# Data Report NBP0507

**Cande, Stock G-071-N / Chile – New Zealand Transit**

**23 Sept – 21 Oct 2005**


**United States Antarctic Program**

**RVIB Nathaniel B. Palmer**

**Raytheon Polar Services**

Data Report Prepared by:

Paul Huckins and Julianne Lamsek

# Table of Contents

# Introduction

The NBP data acquisition systems continuously log data from the instruments used during the cruise. This document describes:

- The structure and organization of the data on the distribution media
- The format and contents of the data strings
- Formulas for calculating values
- Information about the specific instruments in use during the cruise
- A log of acquisition problems and events during the cruise that may affect the data
- Scanned calibration sheets for the instruments in use during the cruise.

The data is distributed on a DVD-R written in ISO9660 format. It is readable by virtually every computing platform.

All data has been packaged in Unix tar archive files. Most tar archives have been compressed using gzip to reduce size. Compressed tar files are identifed by the extension “tgz”. Tools are available on all platforms for uncompressing and de-archiving these formats:

On Macintosh, use Stuffit Expander with DropStuff.

tar, gzip, and gunzip are standard tools on all Unix and Unix-like systems.

MultiBeam and BathyW data are distributed separately.

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

## Archive Commands

All archives were created using the command:

```
tar [z]cvf archive_name files_to_archive
```

With [z] being used to create “.tgz” archives.

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

```
tar [z]tvf  archive_name  > contents.list
```

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

To extract the files from the archive:

```
tar [z]xvf  archive_name file(s)_to_extract
```

# Distribution Contents at a Glance

**Volume (DVD) 1**

```
NBP0507.gmt
NBP0507.mgd
NBP507b.gmt
error.lst
NBP507CN.mgd
NBP507CN.gmt
NBP507Cb.gmt
NBP0507.ps
NBP0507.jpg
NBP0507.trk
507data.doc
507data.pdf
507watch.xls
instcoef.txt

adcp/   0507adcp.tar


imagery/     images.tar
(TeraScan satellite images
and Isobar  plots)


ocean/xbt/ 0507xbt.tar

knudsen/ knudsen.tar

b2000w/   0507b2kw.tar
```

**Volume (DVD) 1**

```
process/    0507jgof.tar
            0507mgd.tar
            0507proc.tar
            0507pco2.tar
            0507qcps.tar


rvdas/nav/  0507adcp.tar
            0507gyr1.tar
            0507seap.tar
            0507trax.tar
            0507pcod.tar


rvdas/uw/   0507bat1.tar
            0507flr.tar
            0507grv.tar
            0507knud.tar
            0507mbdp.tar
            0507mag.tar
            0507met.tar
            0507pco2.tat
            0507svp.tar
            0507tsg.tar
```

# Distribution Contents

## Cruise Information

NBP0507 was intended to be a 21 day transit cruise consisting of geophysical science of opportunity and two days of seismic testing. During the first week of the cruise, one of the ship's personnel experienced heart problems. The NBP returned to Chile where the disabled crewman was airlifted back to Chile via helicopter. This deviation added 5 days to the cruise.

Data collection began on julian day 268 at approx 21:15 when we exited the Chilean EEZ (Exclusive Economic Zone). We stopped collecting data, on julian day 274 at approx 03:00, when we returned inside the Chilean EEZ with the disabled crewman. We resumed data collection on julian day 275 at approx 10:00.

Data collection ended for the cruise on julian day 293 at 18:00 when we reached port in Lyttleton, New Zealand.

We had magnetometer problems at various times during the cruise. Scratches on the magnetometer indicate it may have been bitten by a shark while it was deployed. Magnetic data collection stopped on julian day 274 (at ~01:45) when the Magnetometer was pulled for repair. The Magnetometer was redeployed before resuming data collection on julian day 275 (when the NBP left Chile's EEZ for the second time). Magnetic data collection also stopped on julian day 286 (at ~00:00) when the Magnetometer was pulled for repair. The instrument was redeployed and data collection resumed on julian day 287 (at ~01:00).

Magnetic data collection was interrupted from julian day 290 (at ~19:45) to julian day 291 (at ~10:00) during seismic testing. Data collection for the Magnetometer stopped for the remainder of the cruise on julian day 293 (at ~07:00).

The Knudsen sonar was used to collect bathymetry data during the first segment of the cruise. The Knudsen was replaced by the Bathy 2000 during the second segment of the cruise (after leaving Chile's EEZ for the second time).

We had bad weather during most of the crossing, and it caused problems with the gravity data on several occasions. At times the weather was so bad the gravity meter would bang against its frame. When this happened we got huge spikes in the data. These spikes caused processing errors in the MGD77 file. The data disk has two .mgd files on it. The file with the standard file name NBP0507.mgd is the file as it is normally produced. The file NBP507CN.mgd is the standard .mgd file with the errors removed. The file error.lst is a list of the line numbers of the removed records.

## *Cruise Tracks*

In the root directory of the distribution DVD there are two printable/viewable files of the cruise track: NBP0507.ps and NBP0507.jpg. There is also a data file, NBP0507.trk that contains the latitude and longitude at one minute intervals extracted from the NBP0507.gmt file.

