Data Report NBP0804

New Zealand – Chile, Transit

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United States Antarctic Program

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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, readable by most computing platforms.

All the data has been compressed using Unix "gzip," identified by the ".gz" extension. It has been copied to the distribution media in the Unix tar archive format, ".tar" extension. Tools are available on all platforms for uncompressing and de-archiving these formats: On Macintosh, use Stuffit Expander with DropStuff. On Windows operating systems use WinZip.

MultiBeam 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.

Distribution Contents at a Glance

Volume 1 of 1: NBP0804 File	Description
/	Root level directory
NBP0804.trk	Text file of cruise track (lat,lon)
NBP0804.mgd	Full Cruise MGD77 data file
NBP0804.gmt	GMT binary file of MGD77 data
804WATCH.XLS	Watch log from NBP0804
0804XBT.tar	XBT data colleected for NOAA
/process	Geop data
0804jgof.tar	JGOFS fo0rmat data files
0804qc.tar	Daily RVDAS QC postcript plots
0804pco2.tar	Merged pCO2 data files
0804mgd.tar	MGD Data
/rvdas/nav	Navigation data
0804gyr1.tar	Gyro raw data
0804PCOD.tar	Trimble P-code raw data
0804seap.tar	Seapath data
0804adcp.tar	ADCP Data Sets
/rvdas/uw	Underway data
0804bat1.tar	Bathymetric raw data
0804ctdd.tar	CTD raw data
0804flr1.tar	Fluorometer raw data
0804grv1.tar	Gravimeter raw data
0804met1.tar	Meteorology raw data
0804oyo1.tar	Seismic acquisition data
0804pco2.tar	pCO2 raw data
0804wind.tar	Ultrasonic anemometer raw data
0804tsg1.tar	TSG raw data
0804svp1.tar	Sound velocity probe (in ADCP well)
0804syn1.tar	Syntron data
0804mtsg.tar	Micro TSG data
0804eng1.tar	Engineering Data and PIR
0804hdas.tar	HydroDAS raw data
0804pguv.tar	GUV raw data
0804rtmp.tar	Remote temperature data
0804mbdp.tar	SIMRAD multibeam sonar data
/Imagery	Other Data, Files and Pictures
0804Imag.tar	Satellite imagery
/b2kw	
.dat files	Seg-Y files

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
```

On Windows machines, the common application Winzip can uncompress both `tar` and `gz` formatted files.

Distribution Contents

Cruise Information

NBP0804 was a standard science of opportunity transit cruise. We left Lyttleton New Zealand on March 21st. We collected data in New Zealand and Chilean waters. The cruise included MG&G operations for Dr. Steve Cande, also included was a A NOAA funded Ship of Opportunity program that deployed Argos buoys and collected XBT data. There are 3 data distributions; a master, a Chilean subset, and a New Zealand subset. There were no major problems during the transit and no instruments changed. The whether and the seas were not very cooperative and the Multi-Beam data was not the best. The cruise terminated in Punta Arenas Chile on April 14, 2008.

Cruise Track

The distribution DVD includes a GMT cruise track file 0804.trk. It contains the longitude and latitude at one-minute intervals extracted from the 0804.gmt file.

Jpeg files of the cruise track have also been placed in the / directory.

Satellite Images

Satellite Images received for this cruise can be found in the file called 0804Imag.tar Imagery collected and processed on the ship is in two further subdirectories, Ice and WX (weather). Files are named using the convention, ssss_fff_mmddyy_tttt_ww.gif where:

ssss_fff = satellite and flight number
mm = month
dd = day
yy = year
tttt = time in hours and minutes (UTC)
ww = optional field for identifying wavelength, such as vis (visible) or IR (infrared)

NBP Data Products

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

The data processing scripts used to produce JGOFS and MGD77 data sets create a lot of intermediate files. These intermediate files are included on the data distribution media in the directory /process/proc. They are included to make re-processing easier in the event of an error, but no extensive detail of the formats is included in this document. If you have any questions, please contact itvessel@usap.gov.

JGOFS

The JGOFS data set can be found on the distribution media in the file /process/0804jgof.tar.gz. The ".gz" extension indicates that the tar file has been compressed after archiving. 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" as 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)
16	Ambient air temperature	°C
17	Relative humidity	%
18	Barometric pressure	mBars
19	Sea surface fluorometry	volts (0-5 FSO)
20	Transmissometer	%
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 0804.mgd. The file 0804.gmt is created from the MGD77 dataset using the "mgd77togmt" utility. 0804.gmt can be used with the GMT plotting package.

The data used to produce the 0804.mgd file can be found on the distribution media in the file /process/proc. The data files in the archive contain a day's data and follow the naming convention Dddd.fnl, where ddd is the year-day. These files follow a space-delimited columnar format that may be more accessible for some purposes. Below is a detailed description of the MGD77 data set format. The other files in the archive contain interim processing files and are included to simplify possible reprocessing of the data using the RVDAS NBP processing scripts.

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

Col	Len	Type	Contents	Description, Possible Values, Notes
1	1	Int	Data record type	Set to "5" for data record
2-9	8	Char	Survey identifier	
10-12	3	int	Time zone correction	Corrects time (in characters 13-27) to GMT when added; 0 = GMT
13-16	4	int	Year	4 digit year
17-18	2	int	Month	2 digit month
19-20	2	int	Day	2 digit day
21-22	2	int	Hour	2 digit hour
23-27	5	real	Minutes x 1000	
28-35	8	real	Latitude x 100000	+ = North - = South. (–9000000 to 9000000)
36-44	9	real	Longitude x 100000	+ = East - = West. (–18000000 to 18000000)
45	1	int	Position type code	1=Observed fix 3=Interpolated 9=Unspecified
46-51	6	real	Bathymetry, 2- way travel time	In 10,000th of seconds. Corrected for transducer depth and other such corrections
52-57	6	real	Bathymetry, corrected depth	In tenths of meters.
58-59	2	int	Bathymetric correction code	This code details the procedure used for determining the sound velocity correction to depth
60	1	int	Bathymetric type code	1 = Observed 3 = Interpolated (Header Seq. 12) 9 = Unspecified
61-66	6	real	Magnetics total field, 1ST sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2ND sensor	In tenths of nanoteslas (gammas), for trailing sensor
73-78	6	real	Magnetics residual field	In tenths of nanoteslas (gammas). The reference field used is in Header Seq. 13
79	1	int	Sensor for residual field	1 = 1st or leading sensor 2 = 2nd or trailing sensor 9 = Unspecified
80-84	5	real	Magnetics diurnal	In tenths of nanoteslas (gammas). (In

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

Science of Opportunity

ADCP

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

A data feed is sent from the ADCP system to RVDAS whenever a reference layer is acquired. This feed contains east and north vectors for ship's speed, relative to the reference layer, and ship's heading. Collected files (one per day) are archived in /adcp/`0804adcp.tar`. *Note: This system was not working during cruise NBP0804, thus no data has been archived.*

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 the merged pCO_2 data in file /process/`0804pco2.tar`, 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).

NBP0804 XBT transect.

Onboard NBP0804 was a NOAA funded participant that collected XBT transect data. The NBP0804 data disk contains a tar file of that data (0804XBT.tar). There are documents describing that data inside the .tar file. For further information contact gpezzoli@ucsd.edu .

CTD

No ctd data was collected on NBP0804..

XBT

During the cruise, eXpendable BathyThermographs were used to obtain water column temperature profiles, providing corrections to the sound velocity profile for the multibeam system. The data files from these launches are included as `0804xbt.tar` in the `/ocean` directory.

RVDAS

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

Daily data processing of the RVDAS data is performed to calibrate and convert values into useable units and as a quality-control on operation of the DAS. Raw and processed data sets from RVDAS are included in the data distribution. The tables below provide detailed information on the sensors and data. Be sure to read the "Significant Acquisition Events" section for important information about data acquisition during this cruise.

Sensors and Instruments

RVDAS data is divided into two general categories, *underway and navigation*. They can be found on the distribution media as subdirectories under the top level rvdas directory: `/rvdas/uw`, and `/rvdas/nav`. Processed oceanographic data is in the top level directory, `/process`. Each instrument or sensor produces a data file named with its channel ID. Each data file is g-zipped to save space on the distribution media. Not all data types are collected every day or on every cruise.

The naming convention for data files produced by the sensors and instruments is

[CruiseID][ChannelID].dDDD

Example: `NBP0703met1.d065`

- The CruiseID is the numeric name of the cruise, in this case, 0703, with the NBP prefix.
- 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	R. M. Young 41372LC
Wind Speed/Direction	met1	continuous	1 sec	R.M. Young 05106
Barometer	met1	continuous	1 sec	R.M. Young 61201
PIR (LW radiation)	eng1	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	2 sec	BSI GUV-2511
PUV	puv	not collected		BSI PUG-2500

Geophysics

Measurement	Channel ID	Collect. Status	Rate	Instrument
Gravimeter	grv1	continuous	10 sec*	LaCoste & Romberg
Bathymetry	bat1	continuous	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 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
Transmissometry	hdas	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

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

Each section below describes a type of data file (file name extension in parentheses) followed by a typical line of data in the file. In the table(s) for each section is a description of the fields within each line of data. Note: most data files listed below will be included with each cruise's data distribution, however some types of files may be omitted if the instrument was not operating during the cruise. The available data files can be found in the /rvdas/uw directory on the distribution disc.

Sound Velocity Probe (svp1)

