SBE 37-IM MicroCAT

Conductivity and Temperature Recorder (Pressure Optional) with Inductive Modem

User Manual, Version 018

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SBE 37-IM MICROCAT OPERATING AND REPAIR MANUAL

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Manual Generation Date: 13 June 2007

LIMITED LIABILITY STATEMENT

Extreme care should be exercised when using or servicing this equipment. It should be used or serviced only by personnel with knowledge of and training in the use and maintenance of oceanographic electronic equipment.

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SBE 37-IM MicroCAT

Conductivity and Temperature Recorder with Inductive Modem

Shown with standard titanium housing;
optional ShallowCAT plastic housing available

User's Manual

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Manual Version #018, 12/18/06
37-IM Digital Firmware Version 2.3a & later
37-IM Modem Firmware Version 1.3 & later
SIM Firmware Version 3.0 & later

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Table of Contents

Section 1: Introduction

This section includes contact information, Quick Start procedure, photos of a standard MicroCAT shipment, and shipping precautions.

About this Manual

This manual is to be used with the SBE 37-IM MicroCAT Conductivity and Temperature Recorder (pressure optional) with Inductive Modem.

It is organized to guide the user from installation through operation and data collection. We've included detailed specifications, command descriptions, maintenance and calibration information, and helpful notes throughout the manual.

Sea-Bird welcomes suggestions for new features and enhancements of our products and/or documentation. Please e-mail any comments or suggestions to seabird@seabird.com.

How to Contact Sea-Bird

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Business hours:
Monday-Friday, 0800 to 1700 Pacific Standard Time
(1600 to 0100 Universal Time)
Except from April to October, when we are on 'summer time'
(1500 to 0000 Universal Time)

Quick Start

Follow these steps to get a Quick Start using the MicroCAT.
The manual provides step-by-step details for performing each task:

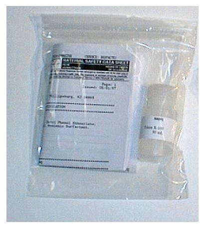
1. Perform pre-check (*Section 3: Preparing MicroCAT for Deployment*):
   A. Install batteries.
   B. Test power and communications, and set MicroCAT ID.
2. Deploy MicroCAT (*Section 4: Deploying and Operating MicroCAT*):
   A. Install new batteries if necessary.
   B. Ensure all data has been uploaded, and then set **#iiSampleNum=0** to make entire memory available for recording if desired.
   C. Set date and then time.
   D. Establish setup and logging parameters.
   E. Deploying multiple MicroCATs: verify MicroCAT set to *Prompt ID*.
   F. Set MicroCAT to start logging now or in the future.
   G. Remove protective plugs from anti-foulant device cups, and verify AF24173 Anti-Foulant Devices are installed. Leave protective plugs off for deployment.
   H. Install MicroCAT on mooring cable.
   I. Install Inductive Cable Coupler (optional) on mooring cable.
   J. Wire system.

Unpacking MicroCAT

Shown below is a typical MicroCAT shipment.

SBE 37-IM MicroCAT

Batteries

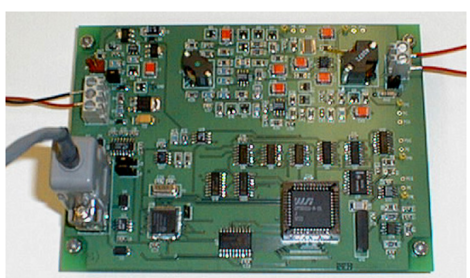


Cell cleaning solution
(Triton-X)

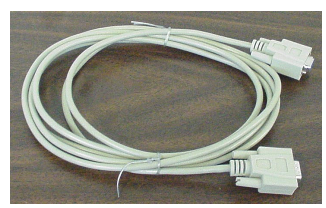
Spare parts (hardware
and o-rings) kit

MicroCAT
User Manual

Software, and Electronics Copies of
Software Manuals and User Manual



Surface Inductive Modem (SIM) PCB
(one per mooring, optional)



I/O Cable
(included with SIM)

25-pin to 9-pin adapter
(for use with computer with
DB-25 connector – included
with SIM I/O cable)

Inductive Cable Coupler (ICC)
(optional with SIM, one per mooring)

Shipping Precautions

Batteries packed in heat-sealed plastic; Sea-Bird then places batteries in bubble-wrap outer sleeve and strong packaging for shipment

Assembled battery pack

WARNING!
Do not ship assembled battery pack by commercial aircraft.

Note:
All setup information is preserved in EEPROM when the batteries are removed.

Note:
Batteries must be removed before returning the instrument to Sea-Bird. Do not return used batteries to Sea-Bird when shipping the MicroCAT for repair.

The MicroCAT was shipped from the factory with the batteries packaged separately within the shipping box (not inside the MicroCAT). When packaged in the manner shown and described at left, the batteries are **not** considered Dangerous/Hazardous Goods, and may be shipped via commercial aircraft (those governed by DOT or IATA, including passenger airlines, or cargo carriers such as FedEx, DHL, UPS, etc.) if no more than the number of batteries required to operate the instrument are included in the shipment (i.e., no spares are included).

IMPORTANT NOTE:
Do not ship the assembled battery pack by commercial aircraft. Refer to *Lithium Battery Shipping Guidelines* for background information on the applicable regulations as well as Sea-Bird's interpretation of those regulations, how they apply to the batteries in our equipment, and how we package and label our equipment.

Before attempting to communicate with the MicroCAT, the batteries must be installed following the instructions in *Section 3: Preparing MicroCAT for Deployment*.

If you will re-ship the MicroCAT by commercial aircraft after you have finished testing:

1. Remove the battery pack assembly from the MicroCAT.
2. Remove the batteries from the battery pack assembly.
3. Pack the batteries separately as described in *Lithium Battery Shipping Guidelines*.

Section 2: Description of MicroCAT

This section describes the functions and features of the SBE 37-IM MicroCAT, including specifications, dimensions, sample timing, battery endurance, and mooring requirements.

System Description

Standard titanium housing

Optional plastic *ShalowCAT* housing

The SBE 37-IM MicroCAT is a high-accuracy conductivity and temperature recorder (pressure optional) with internal battery and non-volatile memory. It uses an Inductive Modem (IM) to transmit data and receive commands over a plastic-jacketed steel mooring cable (or other insulated conductor), using differential-phase-shift-keyed (DPSK) telemetry. No electrical cables or connectors are required. The MicroCAT's built-in inductive coupler (split toroid) and cable clamp provide easy and secure attachment to the mooring cable. Designed for moorings and other long-duration, fixed-site deployments, MicroCATs have non-corroding titanium housings rated for operation to 7000 meters (23,000 feet) or pressure sensor full-scale range. An optional plastic *ShallowCAT* housing rated for 250 meters (820 feet) is also available.

Communicating with one or more MicroCATs requires the use of a Sea-Bird Surface Inductive Modem (SIM). The SIM provides a standard serial interface between the user's computer or other controlling device and up to 100 MicroCATs (or other IM-compatible sensors), coupled to a single cable. The user can communicate with the SIM via full-duplex RS-232C or half-duplex RS-485. Commands and data are transmitted half-duplex between the SIM and the MicroCAT.

Notes:
- For detailed information on inductive modem systems, see *Real-Time Oceanography with Inductive Moorings*, at www.seabird.com under Technical Papers.
- Half-duplex communication is **one-direction** at a time (i.e., you cannot send commands and receive data at the same time). For example, if the SIM commands a MicroCAT to upload data, nothing else can be done while the data is being sent – the data upload cannot be stopped, and commands cannot be sent to other MicroCATs on the line.

Over 50 different commands can be sent to the MicroCAT to provide status display, data acquisition setup, data retrieval, and diagnostic tests. User-selectable operating modes include:

- **Polled sampling** – On command, the MicroCAT wakes up, takes one sample, transmits data, and goes to sleep.
- **Autonomous sampling** – At pre-programmed intervals, the MicroCAT wakes up, samples, stores data in its FLASH memory, and goes to sleep.
- **Combo sampling** –Autonomous sampling is in progress, and the SIM can request the transmission of the last stored data.
- **Averaging sampling** – Autonomous sampling is in progress, and the SIM can request the transmission of the average of the individual data samples acquired since its last request.

Calibration coefficients stored in EEPROM allow the MicroCAT to transmit data in engineering units. The MicroCAT retains the temperature and conductivity sensors used in the SBE 16 SEACAT C-T Recorder, but has improved acquisition electronics that increase accuracy and resolution, and lower power consumption. The MicroCAT's aged and pressure-protected thermistor has a long history of exceptional accuracy and stability (typical drift is less than 0.002 °C per year).

The MicroCAT's internal-field conductivity cell is immune to proximity errors and unaffected by external fouling. A plastic cup with threaded cover at each end of the cell retains the expendable AF24173 Anti-Foulant Device.

The MicroCAT's optional pressure sensor, developed by Druck, Inc., has a superior new design that is entirely different from conventional 'silicon' types in which the deflection of a metallic diaphragm is detected by epoxy-bonded silicon strain gauges. The Druck sensor employs a micro-machined *silicon diaphragm* into which the strain elements are implanted using semiconductor fabrication techniques. Unlike metal diaphragms, silicon's crystal structure is perfectly elastic, so the sensor is essentially free of pressure hysteresis. Compensation of the temperature influence on pressure offset and scale is performed by the SBE MicroCAT's CPU.

Notes:
- Sea-Bird also supplies a DOS software package, SEASOFT-DOS, which can be used with the MicroCAT. However, this manual details only the use of the Windows software with the MicroCAT.
- Help files provide detailed information on the use of SEATERM and SBE Data Processing.
- Separate software manuals on CD-ROM contain detailed information on the setup and use of SBE Data Processing and SEASOFT-DOS.

The MicroCAT is supplied with a powerful Win 95/98/NT/2000/XP software package, SEASOFT-Win32, which includes:

- **SEATERM** –terminal program for easy communication and data retrieval.
- **SBE Data Processing** - program for calculation and plotting of conductivity, temperature, optional pressure, and derived variables such as salinity and sound velocity.

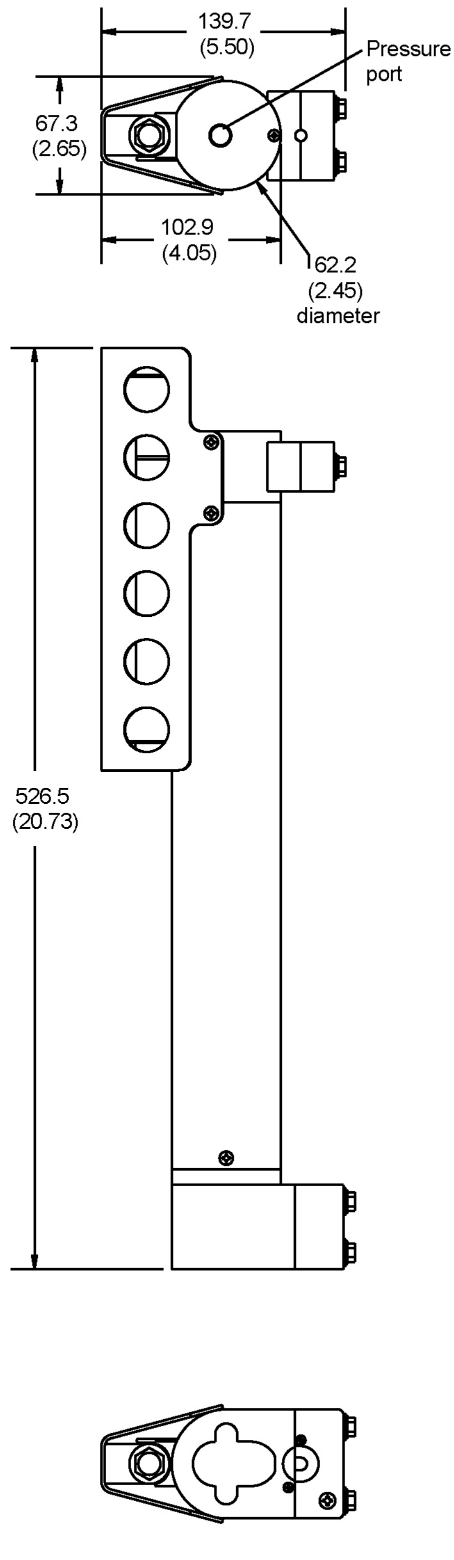
Specifications

Note:
Pressure ranges are expressed in meters of deployment depth capability.

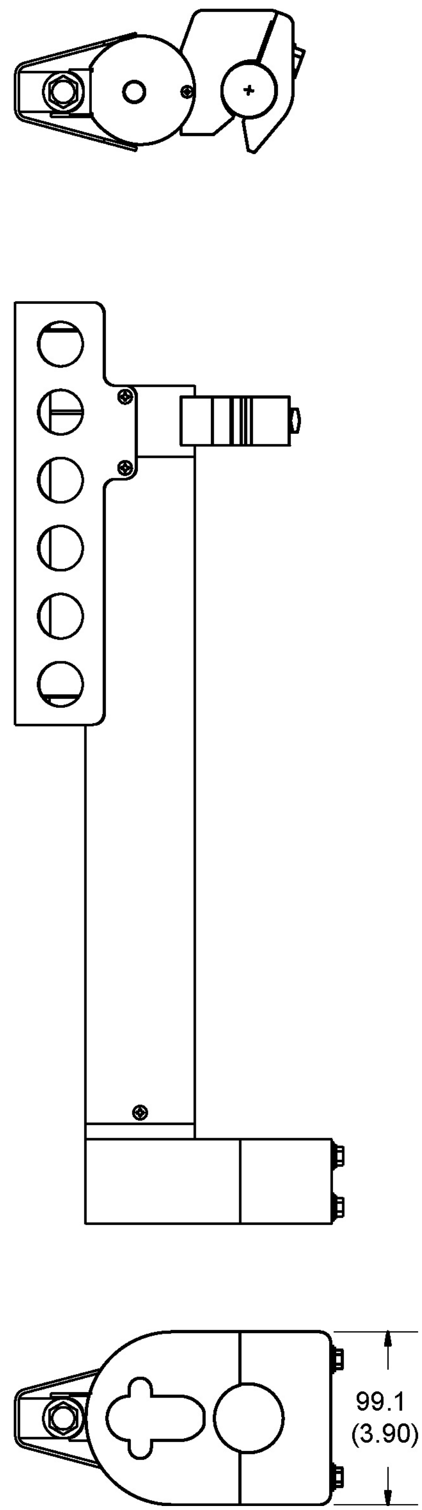
	Temperature (°C)	Conductivity (S/m)	Optional Pressure
Measurement Range	-5 to +35	0 to 7 (0 to 70 mS/cm)	0 to full scale range 20 / 100 / 350 / 600 / 1000 / 2000 / 3500 / 7000 meters
Initial Accuracy	0.002	0.0003 (0.003 mS/cm)	0.1% of full scale range
Typical Stability (per month)	0.0002	0.0003 (0.003 mS/cm)	0.004% of full scale range
Resolution	0.0001	0.00001 (0.0001 mS/cm)	0.002% of full scale range
Sensor Calibration	+1 to +32	0 to 6; physical calibration over the range 2.6 to 6 S/m, plus zero conductivity (air)	Ambient pressure to full scale range in 5 steps
Counter Time-Base	Quartz TCXO, ±2 ppm per year aging; ±5 ppm vs. temperature (-5 to +30 °C)		
Memory	2048K byte non-volatile FLASH memory		
Data Storage	Converted temperature and conductivity: 5 bytes per sample (2.5 bytes each). Time: 4 bytes per sample. Pressure (optional): 2 bytes per sample. **<u>Recorded Parameters</u>** — **<u>Memory Space - Total Number of Samples</u>** C and T — 410,000 C, T, and P — 290,000 C, T, and time — 225,000 C, T, P, and time — 185,000		
Real-Time Clock	Watch-crystal type 32,768 Hz; corrected for drift and aging by comparison to MicroCAT counter time-base to produce overall ± 5 ppm accuracy (±2.6 minutes/year)		
Standard Internal Batteries	Nominal 7.2 Ampere-hour pack consisting of six 9-volt lithium batteries, providing sufficient capacity for more than 100,000 samples. See *Shipping Precautions* in *Section 1: Introduction*.		
Power Requirements	Quiescent Current: < 100 microamps Communications Current: 5.0 milliamps Acquisition Current: 30 milliamps Acquisition Time: 3 seconds per sample Communications Time: 0.5 seconds per sample		
Housing and Depth Rating	*Standard:* Titanium housing, 7000 m (23,000 ft) *Optional:* Plastic *ShallowCAT* housing, 250 m (820 ft)		
Weight (without pressure sensor, with standard mooring guide and clamp)	*Standard titanium housing -* In air: 4.0 kg (8.8 lbs) In water: 2.4 kg (5.3 lbs) *Optional plastic ShallowCAT housing -* In air: 2.9 kg (6.4 lbs) In water: 1.3 kg (2.9 lbs)		

Dimensions

Dimensions in millimeters (inches)



Standard Wire Guide and Mounting Clamp
(1/4 inch through 16 mm wire)



Optional Large Toroid End Cap with Wire Guide
and Heavy Duty Titanium Mounting Clamp
(38 mm wire)

Sample Timing

Note:
If date and time are stored with the data, time is the time at the start of the sample, after a small amount of time for the MicroCAT to wake up and prepare to sample. For example, if the MicroCAT is programmed to wake up and sample at 12:00:00, the stored time will indicate 12:00:01 or 12:00:02.