## *Satellite Images*

Satellite images processed during this cruise can be found in the directory /images in three tar files: ice.tar, isobar.tar, and wx.tar (weather). Ice and weather files are named using the convention, IdDDDYYA.jpg where:

Id = image type (ice = ice, wx = weather)
DDD = year-day
YY = year
A = allows for multiple images of one type for one day

There were no ice images or other special satellite imagery for this cruise.

### *Other*

Both the Knudsen and the Bathy 2000 sonars are capable of collecting sub-bottom data. The Bathy 2000 W is a software-only post processing system used to convert the sub-bottom data from the Bathy 2000 into seg-y format. The Knudsen sonar is capable of saving its data directly to seg-y format. The seg-y data format is not described in this document. The sub-bottom data from both sonars are located in their respective directories on the disk.

## NBP Data Products

Two primary datasets are generated on each NBP cruise: JGOFS and MGD77. The MGD77 and JGOFS datasets are processed data. They have had all calibrations applied, and they have been cleaned of obviously bad data.

Postscript-format plots of processed data for each day of collection are located in: `/process/0507qcps.tar`

The raw data is distributed in the /rvdas directory.

The data processing scripts create a number of intermediate files. These files are included on the data distribution media in the file /process/507proc.tar. They are included to make re-processing easier in the event of an error, but no detail of the formats is included in this document. If you have any questions, please contact Kathleen.Gavahan@usap.gov or itvessel@usap.gov.

### *JGOFS*

The JGOFS data set can be found on the distribution media in the file /process/0507jgof.tar. The archive contains one file produced for each day named jgDDD.dat, where DDD is the year-day the data was acquired. Each daily file consists of 22 columnar fields in text format as described in the table below. The JGOFS data set is created from calibrated data decimated at one-minute intervals. Several fields are derived measurements from more than a single raw input. For example, Course Made Good (CMG) and Speed Over Ground (SOG) are calculated from gyro and GPS inputs. Daily plots during the cruise are produced from the JGOFS data set. Note: Null, unused, or unknown fields are indicated as “NAN” or 9999 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/meter$^2$ 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 (max speed windbird) | meters/sec |
| 15 | True wind direction (max speed windbird) | degrees (azimuth) |

| Field | Data | Units |
|---|---|---|
| 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 NBP0507.mgd. The file NBP0507.gmt is created from the MGD77 dataset using the "mgd77togmt" utility. NBP0507.gmt can be used with the GMT plotting package.

There are two GMT files on the data set. They are the same file--one is in little endian format (for linux) and the other is in big endian format (for Sun). On the NBP0507 cruise the weather caused errors in our .mgd file. As a result we created a second set of .mgd and .gmt files. These files are NBP507CN.mgd, NBP507CN.gmt and NBP507Cb.gmt. CN = Clean and Cb = clean, big endian.

The data used to produce the NBP0507.mgd file can be found on the distribution media in the file /process/0507proc.tar. The data files in the archive contain a day's data and follow the naming convention Dddd.fnl.gz, where ddd is the year-day. These files follow a space-delimited columnar format that may be more accessible for some purposes. They contain data at one-second intervals rather than one minute and are individually "gzipped" to save space. Below is a detailed description of the MGD77 data set format. The other files in the archive contain interim processing files and are included to simplify possible reprocessing of the data using the RVDAS NBP processing scripts.

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

| Col | Len | Type | Contents | Description, Possible Values, Notes |
|---|---|---|---|---|
| 1 | 1 | Int | Data record type | Set to "5" for data record |
| 2-9 | 8 | Char | Survey identifier | |
| 10-12 | 3 | int | Time zone correction | Corrects time (in characters 13-27) to GMT when added; 0 = GMT |
| 13-16 | 4 | int | Year | 4 digit year |
| 17-18 | 2 | int | Month | 2 digit month |
| 19-20 | 2 | int | Day | 2 digit day |
| 21-22 | 2 | int | Hour | 2 digit hour |
| 23-27 | 5 | real | Minutes x 1000 | |
| 28-35 | 8 | real | Latitude x 100000 | + = North<br>- = South. (–9000000 to 9000000) |
| 36-44 | 9 | real | Longitude x 100000 | + = East<br>- = West. (–18000000 to 18000000) |
| 45 | 1 | int | Position type code | 1=Observed fix<br>3=Interpolated<br>9=Unspecified |
| 46-51 | 6 | real | Bathymetry, 2- way travel time | In 10,000th of seconds. Corrected for transducer depth and other such corrections |
| 52-57 | 6 | real | Bathymetry, corrected depth | In tenths of meters. |
| 58-59 | 2 | int | Bathymetric correction | This code details the procedure used for |

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

## Science of Opportunity

### *ADCP*

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

Matlab ".mat" files containing current contour and vector data have been placed in the files `/adcp/0507.tar`.

A data feed is sent from the ADCP system to RVDAS whenever a reference layer is acquired. This feed contains east and north vectors for ship's speed, relative to the reference layer, and ship's heading. Collected files (one per day) are archived in `0507adcp.tar` in the directory `/rvdas/nav`.

### *$pCO_2$*

The NBP carries a $pCO_2$ measurement system from Lamont-Doherty Earth Observatory (LDEO). $pCO_2$ data is recorded by RVDAS and transmitted to LDEO at the end of each cruise. You will find $pCO_2$ data in a file named `0507pco2.tar` in the `/process` 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).