```
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 0959.6 000.2 093.1

-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	(Empty)	
13	PAR (photosynthetically active radiation)*	mV

*See page 24 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	

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

Environmental record ($ENV)

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

Field	Data	Conversion	Units
1	RVDAS time tag		
2	Text string (id field)	$ENV for environmental record	
3	Date	YYYY/MM/DD	
4	Time	HH:MM:SS.SS	
5	Day of Year	DDD	
6	Meter ID		
7	Meter Pressure		inch-Hg
8	Meter temp		°C
9	Ambient temp		°C
10	K-Factor		
11	VCC Coeff		
12	AL Coeff		
13	AX Coeff		
14	VE Coeff		
15	AX2 Coeff		
16	Serial Filter Length		Seconds
17	QC Filter Length		Seconds

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 PW2=Hamming PW3=Cosine PW4=Blackman	
10	Primary transmit frequency	PF1=3.5 kHz PF2=12.0 kHz	kHz
11	Parametric mode secondary frequency	SF1=3.5 kHz SF2=12.0 kHz	kHz
12	Pulse length	PL1=200usec PL2=500usec PL3=1msec PL4=2msec PL5=5msec PL6=10msec PL7=25msec If transmit mode is FM: PL1=25msec PL2=50msec PL3=100msec	
13	Operating mode	MO1=CW parametric MO2=CW MO3=FM parametric MO4=FM	
14	Frequency sweep bandwidth	SB1=1 kHz SB2=2 kHz SB3=5 kHz	kHz
15	Power level	PO1 = 0dB PO2 = -6dB PO3 = -12dB PO4 = -18dB PO5 = -24dB PO6 = -30dB PO6 = -30 dB PO7 = -36dB PO8 = -42dB	
16	Transmit mode	TX1=single ping active TX2=pinger listen TX3=multipinging TR	

Field	Data	Format / Possible Values	Units
		TX4=multipinging TR TX5=multipinging TTRR TX6=multipinging TTTTRRRR TX7=multipinging TTTTTRRRRR	
17	Transmit Rate	TR3 = 4Hz TR4 = 2Hz TR5 = 1Hz TR6 = .5Hz TR7 = .33Hz TR8 = .25Hz TR9 = .20Hz TR: = .10Hz TR; = .05Hz	Hz
18	System gain mode	GM0=hydrographic AGC GM1 to GM9=hydrographic +3db to + 27db manual. GMA to GMD=hydrographic + 30db through + 60db manual GME to GMK=sub-bottom 1 through sub-bottom 7	
19	Speed of sound		m/sec
20	Depth of sonar window below sea-level		meters
21	Background noise level in fixed point reference		dB/V

Knudsen (knud)

```
99+099:00:18:19.775 HF,305.2,LF,304.3
```

Field	Data	Units
1	RVDAS time tag	
2	HF = High frequency flag (12 kHz)	
3	High frequency depth	meters
4	LF = Low frequency flag (3.5 kHz)	
5	Low frequency depth	meters

Simrad EM120 (mbdp)

```
07+280:00:01:38.309 $EMDPT,3189.12,0.0
```

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

Simrad EK500 (sim1)

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

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

Thermosalinograph (tsg1)

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

Field	Data	Units
1	RVDAS time tag	
2	Seabird hex string (see page 24 for conversion to real units)	

Fluorometer (flr1)

```
00+019:23:59:58.061 0  0  7797 :: 10/08/07 00:15:14 = 2.953  (RAW)
```

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	

pCO_2 (pco2)

```
00+021:23:59:43.190 2000021.99920 2382.4 984.2 30.73 50.8 345.9 334.1 -1.70    -
68.046 -144.446 Equil
```

Field	Data	Units
1	RVDAS time tag	
2	pCO_2 time tag (decimal is fractional time of day)	yyyyddd.ttt
3	Raw voltage (IR)	mV
4	Cell temperature	°C
5	Barometer	MBar
6	Concentration	ppm
7	Equilibrated temperature	°C
8	pCO_2 pressure	microAtm
9	Flow rate	ml / min

Field	Data	Units
10	Source ID #	1 or 2 digits
11	Valve position	1 or 2 digits
12	Flow source (Equil = pCO_2 measurement)	text

Engineering (eng1)

```
07+280:06:45:29.359 12.2655 16.29123 134.663 98.51914 83.71822 -
3.354797 45.38742 -0.149594 15.25094 15.08044 NAN
```

Field	Data	Units
1	RVDAS time tag	
2	Power Supply Voltage	
3	Internal Case Temperature	
4	Pump #1 flow rate	L/min
5	Pump #2 flow rate	L/min
6	Seismic air pressure	Lbs/sq-in
7	PIR case resistance	Kohm
8	PIR case ratiometric output	mV
9	Freezer #1 temperature	C
10	Freezer #2 temperature	C
11	Freezer #3 temperature	C

*See page 25 for PIR calculations.

Hydro-DAS (hdas)

```
07+280:00:00:19.352 12.16678 15.94557 244.7432 4432.954 61.5 66.5 80.5
63
```

Field	Data	Units
1	RVDAS time tag	
2	Supply voltage	
3	Panel temperature	
4	Fluorometer	mV
5	Transmissometer	mV
6	Flow meter 1 frequency	Hz
7	Flow meter 2 frequency	Hz
8	Flow meter 3 frequency	Hz
9	Flow meter 4 frequency	Hz

Micro-TSG (mtsg)

```
07+280:00:00:48.058  -1.5017,  2.70111,  33.9692, 1440.723
```

Field	Data	Units
1	RVDAS time tag	
2	Temperature	C
3	Conductivity	s/m
4	Sound velocity	m/s

GUV Data (pguv)

```
07+288:00:00:45.399 101507 000049 .000226 1.627E0 5.253E0 5.831E-1
4.382E-2 6.811E0 1.479E-2 6.719E0 45.707 17.954
```

Field	Data	Units
1	RVDAS time tag	
2	Date	mmddyy
3	Time (UTC)	hhmmss
4	Ed0Gnd	V
5	Ed0320	uW (cm^2 nm)
6	Ed0340	uW (cm^2 nm)
7	Ed0313	uW (cm^2 nm)
8	Ed0305	uW (cm^2 nm)
9	Ed0380	uW (cm^2 nm)
10	Ed0PAR	uW (cm^2 nm)
11	Ed0395	uW (cm^2 nm)

Remote Temperature (rtmp)

```
07+272:00:00:15.960 -1.7870
```

Field	Data	Units
1	RVDAS time tag	
2	Temperature at seawater intake	C

Ultrasonic Anemometer (wind)

```
07+271:00:09:34.240 _A,139,007.55,M,+330.77,-001.52,65,_01
```

Field	Data	Units
1	RVDAS time tag	
2	Code (unit identification)	
3	Wind direction	Degrees
4	Wind speed	m/s
5	Wind speed units (M=M/S)	
6	Sound speed	m/s
7	Temperature (sonic)	C
8	Status (0 = OK, 60 = OK and heated, other code = error state)	
9	Checksum	

Navigational Data

This section uses the same format as the previous section, with a file name (file name extension in parentheses) and data example followed by a table describing the contents of a typical line of data. In some cases a file described herein may not be included in the data distribution.

Seapath GPS (seap)

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

- GPZDA (Date and time string)
- GPGGA (Position and data quality indicators)
- GPVTG (Course and speed)
- GPHDT (Heading)
- PSXN, 20 (Data quality indicators)
- PSXN, 22 (Gyro calibration)
- PSXN, 23 (Roll, pitch, heading, and heave)

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	

Field	Data	Units
12	(empty field)	
13	M	
14	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	(empty field)	
6	M	
7	speed over ground in knots	k.k
8	N	
9	(empty field)	
10	K	
11	Mode	
12	Checksum	

GPHDT

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

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

PSXN,20

```
02+253:00:00:00.942 $PSXN,20,0.43,0.43*39
```

Field	Data	Units
1	RVDAS time tag	
2	$PSXN	
3	20	
4	Horizontal position & velocity quality: 0=normal, 1=reduced performance, 2=invalid data	
5	Height & vertical velocity quality: 0=normal, 1=reduced performance, 2=invalid data	
6	Heading quality: 0=normal, 1=reduced performance, 2=invalid data	
7	Roll & pitch quality: 0=normal, 1=reduced performance, 2=invalid data	
8	Checksum	

PSXN,22

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

Field	Data	Units
1	RVDAS time tag	
2	$PSXN	
3	22	

Field	Data	Units
4	gyro calibration value since system start-up in degrees	d.dd
5	short term gyro offset in degrees	d.dd
6	Checksum	

PSXN,23

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

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

Trimble (P-Code) GPS (PCOD)

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

- Position fix (GGA)
- Latitude / longitude (GLL),
- Track and ground speed (VTG)
- (RMC)
- (ZDA) This is a data/time string in the same format as the SeaPath's GPZDA string described in the previous section.