- **Acquisition (power on) Time** for each sample while logging:
  With Pressure: 2.7 seconds
  Without Pressure: 2.2 seconds
- **Take Sample Timing** for **#iiTS** or **#iiTSR** command:
  With Pressure: 1.6 seconds
  Without Pressure: 1.2 seconds
- **Communications Timing**, which is the time to request and transmit data from each MicroCAT to the computer/controller:
  0.5 seconds

Battery Endurance

Notes:
- If the MicroCAT is logging data and the battery voltage is less than 6.15 volts for ten consecutive scans, the MicroCAT halts logging and displays a low battery indication in the data.
- **See *Specifications* above for data storage limitations**.

The battery pack has a nominal capacity of 7.2 AH. However, for planning purposes, Sea-Bird recommends using a conservative value of 5 AH.

Current consumption is as follows:
- Sampling (acquisition) current is 30 mA. Acquisition time is shown above in *Sample Timing*.
- Communications current is 5 mA. Assuming the fastest practical interrogation scheme (wake all MicroCATs on mooring, send **GData**, send **Dataii** to each MicroCAT, and power off all MicroCATs), the communications current is drawn for approximately 0.5 seconds **per MicroCAT on the mooring**. Each MicroCAT on the mooring draws this current while any of the MicroCATs are being queried to transmit data. Other interrogation schemes require more time.
- Quiescent current is less than 100 microamps (0.9 AH per year).

So, battery endurance is highly dependent on the user-programmed sampling scheme. An example is shown below for 1 sampling scheme.

Example:
10 MicroCATs with pressure sensors will be deployed on a mooring. They will be set up to sample autonomously every 10 minutes (6 times/hour), and the average of the samples will be requested by the computer every hour. How long can the instruments be deployed, given a conservative assumption of 5 AH battery capacity?

Acquisition time for logging is 2.7 seconds; round up to 3 seconds for calculation.
Sampling current consumption = 30 mA * 3 seconds sampling time = 0.090 amp-sec/sample
In 1 hour, sampling consumption = 6 samples * 0.090 amp-sec/sample = 0.54 amp-seconds/hour

Communication current consumption / query = 5 mA * 0.5 seconds/MicroCAT to be queried * 10 MicroCATs on mooring
= 0.025 amp-seconds/hour

Quiescent current = 100 microamps = 0.1 mA
In 1 hour, quiescent current consumption ≈ 0.1 mA * 3600 seconds/hour = 0.36 amp-seconds/hour

In 1 hour, the MicroCAT will take 6 samples and transmit average to computer.
Current consumption / hour = 0.54 + 0.025 + 0.36 = 0.925 amp-sec

Capacity = (5 amp-hours * 3600 seconds/hr) / (0.925 amp-sec/hour) = 19459 hours = 810 days = 2.2 years
However, Sea-Bird recommends that batteries should not be expected to last longer than 2 years in the field.

Surface Inductive Modem (SIM)

A Surface Inductive Modem (SIM) PCB is required for communication with the MicroCAT. The SIM must be supplied with 7 to 25 volts DC power. The operating current is approximately 30 milliamps.

The user's computer or buoy controller is interfaced via RS-232 (optional RS-485) serial port to the SIM. The standard interface protocol between the computer/controller and SIM is 1200, 2400, 4800, or 9600 baud (user-selectable); 8 data bits; no parity; RS-232C; with echoing of characters.

The SIM impresses (*modulates*) the mooring cable with a DPSK signal that is encoded with commands received from the computer/controller. The encoded signals are *demodulated* by MicroCATs coupled to the cable. Replies from MicroCATs are similarly coupled to the cable and *demodulated* by the SIM.

The DPSK communication link between the SIM and MicroCAT(s) is half-duplex, so talking and listening is sequential only. Although the data link between the SIM and the user's computer/controller is established at 1200, 2400, 4800, or 9600 baud, the DPSK modem communication between SIM and MicroCATs always operates at 1200 baud.

Mooring Cable and Wiring Requirements

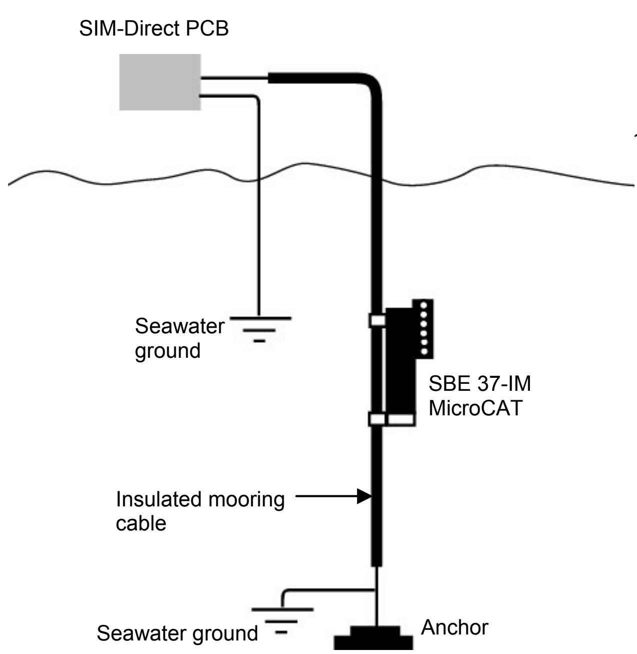
> **Note:**
> See *Appendix V: SIM Hookup and Configuration* for wiring.

The standard MicroCAT can mechanically accommodate mooring cables up to 16 mm (0.63 inches) in diameter. Clamps for specific diameters are available, or can be supplied on a custom basis. An optional large toroid end cap with wire guide and heavy duty titanium mounting clamp is also available for 38 mm (1.5 inch) mooring cables. Suitable mooring cables use steel wire rope with a polypropylene or polyethylene-insulating jacket. The SIM operates without data errors using up to 7000 meters (23,000 feet) of 3 mm (0.12 inches) or larger cable.

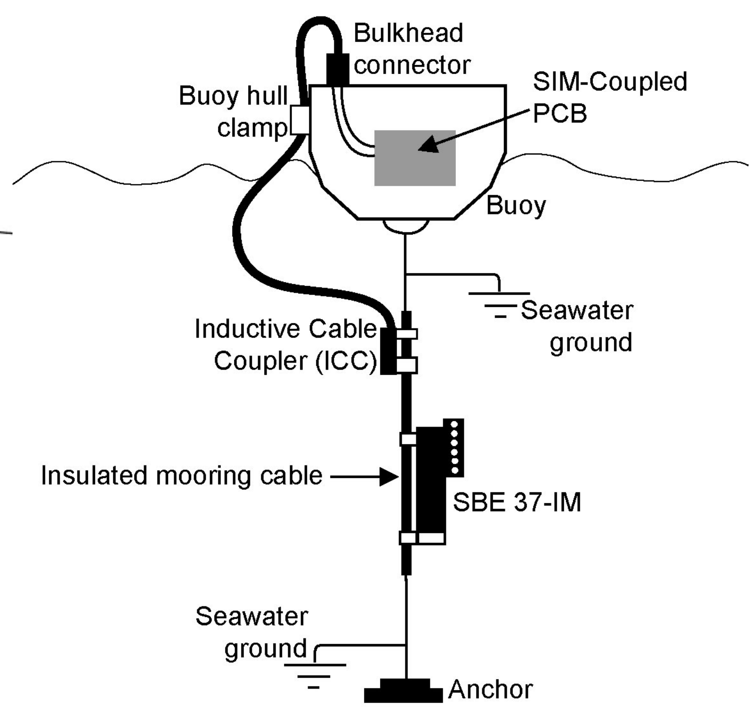
The mooring cable must provide connection to seawater ground below the deepest MicroCAT. Terminating the wire with a metallic eye or clevis readily provides this connection.

The mooring cable must also provide for connection to the SIM.

- In a direct connection (typical cable-to-shore applications), the bottom end of the wire is grounded to seawater, and the top end remains insulated to the connection to the SIM. A second wire from the SIM connects to seawater ground, completing the circuit.
- In typical surface buoys it is often preferable to connect the jacketed mooring wire to the buoy with a length of chain, grounding the jacketed wire to seawater at each end. An Inductive Cable Coupler (ICC) connects the SIM to the jacketed wire above the uppermost MicroCAT and below the point where the wire is grounded.



Direct Connection



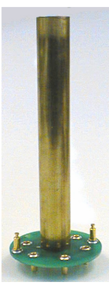
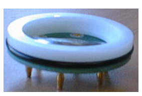
Connection with Inductive Cable Coupler (ICC)

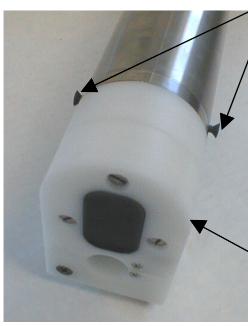
Section 3: Preparing MicroCAT for Deployment

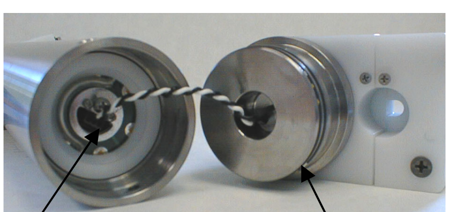
This section describes the pre-check procedure for preparing the MicroCAT for deployment. Installation of the battery pack, testing power and communications, and setting the MicroCAT ID are discussed.

Battery Installation

WARNING!
Do not air-ship the MicroCAT with batteries installed.
See *Shipping Precautions* in *Section 1: Introduction*.



Description of Batteries and Battery Pack

Sea-Bird supplies six 9-volt (nominal 1.2 amp-hour) batteries, shipped with the MicroCAT in a separate bag.

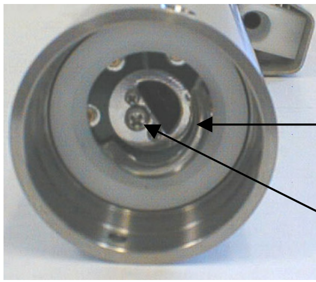
In addition to the six 9-volt batteries, the assembled battery pack consists of:

- a brass sleeve with lower printed circuit board (PCB) containing banana jacks
- upper PCB containing banana plugs

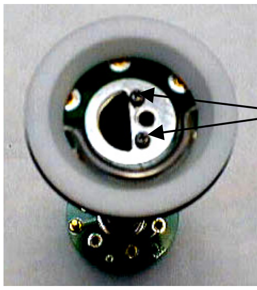
No soldering is required when assembling the battery pack because the batteries use the banana plugs and jacks as (+) and (-) terminals.

Installing Batteries

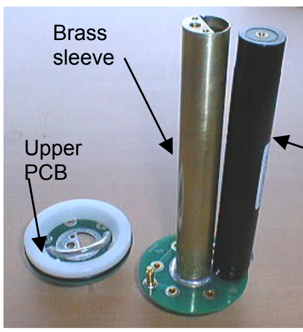
1. Remove the modem end cap:
   A. Wipe the outside of the modem end cap and housing dry, being careful to remove any water at the seam between them.
   B. Remove the two flat Phillips-head titanium machine screws. Do not remove any other screws from the housing.
   C. Remove the end cap by pulling firmly and steadily on the plastic cable mounting bracket/inductive coupler. It may be necessary to twist or rock the end cap back and forth or use a non-marring tool on the edge of the cap to loosen it.
   D. The end cap is electrically connected to the electronics with a 3-pin Molex connector. Holding the wire cluster near the connector, pull gently to detach the female end of the connector from the pins.
   E. Remove any water from the O-ring mating surfaces inside the housing with a lint-free cloth or tissue.
   F. Put the end cap aside, being careful to protect the O-rings from damage or contamination.



2. Remove the battery pack assembly from the housing:
   A. Remove the large Phillips-head screw and lock washer from the upper PCB.
   B. Lift the battery pack assembly straight out of the housing, using the handle.

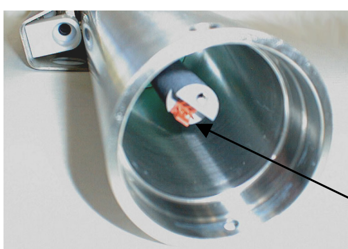


3. Remove the two small Phillips-head screws and lock washers from the upper PCB, and lift the upper PCB off the brass sleeve.



4. Insert each 9-volt battery onto the lower PCB, one at a time, banana plug end (+) first. Ensure each battery is fully inserted.

5. Reinstall the upper PCB:
   A. Press the upper PCB onto the battery pack assembly, aligning the screw holes and mating banana plugs to the batteries. Ensure the banana plugs are fully inserted into the batteries.
   B. Re-fasten the upper PCB to the battery pack assembly with the two small screws and lock washers.



6. Replace the battery pack assembly in the housing:
   A. Align the D-shaped opening in the upper PCB with the D-shaped notch on the shaft. Lower the assembly slowly into the housing, and once aligned, push gently to mate the banana plugs on the battery compartment bulkhead with the lower PCB. A post at the bottom of the battery compartment mates with a hole in the battery pack's lower PCB to prevent improper alignment.
   B. Secure the assembly to the shaft using the large Phillips-head screw and lock washer. Ensure the screw is tight to provide a reliable electrical contact.

7. Reinstall the modem end cap:
   A. Remove any water from the O-rings and mating surfaces in the housing with a lint-free cloth or tissue. Inspect the O-rings and mating surfaces for dirt, nicks, and cuts. Clean as necessary. Apply a light coat of O-ring lubricant (Parker Super O Lube) to O-ring and mating surfaces.
   B. Plug the female end of the 3-pin Molex connector onto the pins, with the flat portion of the female end against the flat portion of the 'D' cutout. Verify the connector is properly aligned – a backward connection will prevent communication with the computer.
   C. Carefully fit the end cap into the housing until the O-rings are fully seated.
   D. Reinstall the flat Phillips-head titanium screws to secure the end cap.

Software Installation

Notes:
- It is possible to use the MicroCAT without SEATERM by sending direct commands from a dumb terminal or terminal emulator, such as Windows HyperTerminal.
- The MicroCAT is supplied with an additional program, Cnv37IMHex.exe, which converts a hexadecimal file to a file with engineering units, providing the benefits of a faster, hex upload with easy-to-use converted output. Cnv37IMHex.exe is a separate program, but is automatically installed in the same directory as SEATERM. See *Appendix III: SBE 37-IM Format 0 to ASCII Converter*.

Recommended minimum system requirements:
Pentium 90 CPU, 64 Mbyte RAM, Windows 98 or later.

If not already installed, install SEATERM and other Sea-Bird software programs on your computer using the supplied software CD:
1. Insert the CD in your CD drive.
2. Double click on **Seasoft-Win32.exe**.
3. Follow the dialog box directions to install the software.

The default location for the software is c:/Program Files/Sea-Bird. Within that folder is a sub-directory for each program. Install all the components, or just install SEATERM (terminal program) and SBE Data Processing.

Power and Communications Test and Setting MicroCAT IDs

The power and communications test will verify that the system works, prior to deployment.

Test Setup

Note:
For testing and setup, an ICC is not required, even if using SIM-Coupled.

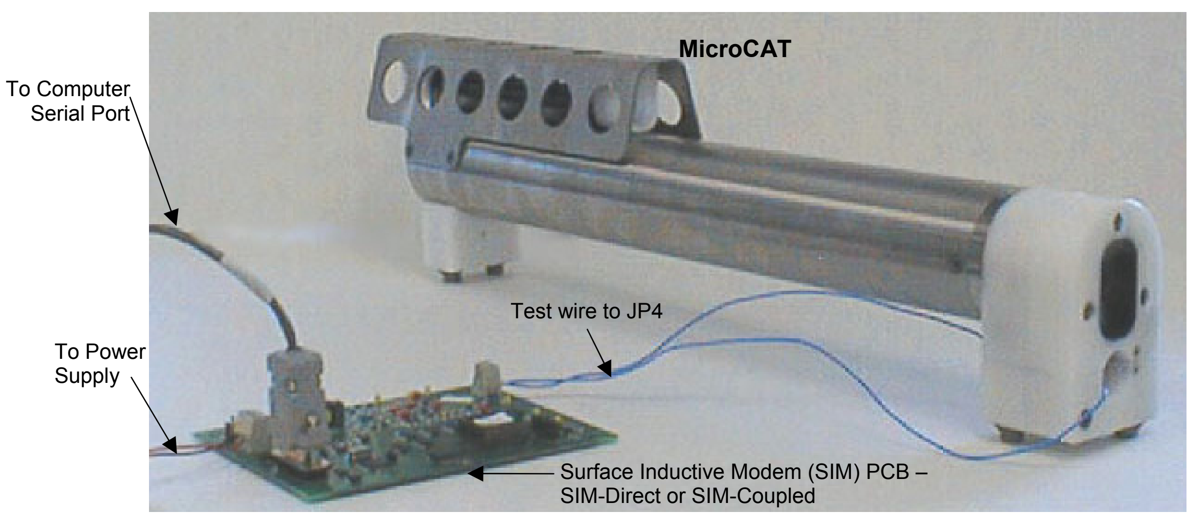
Note:
Important! For Normal Deployed operation, reinstall the jumper across J5.