## Cruise Science

### *XBT*

During the cruise, eXpendable BathyThermographs (XBT) were used to obtain water column temperature profiles, providing corrections to the sound velocity profile for the multibeam system. The data files from these launches are included as `0507xbt.tar` in the `/ocean` directory.

## RVDAS

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

Daily data processing of the RVDAS (Research Vessel Data Acquisition System) data is performed to calibrate and 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 sensors and data. Be sure to read the "Significant Acquisition Events" section for important information about data acquisition during this cruise.

### *Sensors and Instruments*

RVDAS data is divided into two general categories, *underway and navigation*. They can be found on the distribution media as subdirectories under the top level rvdas directory: `/rvdas/uw`, and `/rvdas/nav`. Processed oceanographic data is in the top level directory, `/process`. Each instrument or sensor produces a data file named with its channel ID. 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: `NBP0107met1.d317`

- The CruiseID is the numeric name of the cruise, in this case, NBP0507.
- The ChannelID 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 | not collected | 2 sec | BSI GUV-2511 |
| PUV | puv | not collected | | BSI PUV-2500 |

### Geophysics

| Measurement | Channel ID | Collect. Status | Rate | Instrument |
|---|---|---|---|---|
| Gravimeter | grv1 | continuous | 10 sec* | LaCoste & Romberg |
| Magnetometer | mag1 | Not collected | 15 sec | EG&G G-866 |
| Bathymetry | bat1 | Not collected | Varies | ODEC Bathy 2000 |
| Bathymetry | knu1 | Continuous | 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 SBE-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 |
|---|---|---|---|---|
| Trimble GPS | PCOD | Continuous | 1 sec | Trimble 20636-00SM |
| Gyro | gyr1 | Continuous | 0.2 sec | Yokogawa Gyro |
| SeaPath | seap | Continuous | 1 sec | SeaPath 200 |

### *Raw Data*

Data is received by 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

## 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 |

## 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)

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

**Data record ($DAT):**

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

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

**Environmental record ($ENV)**

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

| Field | Data | Conversion | Units |
|---|---|---|---|
| 1 | RVDAS time tag | | |
| 2 | Text string (id field) | $ENV for environmental record | |
| 3 | Date | YYYY/MM/DD | |
| 4 | Time | HH:MM:SS.SS | |
| 5 | Day of Year | DDD | |
| 6 | Meter ID | | |
| 7 | Meter Pressure | | inch-Hg |
| 8 | Meter temp | | °C |
| 9 | Ambient temp | | °C |
| 10 | K-Factor | | |
| 11 | VCC Coeff | | |

| Field | Data | Conversion | Units |
|---|---|---|---|
| 12 | AL Coeff | | |
| 13 | AX Coeff | | |
| 14 | VE Coeff | | |
| 15 | AX2 Coeff | | |
| 16 | Serial Filter Length | | Seconds |
| 17 | QC Filter Length | | Seconds |

## 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 | |

| Field | Data | Format / Possible Values | Units |
|---|---|---|---|
| | | 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<br>TR5 = 1Hz<br>TR6 = .5Hz<br>TR7 = .33Hz<br>TR8 = .25Hz<br>TR9 = .20Hz<br>TR: = .10Hz<br>TR; = .05Hz | Hz |
| 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 |

## 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 EM120 (mbdp)

| Field | Data | Units |
|---|---|---|
| 1 | LDTDS | |
| 2 | $EMDPT | |
| 3 | Depth (corrected) | Meters |

## 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 fractional time of day) | yyyyddd.ttt |
| 3 | Raw voltage | mV |
| 4 | Barometer | mBar |
| 5 | Cell temperature | °C |
| 6 | Flow rate | ml/min |
| 7 | Concentration | ppm |
| 8 | $pCO_2$ pressure | microAtm |
| 9 | Equilibrated temperature | °C |
| 10 | Latitude (not collected) | |
| 11 | Longitude (not collected) | |
| 12 | 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:

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

### GPZDA

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

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

### GPGGA

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

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

## GPVTG

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

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

## GPHDT

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

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

## PSXN,22

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

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

## PSXN,23

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

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

## 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 | 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) | |

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

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

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

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

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

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

### GLL: GPS Latitude/Longitude

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

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

### VTG: GPS Track and Ground Speed

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

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |

| Field | Data | Units |
|---|---|---|
| 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 | |

## ADCP Course (adcp)

```
05+209:15:04:14.575 $PUHAW,UVH,9.95,-0.98,99.7
```

| Field | Data | Units |
|---|---|---|
| 1 | RVDAS time tag | |
| 2 | $PUHAW | |
| 3 | UVH (E-W, N-S, Heading) | |
| 4 | Ship Speed relative to reference layer, east vector | knots |
| 5 | Ship Speed relative to reference layer, north vector | knots |
| 6 | Ship heading | degrees |

# *Processed Data*

## 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 |

| Field | Data | Units |
|---|---|---|
| 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 | Transmissivity | V |

# Calculations

The file `instcoef.txt` 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 = 6.27 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 = 3.86 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 = 8.19 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, Events, and Notes