GGA: GPS Position Fix – Geoid/Ellipsoid

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

Field	Data	Units
1	RVDAS Time tag	
2	$GPGGA	
3	UTC time at position	hhmmss.sss
4	Latitude	ddmm.mmm
5	North (N) or South (S)	
6	Longitude	ddmm.mmm
7	East (E) or West (W)	
8	GPS quality: 0 = Fix not available or invalid 1 = GPS, SPS mode, fix valid 2 = DGPS (differential GPS), SPS mode, fix valid 3 = P-CODE PPS mode, fix valid	

Field	Data	Units
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)

```
07+288:21:30:18.599 $HEHDT,338.81,T*1e
```

Field	Data	Units

Field	Data	Units
1	RVDAS time tag	
2	$HEHDT	
3	Heading, Degrees True	degrees
4	Checksum	

ADCP Course (adcp)

```
00+019:23:59:59.099 $PUHAW,UVH,-1.48,-0.51,250.6
```

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

Seapath – additional datasets (sp1b) and (sp2b)

Data in these files follows the same format as the typical Seapath GPS (seap) files. See the Seapath dataset explanation at the beginning of this section for a full description.

Processed Data

The processed data sets can be found in the /process directory and subdirectories. Note: many of the subdirectories contain intermediate datasets to facilitate further processing and are not intended to be end-products. Only the final product files and datasets are described below.

pCO2-merged (pco2)

```
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 fractional time of day)	yyyyddd.ttt
3	Raw voltage (IR)	mV
4	Cell temperature	°C
5	Barometer	MBar
6	Concentration	ppm
7	Equilibrated temperature	°C
8	pCO_2 pressure	microAtm
9	Flow rate	ml / min
10	Source ID #	1 or 2 digits
11	Valve position	1 or 2 digits
12	Flow source (Equil = pCO_2 measurement)	text
13	RVDAS latitude	degrees
14	RVDAS longitude	degrees
15	TSG external temperature	°C
16	TSG salinity	PSU
17	TSG fluorometry	V
18	RVDAS true wind speed	m/s
19	RVDAS true wind direction	degrees
20	Barometric Pressure	mBars
21	Uncontaminated seawater pump flow rate	l/min
22	Speed over ground	knots
23	Course made good	degrees

tsgfl

```
07+265:07:37:22.631 005.281 005.069 03.2943 34.11680 0.000000
```

Field	Data	Units
1	RVDAS time tag	
2	Internal water temperature	°C
3	Sea Surface Temperature	°C
4	Conductivity	μSiemens
5	Salinity	PSU

Calculations

The file `0804coef.txt` located in the `/reports` 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 an 18 byte (character) long hex string. Example:

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

Bytes	Data
1-4	Sensor Temperature (in wet lab)
5-8	Conductivity
9-14	Remote Temperature (near seawater intake)
15-18	Not used

The coefficients for temperature and conductivity sensors can be found the 0804coef.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); δ = Ctcor; ε = CPcor

PAR

raw data = mV

calibration scale = 6.27 V/(μEinstiens/cm 2sec)

offset (Vdark) = 0.1 mV

(raw mV - Vdark)/scale x 104 cm2/m2 x 10-3 V/mV= μEinstiens/m2sec

or

(data mV – 0.1 mV) x 1.65 (μEinstiens/m2sec)/mV = μEinstiens/m2sec

PSP

raw data = mV

calibration scale = 7.94 x 10-6 V/(W/m2)

data mV / (scale x 103 mV/V) = W/m2

or

data mV x 120.7 (W/m2)/V = W/m2

PIR

Coefficient pirCoeff for this cruise can be found in the 0804coef txt file. Variable PIRr is the PIR case resistance and PIRmv is the radiometric output, as described in the “eng1” file description. Hard-coded “C” coefficients are shown below:

```
C1=0.0010295
C2=0.0002391
C3=0.0000001568
C4=5.6704e-8

Calculations (extracted from the C code):
raw data = mV
calibration scale =  7.94 x 10-6  V/(W/m2)
data mV / (scale x 103 mV/V) = W/m2
or
data mV x 120.7 (W/m2)/V = W/m2
Rr = log(fabs(PIRr * 1000))
T = 1 / ( C1 + (C2 * Rr) + (C3 * Rr * Rr * Rr) )
Rin = ( (PIRmv * 1000) / pirCoeff) + (C4 * T * T * T * T )
```

Acquisition Problems and Events

This section lists acquisition problem and events 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
081:02:48		Started Loggers
083:09:57		Exited New Zealand EEZ
103:13:50		Entered Chilean EEZ,
104:11:27		Ended data collection for NBP08084

Appendix: Sensors and Calibrations

NBP0804 Sensors:

Sensor	*Serial Number*	*Last Calibration*	*Comments*
Meteorology & Radiometers			
Stbd Anemometer (Gill Ultrasonic)	071739	5/15/2007	Installed 7/19/2007
Stbd Anemometer	WM 73682	6/30/2007	Installed 7/19/2007
Bridge Anemometer	WM 45835	2/28/2007	Bridge (center)
Port Anemometer	WM 46263	6/30/2007	Installed 7/19/2007
Barometer	01706	6/15/2006	Installed 6/27/2007
Humidity/Wet Temp	06135	6/15/2006	Installed 6/27/2007
PIR	33023F3	3/8/2007	Installed 5/30/2007
PSP	33090F3	3/13/2007	Installed 7/20/2007
Mast PAR	6356	8/8/2007	Installed 8/28/2007
GUV (Mast)	25110203114	1/23/2007	Installed 8/28/2007
Underway			
TSG	2131020-3198	5/20/06	Installed 02/07/07
TSG Remote Temp (Primary)	3846730-0352	6/6/2007	Installed 7/15/2007
TSG Remote Temp (Secondary)	031267	4/12/2006	Installed 1/29/07
Micro TSG	4546167-0199	3/21/2007	Installed 6/10/2007
Fluorometer (Primary)	5333-FRXX	Un-calibrated	Installed 4/14/04
Fluorometer (Secondary)	AFL-044	5/31/2006	Installed 6/23/2007
Transmissometer	CST-397DR	2/13/2006	Installed 8/15/07

Calibrations

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

Gravity Tie Start (McMurdo Station)

Gravity Tie Spreadsheet

The fields outlined in BOLD MUST BE FILLED IN for this spreadsheet to operate properly. The automatically calculated values show up in the shaded fields.

Date: 3/16/2008
Location: Lyttelton/Christchurch, New Zealand
Station: Mag-Obs Workshop, Botanical Gardens
Latitude: 43 31.77 S
Longitude: 172 37.18 E
Elevation: 6.7 meters
Gravity: 980494.29

Reference Code Numbers:

ADIC	0217-0
IGC	48732A
DSIR	P11
GW	79
NHO	16

	Value	Time (GMT)
Ship's meter before gravity tie (Gravity (cu))	8182.2	20:41
Ship's meter after gravity tie (Gravity (cu))	8181.8	1:18
Average	8182.0	
Ship Gravimeter's Calibration Constant	1.0046	
Corrected ship's meter (QC Grav (mgal))	8219.6	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	8182.2	20:41
Ship's meter after gravity tie (serial, RVDAS)	8181.8	1:18
Average (for comparison check only)	8182.0	

Portable Gravimeter Interval Factor: 1.00953 From Table 1 of Model G #807 Meter

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	4127.01	20:57	53.5	March 16, 2008	
Pier measurement 2	4127.04	21:06	53.5	March 16, 2008	4166.36
Pier measurement 3	4127.05	21:10	53.5	March 16, 2008	
Average	4127.03				
Station measurement 1	4095.34	23:50	53.5	March 16, 2008	OBS mgal, averaged
Station measurement 2	4095.41	23:54	53.5	March 16, 2008	4134.41
Station measurement 3	4095.40	23:55	53.5	March 16, 2008	
Average	4095.38				
Pier measurement 4	4126.94	1:04	53.5	March 17, 2008	OBS mgal, averaged
Pier measurement 5	4126.91	1:08	53.5	March 17, 2008	4166.30
Pier measurement 6	4127.06	1:07	53.5	March 17, 2008	
Average	4126.97				

Gravity offset from last tie 972304.41
Drift since last tie 2.34

OBS Differences	
Station to Pier (1, 2, & 3 averaged)	31.95
Station to Pier (4, 5, & 6 averaged)	31.89
Averaged Differences	31.92
Gravity at pier	980526.21
Elevation of pier above gravimeter, meters	0.6
Earth differential gravity, mgal/meter	0.3
Gravity at ship's gravimeter	980526.39
Gravity Offset (for RVDAS)	972306.75

Comments

Gravity Tie done by Sheldon Blackman, Joel Lenorovitz, Dmitry Triy.

Meteorology System

Anemometer (Port)

RM Young Anemometer Calibration, Model 05106

S/N: 46263 Date: 30-Jun-07 Cal'd By: George Aukon

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.10	-0.10	0.0
200	0.98	0.90	0.08	1.9
500	2.45	2.30	0.15	4.8
1000	4.90	4.80	0.10	9.5
1500	7.35	7.30	0.05	14.3
2000	9.80	9.80	0.00	19.0
3000	14.70	14.70	0.00	28.6
4000	19.60	19.60	0.00	38.1
5000	24.50	24.60	-0.10	47.6
6000	29.40	29.40	0.00	57.1
7000	34.30	34.30	0.00	66.6
8000	39.20	39.40	-0.20	76.2
9000	44.10	44.20	-0.10	85.7
10000	49.00	49.10	-0.10	95.2
12000	58.80	58.90	-0.10	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	30	0
60	59	1
90	89	1
120	118	2
150	148	2
180	179	1
210	210	0
240	240	0
270	270	0
300	300	0
330	330	0
0	0	0

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

Counter Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s
0	0.00	0.10	-0.10
200	0.98	0.80	0.18
500	2.45	2.40	0.05
1000	4.90	4.80	0.10
1500	7.35	7.30	0.05
2000	9.80	9.80	0.00
3000	14.70	14.70	0.00
4000	19.60	19.60	0.00
5000	24.50	24.60	-0.10
6000	29.40	29.50	-0.10
7000	34.30	34.40	-0.10
8000	39.20	39.30	-0.10
9000	44.10	44.30	-0.20
10000	49.00	49.20	-0.20
12000	58.80	58.90	-0.10

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

Wind Speed Threshold < 2.9 gm?	2