1. Loop insulated wire through the MicroCAT's modem coupling core to simulate a mooring cable. Connect the test wire ends to the SIM's mooring cable terminals (JP4) (see *Appendix V: SIM Hookup and Configuration*).

2. On the SIM, remove the J5 jumper (see *Appendix V*). This inserts a 1K resistor in series with the inductive loop and reduce signal amplitude, preventing MicroCATs that are near, but not attached to, the inductive loop from responding to commands (especially important when sending ***ID=**).

3. Connect the SIM to a 7-25 VDC power supply. Approximately 30 milliamperes are required. **Do not turn on the power supply yet**.

4. Connect the SIM to your computer's serial port using the 9-pin to 9-pin cable supplied with the SIM.



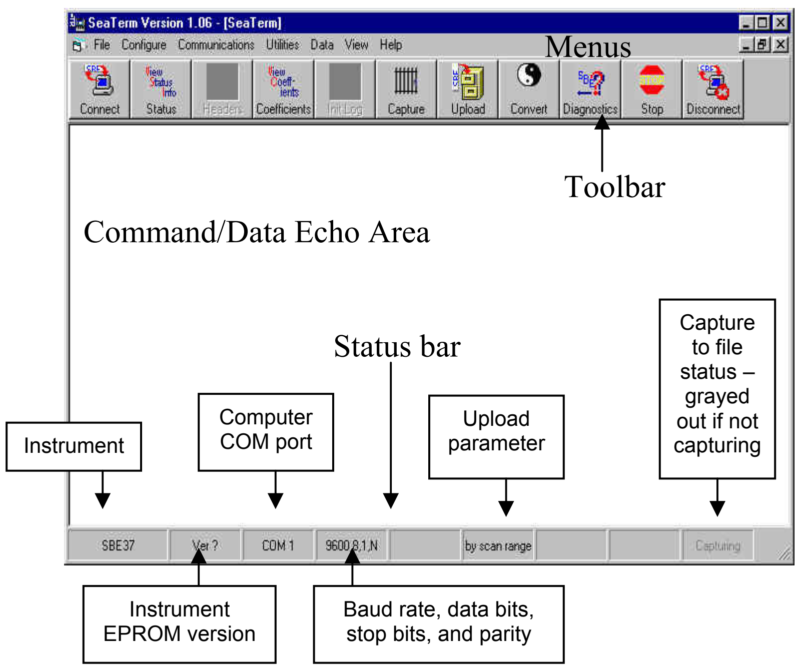
Test and Set MicroCAT ID

> **Note:**
> See SEATERM's help files for detailed information on the use of the program.

1. Double click on SeaTerm.exe. If this is the first time the program is used, the setup dialog box may appear:

Select the instrument type (SBE 37) and the computer COM port for communication with the MicroCAT. Click OK.

2. The main screen looks like this:



- Menus – Contains tasks and frequently executed instrument commands.
- Toolbar – Contains buttons for frequently executed tasks and instrument commands. All tasks and commands accessed through the Toolbar are also available in the Menus. To display or hide the Toolbar, select View Toolbar in the View menu. Grayed out Toolbar buttons are not applicable.
- Command/Data Echo Area – Echoes a command executed using a Menu or Toolbar button, as well as the instrument's response. Additionally, a command can be manually typed in this area, from the available commands for the instrument. Note that the instrument must be *awake* for it to respond to a command (use Connect on the Toolbar to wake up the instrument).
- Status bar – Provides status information. To display or hide the Status bar, select View Status bar in the View menu.

> **Note:**
> There is at least one way, and as many as three ways, to enter a command:
> - Manually type a command in Command/Data Echo Area
> - Use a menu to automatically generate a command
> - Use a Toolbar button to automatically generate a command

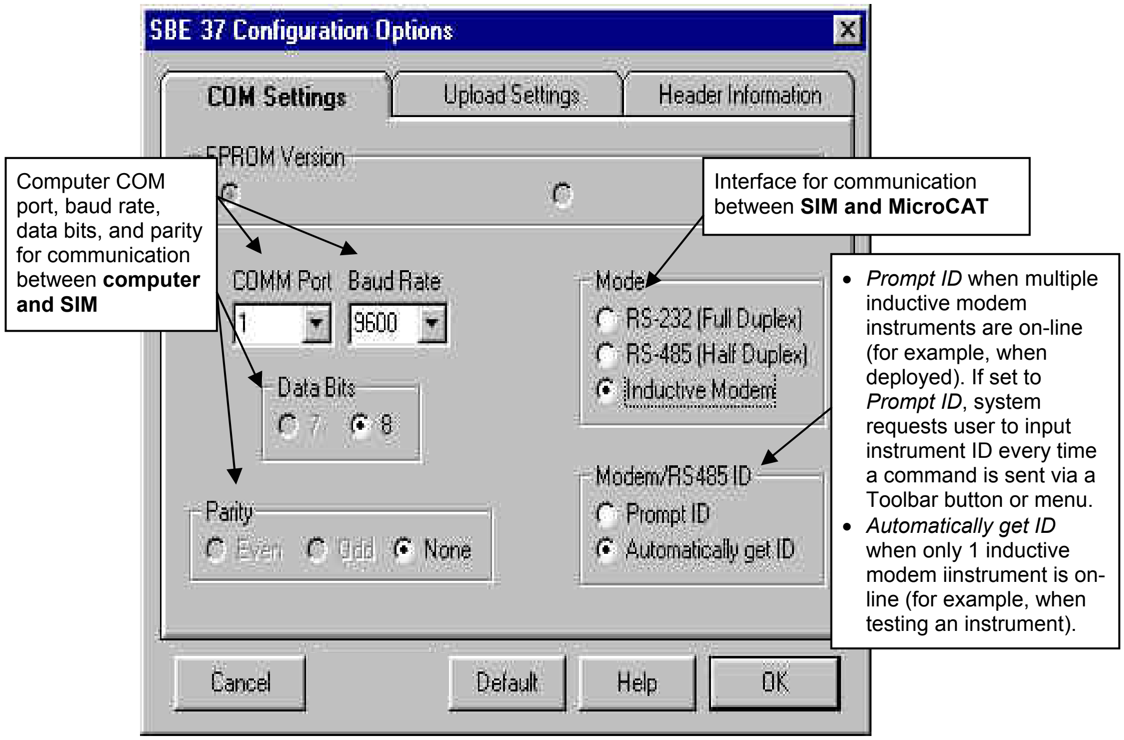
> **Note:**
> Once the system is configured and connected (Steps 3 through 5 below), to update the Status bar:
> - on the Toolbar, click Status; or
> - from the Utilities menu, select Instrument Status.
>
> SEATERM sends the status command, which displays in the Command/Data Echo Area, and updates the Status bar.

Following are the Toolbar buttons applicable to the MicroCAT:

Toolbar Buttons	Description	Equivalent Command*
Connect	Re-establish communications by sending wakeup tone to **all** MicroCATs. Computer responds with S> prompt. MicroCATs *go to sleep* after 2 minutes without communication from computer have elapsed.	**PwrOn**
Status	Display instrument setup and status (logging, number of samples in memory, etc.).	**#iiDS**
Coefficients	Display calibration coefficients.	**#iiDC**
Capture	Capture instrument responses on screen to file; may be useful for diagnostics. File has .cap extension. Press Capture again to turn off capture. Capture status displays in Status bar.	—
Upload	Upload data stored in memory, in format Convert utility can use to allow for post-processing by SBE Data Processing. Uploaded data has .asc extension. Before using Upload: • Configure upload and header parameters in Configure menu. • Send **#iiStop** to stop logging.	**#iiDDb,e** (use Upload button if you will be processing data with SBE Data Processing)
Convert	Convert uploaded .asc data file to .cnv data file, which can be processed by SBE Data Processing.	—
Diagnostics	Perform one or more diagnostic tests on MicroCAT. Diagnostic test(s) accessed in this manner are non-destructive – they do not write over any existing instrument settings.	**#iiDS, #iiDC, #iiTS,** and **#iiTSR**
Stop	—	**Not applicable to 37-IM MicroCAT**
Disconnect	Free computer COM port used to communicate with MicroCAT. COM port can then be used by another program.	—

*See *Command Descriptions* in *Section 4: Deploying and Operating MicroCAT*.

3. In the Configure menu, select SBE 37. The dialog box looks like this:



Notes:

- SEATERM's baud rate must be the same as the SIM baud rate (set with **Baud=**). Baud is factory-set to 9600, but can be changed by the user (see *Command Descriptions* in *Section 4: Deploying and Operating MicroCAT*).
- When you click OK, SEATERM saves the Configuration Options settings to the SeaTerm.ini file in your Windows directory. SeaTerm.ini contains the last saved settings for each instrument (SBE 37, 44, etc.). When you open SEATERM and select the desired instrument in the Configure menu, the Configuration Options dialog box shows the last saved settings for that instrument.
- When deploying on a mooring cable with multiple MicroCATs, change **Modem/RS485 ID** to **Prompt ID** after testing is complete.

Make the selections in the Configuration Options dialog box:

- **COMM Port**: COM 1 through COM 10, as applicable
- **Baud Rate**: 1200, 2400, 4800, or 9600, as applicable (see Configuration Sheet in manual)
- **Data Bits**: 8
- **Parity**: None
- **Mode**: Inductive Modem
- **Modem/RS485 ID**: Automatically get I.D.

Click OK to save the settings.

4. Turn on the SIM power supply (if already on, turn it off and then on again). The display looks like this:

```
SBE 37 SURFACE MODEM V 2.8a
S>
Sending wake up tone, wait 4 seconds
S>
```

This shows that correct communications between the computer and SIM has been established, and the SIM has sent the wake-up signal to the MicroCAT.
If the system does not respond as shown above:

- Click Connect on the Toolbar.
- Verify the correct instrument was selected in the Configure menu and the settings were entered correctly in the Configuration Options dialog box. Note that the baud rate is documented on the Configuration Sheet in the manual.
- Check cabling between the computer, SIM, and MicroCAT.

5. Click Connect on the Toolbar. This allows the system to use the *Automatically get I.D.* feature when using the Toolbar keys or menus.

6. Confirm the MicroCAT has responded to the wake-up signal by typing **ID?** and pressing the Enter key. The display looks like this:

```
id=01
```

where 01 is the number set at the factory or by the previous user. See the Configuration Sheet for the factory-set identification (ID) number. Note that the ID is stored in the MicroCAT's EEPROM and can be changed so that multiple MicroCATs on a single mooring each have a unique ID.

Press the Enter key to get the S> prompt.

Note:
The SIM and MicroCAT have timeout algorithms designed to:
- restore control to the computer if an illegal command is sent
- conserve battery energy if too much time elapses between commands

If the system does not appear to respond, see *Timeout Descriptions* in *Section 4: Deploying and Operating MicroCAT* for details.

7. Display MicroCAT status information by typing **#iiDS** (ii=MicroCAT ID number) and pressing the Enter key. The display looks like this:

```
SBE 37-IM V 2.3 SERIAL NO. 1000 05-27-2004 11:55:19
logging not started
sample interval = 20 seconds
samplenumber = 52, free = 127948
store time with each sample
transmit sample number
A/D cycles to average = 4
internal pump is not installed
temperature =19.48 deg C
```

8. Command the MicroCAT to take a sample by typing **#iiTS** (ii = MicroCAT ID number) and pressing the Enter key. The display looks like this (if MicroCAT includes optional pressure sensor and **#iiFormat=1**):

```
01000, 23.7658, 0.00019, 0.062, 27 Feb 2004, 11:55:45
```

where 01000 = MicroCAT serial number 69 (37IM15956-1000)
23.7658 = temperature in degrees Celsius
0.00019 = conductivity in S/m
0.062 = pressure in decibars
27 Feb 2004 = date
11:55:45 = time

These numbers should be reasonable; i.e., room temperature, zero conductivity, barometric pressure (gauge pressure), current date and time (shipped from the factory set to Pacific Daylight or Standard Time).

Press the Enter key to get the S> prompt.

Note:
If more than one MicroCAT is on-line when you set the ID, all MicroCATs will be set to the same ID.

9. Each MicroCAT on a mooring must have a unique ID for communicating with the SIM and computer. Set the ID as described below, first verifying that only one MicroCAT is on-line before you set the ID:
   A. Set the MicroCAT ID by typing ***ID=ii** (ii= user-assigned ID number) and pressing the Enter key.
   B. The computer responds by requesting verification, requiring you to again type ***ID=ii** and press the Enter key.
   C. Record the ID for future reference.
   D. Press the Enter key to get the S> prompt.
   E. Click Connect on the Toolbar. This allows the system to use the *Automatically get I.D.* feature when using the Toolbar keys or menus.

10. Command the MicroCAT to go to sleep (quiescent state) by typing **PwrOff** and pressing the Enter key.

The MicroCAT is ready for programming and deployment.

Important! When testing and ID setting is complete for all the MicroCATs, reinstall the J5 jumper on the SIM PCB. The jumper must be installed for Normal Deployed operation.

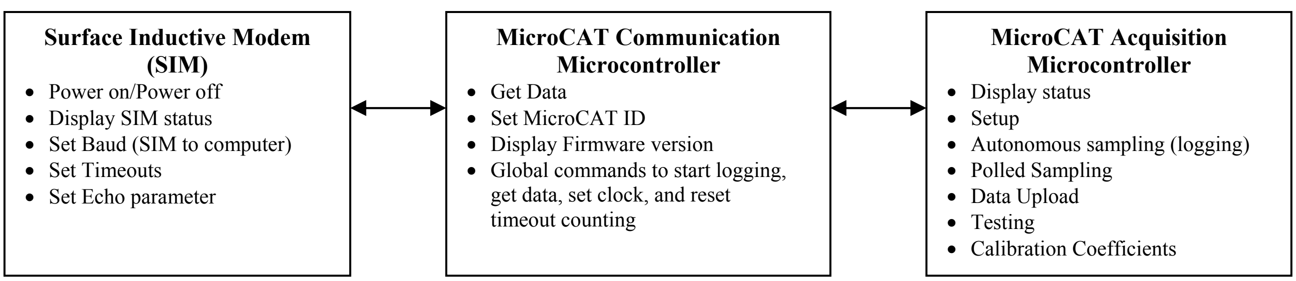
Section 4: Deploying and Operating MicroCAT

This section includes a discussion of system operation, example sets of operation commands, and detailed command descriptions and data output formats. It also provides instructions for deploying and recovering the MicroCAT, and uploading and processing data from the MicroCAT's memory.

Operation Description

The MicroCAT's internal functions are supervised by two internal microcontrollers. The acquisition microcontroller supervises measurement acquisition, and setup and sampling functions. The communication microcontroller supervises communication between the MicroCAT and SIM. These two microcontrollers allows for independent control of power usage by the communication and acquisition circuits. Acquisition consumes more power, but for shorter duration. Communication protocols take proportionately more time, but can be controlled separately and operate at lower power, thus maximizing battery life. This also prevents communication protocols from interfering with measurement acquisition timing.

Commands sent to the SIM can be directed to the SIM, the MicroCAT communication microcontroller, or the MicroCAT acquisition microcontroller. A command prefix (ID) is used to direct commands to a MicroCAT with the same ID. Global commands do not require a prefix and are recognized by all MicroCATs attached to the same inductive cable.



Note:
The following commands do not wake up the acquisition microcontroller: **Dataii**, **ID?**, ***ID**, and these SIM commands (**DS**, **Baud=**, **DataNNMax=**, **RelayMax=**, **EchoOn**, **EchoOff**, **AutoPwrOn=**). All other commands wake up the acquisition microcontroller.

Each time a command is sent that wakes up the MicroCAT's acquisition microcontroller:

1. The MicroCAT responds to the transmitted command, and
2. The acquisition microcontroller goes back to sleep (quiescent state).

Timeout Descriptions

Both the SIM and the MicroCAT have timeout algorithms.

SIM timeouts restore control to the computer if no reply is received from the MicroCAT (for example, upon sending an illegal command) within a specified length of time. This allows new commands to be sent. There are two user-programmable SIM timeouts that are applicable for use with the MicroCAT:

- **DataNNMax** – timeout for **Dataii** only. Default 1000 milliseconds.
- **RelayMax** – timeout for all other commands. Default 20 seconds.

When using RS-232 between the SIM and computer, control of the SIM can be re-established sooner than the timeout by pressing the Esc key and then the Enter key. When the `S>` prompt is displayed, new commands can be sent.

The MicroCAT timeout powers down the MicroCAT communication circuits if the MicroCAT does not receive a command for two minutes, to prevent battery exhaustion. **To re-establish control, send PwrOn or click Connect on the Toolbar.**

Sampling Modes

The MicroCAT has four basic sampling modes for obtaining data on temperature, conductivity, and optional pressure:

- Polled Sampling
- Autonomous Sampling
- Combo Sampling
- Averaging Sampling

Commands can be used in various combinations and in one or more sampling modes to provide a high degree of operating flexibility. Review the operation of the four basic sampling modes and the commands described in *Command Descriptions* before setting up your system.

Descriptions and examples of the sampling modes follow for a system with three MicroCATs (IDs 01, 02, and 03) on a mooring cable. Note that the MicroCAT's response to each command is not shown in the examples.