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 |
|---|---|---|
| 268:21:15 | | Started instrument logging, left Chilean EEZ/entered international waters. |
| 268:23:55 | | Magnetometer turned off. |
| 269:00:33 | | Magnetometer turned on. |
| 270:12:30 | | Magnetometer having issues: start of bad data. |
| 271:00:45 | | Magnetometer back online & collecting reasonable data again. |
| 272:01:45 | | Data collection stopped for Magnetometer. Instrument pulled for repair. Magnetometer is redeployed before resumption of data logging on day 275. |
| 274:00:15 | | Knudsen shut down / Knudsen logging stopped. |
| | 274:03:00 | Stopped instrument logging, returned inside Chilean EEZ. |
| 275:10:00 | | Resumed instrument logging, left Chilean EEZ/entered international waters. The Knudsen has been replaced by the Bathy2000. |
| 277:19:15 | | Restarted multibeam (rough seas). |
| 277:19:45 | | Multibeam back online. |
| 281:14:15 | | PCO2 collecting erratic data. Nitrogen was discovered to be empty for PC02. |
| 281:20:30 | | PC02 back online & collecting reasonable data again. |
| 286:00:00 | | Data collection stopped for Magnetometer. Instrument pulled for repair. |
| 287:01:00 | | Magnetometer redeployed; logging resumes. |
| 290:19:45 | | Data collection stopped for Magnetometer; instrument removed from water during seismic testing. |
| 290:22:00 | | Entering New Zealand EEZ. |
| 291:10:00 | | Magnetometer redeployed and data collection resumes. |
| 293:07:00 | | Stopped data collection for Magnetometer. Pulled instrument from water. |
| 293:08:00 | | Stopped data collection for PC02, TSG. |
| 293:12:30 | | Stopped collecting Bathy 2000 W sub-bottom data. |
| | 293:18:00 | Stopped instrument logging and data collection, arrived Lyttelton, New Zealand. |

# Appendix: Sensors and Calibrations

## NBP0507 Sensors

### *Shipboard Sensors*

| Sensor | Description | Serial # | Last Calibration Date | Status |
|---|---|---|---|---|
| **Meteorology & Radiometers** | | | | |
| Port Anemometer | RM Young 5105 | WM46262 | 08/07/05 | Collect |
| Stbd Anemometer | RM Young 5106 | WM46263 | 03/25/05 | Collect |
| Barometer | RM Young 61201 | 61201 | 2003 | Collect |
| Air Temp/Rel. Hum. | RM Young 41372LC | 06135 | 04/23/05 | Collect |
| Mast PRR | BSI PRR-610 | | | Not used |
| Profiling PRR | BSI PRR-600 | | | Not used |
| PIR (Pyrgeometer) | Eppley PIR | 33023F3 | 01/20/05 | Collect |
| PSP (Pyranometer) | Eppley PSP | 33090F3 | 11/08/04 | Collect |
| Mast PAR | BSI QSR-240 | 6356 | 5/16/05 | Collect |
| Mast GUV | | | | Not used |
| Profiling PUV | | | | Not used |
| **Underway** | | | | |
| TSG | SeaBird SBE-21 | 3198 | 02/01/05 | Collect |
| TSG Remote Temp | SeaBird 3-01/S | 1267 | 01/27/05 | Collect |
| Fluorometer | Turner 10-AU-005 | 5333-FRXX | | Collect |
| Transmissometer | WET Labs C-Star | CST-439DR | 09/27/04 | Collect |
| Magnetometer | Geometrics G-877 | | | Collect |
| Gravimeter | LaCoste & Romberg Gravity Meter | S-036 | 09/20/05 | Collect |
| Bathymetry | Simrad EK500 | 3001 | 11/1/95 | Collect |
| Bathymetry | Knudsen 320B/R | | | Collect |
| Bathymetry | Bathy 2000 | | | Collect |

## Calibrations

The following pages are replicas of 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:** 9/20/2005
**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) | 8968.1 | 12:55 |
| Ship's meter after gravity tie (Digital Gravity) | 8968.1 | 13:32 |
| Average | 8968.1 | |
| Ship Gravimeter's Calibration Constant | 1.0046 | |
| Corrected ship's meter (Digital Gravity) | 9009.4 | |

| | Value | Time (GMT) |
|---|---|---|
| Ship's meter before gravity tie (serial, RVDAS) | 8968.1 | 12:55 |
| Ship's meter after gravity tie (serial, RVDAS) | 8968.1 | 13:32 |
| Average (for comparison check only) | 8968.1 | |

Portable Gravimeter Correction Divisor 1.007937

| Station | Value | Time (GMT) | Temp | Date | OBS mgal, averaged |
|---|---|---|---|---|---|
| Pier measurement 1 | 4908.49 | 12:47 | 53.5 | September 20, 2005 | |
| Pier measurement 2 | 4908.48 | 12:48 | 53.5 | September 20, 2005 | 4869.83 |
| Pier measurement 3 | 4908.47 | 12:50 | 53.5 | September 20, 2005 | |
| Average | 4908.48 | | | | |
| Station measurement 1 | 4909.11 | 13:12 | 53.5 | September 20, 2005 | |
| Station measurement 2 | 4909.10 | 13:13 | 53.5 | September 20, 2005 | 4870.46 |
| Station measurement 3 | 4909.13 | 13:15 | 53.5 | September 20, 2005 | |
| Average | 4909.11 | | | | |
| Pier measurement 4 | 4908.56 | 13:26 | 53.5 | September 20, 2005 | |
| Pier measurement 5 | 4908.58 | 13:28 | 53.5 | September 20, 2005 | 4869.92 |
| Pier measurement 6 | 4908.58 | 13:30 | 53.5 | September 20, 2005 | |
| Average | 4908.57 | | | | |