Wind Direction Threshold < 30 gm?	15

Additional Comments

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: 73682 Date: 30-Jun-07 Cal'd By: George Aukon

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.10	-0.10	0.0
200	0.98	0.80	0.18	1.9
500	2.45	2.40	0.05	4.8
1000	4.90	4.80	0.10	9.5
1500	7.35	7.30	0.05	14.3
2000	9.80	9.80	0.00	19.0
3000	14.70	14.70	0.00	28.6
4000	19.60	19.60	0.00	38.1
5000	24.50	24.60	-0.10	47.6
6000	29.40	29.50	-0.10	57.1
7000	34.30	34.40	-0.10	66.6
8000	39.20	39.30	-0.10	76.2
9000	44.10	44.30	-0.20	85.7
10000	49.00	49.20	-0.20	95.2
12000	58.80	58.90	-0.10	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	29	1
60	59	1
90	89	1
120	119	1
150	148	2
180	178	2
210	207	3
240	237	3
270	267	3
300	297	3
330	328	2
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	0.10	-0.10
200	0.98	0.90	0.08
500	2.45	2.30	0.15
1000	4.90	4.80	0.10
1500	7.35	7.30	0.05
2000	9.80	9.80	0.00
3000	14.70	14.70	0.00
4000	19.60	19.60	0.00
5000	24.50	24.60	-0.10
6000	29.40	29.40	0.00
7000	34.30	34.30	0.00
8000	39.20	39.40	-0.20
9000	44.10	44.20	-0.10
10000	49.00	49.10	-0.10
12000	58.80	58.90	-0.10

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

Wind Speed Threshold < 2.9 gm?	2.3
Wind Direction Threshold < 30 gm?	15

Additional Comments

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

Anemometer (Bridge)

RM Young Anemometer Calibration, Model 05106

S/N: 45835 Date: 28-Feb-07 Cal'd By: George Aukon

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.00	0.00	0.0
200	0.98	0.90	0.08	1.9
500	2.45	2.40	0.05	4.8
1000	4.90	4.80	0.10	9.5
1500	7.35	7.30	0.05	14.3
2000	9.80	9.80	0.00	19.0
3000	14.70	14.60	0.10	28.6
4000	19.60	19.50	0.10	38.1
5000	24.50	24.30	0.20	47.6
6000	29.40	29.20	0.20	57.1
7000	34.30	34.10	0.20	66.6
8000	39.20	39.00	0.20	76.2
9000	44.10	43.90	0.20	85.7
10000	49.00	48.80	0.20	95.2
12000	58.80	58.60	0.20	114.2

Direction	Measured Direction	Delta Direction
0	359	0
30	29	1
60	59	1
90	89	1
120	119	1
150	148	2
180	179	1
210	210	0
240	240	0
270	270	0
300	301	-1
330	331	-1
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	0.00	0.00
200	0.98	1.00	-0.02
500	2.45	2.50	-0.05
1000	4.90	4.90	0.00
1500	7.35	7.40	-0.05
2000	9.80	9.80	0.00
3000	14.70	14.80	-0.10
4000	19.60	19.80	-0.20
5000	24.50	24.60	-0.10
6000	29.40	29.50	-0.10
7000	34.30	34.50	-0.20
8000	39.20	39.40	-0.20
9000	44.10	44.40	-0.30
10000	49.00	49.30	-0.30
12000	58.80	59.60	-0.80

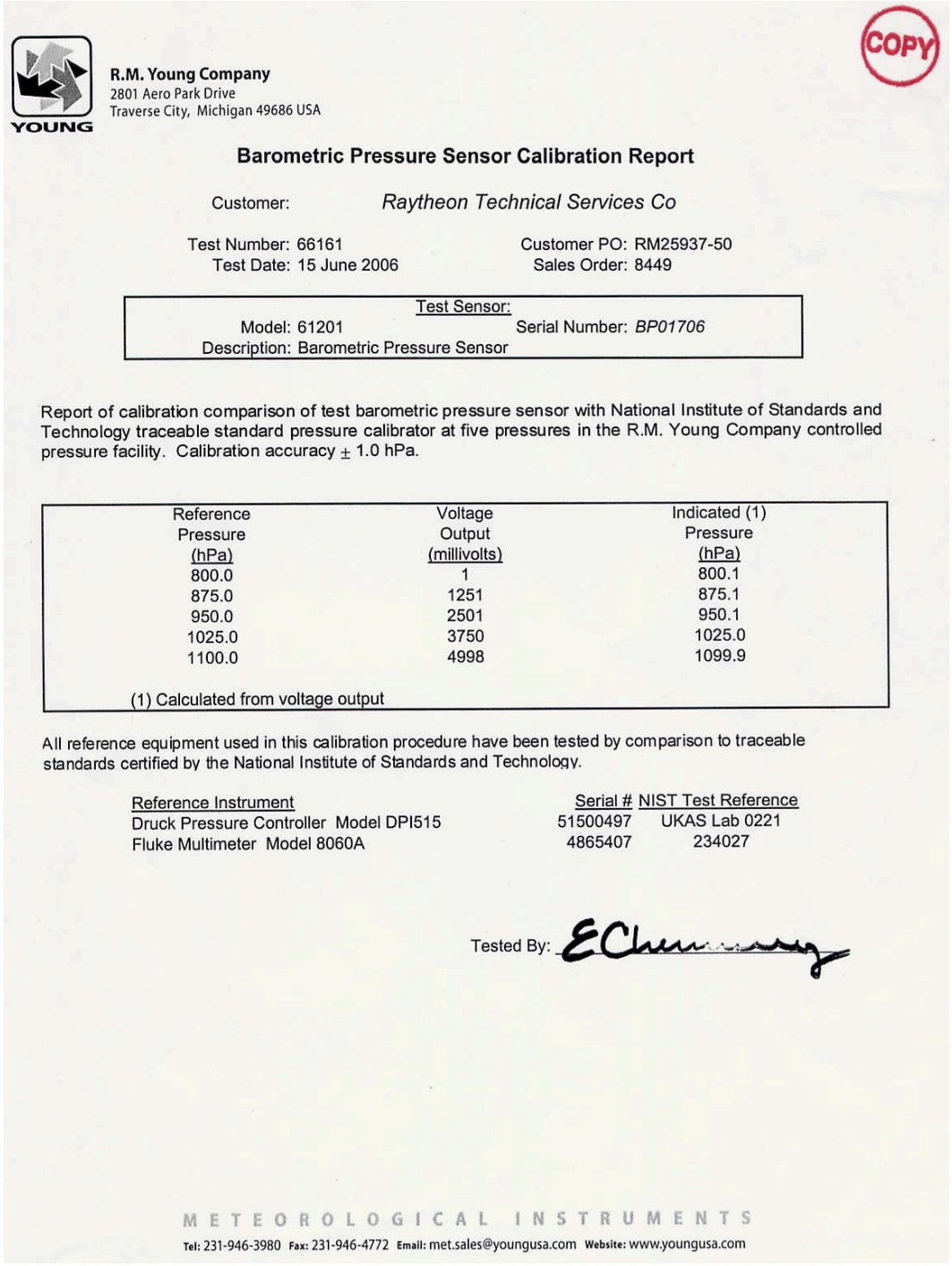
Caution: Do Not exceed 12000 rpm during Wind Speed test.

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

Additional Comments
Potentiometer and potentiometer coupling were replaced , vertical shaft bearings were cleaned and lubricated.

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

Barometer



COPY

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

YOUNG

Barometric Pressure Sensor Calibration Report

Customer: *Raytheon Technical Services Co*

Test Number: 66161 Customer PO: RM25937-50
Test Date: 15 June 2006 Sales Order: 8449

Test Sensor:
Model: 61201 Serial Number: *BP01706*
Description: Barometric Pressure Sensor

Report of calibration comparison of test barometric pressure sensor with National Institute of Standards and Technology traceable standard pressure calibrator at five pressures in the R.M. Young Company controlled pressure facility. Calibration accuracy ± 1.0 hPa.

Reference Pressure (hPa)	Voltage Output (millivolts)	Indicated (1) Pressure (hPa)
800.0	1	800.1
875.0	1251	875.1
950.0	2501	950.1
1025.0	3750	1025.0
1100.0	4998	1099.9

(1) Calculated from voltage output

All reference equipment used in this calibration procedure have been tested by comparison to traceable standards certified by the National Institute of Standards and Technology.

Reference Instrument	Serial #	NIST Test Reference
Druck Pressure Controller Model DPI515	51500497	UKAS Lab 0221
Fluke Multimeter Model 8060A	4865407	234027

Tested By: E Chemmery

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

Humidity Sensor

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

Relative Humidity Sensor Calibration Report

Customer: *Raytheon Technical Services Co*

Test Number: 66900R
Test Date: 15 June 2006
Customer PO: RM25937-50
Sales Order: 8449

Test Sensor:
Model: 41372LC Serial Number: *6135*
Description: Temperature/Relative Humidity Sensor

Report of calibration comparison of test relative humidity sensor with National Institute of Standards and Technology traceable standard relative humidity sensor at five humidity levels in the R.M. Young Company controlled humidity chamber facility. Calibration accuracy ± 2.0 %.

Reference Humidity (%)	Current Output (milliamps)	Indicated (1) Humidity (%)
10.4	6.0	12.3
30.0	8.8	30.1
49.8	12.0	50.2
70.0	15.2	69.7
89.5	17.8	86.5

(1) Calculated from voltage output

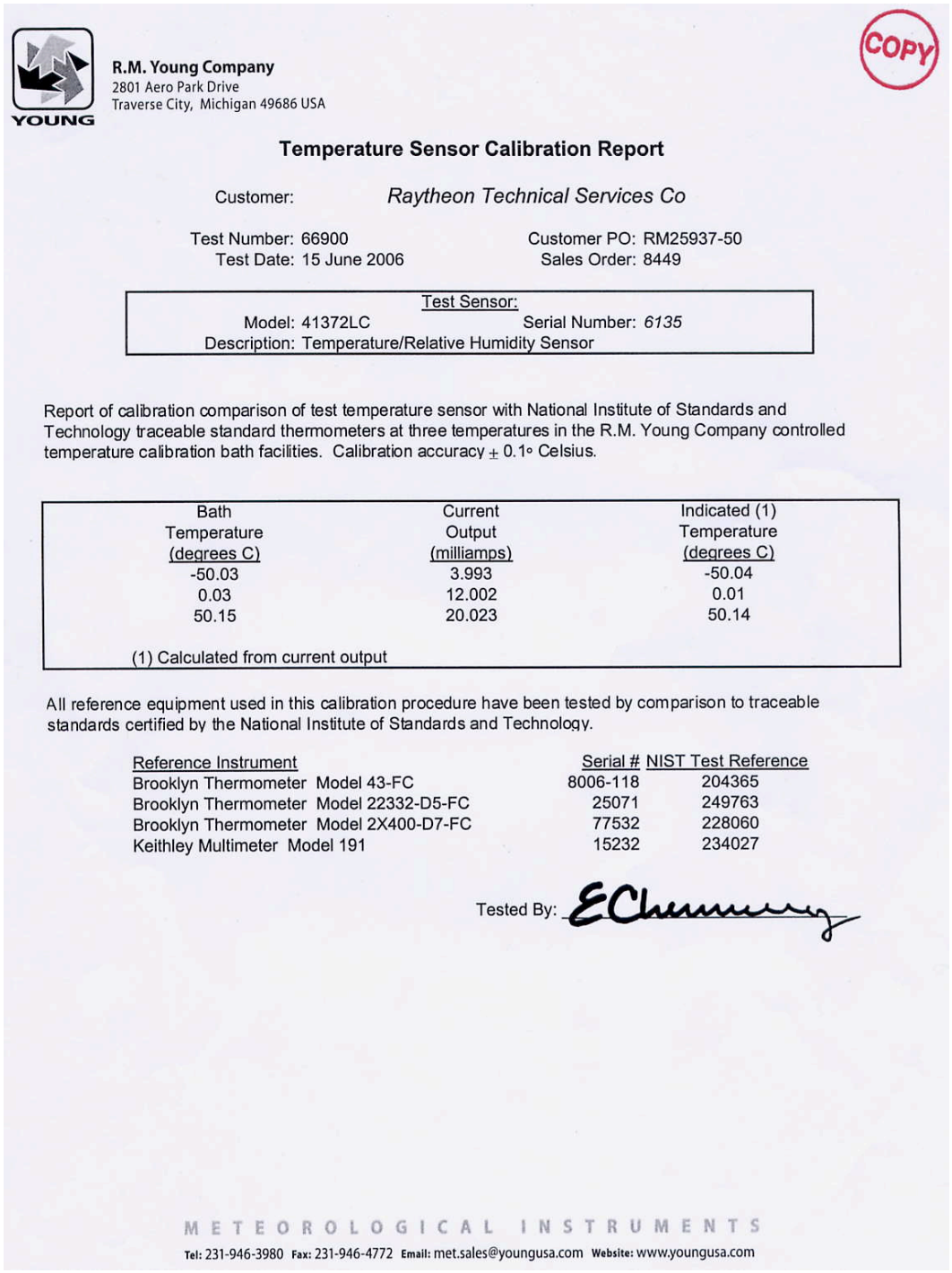
All reference equipment used in this calibration procedure have been tested by comparison to traceable standards certified by the National Institute of Standards and Technology.

Reference Instrument	Serial #	NIST Test Reference
Vaisala Humidity Sensor Model 35AC	N475040	TN 266152