Polled Sampling

On command, the MicroCAT takes one sample of data and sends the data to the SIM. Storing of data in the MicroCAT's FLASH memory is dependent on the particular command used. Note that it is not possible to synchronize the data samples from each MicroCAT in polled sampling.

Example: ***Polled Sampling*** (user input in bold)
Send wakeup tone to all MicroCATs. Command each MicroCAT to take a sample, and send converted data to SIM. Send power-off command to all MicroCATs.

(Click Connect on Toolbar to wake up all MicroCAT communication microcontrollers.)

```
S>#01TS
S>#02TS
S>#03TS
S>PWROFF
```

Autonomous Sampling (Logging commands)

Note:
If the FLASH memory is filled to capacity, sampling continues, but excess data is not saved in memory (i.e., the MicroCAT does not overwrite the data in memory).

At pre-programmed intervals, the MicroCAT wakes up, samples data, stores the data in its FLASH memory, and goes to sleep (enters quiescent state). The MicroCAT does not transmit data to the SIM. Logging is started with **ResumeLogging**, **GData**, **#iiStartNow**, or **#iiStartLater**, and is stopped with **#iiStop**.

To synchronize the data samples for each MicroCAT in Autonomous Sampling (see *Specifications* in *Section 2: Description of MicroCAT* for the real-time clock specifications):

1. Send a global command to set the date and then time for all the MicroCATs to the same value.
2. Set the sampling interval for each MicroCAT to the same value.
3. Set the delayed logging start date and time for each MicroCAT to the same value, and then send **#iiStartLater**, **or**
   Start logging now using the global **ResumeLogging** or **GData** command.

Note:
Use **#iiStop** to:
- stop logging
- stop waiting to start logging (after **#iiStartLater** has been sent)

Once **#iiStop** is sent, the MicroCAT will accept all commands again.

The MicroCAT has a *lockout* feature to prevent unintended interference with sampling. If the MicroCAT is logging or is waiting to start logging (**#iiStartLater** has been sent, but logging hasn't started yet), only the following commands will be accepted:

- All SIM commands,
- These MicroCAT Communication Microcontroller commands: **GData**, **Dataii**, **?ID**, **!iiDS**
- These MicroCAT Acquisition Microcontroller commands: **#iiDS**, **#iiDC**, **#iiTS**, **#iiTSR**, **#iiSL**, **#iiSLT**, **#iiSLTR**, **#iiGA**, **#iiSACG**, **#iiSARG**, **#iiSAC**, **#iiSAR**, **#iiSS**, **#iiDNx**, and **#iiStop**.

Example: ***Autonomous Sampling*** (user input in bold).
Send wakeup tone to all MicroCATs. Set the time and date, using the global command. For each MicroCAT: set sample number to 0 to overwrite previous data in FLASH memory, take samples every 10 seconds, store data in FLASH memory, store time and date with samples, and start on 10 June 2004 at 12:00:00.

(Click Connect on Toolbar to wake up all MicroCATs.)

```
S>MMDDYY=060504
S>HHMMSS=120000
S>#01SAMPLENUM=0
S>#01INTERVAL=10
S>#01STORETIME=Y
S>#01STARTMMDDYY=061004
S>#01STARTHHMMSS=120000
S>#01STARTLATER
```

(repeat **#iiSAMPLENUM** through **#iiSTARTLATER** for MicroCATs 02 and 03)

```
S>PWROFF
```

When ready to upload all data to computer, wake up all MicroCATs, stop sampling, and upload data:

(Click Connect on Toolbar to wake up all MicroCATs.)

```
S>#01STOP
```

(Click Upload on Toolbar – program leads you through screens to define data to be uploaded and where to store it)
(repeat **#iiSTOP** through Upload for MicroCATs 02 and03)

```
S>PWROFF
```

Combo Sampling

Combo Sampling combines Autonomous Sampling with the ability to retrieve the last stored data sample from each MicroCAT, to allow the user to look at some data without stopping the sampling. As in Autonomous Sampling, at pre-programmed intervals the MicroCAT wakes up, samples data, stores the data in its FLASH memory, and goes to sleep (enters quiescent state).
When desired, the user can request the last stored data sample from a particular MicroCAT.

Example: ***Combo Sampling*** (user input in bold)
Send wakeup tone to all MicroCATs. Set the time and date, using the global command. For each MicroCAT: set sample number to 0 to overwrite previous data in FLASH memory, take samples every 10 seconds, store data in FLASH memory, store time and date with samples, and start on 10 June 2004 at 12:00:00.

(Click Connect on Toolbar to wake up all MicroCATs.)

```
S>MMDDYY=060504
S>HHMMSS=120000
S>#01SAMPLENUM=0
S>#01INTERVAL=10
S>#01STORETIME=Y
S>#01STARTMMDDYY=061004
S>#01STARTHHMMSS=120000
S>#01STARTLATER
```

(repeat **#iiSAMPLENUM** through **#iiSTARTLATER** for MicroCATs 02 and03)

```
S>PWROFF
```

After logging begins, look at data from last sample to check results:

(Click Connect on Toolbar to wake up all MicroCATs.)

```
S>#01SL
S>#02SL
S>#03SL
S>PWROFF
```

When ready to upload all data to computer, wake up all MicroCATs, stop sampling, and upload data:

(Click Connect on Toolbar to wake up all MicroCATs.)

```
S>#01STOP
```

(Click Upload on Toolbar – program leads you through screens to define data to be uploaded and where to store it)
(repeat **#iiSTOP** through Upload for MicroCATs 02 and03)

```
S>PWROFF
```

Averaging Sampling

Averaging Sampling combines Autonomous Sampling with the ability to retrieve averaged data from each MicroCAT, to allow the user to look at averaged data without stopping sampling. As in Autonomous Sampling, at pre-programmed intervals the MicroCAT wakes up, samples data, stores the data in its FLASH memory, and goes to sleep (enters quiescent state). As the MicroCAT is sampling, it automatically adds the data values (C, T, and optional P) for each sample to an *averaging section* in the FLASH memory, and keeps track of the number of samples since the last averaging request. When desired, the user can globally request the average of the data sampled since the last request. Each MicroCAT gets the data from the averaging section in FLASH, divides the sums by the number of samples, holds the averaged data (C, T, and optional P) in a buffer, and resets the averaging section to begin a new average. The user can then request the averaged data from a particular MicroCAT.

*Example: **Averaging Sampling*** (user input in bold)
Send wakeup tone to all MicroCATs. Set the time and date, using the global command. For each MicroCAT: set sample number to 0 to overwrite previous data in FLASH memory, take samples every 10 seconds, store data in FLASH memory, store time and date with samples, and start on 10 June 2004 at 12:00:00.

(Click Connect on Toolbar to wake up all MicroCATs.)
```
S>MMDDYY=060504
S>HHMMSS=120000
S>#01SAMPLENUM=0
S>#01INTERVAL=10
S>#01STORETIME=Y
S>#01STARTMMDDYY=061004
S>#01STARTHHMMSS=120000
S>#01STARTLATER
```
(repeat **#iiSAMPLENUM** through **#iiSTARTLATER** for MicroCATs 02 and03)
```
S>PWROFF
```

After logging begins, send the global command to calculate converted average data and start a new average for each MicroCAT. Then send the command to each MicroCAT to transmit the averaged data.

(Click Connect on Toolbar to wake up all MicroCATs.)
```
S>GDATA
S>DATA01
S>DATA02
S>DATA03
S>PWROFF
```

When ready to upload all data to computer, wake up all MicroCATs, stop sampling, and upload data:

(Click Connect on Toolbar to wake up all MicroCATs.)
```
S>#01STOP
```
(Click Upload on Toolbar – program leads you through screens to define data to be uploaded and where to store it)
(repeat **#iiSTOP** through Upload for MicroCATs 02 and03)
```
S>PWROFF
```

Note:
Sending **GData** resets the logging time base. The next sample is taken at **#iiInterval**/2 after the MicroCAT receives **GData**.

Command Descriptions

This section describes commands and provides sample outputs.
See *Appendix IV: Command Summary* for a summarized command list.

When entering commands:

- Input commands to the MicroCAT in upper or lower case letters and register commands by pressing the Enter key.
- The MicroCAT sends `? CMD` if an invalid command is entered.
- If the system does not return an `S>` prompt after executing a command, press the Enter key to get the `S>` prompt.
- If a new command is not received within two minutes after the completion of a command, the MicroCAT communication microcontroller returns to the quiescent (sleep) state.
- If in quiescent state, re-establish communications by clicking Connect on the Toolbar or sending **PwrOn** to get an `S>` prompt.

SIM Commands

SIM commands are directed to the Surface Inductive Modem, to set it up for operation with the MicroCAT.

PwrOn Send wakeup tone to **all** MicroCATs. Equivalent to Connect on Toolbar.

PwrOff Send power-off command to **all** MicroCATs. Main power turned off and MicroCATs placed in quiescent (sleep) state. Logging and memory retention not affected.

DS Display SIM firmware version and status. Example includes command used to modify parameter [in parentheses].

Example: (user input in bold)

```
S>DS
SBE 37 SURFACE MODEM V 2.8a
wait time for dataNN response = 1000 msec                 [DataNNMax=]
wait time for relay command response = 20 seconds         [RelayMax=]
binary relay character timeout = 1000 msec                [not applicable to MicroCAT]
echo = yes                                                [EchoOn or EchoOff]
execute pwron command on powerup = yes                    [AutoPwrOn=]
```

Note:
The SIM's baud rate (set with **Baud=**) must be the same as SEATERM's baud rate (set in the Configure menu).

Baud=x **x**= baud rate between SIM and computer / controller (1200, 2400, 4800, or 9600). Default 9600.

DataNNMax=x **x=** timeout (0-32767 milliseconds; SIM rounds down to nearest 50 milliseconds) that applies to **Dataii** only. If no reply received within **DataNNMax**, control returned to computer and other commands can be sent. Default 1000 milliseconds.

RelayMax=x **x=** timeout (0-3276 seconds) that applies to all other commands. If no reply received within **RelayMax**, control returned to computer and other commands can be sent. Default 20 seconds.

EchoOn Echo characters received from computer (default) - computer monitor will show entered commands as you type.

EchoOff Do not echo characters received from computer - computer monitor will not show entered commands as you type.

Note:
AutoPwrOn=N is typically used only with a *Tone Detect* board system for an SBE 44 Underwater Inductive Modem.

AutoPwrOn=x **x=Y** (default): Automatically send **PwrOn** to MicroCATs when power applied to SIM. This wakes up all MicroCATs on line.

x=N: Do not send **PwrOn** when power applied to SIM.

MicroCAT Communication Microcontroller Commands

Notes:
- **DDMMYY=** and **MMDDYY=** are equivalent. Either can be used to set the date.
- If the MicroCAT battery pack has been removed, the date and then time must be reset.
- **Always set date and then time.** If a new date is entered but not a new time, the new date will not be saved. If a new time is entered without first entering a new date, the date will reset to the last date it was set for with **MMDDYY=** or **DDMMYY=**.

Notes:
- Either **ResumeLogging** or **GData** can be used to simultaneously start logging in all MicroCATs.
- If the MicroCAT is logging, taking a sample every **#iiInterval** seconds, sending **GData** resets the logging time base. The next sample is taken at the current time plus (**#iiInterval**/2). This reset occurs each time that **GData** is sent (see example).

Global Commands

MMDDYY=mmddyy — Set real-time clock month, day, and year for **all** MicroCATs. Must be followed by **HHMMSS=** to set time.

DDMMYY=ddmmyy — Set real-time clock day, month, and year for **all** MicroCATs. Must be followed by **HHMMSS=** to set time.

HHMMSS=hhmmss — Set real-time clock hour, minute, and second for **all** MicroCATs.

ResumeLogging — Simultaneously command **all** MicroCATs to start logging.

GData — Simultaneously command **all** communication microcontrollers to get **average** data from acquisition units, (re)start logging, and start next averaging cycle. Communication microcontrollers hold averaged data in a buffer until receiving **Dataii**.

Example: **#iiInterval=600** (10 minutes)

Hr	**min**	**sec**	
00	00	00	**#iiStartNow** received, sample
00	10	00	Sample
00	13	00	**GData** received (average 2 data sets)
00	18	00	Sample at **#iiInterval**/2 from when **GData** received
00	28	00	Sample
00	38	00	Sample

. . .

StayOn — Command **all** MicroCATs to reset counting for 2-minute timeout, preventing individual MicroCATs from going to sleep while you are communicating with another MicroCAT on the mooring.

Get Data Command

Dataii — Get **averaged data** obtained with **GData** from MicroCAT with ID = ii.

MicroCAT ID Command

Only one MicroCAT can be on line when sending these commands.

ID? — Display MicroCAT ID (0-99).

***ID=ii** — Set MicroCAT ID to ii (ii= 0-99). Must be sent twice, because computer requests verification. **If more than 1 MicroCAT on-line, all MicroCATs set to same ID**.

MicroCAT Communication Microcontroller Firmware Version Command

!iiDS — Display communication microcontroller firmware version for MicroCAT with ID=ii.

MicroCAT Acquisition Microcontroller Commands

All MicroCAT Acquisition Microcontroller commands are preceded by **#ii** (ii= MicroCAT ID).

Status Command

#iiDS Display operating status and setup parameters.
Equivalent to Status on Toolbar.

List below includes, where applicable, command used to modify parameter:
- firmware version, serial number, date and time [**#iiMMDDYY=** or **#iiDDMMYY=**, and **#iiHHMMSS=**; or equivalent global commands]
- logging status
- sample interval time [**#iiInterval=**]
- number of samples in memory [**#iiSampleNum=**] and available sample space in memory
- whether time is stored with each sample [**#iiStoreTime=**]
- whether sample number is transmitted when polled sampling command is sent [**#iiTxSampleNum=**]
- number of A/D cycles to average per sample (set by Sea-Bird to 4; cannot be changed by customer)
- reference pressure [**#iiRefPress=**]; only displays if no pressure sensor installed
- whether internal pump is installed (never installed in 37-IM) [**#iiPumpInstalled=N**]
- current temperature

Logging status can be:
- logging not started
- logging data
- not logging: waiting to start at…
- not logging:received stop command
- not logging: low battery
- unknown status

Notes:
- If the battery voltage is below 6.15 volts, the following displays in response to the status command: `WARNING: LOW BATTERY VOLTAGE!!` Replace the batteries before continuing.
- *A/D cycles to average = 4* refers to a factory configuration of an A/D converter. The thermistor and (optional) pressure sensor are sampled 4 times in rapid succession, and average values are recorded; during this time the conductivity measurement is also integrated and the average is recorded. Averaging 4 A/D cycles provides the optimum trade-off between low RMS noise in the measurement and battery endurance.
- The 37-IM and 37-IMP use the same firmware. The internal pump is applicable to the 37-IMP MicroCAT only.

Example: Display status for MicroCAT 01 (user input in bold, command used to modify parameter in parentheses).

```
S>#01DS
SBE37-IM V 2.3  SERIAL NO. 1000 05-27-2004 11:55:19      [#iiMMDDYY=, #iiHHMMSS=]
logging data
sample interval = 30 seconds                             [#iiInterval=]
samplenumber = 52, free = 127948                         [#iiSampleNum=]
store time with each sample                              [#iiStoreTime=]
transmit sample number                                   [#iiTxSampleNum=]
A/D cycles to average = 4                                [set at factory; cannot be changed]
reference pressure = 0.0 db                              [#iiRefPress=]
internal pump not installed                              [#iiPumpInstalled=N; only valid setting for 37-IM]
temperature = 7.54 deg C
```

Setup Commands

Notes:
- **#iiDDMMYY=** and **#iiMMDDYY=** are equivalent. Either can be used to set the date.
- If the MicroCAT battery pack has been removed, the date and time must be reset.
- **Always set date and then time.** If a new date is entered but not a new time, the new date will not be saved. If a new time is entered without first entering a new date, the date will reset to the last date it was set for with **#iiMMDDYY=** or **#iiDDMMYY=**.

#iiMMDDYY=mmddyy Set real-time clock month, day, and year. Must be followed by **#iiHHMMSS=** command to set time.

#iiDDMMYY=ddmmyy Set real-time clock day, month, and year. Must be followed by **#iiHHMMSS=** command to set time.

#iiHHMMSS=hhmmss Set real-time clock hour, minute, and second.

Example: Set current date and time for MicroCAT 01 to 10 May 2004 12:00:00 (user input in bold).

```
S>#01MMDDYY=051004
S>#01HHMMSS=120000
```

or

```
S>#01DDMMYY=100504
S>#01HHMMSS=120000
```

Note:
See *Data Format* after these *Command Descriptions*.

#iiFormat=x **x=0**: Output hex data; use for diagnostic purposes or to increase speed of data upload. See *Appendix III: SBE 37-IM Format 0 to ASCII Converter*.

x=1 (default): Output converted data.
date format dd mmm yyyy,
conductivity =S/m,
temperature precedes conductivity

x=2: Output converted data.
date format mm-dd-yyyy,
conductivity=mS/cm,
conductivity precedes temperature

Note:
#iiTxSampleNum=Y could be used to verify that logging is occurring at the correct rate. For example, while logging:
1. Send **#iiSL**.
2. After some interval, send **#iiSL** again. Compare change in output sample numbers to expected change based on **#iiInterval**.

