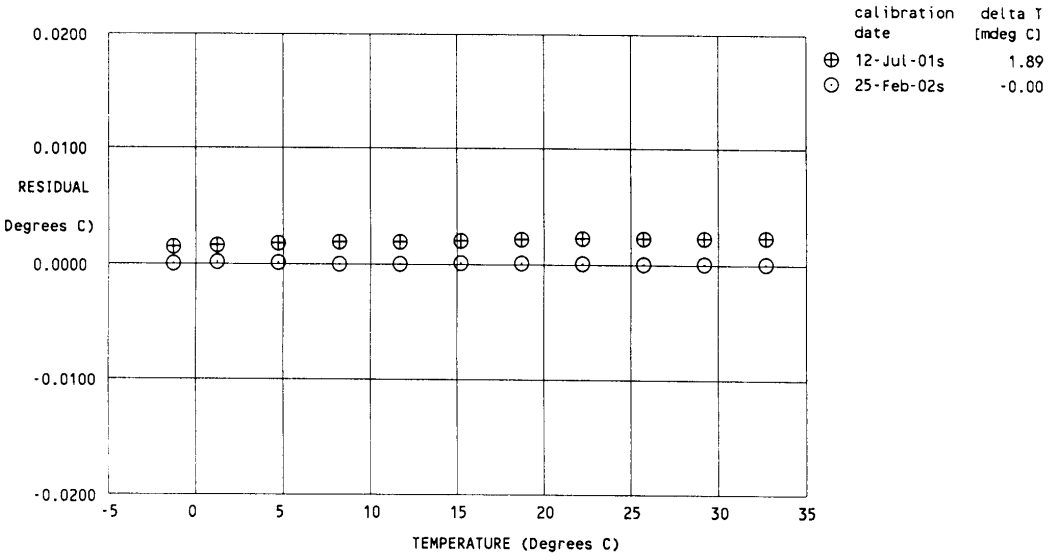
| BATH TEMP (ITS-90 °C) | INSTRUMENT FREQ (Hz) | INST TEMP (ITS-90 °C) | RESIDUAL (ITS-90 °C) |
|---|---|---|---|
| -1.4998 | 6157.246 | -1.4999 | -0.00005 |
| 1.0002 | 6513.066 | 1.0003 | 0.00008 |
| 4.5002 | 7035.721 | 4.5002 | 0.00003 |
| 8.0002 | 7587.721 | 8.0001 | -0.00007 |
| 11.5002 | 8169.871 | 11.5001 | -0.00005 |
| 15.0002 | 8782.920 | 15.0002 | 0.00003 |
| 18.5002 | 9427.577 | 18.5002 | 0.00004 |
| 22.0002 | 10104.554 | 22.0002 | 0.00002 |
| 25.5002 | 10814.532 | 25.5002 | -0.00003 |
| 29.0002 | 11558.185 | 29.0002 | -0.00000 |
| 32.5002 | 12336.121 | 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



## *Secondary Temperature Sensor (CTD)*

T2

**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 = 1541
CALIBRATION DATE: 12-Jan-02s

TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.82590834e-03
h = 6.66204274e-04
i = 2.42682222e-05
j = 1.85656243e-06
$f_0$ = 1000.000

IPTS-68 COEFFICIENTS

a = 3.67963857e-03
b = 5.96320570e-04
c = 1.41302217e-05
d = 1.85789931e-06
$f_0$ = 6202.742