Fluke Multimeter Model 8060A	4865407	234027

Tested By: EChenney

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

Temperature Sensor



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

COPY

Temperature Sensor Calibration Report

Customer: *Raytheon Technical Services Co*

Test Number: 66900 Customer PO: RM25937-50
Test Date: 15 June 2006 Sales Order: 8449

Test Sensor:
Model: 41372LC Serial Number: *6135*
Description: Temperature/Relative Humidity Sensor

Report of calibration comparison of test temperature sensor with National Institute of Standards and Technology traceable standard thermometers at three temperatures in the R.M. Young Company controlled temperature calibration bath facilities. Calibration accuracy ± 0.1° Celsius.

Bath Temperature (degrees C)	Current Output (milliamps)	Indicated (1) Temperature (degrees C)
-50.03	3.993	-50.04
0.03	12.002	0.01
50.15	20.023	50.14

(1) Calculated from current output

All reference equipment used in this calibration procedure have been tested by comparison to traceable standards certified by the National Institute of Standards and Technology.

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

Tested By: E Chemmerly

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

PIR

THE EPPLEY LABORATORY, INC.

12 Sheffield Ave., P.O. Box 419, Newport, RI 02840 USA
Telephone: 401-847-1020 Fax: 401-847-1031
Email: info@eppleylab.com Internet: www.eppleylab.com

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 against Eppley's Blackbody Calibration System under radiation intensities of approximately 200 watts meter^{-2} and an average ambient temperature of 23 °C as measured by Standard Omega Temperature Probe, RTD#1.

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

$$3.87 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 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.

Unless specified in the Remarks section, this instrument was not modified and the results are "AS FOUND / AS LEFT".

For highest precision, Eppley recommends annual recalibration.

Shipped to:
National Science Foundation
Port Hueneme, CA

Date of Test: March 8, 2007

In Charge of Test: R. T. Eppley

S.O. Number: 61041
Date: March 13, 2007

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: info@eppleylab.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:

8.16 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: February 27, 2007

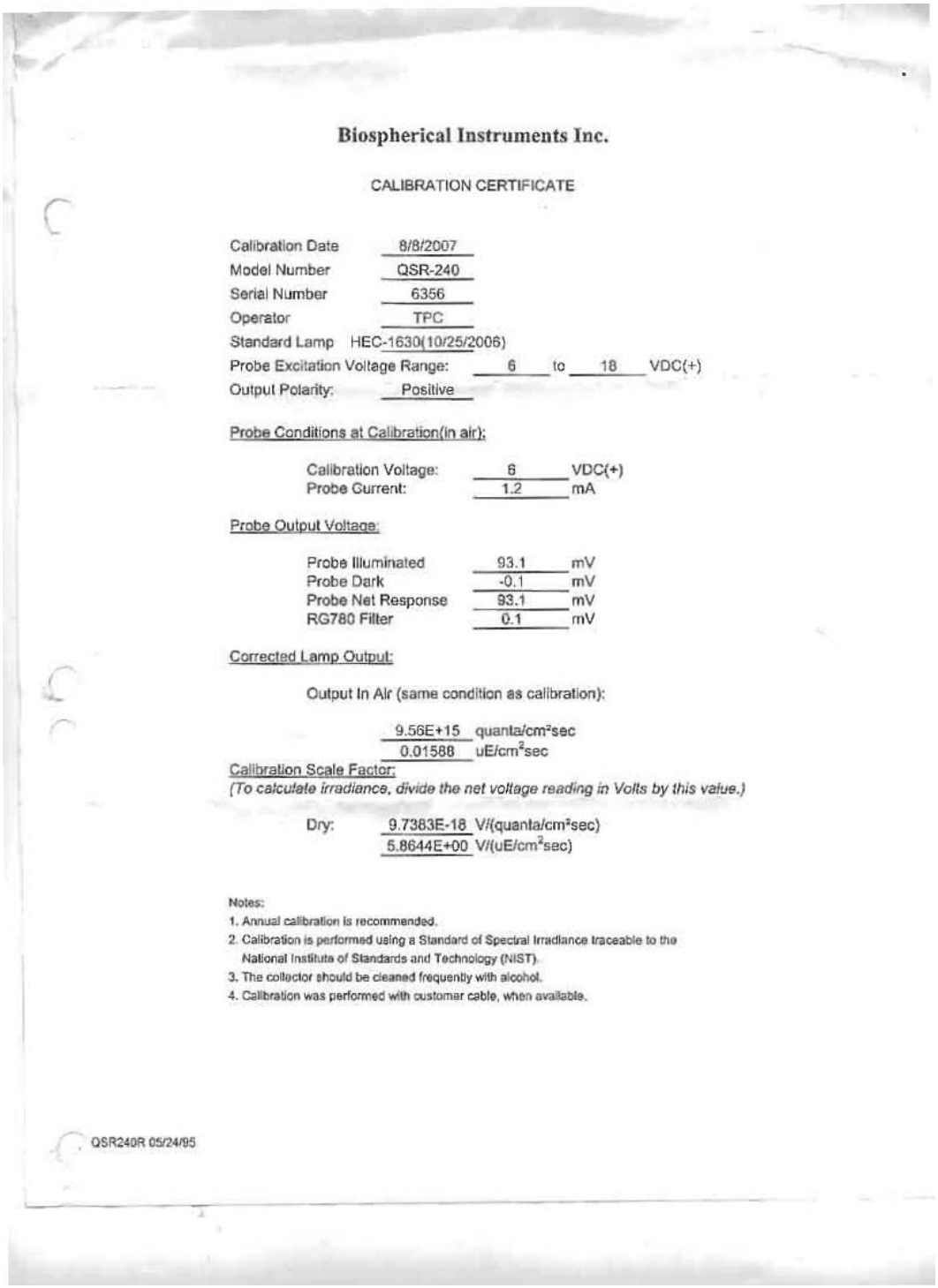
In Charge of Test: R. T. Eppley

S.O. Number: 61042
Date: March 13, 2007

Reviewed by: Thomas D Kuhl

Remarks:

PAR



Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	8/8/2007
Model Number	QSR-240
Serial Number	6356
Operator	TPC
Standard Lamp	HEC-1630(10/25/2006)
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	93.1	mV
Probe Dark	-0.1	mV
Probe Net Response	93.1	mV
RG780 Filter	0.1	mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

9.56E+15	quanta/cm²sec
0.01588	uE/cm²sec

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

Dry:	9.7383E-18	V/(quanta/cm²sec)
	5.8644E+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

GUV

Biospherical Instruments Inc.

GUV-2511 Calibration Certificate

System Serial Number	25110203114	Date of Calibration	1/23/07
Calibration database	25110203114v4.mdb	Date of Certificate	1/23/2007
DASSN	0069	Standard of Spectral Irradiance	F863(9/30/06)
Microprocessor Tag Number	4	Operator	TC

Monochromatic Channels	Address	Wavelength [nm]	Responsivity [Amps per µW/(cm²·nm)]	ScaleSmall [Volts per µW/(cm²·nm)]	ScaleMedium [Volts per µW/(cm²·nm)]	ScaleLarge [Volts per µW/(cm²·nm)]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0320	2	320	2.5198E-10	2.5702E-05	7.5090E-03	2.3700E+00	-1.3400E-04	-1.3800E-04	2.2400E-04	µW/(cm²nm)
Ed0340	6	340	1.9673E-10	2.0067E-05	5.8626E-03	2.0111E+00	1.0500E-04	1.0400E-04	1.1050E-03	µW/(cm²nm)
Ed0313	8	313	2.5200E-10	2.5716E-05	7.5131E-03	2.6373E+00	8.2200E-04	8.1300E-04	-1.7710E-03	µW/(cm²nm)
Ed0305	10	305	1.1500E-11	1.1757E-06	3.4350E-04	1.1807E-01	2.5100E-04	2.5100E-04	1.0430E-03	µW/(cm²nm)
Ed0380	12	380	8.4374E-11	8.6061E-06	2.5143E-03	8.0645E-01	2.1100E-04	2.1000E-04	-2.4700E-04	µW/(cm²nm)
Ed0395	18	395	3.0176E-10	3.0779E-05	8.9923E-03	2.8425E+00	2.8700E-04	2.9000E-04	1.4220E-03	µW/(cm²nm)

Broadband Channels	Address	Wavelength [nm]	Responsivity [Amps per µE/(cm²·s)]	ScaleSmall [Volts per µE/(cm²·s)]	ScaleMedium [Volts per µE/(cm²·s)]	ScaleLarge [Volts per µE/(cm²·s)]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0PAR	13	400-700	1.7315E-05	1.7662E+00	5.1600E+02	1.8236E+05	4.8000E-04	4.8000E-04	-6.6400E-04	µE/(cm²sec)

Auxilliary Channels	Address	Wavelength	Responsivity	ScaleS	ScaleM	ScaleL	OffsetS	OffsetM	OffsetL	Measurement Units
Ed0Temp	22	0	1.0000E+00	1.0000E-02	1.0000E-02	1.0000E-02	0.0000E+00	0.0000E+00	0.0000E+00	C
Ed0Vin	27	0	1.0000E+00	-2.5000E-01	-2.5000E-01	-2.5000E-01	0.0000E+00	0.0000E+00	0.0000E+00	V

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Calibration Data – Do Not Destroy

page 2 of 2

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: 20-May-06

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

GHIJ COEFFICIENTS