Gravity offset from last tie 972308.367
Drift since last tie 2.82

**OBS Differences**

| | |
|---|---|
| Station to Pier (1, 2, & 3 averaged) | -0.63 |
| Station to Pier (4, 5, & 6 averaged) | -0.54 |
| Averaged Differences | -0.58 |
| Gravity at pier | 981320.24 |
| Elevation of pier above gravimeter, meters | 1.0 |
| Earth differential gravity, mgal/meter | 0.3 |
| Gravity at ship's gravimeter | 981320.54 |
| Gravity Offset | 972311.18 |

**Comments**

Evers / Lenorovitz completed tie at PA dock and had consistent values throughout. Good tie.

## Meteorology System

### *Anemometer (Port)*

**RM Young Anemometer Calibration, Model 05106**

**S/N:** 46262 **Date:** 12-Dec-04 **Cal'd By:** W. Gallagher

| Clockwise Cal Motor RPM | Calculated Windspeed m/s | Measured Windspeed m/s | Delta m/s | Knots |
|---|---|---|---|---|
| 0 | 0.00 | 0.0 | 0.0 | 0.0 |
| 200 | 0.98 | 0.9 | 0.1 | 1.9 |
| 500 | 2.45 | 2.3 | 0.2 | 4.8 |
| 1000 | 4.90 | 4.9 | 0.0 | 9.5 |
| 1500 | 7.35 | 7.4 | -0.1 | 14.3 |
| 2000 | 9.80 | 9.8 | 0.0 | 19.0 |
| 3000 | 14.70 | 14.8 | -0.1 | 28.6 |
| 4000 | 19.60 | 19.8 | -0.2 | 38.1 |
| 5000 | 24.50 | 24.8 | -0.3 | 47.6 |
| 6000 | 29.40 | 29.8 | -0.4 | 57.1 |
| 7000 | 34.30 | 34.7 | -0.4 | 66.6 |
| 8000 | 39.20 | 39.8 | -0.6 | 76.2 |
| 9000 | 44.10 | 44.7 | -0.6 | 85.7 |
| 10000 | 49.00 | 49.7 | -0.7 | 95.2 |
| 12000 | 58.80 | 59.5 | -0.7 | 114.2 |

| Direction | Measured Direction | Delta Direction |
|---|---|---|
| 0 | 1 | 0 |
| 30 | 30 | 0 |
| 60 | 60 | 0 |
| 90 | 89 | 1 |
| 120 | 119 | 1 |
| 150 | 149 | 1 |
| 180 | 179 | 1 |
| 210 | 210 | 0 |
| 240 | 241 | -1 |
| 270 | 272 | -2 |
| 300 | 302 | -2 |
| 330 | 332 | -2 |
| 0 | 1 | -1 |

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

| Counter Clockwise Cal Motor RPM | Calculated Windspeed m/s | Measured Windspeed m/s | Delta m/s |
|---|---|---|---|
| 0 | 0.00 | 0.0 | 0.0 |
| 200 | 0.98 | 0.9 | 0.1 |
| 500 | 2.45 | 2.3 | 0.2 |
| 1000 | 4.90 | 4.9 | 0.0 |
| 1500 | 7.35 | 7.3 | 0.0 |
| 2000 | 9.80 | 9.8 | 0.0 |
| 3000 | 14.70 | 14.8 | -0.1 |
| 4000 | 19.60 | 19.8 | -0.2 |
| 5000 | 24.50 | 24.8 | -0.3 |
| 6000 | 29.40 | 29.8 | -0.4 |
| 7000 | 34.30 | 34.8 | -0.5 |
| 8000 | 39.20 | 39.8 | -0.6 |
| 9000 | 44.10 | 44.7 | -0.6 |
| 10000 | 49.00 | 49.8 | -0.8 |
| 12000 | 58.80 | 59.7 | -0.9 |

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

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

**Additional Comments**

INSTALLED NEW BEARINGS AND PROPELLER SHAFT. TESTED OKAY

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

## *Anemometer (Starboard)*

### RM Young Anemometer Calibration, Model 05106

**S/N:** 46263 **Date:** 27-Sep-04 **Cal'd By:** W. Gallagher

| Clockwise Cal Motor RPM | Calculated Windspeed m/s | Measured Windspeed m/s | Delta m/s | Knots |
|---|---|---|---|---|
| 0 | 0.00 | 0.0 | 0.0 | 0.0 |
| 200 | 0.98 | 0.9 | 0.1 | 1.9 |
| 500 | 2.45 | 2.3 | 0.2 | 4.8 |
| 1000 | 4.90 | 4.8 | 0.1 | 9.5 |
| 1500 | 7.35 | 7.2 | 0.1 | 14.3 |
| 2000 | 9.80 | 9.6 | 0.2 | 19.0 |
| 3000 | 14.70 | 14.4 | 0.3 | 28.6 |
| 4000 | 19.60 | 19.4 | 0.2 | 38.1 |
| 5000 | 24.50 | 24.2 | 0.3 | 47.6 |
| 6000 | 29.40 | 29.0 | 0.4 | 57.1 |
| 7000 | 34.30 | 33.9 | 0.4 | 66.6 |
| 8000 | 39.20 | 38.8 | 0.4 | 76.2 |
| 9000 | 44.10 | 43.6 | 0.5 | 85.7 |
| 10000 | 49.00 | 48.3 | 0.7 | 95.2 |
| 12000 | 58.80 | 56.4 | 2.4 | 114.2 |