#iiTxSampleNum=x **x=Y**: Output six-character sample number (number of samples in memory at time sample was taken) with data from **Dataii**, **#iiTS**, **#iiSLT**, **#iiTSSTx**, **#iiSL**, **#iiSACG**, and **#iiSAC**.

x=N: Do not output sample number.

#iiRefPress=x **x** = reference pressure (gauge) in decibars. MicroCAT without installed pressure sensor uses this reference pressure in conductivity calculation. Entry ignored if MicroCAT includes pressure sensor.

#iiPumpInstalled=x **x =Y**: Not applicable to 37-IM.

x=N: Internal pump not installed **(only valid setting for 37-IM)**.

Notes:
- If the MicroCAT is logging and the battery voltage is less than 6.15 volts for ten consecutive scans, the MicroCAT halts logging and sets the logging status to low battery.
- If the FLASH memory is filled to capacity, sampling continues, but excess data is not saved in memory (i.e., the MicroCAT does not overwrite the data in memory).

Note:
Do not send #iiSampleNum=0 until all data has been uploaded. #iiSampleNum=0 does not delete the data; it just resets the data pointer. **If you accidentally send this command before uploading**, recover the data as follows:
1. Set **#iiSampleNum=x**, where **x** is your estimate of number of samples in memory (estimate based on length of deployment and interval between samples).
2. Upload data. If **x** is more than actual number of samples in memory, data for non-existent samples will be bad, random data. Review uploaded data carefully and delete any bad data.
3. If desired, increase **x** and upload data again, to see if there is additional valid data in memory.

Note:
#iiStartDDMMYY= and **#iiStartMMDDYY=** are equivalent. Either can be used to set the delayed start date.

Notes:
- After receiving **#iiStartLater**, the MicroCAT displays `not logging: waiting to start` in reply to the Display Status (**#iiDS**) command. Once logging starts, the **#iiDS** reply shows `logging data`.
- If the delayed start time has already passed when **#iiStartLater** is received, the MicroCAT executes **#iiStartNow**.

Autonomous Sampling (Logging) Commands

Logging commands direct the MicroCAT to sample data at pre-programmed intervals and store the data in its FLASH memory.

#iiInterval=x
x= interval (10 – 32767 seconds) between samples. When commanded to start sampling (with **#iiStartNow**, **#iiStartLater**, **GData**, or **ResumeLogging**), MicroCAT takes a sample, stores data in FLASH memory, and powers down at **x** second intervals.

#iiSampleNum=x
x= sample number for first sample when logging. After all previous data has been uploaded from MicroCAT, set sample number to 0 before starting to log to make entire memory available for recording. If **#iiSampleNum** is not reset to 0, data will be stored after last recorded sample.

#iiStoreTime=x
x=Y: Store date and time with each sample. This adds 4 bytes per scan.

x=N: Do not.

#iiStartNow
Start logging now, at rate defined by **#iiInterval**. Data is stored in FLASH memory.

#iiStartMMDDYY=mmddyy
Set delayed logging start month, day, and year. Must be followed by **#iiStartHHMMSS=** to set delayed start time.

#iiStartDDMMYY=ddmmyy
Set delayed logging start day, month, and year. Must be followed by **#iiStartHHMMSS=** to set delayed start time.

#iiStartHHMMSS=hhmmss
Set delayed logging start hour, minute, and second.

#iiStartLater
Start logging at time set with delayed start date and time commands, at rate defined by **#iiInterval**. Data is stored in FLASH memory.

Example: Program MicroCAT 01 to start logging on 20 May 2004 12:00:00 (user input in bold).

```
S>#01STARTMMDDYY=052004
S>#01STARTHHMMSS=120000
S>#01STARTLATER
```

or

```
S>#01STARTDDMMYY=200504
S>#01STARTHHMMSS=120000
S>#01STARTLATER
```

Autonomous Sampling (Logging) Commands (continued)

#iiStop Stop logging or stop waiting to start logging (if **#iiStartLater** was sent but logging has not begun). Press Connect on Toolbar to get `S>` prompt before entering **#iiStop**. **#iiStop** must be sent before uploading data.

Notes:
- Averaged data obtained with **#iiSACG**, **#iiSARG**, **#iiSAC**, or **#iiSAR** is not stored in FLASH memory.
- Logging commands related to averaging are typically used only for customized acquisition. **GData** and **Dataii** more easily start averaging and get averaged data (see *MicroCAT Communication Microcontroller Commands*).

#iiGA Start logging now. First sample will be taken after delay of (**#iiInterval**/2). Data is stored in FLASH memory.

#iiSACG Output averaged data, converted. Start new average.

#iiSARG Output averaged data, raw. Start new average.

#iiSAC Output averaged data, converted. Continue averaging.

#iiSAR Output averaged data, raw. Continue averaging.

Polled Sampling Commands

These commands are used by an external controller to request a sample from the MicroCAT.

#iiTS Take sample and output converted data. Data is **not** stored in FLASH memory.

#iiTSR Take sample and output raw data. Data is **not** stored in FLASH memory.

#iiSLT Output converted data from last sample, and then take new sample. Data is **not** stored in FLASH memory.

#iiSLTR Output raw data from last sample, and then take new sample. Data is **not** stored in FLASH memory.

#iiTSSTx Take sample, **store in FLASH memory**, and transmit converted data. If MicroCAT is logging or waiting to log when **#iiTSSTx** is sent, MicroCAT executes **#iiTS** instead.

#iiSL Output converted data from last sample taken with either polled sampling or autonomous sampling (logging).

Data Upload Commands

Notes:
- **Use Upload on the Toolbar or Upload Data in the Data menu to upload data that will be processed by SBE Data Processing**. Manually entering a data upload command does not produce data with the required header information and required format for processing by our software. These commands are included here for reference for users who are writing their own software.
- To save data to a file, click Capture on the Toolbar before entering **#iiDDb,e** or **#iiDNx**.
- See *Data Format* after these *Command Descriptions*; also see *Appendix III: SBE 37-IM Format 0 to ASCII Converter*.

#iiDDb,e

Upload data from memory scan **b** to **e**. First sample is number 1. Maximum of 250 samples can be uploaded at one time with **#iiDDb,e**. (When Upload on Toolbar or Upload Data in Data menu are used, samples numbering more than 250 are automatically received.)
As data is uploaded, screen first displays `start time =, sample interval =, and start sample number =.` These are start time, sample interval, and starting sample number for last set of logged data. This information can be useful in determining what data to review.
Send #iiStop to stop logging before sending #iiDDB,e.

Example: Upload samples 1 through 200 for MicroCAT 01 (user input in bold):
S>**#01STOP** (stop logging for MicroCAT 01)
(Click Capture on Toolbar and enter desired filename in dialog box.)
S>**#01DD1,200** (upload samples 1 through 200 from MicroCAT 01)

#iiDNx

Upload last **x** scans from memory. Most often used to retrieve data periodically from MicroCAT while it is on mooring. Maximum of 250 samples can be uploaded at one time with **#iiDNx**.
You do not need to stop logging (#iiStop) before sending #iiDNx.

Example: For a system with MicroCATs 01, 02, and 03 which is sampling every 10 minutes (144 times/day), upload latest data once per day (user input in bold):
(Click Capture on Toolbar and enter desired filename in dialog box.)
S>**#01DN144** (upload last 144 samples from MicroCAT 01)
S>**STAYON** (reset time-out timer on all MicroCATs so 02 and 03 do not go to sleep while uploading data from 01)
S>**#02DN144** (upload last 144 samples from MicroCAT 02)
S>**STAYON** (reset time-out timer on all MicroCATs so 01 and 03 do not go to sleep while uploading data from 02)
S>**#03DN144** (upload last 144 samples from MicroCAT 03)
S>**STAYON** (reset time-out timer on all MicroCATs so 01 and 02 do not go to sleep while uploading data from 03)
S>**PWROFF** (send power-off command to all MicroCATs; logging not affected)

Testing Commands

Data obtained with these commands is **not** stored in FLASH memory.

#iiSS	Output averaged raw data – average, maximum, minimum, and number of samples.
#iiTT	Measure temperature for 30 samples, output converted data.
#iiTC	Measure conductivity for 30 samples, output converted data.
#iiTP	Measure pressure for 30 samples, output converted data.
#iiTTR	Measure temperature for 30 samples, output raw data.
#iiTCR	Measure conductivity for 30 samples, output raw data.
#iiTPR	Measure pressure for 30 samples, output raw data.
#iiTR	Measure real-time clock frequency for 30 samples, output data.

Notes:
- Dates shown are when calibrations were performed. Calibration coefficients are initially factory-set and should agree with Calibration Certificates shipped with MicroCAT.
- See individual Coefficient Commands below for definitions of the data in the example.

Calibration Coefficients Commands

#iiDC	Display calibration coefficients. Equivalent to Coefficients on Toolbar.

Example: Display coefficients for MicroCAT 01, which does not have a pressure sensor (user input in bold).

```
S>#01DC
SBE37-IM V 2.3 1000
temperature:      09-feb-03
TA0 = -9.420702e-05
TA1 =  2.937924e-04
TA2 = -3.739471e-06
TA3 =  1.909551e-07
conductivity:     09-feb-03
G =          -1.036689e+00
H =           1.444342e-01
I =          -3.112137e-04
J =           3.005941e-05
CPCOR =      -9.570001e-08
CTCOR =       3.250000e-06
WBOTC =       1.968100e-05
rtc:         09-feb-03
RTCA0 =       9.999782e-01
RTCA1 =       1.749351e-06
RTCA2 =       -3.497835e-08
```

The individual Coefficient Commands listed below are used to modify a particular coefficient or date:

Note:
F = floating point number
S = string with no spaces

#iiTCalDate=S	**S**=Temperature calibration date
#iiTA0=F	**F**=Temperature A0
#iiTA1=F	**F**=Temperature A1
#iiTA2=F	**F**=Temperature A2
#iiTA3=F	**F**=Temperature A3
#iiCalDate=S	**S**=Conductivity calibration date
#iiCG=F	**F**=Conductivity G
#iiCH=F	**F**=Conductivity H
#iiCI=F	**F**=Conductivity I
#iiCJ=F	**F**=Conductivity J
#iiWBOTC=F	**F**=Conductivity wbotc
#iiCTCOR=F	**F**=Conductivity ctcor
#iiCPCOR=F	**F**=Conductivity cpcor
#iiPCalDate=S	**S**=Pressure calibration date
#iiPA0=F	**F**=Pressure A0
#iiPA1=F	**F**=Pressure A1
#iiPA2=F	**F**=Pressure A2
#iiPTCA0=F	**F**=Pressure ptca0
#iiPTCA1=F	**F**=Pressure ptca1
#iiPTCA2=F	**F**=Pressure ptca2
#iiPTCB0=F	**F**=Pressure ptcb0
#iiPTCB1=F	**F**=Pressure ptcb1
#iiPTCB2=F	**F**=Pressure ptcb2
#iiPOffset=F	**F**=Pressure offset
#iiRCalDate=S	**S**=Real-time clock calibration date
#iiRTCA0=F	**F**=Real-time clock A0
#iiRTCA1=F	**F**=Real-time clock A1
#iiRTCA2=F	**F**=Real-time clock A2

Data Format

Notes (for **#iiFormat=1** or **2**):
i = MicroCAT ID
s = MicroCAT serial number
t = temperature (°C, ITS-90)
c = conductivity
p = pressure (decibars); sent only if optional pressure sensor installed
hh:mm:ss = hour, minute, second
dd mmm yyyy = day, month (Jan, Feb, Mar, etc.), year
mm-dd-yyyy = month, day, year
n = number of data samples contained in average
sample = six-digit sample number, sent only if **#iiTxSampleNum=Y**

- Leading zeros are suppressed, except for one zero to the left of the decimal point.
- The MicroCAT's pressure sensor is an absolute sensor, so its **raw** output includes the effect of atmospheric pressure (14.7 psi). As shown on the Calibration Sheet, Sea-Bird's calibration (and resulting calibration coefficients) is in terms of psia. However, when outputting pressure in **decibars**, the MicroCAT outputs pressure relative to the ocean surface (i.e., at the surface the output pressure is 0 decibars). The MicroCAT uses the following equation to convert psia to decibars:
pressure (db) =
[pressure (psia) - 14.7] * 0.689476

Each scan ends with a carriage return <CR> and line feed <LF>. The exact format of the output varies, depending on the command sent, the user's selection for **#iiFormat=**, and whether pressure and date and time are stored with the data.

- **#iiFormat=0**: hexadecimal data, intended for diagnostic use at Sea-Bird, **or to increase speed of data upload**. See *Appendix III: SBE 37-IM Format 0 to ASCII Converter* for details.
- **#iiFormat=1** or **2**: see below.

Data Format after Sending Get Data (Dataii) Command

Date and time are sent only if **#iiStoreTime=Y**. The six-digit sample number is the number of samples in FLASH memory at the time the command to take a sample (**GData**) was sent.

- **#iiFormat=1** (default): Conductivity = S/m
  ii, sssss, ttt.tttt, cc.ccccc, pppp.ppp, dd mmm yyyy, hh:mm:ss, sample, n

- **#iiFormat=2:** Conductivity = mS/cm
  ii, sssss, ccc.cccc, ttt.tttt, pppp.ppp, hh:mm:ss, mm-dd-yyyy, sample, n

Data Format after Sending Polled Sampling Commands (#iiTS, #iiSL, #iiSLT, #iiTSSTx)

Date and time are always sent, regardless of the setting for **#iiStoreTime**. The six-digit sample number is the number of samples in FLASH memory at the time the command to take a sample was sent.

- **#iiFormat=1** (default): Conductivity = S/m
  sssss, ttt.tttt, cc.ccccc, pppp.ppp, dd mmm yyyy, hh:mm:ss, sample

- **#iiFormat=2:** Conductivity = mS/cm
  sssss, ccc.cccc, ttt.tttt, pppp.ppp, hh:mm:ss, mm-dd-yyyy, sample

Data Format after Sending Data Upload Command (#iiDDb,e; #iiDNx; Upload button on Toolbar; or Upload Data in Data menu)

Date and time are sent only if **#iiStoreTime=Y**.

- **#iiFormat=1** (default): Conductivity = S/m
  ttt.tttt, cc.ccccc, pppp.ppp, dd mmm yyyy, hh:mm:ss

- **#iiFormat=2:** Conductivity = mS/cm
  ccc.cccc, ttt.tttt, pppp.ppp, hh:mm:ss, mm-dd-yyyy

Setup for Deployment

.

Notes:
- If the battery pack has been removed, the date and time must be reset.
- **Always set both date and then time.** If a new date is entered but not a new time, the new date will not be saved. If a new time is entered without first entering a new date, the date will reset to the last date it was set for with **MMDDYY=**, **DDMMYY=**, **#iiMMDDYY=**, or **#iiDDMMYY=**.

1. Install new batteries or ensure the existing battery pack has enough capacity to cover the intended deployment. See *Section 5: Routine Maintenance and Calibration* for details on installing new batteries.

2. Program the MicroCAT for the intended deployment (*see Section 3: Preparing MicroCAT for Deployment* for connection information; see information in this section on commands and sampling modes):

   A. Ensure all data has been uploaded, and then set **#iiSampleNum=0** to make the entire memory available for recording. If **#iiSampleNum** is not reset to 0, data will be stored after the last recorded sample.

   B. Set the date and then time. Note that the date and time can be set globally for all MicroCATs online (**MMDDYY=** or **DDMMYY=** to set date; **HHMMSS=** to set time) or individually for each MicroCAT (**#iiMMDDYY=** or **#iiDDMMYY=** to set date; **#iiHHMMSS=** to set time). To synchronize autonomous sampling for a system with multiple MicroCATs on a mooring cable, set the date and time globally, with all the MicroCATs online (see *Autonomous Sampling* in this section for details on synchronization).

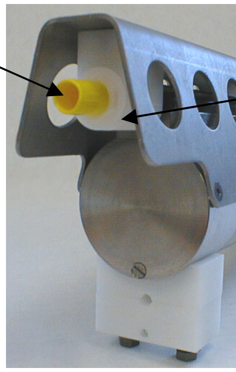
   C. Establish the setup and logging parameters.

   D. If the system will have multiple MicroCATs (or other inductive instruments) on the mooring cable, verify the MicroCAT is set to *Prompt ID* to allow use of the Toolbar buttons and Menus:
      1) In the Configure menu, select SBE 37.
      2) Click on the COM Settings tab.
      3) For Modem/RS485 ID, click on *Prompt ID*.
      4) Click OK.

   E. Use **one** of the following sequences to initiate logging:
      - **#iiStartNow** to start logging now, taking a sample every **#iiInterval** seconds.
      - **#iiStartMMDDYY=**, **#iiStartHHMMSS=**, and **#iiStartLater** to start logging at the specified date and time, taking a sample every **#iiInterval** seconds.
      - **ResumeLogging** or **GData** to globally start logging now for all MicroCATs online, taking a sample every **#iiInterval** seconds.

Attaching MicroCAT to Mooring Cable

Remove plugs (2)



Anti-foulant device cups (2)

Note:
See *Application Note 85: Handling of Ferrite Core on Instruments with Inductive Modem Telemetry* for more detailed information on handling and installation.

Mounting clamp, with opening sized to specified cable diameter – cable **clamped** by this bracket. Note: Installing clamp on larger cable than specified may cause damage to cable and/or modem and prevent IM communications.