```
g = -4.27061383e+000
h =  5.04384737e-001
i = -4.53257393e-004
j =  4.72934991e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  2.81077465e-006
b =  5.02715558e-001
c = -4.26259709e+000
d = -8.83813520e-005
m =  4.8
CPcor = -9.5700e-008 (nominal)
```

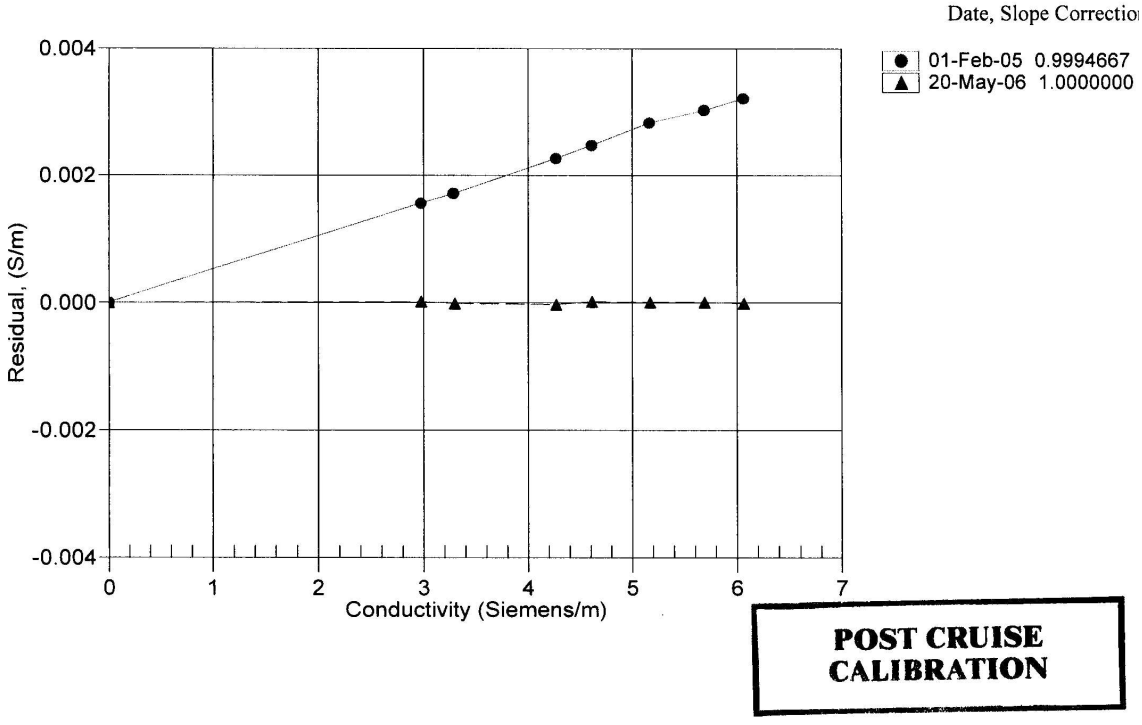
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.91246	0.00000	0.00000
1.0000	34.8123	2.97566	8.21793	2.97567	0.00002
4.6261	34.7919	3.29397	8.59263	3.29396	-0.00001
15.0000	34.7503	4.26437	9.64425	4.26434	-0.00003
18.4999	34.7417	4.60953	9.99119	4.60955	0.00002
24.0000	34.7323	5.16751	10.52728	5.16752	0.00001
29.0000	34.7279	5.68947	11.00456	5.68948	0.00001
32.4999	34.7263	6.06206	11.33261	6.06205	-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]; δ = CTcor; ε = CPcor;

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



POST CRUISE CALIBRATION

Underway Temperature Sensor

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 3198
CALIBRATION DATE: 20-May-06

SBE21 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

g = 4.22473160e-003
h = 6.29770835e-004
i = 2.05272425e-005
j = 1.54706370e-006
f0 = 1000.0

ITS-68 COEFFICIENTS

a = 3.64763347e-003
b = 5.95315785e-004
c = 1.61762223e-005
d = 1.54852177e-006
f0 = 2568.439

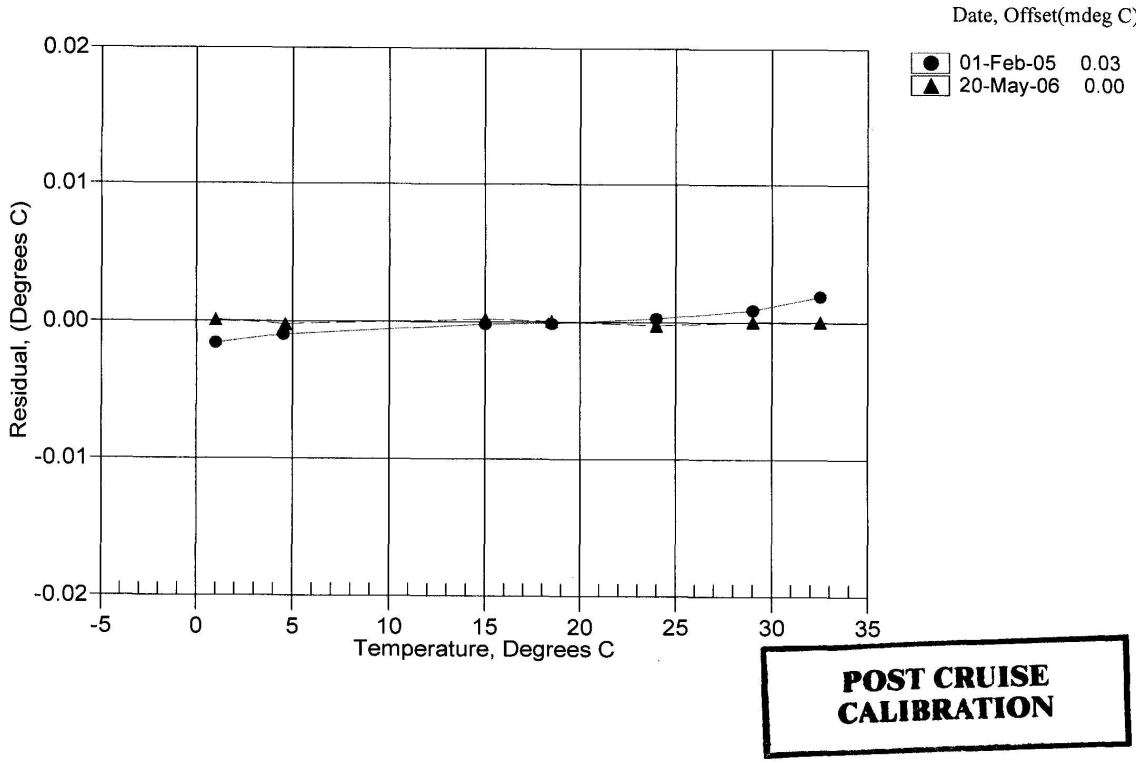
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	2568.439	1.0001	0.00011
4.6261	2782.830	4.6259	-0.00021
15.0000	3467.526	15.0002	0.00020
18.4999	3723.433	18.5000	0.00006
24.0000	4152.193	23.9998	-0.00023
29.0000	4571.111	29.0000	0.00004
32.4999	4881.298	32.4999	0.00004

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 Temperature Sensor (Primary Remote)

44

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: 0352
CALIBRATION DATE: 06-Jun-07

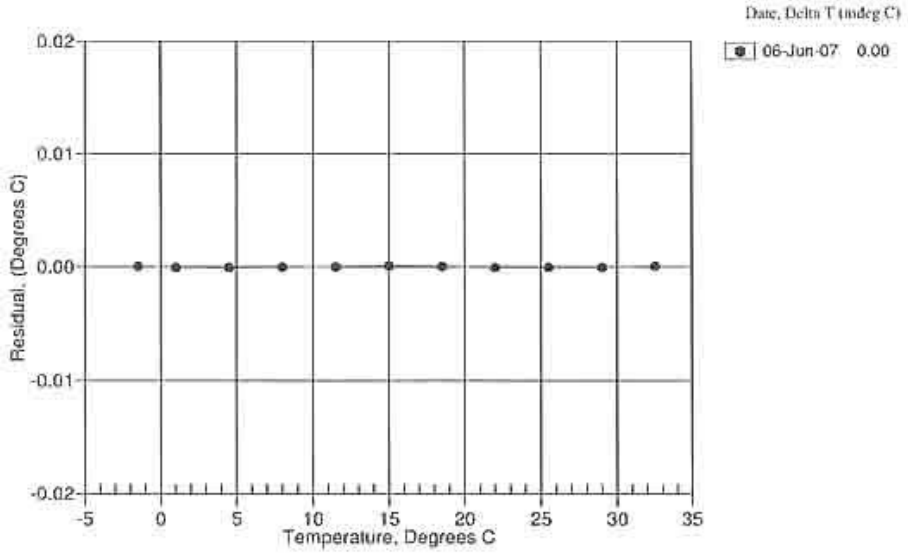
SBE 38 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = -1.791146e-005
a1 = 2.748666e-004
a2 = -2.288718e-006
a3 = 1.522128e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50010	809858.1	-1.50005	0.00005
0.99990	723216.3	0.99986	-0.00004
4.50000	619038.5	4.49993	-0.00007
7.99990	531605.5	7.99989	-0.00001
11.50000	457969.9	11.50002	0.00002
14.99990	395755.0	15.00000	0.00010
18.49990	343018.4	18.49995	0.00005
22.00000	298175.3	21.99994	-0.00006
25.50000	259928.8	25.49995	-0.00005
29.00000	227212.0	28.99995	-0.00005
32.50000	199144.2	32.50006	0.00006

Temperature ITS-90 = $1/\{a0 + a1\{ln(n)\} + a2\{ln^2(n)\} + a3\{ln^3(n)\}\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



Underway Temperature Sensor (Secondary Remote)

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: 12-Apr-06

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

g = 4.76625066e-003
h = 6.64522185e-004
i = 2.84261863e-005
j = 2.62601374e-006
f0 = 1000.0

ITS-68 COEFFICIENTS

a = 3.68121498e-003
b = 5.89543636e-004
c = 1.47312260e-005