| Direction | Measured Direction | Delta Direction |
|---|---|---|
| 0 | 0 | 0 |
| 30 | 30 | 0 |
| 60 | 60 | 0 |
| 90 | 90 | 0 |
| 120 | 119 | 1 |
| 150 | 150 | 0 |
| 180 | 180 | 0 |
| 210 | 210 | 0 |
| 240 | 240 | 0 |
| 270 | 270 | 0 |
| 300 | 300 | 0 |
| 330 | 331 | -1 |
| 0 | 0 | 0 |

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

| Counter Clockwise Cal Motor RPM | Calculated Windspeed m/s | Measured Windspeed m/s | Delta m/s |
|---|---|---|---|
| 0 | 0.00 | 0.0 | 0.0 |
| 200 | 0.98 | 0.9 | 0.1 |
| 500 | 2.45 | 2.3 | 0.2 |
| 1000 | 4.90 | 4.7 | 0.2 |
| 1500 | 7.35 | 7.2 | 0.1 |
| 2000 | 9.80 | 9.7 | 0.1 |
| 3000 | 14.70 | 14.5 | 0.2 |
| 4000 | 19.60 | 19.5 | 0.1 |
| 5000 | 24.50 | 24.4 | 0.1 |
| 6000 | 29.40 | 29.2 | 0.2 |
| 7000 | 34.30 | 33.9 | 0.4 |
| 8000 | 39.20 | 38.6 | 0.6 |
| 9000 | 44.10 | 43.3 | 0.8 |
| 10000 | 49.00 | 48.0 | 1.0 |
| 12000 | 58.80 | 57.1 | 1.7 |

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

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

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

**Additional Comments**

Installed new housing assy and wind direction coupling. Good calibration

***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: 33023F3

Resistance: 764 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 25 °C.

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

$3.86 \times 10^{-6}$ volts/watts meter$^{-2}$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 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: 60151
Date: January 24, 2005

Date of Test: January 20, 2005

In Charge of Test: R. Eppley

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
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 Science Foundation
Port Hueneme, CA

Date of Test: November 8, 2004

In Charge of Test: R.T. Eppley

S.O. Number: 60076
Date: November 11, 2004

Reviewed by: Thomas D. Kirk

Remarks:

## *PAR*

**Biospherical Instruments Inc.**

CALIBRATION CERTIFICATE

| | |
|---|---|
| Calibration Date | 5/16/2005 |
| Model Number | QSR-240 |
| Serial Number | 6356 |
| Operator | TPC |
| Standard Lamp | 99189(4/12/05) |
| Probe Excitation Voltage Range: | 6 to 18 VDC(+) |
| Output Polarity: | POSITIVE |

Probe Conditions at Calibration(in air):

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

Probe Output Voltage:

| | |
|---|---|
| Probe Illuminated | 86.9 mV |
| Probe Dark | 0.1 mV |
| Probe Net Response | 86.8 mV |

Corrected Lamp Output:

Output In Air (same condition as calibration):

8.34E+15 quanta/cm²sec
0.01384 uE/cm²sec

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

| | |
|---|---|
| Dry: | 1.04E-17 V/(quanta/cm²sec) |
| | 6.27E+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.

QSR240R 05/24/95

## 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 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 3198
CALIBRATION DATE: 01-Feb-05