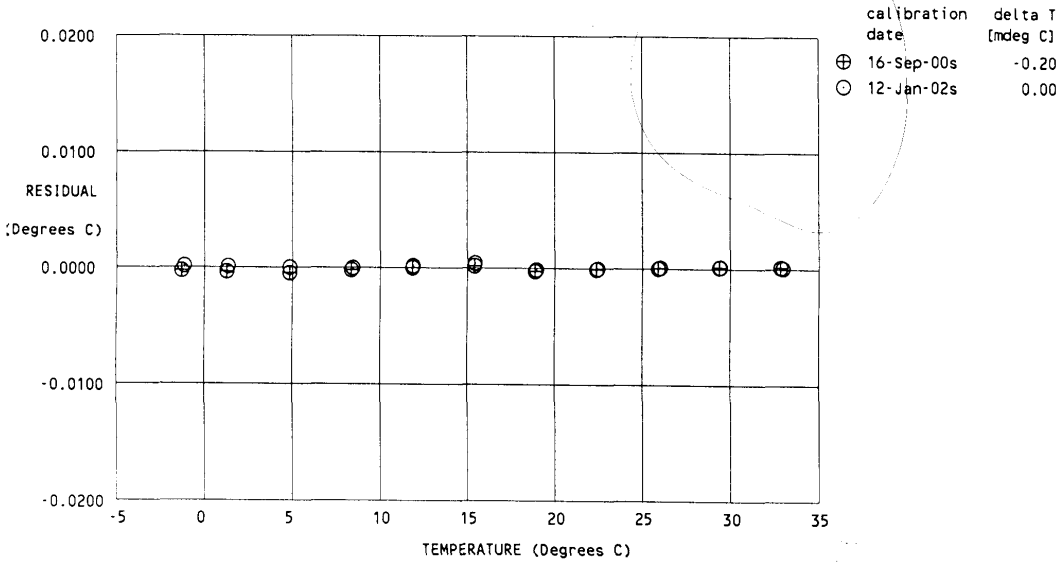
| BATH TEMP (ITS-90 °C) | INSTRUMENT FREQ (Hz) | INST TEMP (ITS-90 °C) | RESIDUAL (ITS-90 °C) |
|---|---|---|---|
| -1.3839 | 6202.742 | -1.3838 | 0.00004 |
| 1.1262 | 6563.677 | 1.1262 | -0.00000 |
| 4.6228 | 7091.330 | 4.6227 | -0.00010 |
| 8.2233 | 7665.717 | 8.2232 | -0.00011 |
| 11.6609 | 8244.339 | 11.6610 | 0.00010 |
| 15.2211 | 8875.467 | 15.2214 | 0.00034 |
| 18.7299 | 9529.818 | 18.7297 | -0.00023 |
| 22.2339 | 10216.313 | 22.2337 | -0.00011 |
| 25.7992 | 10949.316 | 25.7992 | 0.00001 |
| 29.2206 | 11686.074 | 29.2207 | 0.00005 |
| 32.7605 | 12483.354 | 32.7605 | 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



## *Dissolved Oxygen Sensor (1) (CTD)*

001

**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 = 0082
CALIBRATION DATE: 04-Jan-02w

SBE 43
OXYGEN CALIBRATION DATA

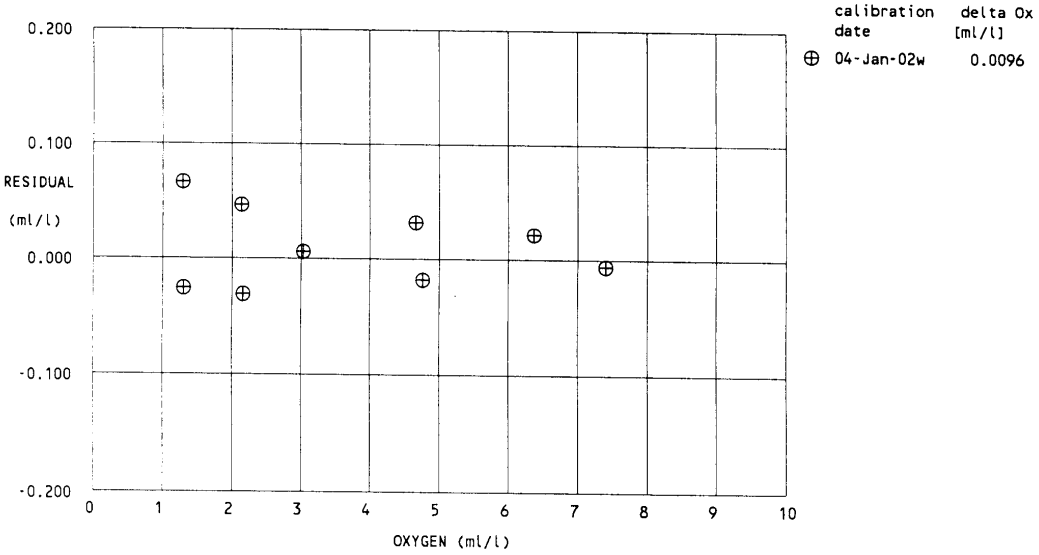
COEFFICIENTS:

Soc = 0.3710
Boc = 0.0214
Voffset = -0.6270

TCor = 0.0023
PCor = 1.350e-04

| BATH OX ml/l | BATH TEMP (ITS-90 °C) | BATH SAL PSU | INSTRUMENT VOLTS | INST OX ml/l | RESIDUAL ml/l |
|---|---|---|---|---|---|
| 1.24 | 5.00 | 0.04 | 0.967 | 1.31 | 0.07 |
| 1.25 | 25.00 | 0.03 | 1.140 | 1.22 | -0.03 |
| 2.09 | 5.00 | 0.04 | 1.215 | 2.14 | 0.05 |
| 2.11 | 25.00 | 0.03 | 1.517 | 2.08 | -0.03 |
| 2.98 | 25.00 | 0.03 | 1.917 | 2.99 | 0.01 |
| 4.61 | 5.00 | 0.04 | 1.963 | 4.64 | 0.03 |
| 4.71 | 25.00 | 0.03 | 2.670 | 4.69 | -0.02 |
| 6.32 | 25.00 | 0.03 | 3.397 | 6.34 | 0.02 |
| 7.35 | 5.00 | 0.04 | 2.770 | 7.34 | -0.01 |

V = voltage output from SBE-43
T = ocean temperature [°C] from CTD
S = ocean salinity [PSU] from CTD
P = ocean pressure [dbar] from CTD
Oxsat(T, S) = oxygen saturation [ml/l]
oxygen (ml/l) = (Soc * (V + Voffset) + Boc * exp(-0.03 * T)) * exp(Tcor * T) * Oxsat(T, S) * exp(Pcor * P)
Residual = instrument oxygen - bath oxygen



## *PAR (CTD)*

### Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

**Calibration Date:** 12/12/01 **Job No.:** R7902
**Model Number:** QSP200L
**Serial Number:** 4361
**Operator:** TPC
**Standard Lamp:** 94532 (05/19/01)
**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:** | **1.80E+12** | **quanta/cm² sec/"amps"** | **3.00E-06** | **µEinsteins/cm² sec/"amps"** |
| **Wet Calibration Factor:** | **3.04E+12** | **quanta/cm² sec/"amps"** | **5.05E-06** | **µEinsteins/cm² sec/"amps"** |

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

| | | | | | |
|---|---|---|---|---|---|
| Sensor Supply Current (Dark): | 76.5 | mA | | | |
| Supply Voltage: | 6 | Volts | | | |
| mp Integrated PAR Irradiance: | 8.58E+15 | quanta/cm² sec | 0.01424 | 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% | 3.677 | 100.00% | | 4.75E-07 | 4.75E-07 | 3.677 | 0.000 | 0.0 | 8.58E+15 |
| 0.3 | 36.10% | 3.231 | 35.79% | | 1.70E-07 | 1.72E-07 | 3.235 | 0.004 | 0.9 | 3.07E+15 |
| 0.5 | 27.60% | 3.120 | 27.71% | | 1.32E-07 | 1.31E-07 | 3.118 | -0.002 | -0.4 | 2.38E+15 |
| 1 | 9.27% | 2.660 | 9.59% | | 4.56E-08 | 4.41E-08 | 2.646 | -0.014 | -3.3 | 8.22E+14 |
| 2 | 1.11% | 1.759 | 1.18% | | 5.59E-09 | 5.28E-09 | 1.735 | -0.024 | -5.7 | 1.01E+14 |
| 3 | 0.05% | 0.730 | 0.08% | | 3.86E-10 | 2.54E-10 | 0.607 | -0.123 | -34.3 | 6.97E+12 |

Dark Before: 0.178 Volts
Light - No Filter Hldr.: 3.678 Volts
Dark After - NFH: 0.178 Volts
Average Dark 0.1781 Volts

$I_{Ref}$ = 1.00E-10 Amps
$I_{Dark}$ = 1.51E-10 Amps
$10^{VDark}$ = 1.506954 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.

Cal Constant = $10^5$ / Biospherical Wet Cal Factor
= 1.9801 x $10^{10}$

QSP-200L .xls

## *Transmissometer (CTD)*

4

### 25 cm TRANSMISSOMETER OPERATING INSTRUCTIONS

OPERATION & CALIBRATION:

First, connect a power source (9 to 30 VDC) to the instrument as shown on the connector wiring diagram, see figure 1. Observe polarity when connecting the power supply to the transmissometer, connect positive to pin 4 and negative to pin 1.

Use a voltmeter to measure the output voltage, pin 2 is the output and pin 3 is ground.

Block the light path to measure the zero output, it should be 0.00, +/- .01 VDC.

Clean the windows using kimwipes (or other non abrasive material), with a solution of dish washing liquid and water. When the windows are clean, the output voltage in air should be within +/- .02 VDC of the AIR CALIBRATION value listed below.