For both mounting brackets – loosen hardware to separate bracket halves and mount on mooring cable

Mounting guide / inductive modem coupler – contains modem coupling toroid core. Cable goes through here but is **not clamped**, to avoid putting through tension on end cap (which could pull off end cap).

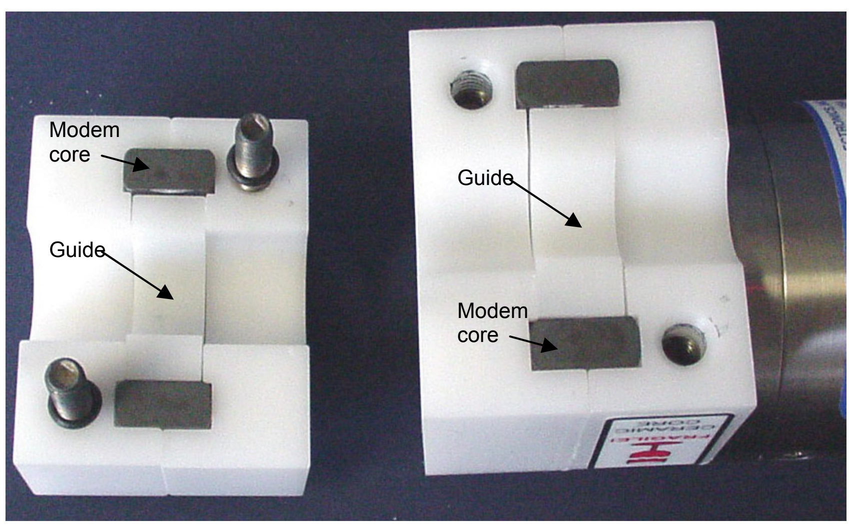
For proper communications, 2 halves of modem coupling toroid core must mate, with no gaps

1. New MicroCATs are shipped with AF24173 Anti-Foulant Devices and protective plugs pre-installed.
   A. Remove the protective plugs, if installed, from the anti-foulant device cups. **The protective plugs must be removed prior to deployment or pressurization.** If the plugs are left in place during deployment, the sensor will not register conductivity. If left in place during pressurization, the cell may be destroyed.
   B. Verify that the anti-foulant device cups contain AF24173 Anti-Foulant Devices (see *Section 5: Routine Maintenance and Calibration*).

2. Attach the mounting brackets to the insulated mooring cable:
   A. Open each mounting bracket by unthreading the two large titanium hex bolts.
   B. Place the insulated mooring cable inside the brackets' grooves.
   C. Reinstall each bracket half with the hex bolts.
   D. Verify that the two halves of the modem coupling toroid have come together evenly, and that the mounting clamp is secure.

3. Verify that the hardware and external fittings are secure.

Mounting guide / Inductive Modem Coupler Detail
Guide is sized ***slightly*** bigger than specified cable diameter, to allow cable to pass through freely but limit vibration of MicroCAT on cable



System Installation and Wiring

For system installation and wiring details, refer to:

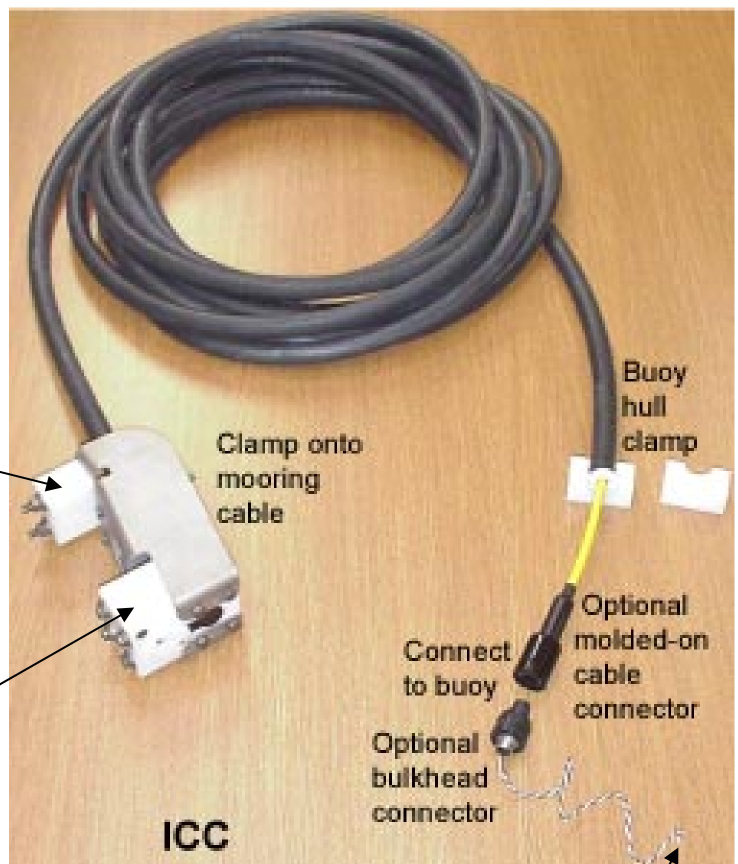
- *Mooring Cable and Wiring Requirements* in *Section 2: Description of MicroCAT*
- *Appendix V: SIM Hookup and Configuration*.

Installing Optional Inductive Cable Coupler (ICC)

Note:
See *Application Note 85: Handling of Ferrite Core on Instruments with Inductive Modem Telemetry* for more detailed information on handling and installation.

1. Loosen the titanium hex head bolts connecting the two halves of each of the ICC brackets. Pull the halves apart.
2. Place the insulated mooring cable inside the brackets' grooves.
3. Reinstall each bracket half with the hex bolts.
4. Verify that the two halves of the modem coupling toroid have come together evenly, and that the mounting clamp is secure.

Mounting clamp, with opening sized to specified cable diameter – cable **clamped** by this bracket. Note: Installing clamp on larger cable than specified may cause damage to cable and/or modem and prevent IM communications.



Mounting guide / inductive modem coupler – contains modem coupling toroid. Cable goes through here but is **not clamped**, to avoid putting through tension on end cap (which could pull off end cap).
Detail of guide and core is similar to shown above for the 37-IM guide and core.

Wiring to SIM PCB

Recovery

WARNING!
If the MicroCAT stops working while underwater, is unresponsive to commands, or shows other signs of flooding or damage, carefully secure it away from people until you have determined that abnormal internal pressure does not exist or has been relieved. Pressure housings may flood under pressure due to dirty or damaged o-rings, or other failed seals. When a sealed pressure housing floods at great depths and is subsequently raised to the surface, water may be trapped at the pressure at which it entered the housing, presenting a danger if the housing is opened before relieving the internal pressure. Instances of such flooding are rare. However, a housing that floods at 5000 meters depth holds an internal pressure of more than 7000 psia, and has the potential to eject the end cap with lethal force. A housing that floods at 50 meters holds an internal pressure of more then 85 psia; this force could still cause injury.

If you suspect the MicroCAT is flooded, point it in a safe direction away from people. There are 4 socket head cap screws securing the conductivity cell tray to the end cap. There is an o-ring face seal between the cell tray and end cap. Using a 9/64 inch Allen hex key, loosen each screw 1/4-turn, in a crossing pattern, while looking for signs of internal pressure (hissing or water leakage). If no sign of pressure is detected, continue to loosen the screws in 1/4-turn increments until the cell tray is loose and the o-ring seal is broken. If internal pressure is detected, let it bleed off slowly. Then, you can safely remove the end cap.

The seals and surrounding surfaces must be properly cleaned before remounting the cell tray; we recommend that this work be performed at Sea-Bird. Remount the tray (to secure the conductivity cell for transport) and send the MicroCAT to Sea-Bird for servicing, with a note that the cell tray o-ring seals have been broken.

Physical Handling

1. Rinse the instrument and conductivity cell with fresh water. (See *Section 5: Routine Maintenance and Calibration* for cell cleaning and storage.)

2. Reinsert the protective plugs in the anti-foulant device cups.

3. If the batteries are exhausted, new batteries must be installed before the data can be uploaded. Stored data will not be lost as a result of exhaustion or removal of batteries, but the current date and time will have to be re-entered upon redeployment. (See *Section 5: Routine Maintenance and Calibration* for replacement of batteries.)

4. If immediate redeployment is not required, it is best to leave the MicroCAT with batteries in place and in a quiescent (sleep) state (**PwrOff**), so that date and time are retained. Because the quiescent current required is less than 100 microamps, the batteries can be left in place without significant loss of capacity (less than 20% loss per year).

Uploading and Processing Data

Note:
Data may be uploaded during deployment or after recovery.
If uploading after recovery:
1. Wire the MicroCAT and SIM as described in *Power and Communications Test and Setting MicroCAT IDs* in *Section 3: Preparing MicroCAT for Deployment*.
2. Set Modem/RS485 ID (on COM Settings tab of SBE 37 Configuration Options dialog box) to *Automatically get ID*.

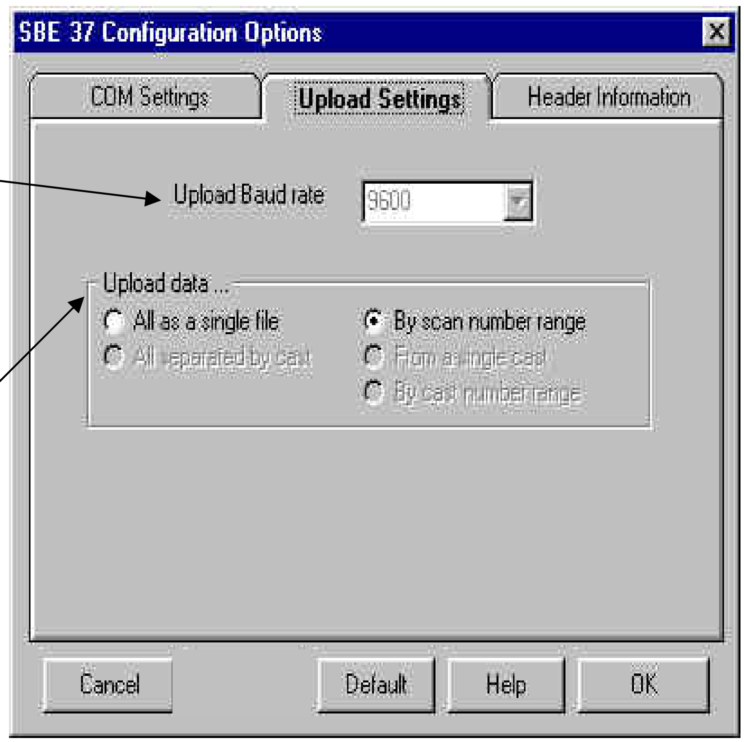
If uploading during deployment: Leave Modem/RS485 ID on *Prompt ID*. SEATERM will prompt you for the MicroCAT ID when you use Toolbar or menu shortcuts for commands.

1. Double click on SeaTerm.exe. The display shows the main screen.

2. In the Configure menu, select SBE 37. Click on the Upload Settings tab. The dialog box looks like this:

Baud rate for communication between **SIM and computer** for uploading data from MicroCAT to computer. Same as baud rate for general communication, which was set on COM Settings tab.

Defines data upload type when using Upload on Toolbar or Upload Data in Data menu:
- All as single file – All data uploaded into one file.
- By scan number range – SEATERM prompts for beginning and ending scan (sample) numbers, and uploads all data within range into one file.

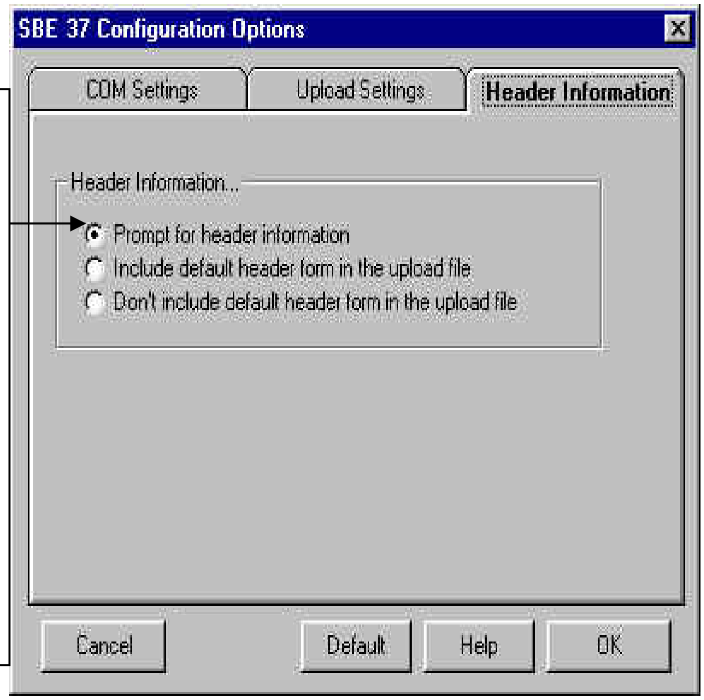


Make the selection for Upload Settings.

Note:
Set up **Upload Settings**, **Header Information**, and/or **Header Form** (Steps 2 through 4):
- The first time you upload data, and
- If you want to change upload or header parameters.

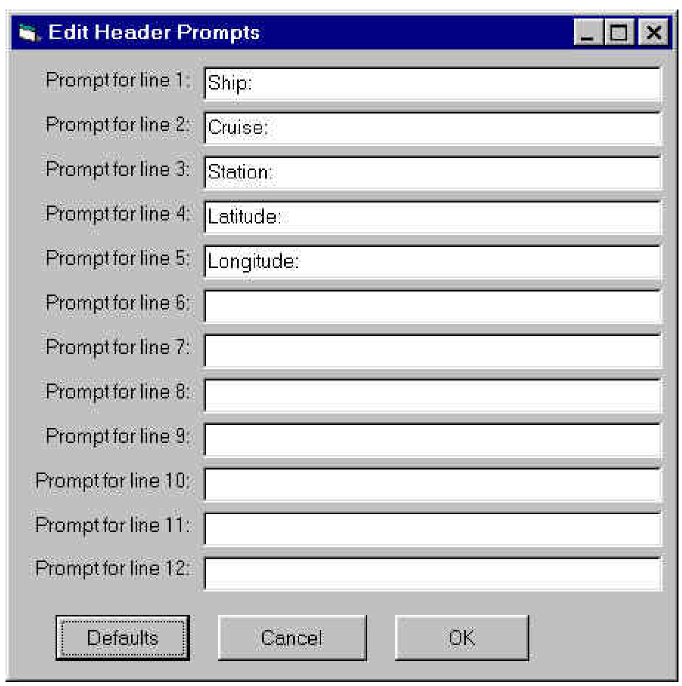
3. Click on the Header Information tab. The dialog box looks like this:

Defines header information included with uploaded data:
- Prompt for header information – Each time data is uploaded, user is prompted to fill out user-defined header form.
- Include default header form in upload file – User-defined default header form included in upload file. User is not prompted to add any information when data is uploaded.
- Don't include default header form in upload file – Header information not included in upload file.



Select the desired header information option. Click OK to save the settings.

4. In the Configure menu, select Header Form to customize the header. The dialog box looks like this (default prompts are shown):



The entries are free form, 0 to 12 lines long. This dialog box establishes:
- the header prompts that appear for the user to fill in when uploading data, if *Prompt for header information* was selected in the Configuration Options dialog box (Step 3)
- the header included with the uploaded data, if *Include default header form in upload file* was selected in the Configuration Options dialog box (Step 3)

Enter the desired header/header prompts. Click OK.

5. Click Connect on the Toolbar to begin communications with the MicroCAT. The display looks like this:

```
SBE 37 SURFACE MODEM V 2.8a
S>
Sending wake up tone, wait 4 seconds
S>
```

This shows that correct communications between the computer and SIM has been established, and the SIM has sent the wake-up signal to the MicroCAT(s).
If the system does not respond as shown above:
- Click Connect again.
- Check cabling between the computer, SIM, and MicroCAT(s).
- Verify the correct instrument was selected and the COM settings were entered correctly in the Configure menu.

Note:
You may need to send **#iiStop** several times to get the MicroCAT to respond.

6. If you have not already done so, command the MicroCAT to stop logging by typing **#iiStop** (ii=MicroCAT ID) and pressing the Enter key.

7. Display MicroCAT status information by clicking Status on the Toolbar. The display looks like this:

```
SBE 37-IM V 2.3 SERIAL NO. 1000  05-23-2004 11:55:19
   not logging: received stop command
   sample interval = 20 seconds
   samplenumber = 52, free = 127948
   store time with each sample
   transmit sample number
   A/D cycles to average = 4
   internal pump not installed
   temperature =19.48 deg C
```

8. Click Upload on the Toolbar to upload stored data. SEATERM responds as follows:
   A. SEATERM sends the status (**#iiDS**) command, displays the response, and writes the command and response to the upload file. **#iiDS** provides you with information regarding the number of samples in memory.
   B. **If you selected *By scan number range* in the Configuration Options dialog box (Configure menu)** – a dialog box requests the range. Enter the desired value(s), and click OK.
   C. SEATERM sends the calibration coefficients (**#iiDC**) command, displays the response, and writes the command and response to the upload file. **#iiDC** displays the MicroCAT's calibration coefficients.
   D. **If you selected *Prompt for header information* in the Configuration Options dialog box (Configure menu)** – a dialog box with the header form appears. Enter the desired header information, and click OK.
   E. In the Open dialog box, enter the desired upload file name and click OK. The upload file has a .asc extension.
   F. SEATERM sends the data upload command (**#iiDDb,e**).
   G. When the data has been uploaded, SEATERM shows the `S>` prompt.