SBE21 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -4.26982501e+000
h =  5.04451229e-001
i = -5.14140226e-004
j =  5.01516148e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  1.64605226e-006
b =  5.02580692e-001
c = -4.26144824e+000
d = -8.98538292e-005
m =  5.0
CPcor = -9.5700e-008 (nominal)
```

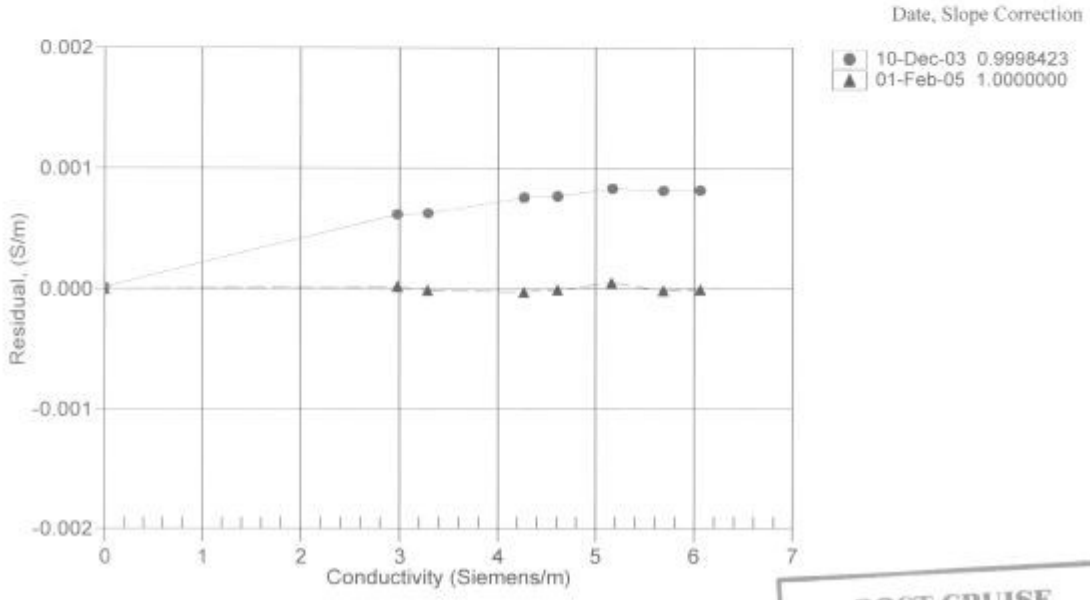
| BATH TEMP (ITS-90) | BATH SAL (PSU) | BATH COND (Siemens/m) | INST FREQ (kHz) | INST COND (Siemens/m) | RESIDUAL (Siemens/m) |
|---|---|---|---|---|---|
| 22.0000 | 0.0000 | 0.00000 | 2.91244 | 0.00000 | 0.00000 |
| 0.9999 | 34.7963 | 2.97441 | 8.21830 | 2.97443 | 0.00002 |
| 4.4999 | 34.7760 | 3.28129 | 8.58001 | 3.28127 | -0.00001 |
| 15.0000 | 34.7322 | 4.26239 | 9.64456 | 4.26236 | -0.00003 |
| 18.5000 | 34.7227 | 4.60729 | 9.99140 | 4.60728 | -0.00001 |
| 24.0000 | 34.7124 | 5.16487 | 10.52745 | 5.16492 | 0.00005 |
| 29.0000 | 34.7074 | 5.68649 | 11.00459 | 5.68647 | -0.00001 |
| 32.5001 | 34.7057 | 6.05889 | 11.33265 | 6.05888 | -0.00001 |

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

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

t = temperature[°C]; p = pressure[decibars]; $\delta$ = CTcor; $\varepsilon$ = 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 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 3198
CALIBRATION DATE: 01-Feb-05

SBE21 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

g = 4.22378538e-003
h = 6.27547484e-004
i = 1.87696196e-005
j = 1.08059211e-006
f0 = 1000.0

ITS-68 COEFFICIENTS

a = 3.64763575e-003
b = 5.95164358e-004
c = 1.57386940e-005
d = 1.08194901e-006
f0 = 2568.337

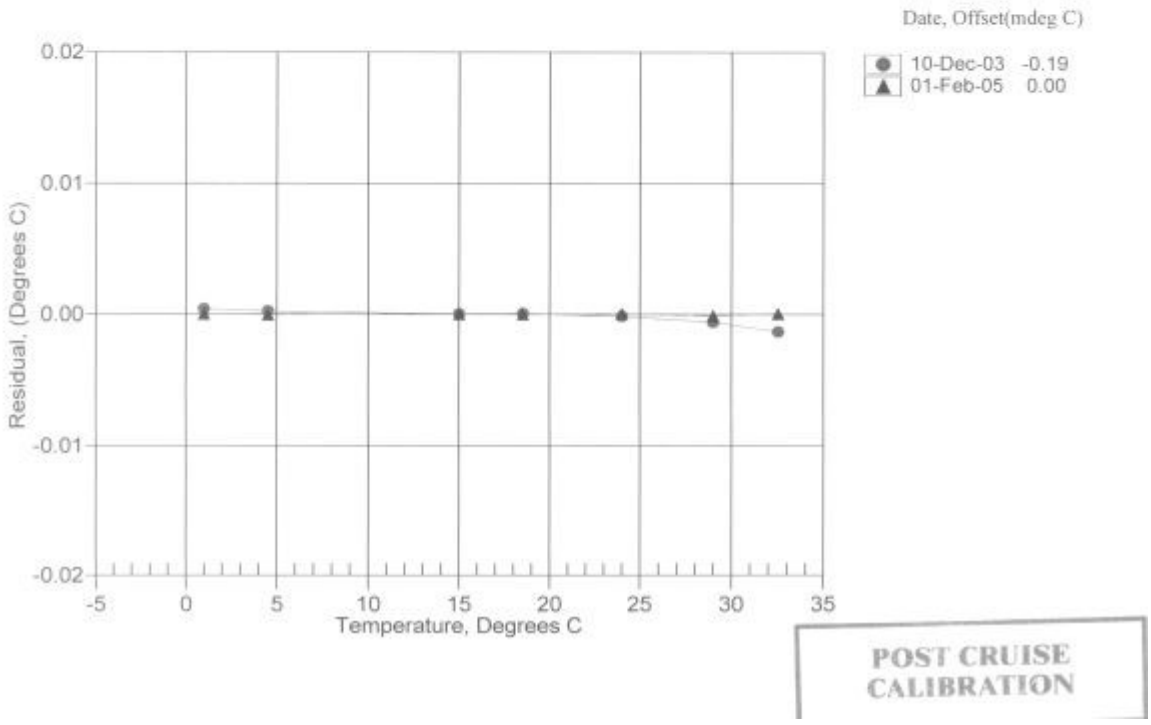
| BATH TEMP (ITS-90) | INSTRUMENT FREQ (Hz) | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| 0.9999 | 2568.337 | 0.9999 | 0.00002 |
| 4.4999 | 2775.111 | 4.4998 | -0.00004 |
| 15.0000 | 3467.500 | 15.0000 | 0.00002 |
| 18.5000 | 3723.427 | 18.5000 | 0.00000 |
| 24.0000 | 4152.232 | 24.0000 | 0.00004 |
| 29.0000 | 4571.184 | 28.9999 | -0.00009 |
| 32.5001 | 4881.480 | 32.5001 | 0.00005 |

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 ITS-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