Perform the above procedure before each calibration and use of the instrument to measure transmission of water. The wavelength of the source is 660 nm, and at this wavelength the maximum value for light transmission in clean water with a 25 cm path length is 91.3% (4.565 VDC). Pure water absorption is 8.7% for a 25 cm path length at 660 nm.

MOUNTING INSTRUCTIONS:

A mounting bracket is provided with the transmissometer to simplify mounting the instrument on your system, see figure 2.

PRECAUTIONS:

DO NOT OPEN THE INSTRUMENT--this voids the warranty. If the instrument does not function properly, please consult the factory.

DO NOT LEAVE THE INSTRUMENT ON WHEN NOT IN USE. The LED is quite stable, but it will decrease in intensity, like most light sources, if left on for a long period of time.

DATA REDUCTION:

Air calibration may change with time. The LED light output can decrease approximately 1% in 1000 hours of operation. If the air calibration is measured frequently and the following correction is applied, then this change can be compensated for and will not affect the accuracy of the data.

**V=(A/B) • (X-Z) and % Transmission = 20 • V**

V=Corrected output voltage, (≤ 4.565 VDC since 91.3% is pure water).
A=Air calibration value listed below.
B=Air calibration (present value).
X=Data value (output voltage measured in water).
Z=Zero offset with light path blocked.

The AIR CALIBRATION for SN- 207D was 4.650 VDC on 6/21/2001.

The ZERO OFFSET with the light path blocked is -0.001 VDC

11/12/01 Air Calibration 4.528 VDC
11/12/01 Zero offset 0.020VDC

## *Primary Conductivity Sensor (CTD)*

C1

**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: 26-Feb-02s

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

GHIJ COEFFICIENTS

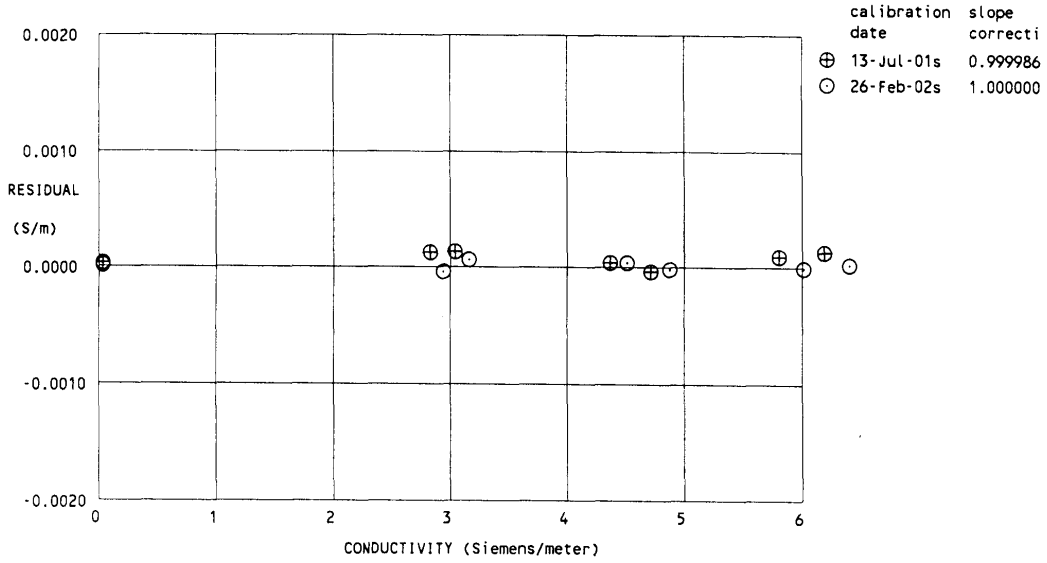
g = -4.25126837e+00
h = 5.52009987e-01
i = -2.59621095e-04
j = 4.23501439e-05
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)

ABCDM COEFFICIENTS

a = 7.34008230e-06
b = 5.51292431e-01
c = -4.24966663e+00
d = -9.34327006e-05
m = 4.5
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) |
|---|---|---|---|---|---|
| 0.0000 | 0.0000 | 0.00000 | 2.77614 | 0.00000 | 0.00000 |
| -1.4000 | 36.7466 | 2.90961 | 7.76857 | 2.90956 | -0.00005 |
| 1.0464 | 36.7467 | 3.12889 | 8.01933 | 3.12894 | 0.00005 |
| 15.0000 | 36.7472 | 4.48251 | 9.41799 | 4.48254 | 0.00003 |
| 18.5000 | 36.7471 | 4.84587 | 9.75876 | 4.84584 | -0.00003 |
| 29.0000 | 36.7438 | 5.98122 | 10.75286 | 5.98120 | -0.00002 |
| 32.5000 | 36.7364 | 6.37159 | 11.07358 | 6.37161 | 0.00002 |