9. If the data format was set to **#iiFormat=0** (hex data), run SBE 37-IM Format 0 to ASCII Converter (Cnv37imHex.exe) to convert the hex data to ASCII engineering units (see *Appendix III: SBE 37-IM Format 0 to ASCII Converter*).

10. Ensure all data has been uploaded from the MicroCAT by reviewing the data:

A. SEATERM contains a utility to convert the .asc file to a .cnv file that can be used by SBE Data Processing. To convert the data:
   1) In SEATERM, click Convert on the Toolbar. The Convert dialog box appears.
   2) In the dialog box, enter the input (.asc) file name and the desired output (.cnv) file name; file names must include the path.
   3) If desired, click *Start new year at Julian time 0* to reset the Julian Day to 0 on January 1. Date and time (if present in the uploaded file) is converted to Julian Day with five significant digits. As the default, Convert does not reset the Julian Day to 0 when rolling over from December 31 to January 1.
   4) If desired, click *Insert deployment pressure*. A field for the deployment pressure appears in the dialog box; enter the pressure (in decibars) at which the MicroCAT was deployed. Convert will add a pressure column to the data; the entered deployment pressure will be inserted in every row of the pressure column in the output .cnv file.

Notes:
- The entered deployment pressure can differ from the reference pressure entered prior to deployment using **#iiRefPress=**. Pressure, used internally by the MicroCAT to calculate conductivity, has only a small effect on conductivity. However, pressure has a larger effect on the salinity calculation (performed in SBE Data Processing's Derive module). Entering the deployment pressure when converting the data allows you to provide more accurate pressure information for the salinity calculation than may have been available prior to deployment.
- If your MicroCAT includes an optional pressure sensor, entering a deployment pressure has no effect on the data. Convert **does not overwrite actual pressure data** in the file with the entered deployment pressure.

B. Use SBE Data Processing's Derive module to compute salinity, density, and other parameters. See the software manual on CD-ROM or Help files for complete details.
   1) Derive will require you to select an instrument configuration (.con) file before it processes data. A MicroCAT does not have a .con file, but you can use a .con file from **any** other Sea-Bird instrument; the contents of the .con file will not affect the results. If you do not have a .con file for another Sea-Bird instrument, create one by clicking SBE Data Processing's Configure menu and selecting **any** instrument. In the Configuration dialog box, click Save As, and save the .con file with the desired name and location; for ease of use, save the file with the same name and to the same directory as your .cnv file (for example, save the .con file for test.cnv as test.con).
   2) In SBE Data Processing's Run menu, select Derive.
   3) In the Derive dialog box, click on the File Setup tab. Select the instrument configuration (.con) file from Step 10B1. Select the .cnv file you created in Step 10A.
   4) Click on the Data Setup tab, and click Select Derived Variables. Select the desired output variables, and click OK. Then click Start Process. Derive will output a .cnv file which includes all the data in the input .cnv file as well as the desired derived variables.

Notes:
To prepare for re-deployment:
1. After all data has been uploaded, send **#iiSampleNum=0**. If this command is not sent, new data will be stored after the last recorded sample, preventing use of the entire memory capacity.
2. Do *one* of the following:
   - Send **PwrOff** to put the MicroCAT in quiescent (sleep) state until ready to redeploy. Leaving the MicroCAT with the batteries in place and in quiescent state retains the date and time. The quiescent current is only 10 microamps, so the batteries can be left in place without significant loss of capacity.
   - Use **#iiStartNow**, **ResumeLogging**, or **GData** to begin logging immediately.
   - Set a date and time for logging to start using **#iiStartMMDDYY** or **#iiStartDDMMYY**, **#iiStartHHMMSS**, and **#iiStartLater**.

C. Use SBE Data Processing's SeaPlot module to plot the data.

Section 5: Routine Maintenance and Calibration

This section reviews corrosion precautions, conductivity cell storage and cleaning, pressure sensor maintenance, replacement of batteries, replacement of AF24173 Anti-Foulant Devices, and sensor calibration. The accuracy of the MicroCAT is sustained by the care and calibration of the sensors and by establishing proper handling practices.

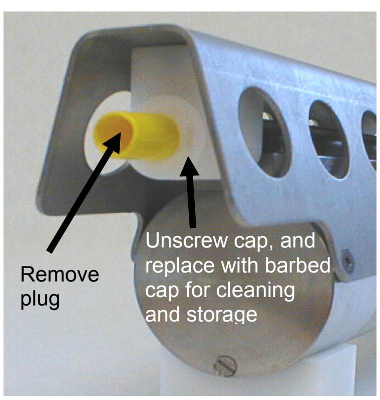
Corrosion Precautions

Rinse the MicroCAT with fresh water after use and prior to storage.

All exposed metal is titanium; other materials are plastic. No corrosion precautions are required, but avoid direct electrical connection of the MicroCAT housing to mooring or other dissimilar metal hardware.

Conductivity Cell Maintenance

CAUTIONS:
- **Do not put a brush or any object inside the conductivity cell to clean it.** Touching and bending the electrodes can change the calibration. Large bends and movement of the electrodes can damage the cell.
- **Do not store the MicroCAT with water in the conductivity cell.** Freezing temperatures (for example, in Arctic environments or during
air shipment) can break the



The MicroCAT's conductivity cell is shipped dry to prevent freezing in shipping. **Refer to *Application Note 2D: Instructions for Care and Cleaning of Conductivity Cells* for conductivity cell cleaning procedures and cleaning materials.**
- The Active Use (after each cast) section of the application note is not applicable to the MicroCAT, which is intended for use as a moored instrument.

A conductivity cell filling and storage kit is available from Sea-Bird. The kit (PN 50087.1) includes a syringe and tubing assembly, and two anti-foulant device caps with hose barbs. The tubing cannot attach to an anti-foulant device cap that is not barbed.

Cleaning and storage instructions require use of the syringe and tubing assembly at the intake end of the cell (requiring one barbed cap), and looping Tygon tubing from end to end of the cell (requiring two barbed caps). Remove the installed anti-foulant device cap(s) and replace them with the anti-foulant device cap(s) with hose barbs **for cleaning and storage only**. Remember to reinstall the original anti-foulant device cap(s) before deployment. **Deploying a MicroCAT with barbed anti-foulant device cap(s) in place of the installed caps is likely to produce undesirable results in your data.** See *Replacing Anti-Foulant Devices* for safety precautions when handling the AF24173 Anti-Foulant Devices.

Pressure Sensor (optional) Maintenance

Pressure sensor port plug

CAUTION:
Do not put a brush or any object in the pressure port. Doing so may damage or break the pressure sensor.

The pressure port plug has a small vent hole to allow hydrostatic pressure to be transmitted to the pressure sensor inside the instrument, while providing protection for the pressure sensor, keeping most particles and debris out of the pressure port.

Periodically (approximately once a year) inspect the pressure port to remove any particles, debris, etc:

1. Unscrew the pressure port plug from the pressure port.
2. Rinse the pressure port with warm, de-ionized water to remove any particles, debris, etc.
3. Replace the pressure port plug.

Replacing Batteries

Note:
See *Installing Batteries* in *Section 3: Preparing MicroCAT for Deployment*.

1. Remove the modem end cap and battery pack assembly.
2. Remove the upper PCB from the assembly as follows:
   A. Remove the two small Phillips-head screws and lock washers from the upper PCB.
   B. Carefully pry the upper PCB away from the batteries, gently going around the circle of batteries to avoid bending the banana plugs.
3. Remove the existing batteries and replace with new batteries, banana plug end (+) first. Ensure each battery is fully inserted.
4. Reinstall the upper PCB, replace the battery pack assembly, and reinstall the end cap.

Replacing Anti-Foulant Devices (SBE 37-SI, SM, IM)

AF24173
Anti-Foulant
Device

The MicroCAT has an anti-foulant device cup and cap on each end of the cell. New MicroCATs are shipped with an Anti-Foulant Device and a protective plug pre-installed in each cup.

WARNING!

AF24173 Anti-Foulant Devices contain bis(tributyltin) oxide. Handle the devices only with rubber or latex gloves. Wear eye protection. Wash with soap and water after handling.

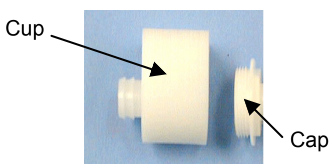
Read precautionary information on product label (see *Appendix VI*) before proceeding.

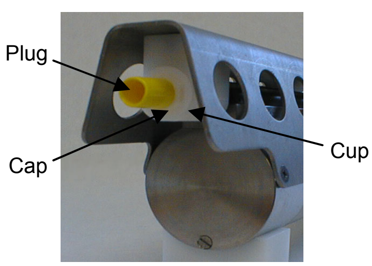
It is a violation of US Federal Law to use this product in a manner inconsistent with its labeling.

Wearing rubber or latex gloves, follow this procedure to replace each Anti-Foulant Device (two):

1. Remove the protective plug from the anti-foulant device cup;
2. Unscrew the cap with a 5/8-inch socket wrench;
3. Remove the old Anti-Foulant Device. If the old device is difficult to remove:
   - Use needle-nose pliers and carefully break up material;
   - If necessary, remove the guard to provide easier access.

   Place the new Anti-Foulant Device in the cup;
4. Rethread the cap onto the cup. Do not over tighten;
5. If the MicroCAT is to be stored, reinstall the protective plug. **Note that the plugs must be removed prior to deployment or pressurization.** If the plugs are left in place during deployment, the cell will not register conductivity. If left in place during pressurization, the cell may be destroyed.





CAUTION:
Anti-foulant device cups are attached to the guard and connected with tubing to the cell. **Removing the guard without disconnecting the cups from the guard will break the cell.** If the guard must be removed:

1. Remove the two screws connecting each anti-foulant device cup to the guard.
2. Remove the four Phillips-head screws connecting the guard to the housing and sensor end cap.
3. Gently lift the guard away.

Sensor Calibration

Notes:
- Batteries must be removed before returning the MicroCAT to Sea-Bird. Do not return used batteries to Sea-Bird when shipping the MicroCAT for recalibration or repair.
- Please remove AF24173 Anti-Foulant Devices from the anti-foulant device cups before returning the MicroCAT to Sea-Bird. Store them for future use. See *Replacing Anti-Foulant Devices* for removal procedure.

Sea-Bird sensors are calibrated by subjecting them to known physical conditions and measuring the sensor responses. Coefficients are then computed, which may be used with appropriate algorithms to obtain engineering units. The sensors on the MicroCAT are supplied fully calibrated, with coefficients printed on their respective Calibration Certificates (see back of manual). These coefficients have been stored in the MicroCAT's EEPROM.

We recommend that MicroCATs be returned to Sea-Bird for calibration.

Conductivity Sensor Calibration

The conductivity sensor incorporates a fixed precision resistor in parallel with the cell. When the cell is dry and in air, the sensor's electrical circuitry outputs a frequency representative of the fixed resistor. This frequency is recorded on the Calibration Certificate and should remain stable (within 1 Hz) over time.

The primary mechanism for calibration drift in conductivity sensors is the fouling of the cell by chemical or biological deposits. Fouling changes the cell geometry, resulting in a shift in cell constant.

Accordingly, the most important determinant of long-term sensor accuracy is the cleanliness of the cell. We recommend that the conductivity sensors be calibrated before and after deployment, but particularly when the cell has been exposed to contamination by oil slicks or biological material.

Temperature Sensor Calibration

The primary source of temperature sensor calibration drift is the aging of the thermistor element. Sensor drift will usually be a few thousandths of a degree during the first year, and less in subsequent intervals. Sensor drift is not substantially dependent upon the environmental conditions of use, and — unlike platinum or copper elements — the thermistor is insensitive to shock.

Pressure Sensor (optional) Calibration

> **Note:**
> The MicroCAT's pressure sensor is an absolute sensor, so its **raw** output (**#iiFormat=0**) includes the effect of atmospheric pressure (14.7 psi). As shown on the Calibration Sheet, Sea-Bird's calibration (and resulting calibration coefficients) is in terms of psia. However, when outputting pressure in **engineering units**, the MicroCAT outputs pressure relative to the ocean surface (i.e., at the surface the output pressure is 0 decibars). The MicroCAT uses the following equation to convert psia to decibars:
> Pressure (db) =
> [pressure (psia) - 14.7] * 0.689476

The optional strain-gauge pressure sensor is a mechanical diaphragm type, with an initial static error band of 0.05%. Consequently, the sensor is capable of meeting MicroCAT's 0.10% error specification with some allowance for aging and ambient-temperature induced drift.

Pressure sensors show most of their error as a linear offset from zero. A technique is provided below for making small corrections to the pressure sensor calibration using the *offset* (**#iiPOffset=**) calibration coefficient term by comparing MicroCAT pressure output to readings from a barometer.

Allow the MicroCAT to equilibrate in a reasonably constant temperature environment for at least 5 hours before starting. Pressure sensors exhibit a transient change in their output in response to changes in their environmental temperature. Sea-Bird instruments are constructed to minimize this by thermally decoupling the sensor from the body of the instrument. However, there is still some residual effect; allowing the MicroCAT to equilibrate before starting will provide the most accurate calibration correction.

1. Place the MicroCAT in the orientation it will have when deployed.
2. In SEATERM:
   A. Set the pressure offset to 0.0 (**#iiPOffset=0**).
   B. Send **#iiTP** to measure the MicroCAT pressure 30 times and transmit converted data (decibars).
3. Compare the MicroCAT output to the reading from a good barometer at the same elevation as the MicroCAT's pressure sensor.
   Calculate *offset* = barometer reading – MicroCAT reading
4. Enter the calculated offset (positive or negative) in the MicroCAT's EEPROM, using **#iiPOffset=** in SEATERM.

> *Offset Correction Example*
> Absolute pressure measured by a barometer is 1010.50 mbar. Pressure displayed from MicroCAT is -2.5 dbars.
> Convert barometer reading to dbars using the relationship: mbar * 0.01 = dbar
> Barometer reading = 1010.50 mbar * 0.01 = 10.1050 dbar
> The MicroCAT's internal calculations output gage pressure, using an assumed value of 14.7 psi for atmospheric pressure. Convert MicroCAT reading from gage to absolute by adding 14.7 psia to the MicroCAT's output:
> -2.5 dbars + (14.7 psi * 0.689476 dbar/psia) = -2.5 + 10.13 = 7.635 dbars
> Offset = 10.1050 – 7.635 = + 2.47 dbars
> Enter offset in MicroCAT.

For demanding applications, or where the sensor's air ambient pressure response has changed significantly, calibration using a dead-weight generator is recommended. The pressure sensor port uses a 7/16-20 straight thread for mechanical connection to the pressure source. Use a fitting that has an O-ring tapered seal, such as Swagelok-200-1-4ST, which conforms to MS16142 boss.

Section 6: Troubleshooting

This section reviews common problems in operating the MicroCAT, and provides the most common causes and solutions.

Problem 1: Unable to Communicate with MicroCAT

The `S>` prompt indicates that communications between the MicroCAT and computer have been established. Before proceeding with troubleshooting, attempt to establish communications again by clicking Connect on SEATERM's toolbar or pressing the Enter key several times.

Cause/Solution 1: The I/O cable connection may be loose. Check the cabling between the SIM and computer for a loose connection.

Cause/Solution 2: The instrument type and/or its communication settings may not have been entered correctly in SEATERM. Select the *SBE 37* in the Configure menu and verify the settings in the Configuration Options dialog box. The settings should match those on the instrument Configuration Sheet.

Cause/Solution 3: The I/O cable between the SIM and computer may not be the correct one. The I/O cable supplied with the SIM permits connection to standard 9-pin RS-232 interfaces.

Cause/Solution 4: The modem core in the SBE 37-IM (and/or the ICC, if applicable) may have a gap, be misaligned, or be damaged. See *Application Note 85: Handling of Ferrite Core in Instruments with Inductive Modem Telemetry* for details on inspecting the modem core and proper installation of the MicroCAT and the ICC (if applicable) on the cable.

Problem 2: No Data Recorded

Cause/Solution 1: The memory may be full; once the memory is full, no further data will be recorded. Verify that the memory is not full using **#iiDS** (*free = 0* or *1* if memory is full). Sea-Bird recommends that you upload all previous data before beginning another deployment. Once the data is uploaded, send **#iiSampleNum=0** to reset the memory. After the memory is reset, **#iiDS** will show *samplenumber = 0*.

Problem 3: Unreasonable T, C, or P Data

The symptom of this problem is a data file that contains unreasonable values (for example, values that are outside the expected range of the data).

Cause/Solution 1: A data file with unreasonable (i.e., out of the expected range) values for temperature, conductivity, or pressure may be caused by incorrect calibration coefficients in the MicroCAT. Send **#iiDC** to verify the calibration coefficients in the MicroCAT match the instrument Calibration Certificates. Note that calibration coefficients do not affect the raw data stored in MicroCAT memory. If you have not yet overwritten the memory with new data, you can correct the coefficients and then upload the data again.