d = 2.62748536e-006
f0 = 5707.029

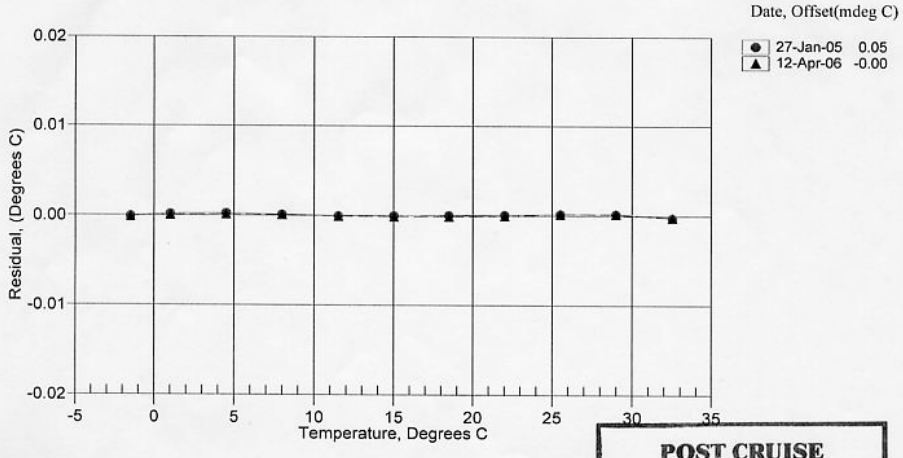
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5001	5707.029	-1.5002	-0.00010
1.0000	6042.027	1.0001	0.00005
4.4999	6534.652	4.5000	0.00014
7.9999	7055.608	8.0000	0.00007
11.4999	7605.659	11.4998	-0.00008
14.9999	8185.578	14.9998	-0.00014
18.4999	8796.088	18.4998	-0.00011
22.0000	9437.895	22.0000	-0.00003
25.4999	10111.624	25.5001	0.00019
28.9999	10817.898	29.0001	0.00019
32.4999	11557.257	32.4997	-0.00019

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

Temperature 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 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 February 13, 2006 Customer National Science Foundation Work order 009

Job # 0009009 S/N# CST-397DR Pathlength 25 cm

	Analog meter
V_d	0.061 V
V_{air}	4.860 V
V_{ref}	4.772 V

Temperature of calibration water	18.2 °C
Ambient temperature during calibration	23.0 °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.

cstarwkbkf1.xls Revision F 1/17/05

Micro-TSG Calibration Files

Temperature Sensor (Micro-TSG)

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SEA-BIRD ELECTRONICS, INC.

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

SENSOR SERIAL NUMBER: 0199
CALIBRATION DATE: 21-Mar-07

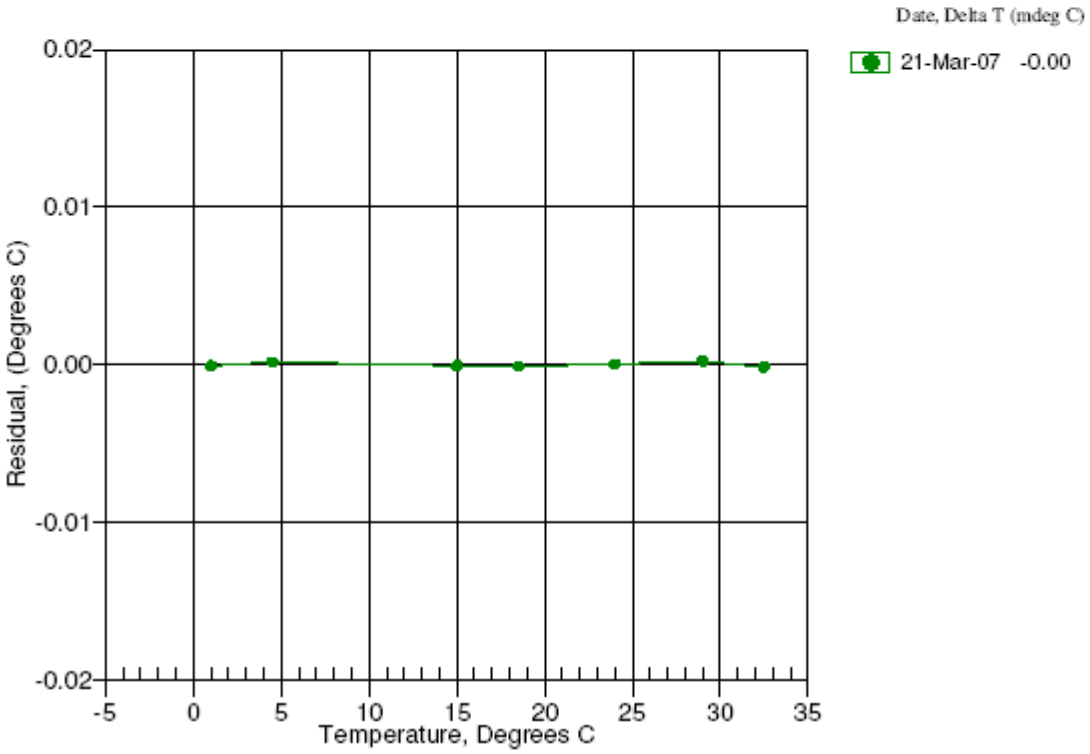
SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = -1.943659e-005
a1 = 2.808678e-004
a2 = -2.841613e-006
a3 = 1.685518e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	678415.8	0.9999	-0.0001
4.4999	580530.8	4.5001	0.0002
15.0001	370823.7	15.0000	-0.0001
18.5000	321316.6	18.4999	-0.0001
24.0000	258030.0	24.0000	0.0000
29.0000	212647.5	29.0002	0.0002
32.5000	186328.0	32.4999	-0.0001

Temperature ITS-90 = $1/\{a0 + a1[ln(n)] + a2[ln^2(n)] + a3[ln^3(n)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



Conductivity Sensor (Micro-TSG)

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SENSOR SERIAL NUMBER: 0199
CALIBRATION DATE: 21-Mar-07

SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

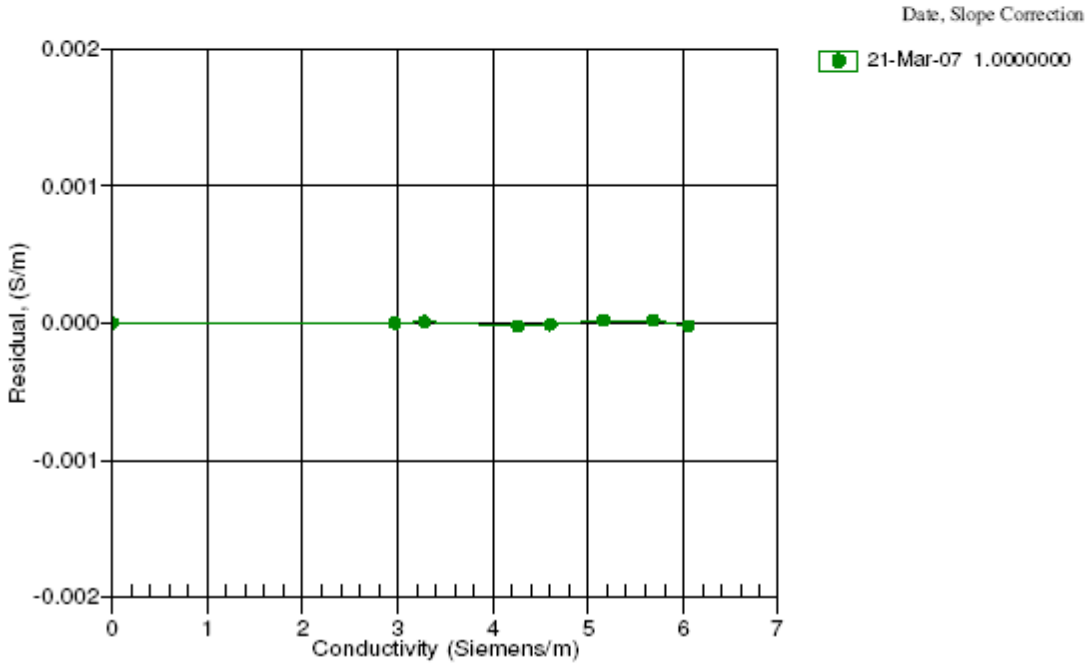
g = -1.000752e+000
h = 1.423709e-001
i = -1.466251e-004
j = 3.326706e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = -1.0552e-005

BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2653.01	0.00000	0.00000
1.0000	34.7405	2.97010	5278.39	2.97010	0.00000
4.4999	34.7201	3.27653	5477.59	3.27655	0.00001
15.0001	34.6771	4.25635	6070.06	4.25632	-0.00002
18.5000	34.6679	4.60080	6264.80	4.60079	-0.00001
24.0000	34.6577	5.15763	6567.11	5.15765	0.00002
29.0000	34.6517	5.67838	6837.44	5.67841	0.00002
32.5000	34.6477	6.04991	7023.73	6.04989	-0.00002

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

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

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

Residual = instrument conductivity - bath conductivity