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]; $\delta$ = CTcor; $\epsilon$ = CPcor;
Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



## *Secondary Conductivity Sensor (CTD)*

C2

**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 = 2069
CALIBRATION DATE: 26-Feb-02s

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

GHIJ COEFFICIENTS

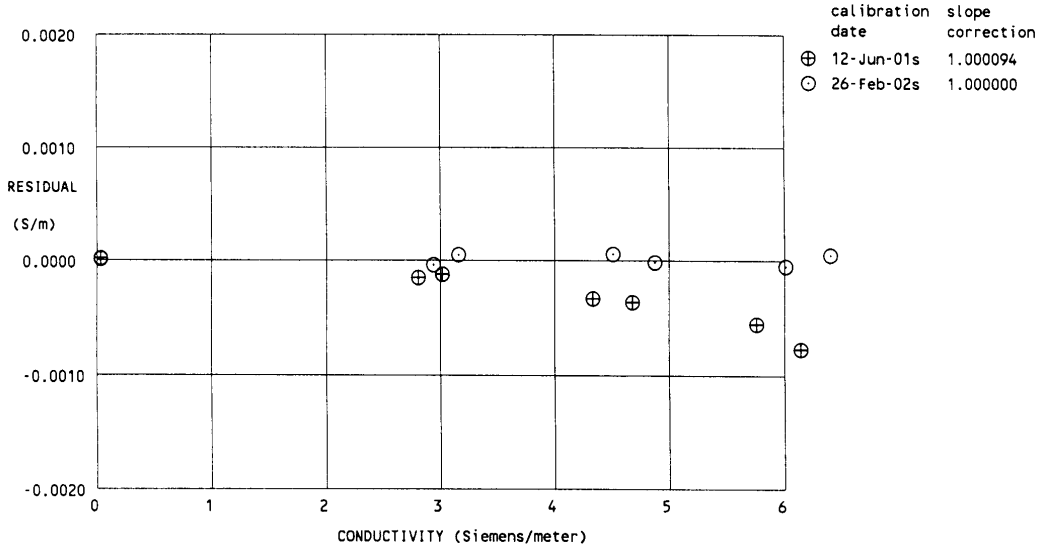
```
g = -1.03852400e+01
h =  1.45055564e+00
i = -4.37394148e-03
j =  3.87871790e-04
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)
```

ABCDM COEFFICIENTS

```
a =  2.84539481e-09
b =  1.43679554e+00
c = -1.03489252e+01
d = -4.62728567e-05
m =  8.7
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) |
|---|---|---|---|---|---|
| 0.0000 | 0.0000 | 0.00000 | 2.68401 | 0.00000 | 0.00000 |
| -1.4000 | 36.7466 | 2.90961 | 5.23926 | 2.90956 | -0.00005 |
| 1.0464 | 36.7467 | 3.12889 | 5.38293 | 3.12893 | 0.00004 |
| 15.0000 | 36.7472 | 4.48251 | 6.19568 | 4.48256 | 0.00005 |
| 18.5000 | 36.7471 | 4.84587 | 6.39608 | 4.84585 | -0.00002 |
| 29.0000 | 36.7438 | 5.98122 | 6.98485 | 5.98116 | -0.00006 |
| 32.5000 | 36.7364 | 6.37159 | 7.17599 | 6.37163 | 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]; $\delta$ = CTcor; $\epsilon$ = CPcor;
Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



## *Fluorimeter (CTD)*

2/1/02

Fluorimeter calibration readings

Ambient temperature 20°C

Output for detector mechanically blanked 0.0273 Volts

Output for pure water 0.1136 Volts

| chlorophyll concentration in acetone (µg/l) | Output (volts) |
|---|---|
| Acetone (pure) | 0.1179 |
| 0.1 | 0.9900 |
| 0.3 | 1.3403 |
| 1.0 | 1.8602 |
| 2.99 | 2.3500 |
| 9.9 | 2.8689 |
| 29.1 | 3.3242 |
| 90.9 | 3.7978 |

The uncertainty of the chlorophyll concentration is estimated not to exceed 3%. The uncertainty of output voltage measurement is estimated not to exceed 2mV.

Signed [signature] Date 1st Feb 2002

Serial number 088080 Page 2 of 2