### *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 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 1267
CALIBRATION DATE: 27-Jan-05

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

g = 4.76634262e-003
h = 6.64670506e-004
i = 2.85058534e-005
j = 2.64012684e-006
f0 = 1000.0

ITS-68 COEFFICIENTS

a = 3.68121281e-003
b = 5.89542737e-004
c = 1.47371122e-005
d = 2.64160048e-006
f0 = 5707.057

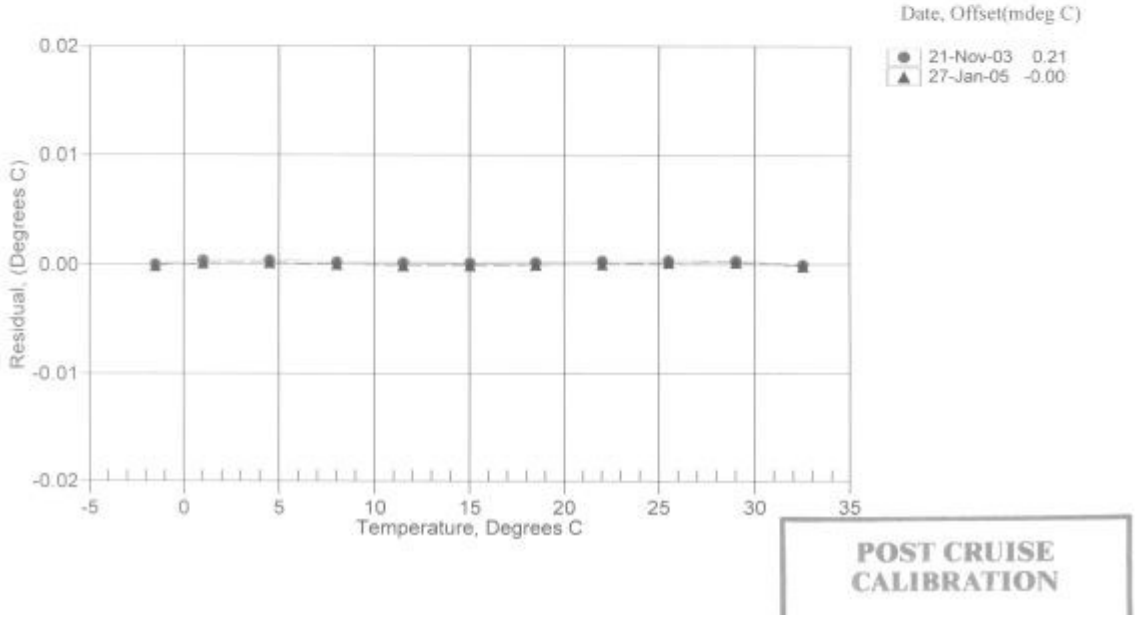
| BATH TEMP (ITS-90) | INSTRUMENT FREQ (Hz) | INST TEMP (ITS-90) | RESIDUAL (ITS-90) |
|---|---|---|---|
| -1.4999 | 5707.057 | -1.5000 | -0.00014 |
| 1.0002 | 6042.071 | 1.0003 | 0.00011 |
| 4.5002 | 6534.710 | 4.5004 | 0.00017 |
| 8.0002 | 7055.658 | 8.0002 | 0.00002 |
| 11.5002 | 7605.713 | 11.5001 | -0.00013 |
| 15.0002 | 8185.648 | 15.0001 | -0.00012 |
| 18.5002 | 8796.166 | 18.5001 | -0.00006 |
| 22.0002 | 9437.953 | 22.0002 | 0.00001 |
| 25.5002 | 10111.682 | 25.5003 | 0.00014 |
| 29.0002 | 10817.954 | 29.0004 | 0.00017 |
| 32.5002 | 11557.311 | 32.5000 | -0.00017 |

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 ITS-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



## *Underway Transmissometer*

PO Box 518
620 Applegate St.
Philomath, OR 97370

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

WET Labs

# C-Star Calibration

Date September 27, 2004 Customer National Science Foundation Work order 005

Job # 0102007 S/N# CST-439DR Pathlength 25 cm

| | Analog meter |
|---|---|
| $V_d$ | 0.060 V |
| $V_{air}$ | 4.803 V |
| $V_{ref}$ | 4.694 V |

| | |
|---|---|
| Temperature of calibration water | 22.3 °C |
| Ambient temperature during calibration | 22.8 °C |

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

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

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

$V_d$ Meter output with the beam blocked. This is the offset.
$V_{air}$ Meter output in air with a clear beam path.
$V_{ref}$ Meter output with clean water in the path.
Temperature of calibration water: temperature of clean water used to obtain $V_{ref}$.
Ambient temperature: meter temperature in air during the calibration.
$V_{sig}$ Measured signal output of meter.

cstarcalsheet Revision A 6/23/03