Problem 4: Salinity Spikes

Salinity is a function of conductivity, temperature, and pressure, and must be calculated from C, T, and P measurements made on the same parcel of water. Salinity can be calculated in SBE Data Processing's Derive module from the data uploaded from memory (.cnv file).

[*Background information*: Salinity spikes in **profiling** (i.e., moving, fast sampling) instruments typically result from misalignment of the temperature and conductivity measurements in conditions with sharp gradients. This misalignment is often caused by differences in response times for the temperature and conductivity sensors, and can be corrected for in post-processing if the T and C response times are known.]

In **moored,** free-flushing instruments such as the 37-IM MicroCAT, wave action, mooring motion, and currents flush the conductivity cell at a faster rate than the environment changes, so the T and C measurements stay closely synchronized with the environment (i.e., even slow or varying response times are not significant factors in the salinity calculation). More typical causes of salinity spikes in a moored 37-IM include:

Cause/Solution 1: Severe external bio-fouling can restrict flow through the conductivity cell to such an extent that the conductivity measurement is significantly delayed from the temperature measurement.

Cause/Solution 2: For a MicroCAT moored at shallow depth, differential solar heating can cause the actual temperature inside the conductivity cell to differ from the temperature measured by the thermistor. Salinity spikes associated mainly with daytime measurements during sunny conditions may be caused by this phenomenon.

Cause/Solution 3: For a MicroCAT moored at shallow depth, air bubbles from breaking waves or spontaneous formation in supersaturated conditions can cause the conductivity cell to read low of correct.

Glossary

Battery pack – Six 9-volt (nominal 1.2 amp-hour) batteries, each containing lithium cells of the type commonly used in cameras. Battery pack also includes two small PCBs and a brass sleeve.

Convert – Toolbar button in SEATERM to convert ASCII (.asc) data uploaded with SEATERM to .cnv format. Once data is converted to .cnv format, SBE Data Processing can be used to analyze and display data.

Fouling – Biological growth in the conductivity cell during deployment.

ICC – Inductive Cable Coupler, which clamps to the insulated mooring cable and transfers the inductive signal on the wire to the SIM PCB installed inside the buoy or elsewhere.

MicroCAT – High-accuracy conductivity, temperature, and optional pressure recorder. A number of models are available:

- SBE 37-IM (**I**nductive **M**odem, internal battery and memory)
- SBE 37-IMP (**I**nductive **M**odem, internal battery and memory, integral **P**ump)
- SBE 37-SM (**S**erial interface, internal battery and **M**emory)
- SBE 37-SMP (**S**erial interface, internal battery and **M**emory, integral **P**ump)
- SBE 37-SI (**S**erial **I**nterface, no internal battery or memory)
- SBE 37-SIP (**S**erial **I**nterface, integral **P**ump, no internal battery or memory)

The –SM, -SMP, -SI, and -SIP are available with RS-232 (standard) or RS-485 (optional) interface.

PCB – Printed Circuit Board.

SBE 37-IM Format 0 to ASCII Converter (Cnv37IMHex.exe) – Program to convert hex data (**#iiFormat=0**) uploaded from MicroCAT memory to data in ASCII engineering units. Cnv37IMHex.exe is not incorporated in SEATERM's menus, but is automatically installed when you install SEATERM, in the same directory as SEATERM.

SBE Data Processing - Win 95/98/NT/2000/XP data processing software, which calculates and plots temperature, conductivity, and optional pressure, and derives variables such as salinity and sound velocity.

Scan – One data sample containing temperature, conductivity, optional pressure, and optional date and time.

SEASOFT-DOS – Complete DOS software package, which includes software for communication, real-time data acquisition, and data analysis and display.

SEASOFT-Win32 – Complete Win 95/98/NT/2000/XP package, which includes software for communication, real-time data acquisition, and data analysis and display. SEASOFT-Win32 includes ***SEATERM***, SeatermAF, SEASAVE, ***SBE Data Processing***, and Plot39.

SEATERM – Win 95/98/NT/2000/XP software used to communicate with the MicroCAT.

SIM – Surface Inductive Modem PCB, used to interface between the computer serial port and SBE 37-IM MicroCATs or other compatible sensors.

TCXO – Temperature Compensated Crystal Oscillator.

Triton X-100 – Reagent grade non-ionic surfactant (detergent), used for cleaning the conductivity cell. Triton can be ordered from Sea-Bird, but should also be available locally from chemical supply or laboratory products companies. Triton is manufactured by Mallinckrodt Baker (see http://www.mallbaker.com/changecountry.asp?back=/Default.asp for local distributors).

Appendix I: Functional Description

Sensors

The MicroCAT embodies the same sensor elements (3-electrode, 2-terminal, borosilicate glass cell, and pressure-protected thermistor) previously used in the modular SBE 3 and SBE 4 sensors and in Sea-Bird's SEACAT family.

Note:
Pressure ranges are expressed in meters of deployment depth capability.

The MicroCAT's optional pressure sensor, developed by Druck, Inc., has a superior new design that is entirely different from conventional 'silicon' types in which the deflection of a metallic diaphragm is detected by epoxy-bonded silicon strain gauges. The Druck sensor employs a micro-machined silicon diaphragm into which the strain elements are implanted using semiconductor fabrication techniques. Unlike metal diaphragms, silicon's crystal structure is perfectly elastic, so the sensor is essentially free of pressure hysteresis. Compensation of the temperature influence on pressure offset and scale is performed by the MicroCAT's CPU. The pressure sensor is available in the following pressure ranges: 20, 100, 350, 600, 1000, 2000, 3500, and 7000 meters.

Sensor Interface

Temperature is acquired by applying an AC excitation to a hermetically sealed VISHAY reference resistor and an ultra-stable aged thermistor with a drift rate of less than 0.002°C per year. A 24-bit A/D converter digitizes the outputs of the reference resistor and thermistor (and optional pressure sensor).
AC excitation and ratiometric comparison using a common processing channel avoids errors caused by parasitic thermocouples, offset voltages, leakage currents, and reference errors.

Conductivity is acquired using an ultra-precision Wien Bridge oscillator to generate a frequency output in response to changes in conductivity. A high-stability TCXO reference crystal with a drift rate of less than 2 ppm/year is used to count the frequency from the oscillator.

Real-Time Clock

To minimize battery current drain, a low power *watch* crystal is used as the real-time-clock frequency source. Initial error and ambient temperature-induced drift are compensated by measuring its actual frequency against the TCXO each time a reading of temperature and conductivity is made during calibration. The measured discrepancy (if any) is used to arithmetically correct the low power clock during normal operation.

Appendix II: Electronics Disassembly/Reassembly

Disassembly

1. Remove the modem end cap and battery pack following instructions in *Installing Batteries* in *Section 3: Preparing MicroCAT for Deployment*. **Do not remove the titanium guard!**

2. The electronics are on a sandwich of three rectangular PCBs. These PCBs are assembled to a bulkhead that can be seen at the bottom of the battery compartment. To remove the PCB assembly:
   A. Use a long screwdriver (#1 screwdriver) to remove the Phillips-head screw at the bottom of the battery compartment. The Phillips-head screw is a 198mm (7.8 inch) threaded rod with Phillips-head.
   B. Pull out the PCB assembly using the PVC pylon post (post with 3-pin Molex connector). The assembly will pull away from the 10-position edge connector used to connect to the sensors.

Reassembly

Note:
If the rod will not tighten, the PCBs have not fully mated or are mated in reverse.

Note:
Before delivery, a desiccant package is inserted in the housing and the electronics chamber is filled with dry Argon gas. These measures help prevent condensation. To ensure proper functioning:
1. Install a new desiccant bag each time you open the electronics chamber. If a new bag is not available, see *Application Note 71: Desiccant Use and Regeneration (drying)*.
2. If possible, dry gas backfill each time you open the housing. If you cannot, wait at least 24 hours before redeploying, to allow the desiccant to remove any moisture from the housing.

Note that opening the battery compartment does not affect desiccation of the electronics.

1. Sight down into the MicroCAT housing to find the hole into which the Phillips-head screw threads. The hole is at the bottom of the housing, next to the edge connector. The small-diameter brass sleeve between two of the PCBs guides the screw into the hole. Align this sleeve with the hole.

2. Guide the PCB assembly into the housing and push the assembly until the edge connector is fully inserted. A gentle resistance can be felt during the last 3 mm ($^1/_8$ inch) of insertion as the PCB assembly mates to the edge connector.

3. Drop the Phillips-head screw into the hole and tighten gently.

4. If it is difficult to align the cards, obtain a 305mm (12 in.) length of 6-32 threaded rod.
   A. Thread the end of this rod into the hole at the bottom of the housing (next to the edge connector).
   B. Slide the PCB assembly's small diameter brass sleeve down the rod. The rod will help guide the assembly into the proper position.
   C. Push the assembly until the edge connector is fully inserted. After the PCB assembly has been fully inserted, remove the rod.
   D. Drop the Phillips-head screw into the hole and tighten gently.

5. Reinstall the battery pack and modem end cap following instructions in *Installing Batteries* in *Section 3: Preparing MicroCAT for Deployment*.

Appendix III: SBE 37-IM Format 0 to ASCII Converter

SBE 37-IM Format 0 to ASCII Converter (Cnv37IMHex.exe) converts a hexadecimal file (**#iiFormat=0**) to one identical to data uploaded with **#iiFormat=1**, providing the benefits of a faster, hexadecimal upload with easy-to-use converted output. SBE 37-IM Format 0 to ASCII Converter is a separate program that is automatically installed when SEATERM is installed, in the same directory as SEATERM.

Background Information

The speed that data can be uploaded from the MicroCAT to the SIM is dependent on the number of scans, amount of data to be transmitted per scan, and baud rate:

Time to upload data (seconds) =
(number of scans * number of characters/scan * 10 bits/character) / baud rate

where
Number of characters/scan is dependent on the included data and output format. When counting characters, include decimal points, commas, and spaces, and add 2 to the number of characters to account for the carriage return and line feed at the end of each scan.

The MicroCAT communicates with the SIM at 1200 baud. Uploading the entire memory can take a significant amount of time at this baud. Uploading data in hexadecimal rather than converted ASCII format provides a faster upload, because the hex format is more compact.

For example, for 185,000 samples of conductivity, temperature, pressure, and date and time (maximum memory capacity):

#iiFormat=	Number of Characters/Scan	Upload Speed
0 (hexadecimal)	24 (see **#iiFormat=0** below)	37,000 sec = 10.3 hours
1	53	81708 sec = 22.7 hours

#iiFormat=0

All uploaded files contain the same ASCII header, regardless of data format. For **#iiFormat=0**, each scan is output in the following format:

ttttccccccppppTTTTTTTT

where

- ttttt = temperature number in hex
- ccccc = conductivity number in hex
- pppp = pressure number in hex, with bytes in reverse order (output if 37-IM includes pressure sensor)
- TTTTTTTT = time number in hex, with bytes in reverse order (output if **#iiStoreTime=Y**)

The SBE 37-IM Format 0 to ASCII Converter program converts the hex data to temperature, conductivity, pressure, and time in engineering units. The conversions are described below:

temperature (°C, ITS-90) = (temperature number / 10000) – 10

conductivity (S/m) = (conductivity number / 100000) – 0.5

pressure (db):

For MicroCAT firmware version 2.0 and higher:
Pressure (db) =
[pressure number * pressure range / (0.85 * 65536)] – (0.05 * pressure range)

For MicroCAT firmware version less than 2.0:
Pressure (db) =
[pressure number * pressure range / (1.1 * 65536)] – (0.05 * pressure range)

where
Pressure range is in decibars. The file header shows the pressure range in psia in the **DC** (calibration coefficients) command response. The program converts the pressure range from psia to decibars using the following equation:
Pressure (db) = 0.6894757 * [Pressure (psia) – 14.7]

Date and time = date and time number (seconds since January 1, 1980), converted to day month year hour minute second.

Example: Hex Scan = 531850c355e50a06280930

ttttt = 53185 hex = 340357 decimal
temperature (°C) = (ttttt / 10000) – 10 = (340357 / 10000) – 10 = 24.0357 °C

ccccc = 0c355 hex = 50005 decimal
conductivity (S/m) = (ccccc / 100000) – 0.5 = (50005 / 100000) – 0.5 = 0.00005 S/m

pppp = e50a in hex (bytes in reverse order) = 0ae5 in hex = 2789 decimal
From **DC** response in file header, the pressure range is 1000 psia.
Pressure range (db) = 0.6894757 * [Pressure (psia) – 14.7] = 679.34040721
From **DS** response in file header, firmware version is 2.2, so use equation for firmware version 2.0 and higher:
Pressure (db) = [pressure number * pressure range / (0.85 * 65536)] – (0.05 * pressure range)
= [2789 * 679.34040721 / (0.85 * 65536)] – (0.05 * 679.34040721) = 0.045 db

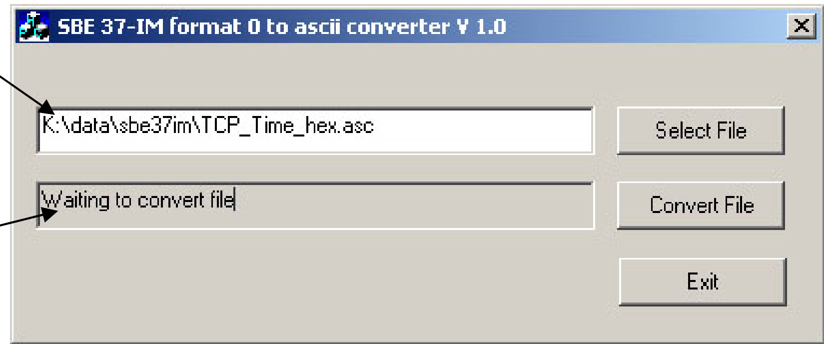
TTTTTTTT = 06280930 hex (bytes in reverse order) = 30092806 = 805906438 decimal
Date and time = 805906438 seconds since January 1, 1980.
805906438 / (3600 sec/hr * 24 hrs/day) = 9327.620810185185185185185185185185 days since January 1, 1980
Converting this to date and time: 15 Jul 2005, 14:53:58

Running SBE 37-IM Format 0 to ASCII Converter

1. Double click on Cnv37IMHex.exe. The dialog box looks like this:

.asc file uploaded from 37-IM memory when 37-IM was set to **#iiFormat=0** (hexadecimal data). Click *Select File* to search for file, or type in path and file name.

Status bar



2. Click *Convert File* to process the data; when completed, the Status bar shows *finished conversion*. The program appends _hta to the file name for the output file, to prevent overwriting the uploaded hex data file. For example, if your hex data file name is test.asc, the output file name will be test_hta.asc.

Note:
If the status bar shows *found unexpected comma while converting data*, you may be trying to convert a file that was already in ASCII format.

Appendix IV: Command Summary

Note:
See *Command Descriptions* in *Section 4: Deploying and Operating MicroCAT* for detailed information and examples.

FUNCTION	CATEGORY	COMMAND	DESCRIPTION
SIM Commands	-	**PwrOn**	Send wakeup tone to **all** MicroCATs.
		PwrOff	Send power off command to **all** MicroCATs. MicroCATs enter quiescent (sleep) state. Main power turned off, but logging and memory retention unaffected.
		DS	Display SIM firmware version and status.
		Baud=x	**x=** baud rate between SIM and computer/controller (1200, 2400, 4800, or 9600). Default 9600.
		DataNNMax=x	**x=** timeout (milliseconds) that applies to **Dataii** only. If no reply received within **x** (0-32767), control returned to computer and other commands can be sent. Default 1000 milliseconds.
		RelayMax=x	**x=** timeout (seconds) that applies to all other commands. If no reply received within **x** (0-3276), control returned to computer and other commands can be sent. Default 20 seconds.
		EchoOn	Echo characters received from computer (default).
		EchoOff	Do not echo characters received from computer.
		AutoPwrOn=x	**x=Y** (default): Automatically send **PwrOn** to MicroCATs when power applied to SIM. This wakes up all MicroCATs on line. **x=N**: Do not send **PwrOn** when power applied to SIM.
MicroCAT Communication Microcontroller Commands	Global	**MMDDYY=mmddyy**	Set real-time clock month, day, year for **all** MicroCATs. Follow with **HHMMSS=** or it will not set date.
		DDMMYY=ddmmyy	Set real-time clock day, month, year for **all** MicroCATs. Follow with **HHMMSS=** or it will not set date.
		HHMMSS=hhmmss	Set real-time clock hour, minute, second for **all** MicroCATs.
		ResumeLogging	Simultaneously command **all** MicroCATs to start logging.
		GData	Command **all** MicroCAT communication microcontrollers to get **average** data from acquisition units and (re)start logging and start next averaging cycle. MicroCAT communication microcontrollers hold averaged data in a buffer until receiving **Dataii**.
		StayOn	Command **all** MicroCATs to reset counting for 2-minute timeout.
	Get data	**Dataii**	Get **averaged** data obtained with **GData** from MicroCAT with ID=ii.
	MicroCAT ID	**ID?**	Get MicroCAT ID (0-99).
		***ID=ii** (only 1 MicroCAT can be on line or all MicroCATs will have same ID)	Set MicroCAT ID to ii (0–99). **#ID=ii** must be sent twice, because computer responds by requesting verification.
	Firmware version	**!iiDS**	Display MicroCAT communication microcontroller firmware version.

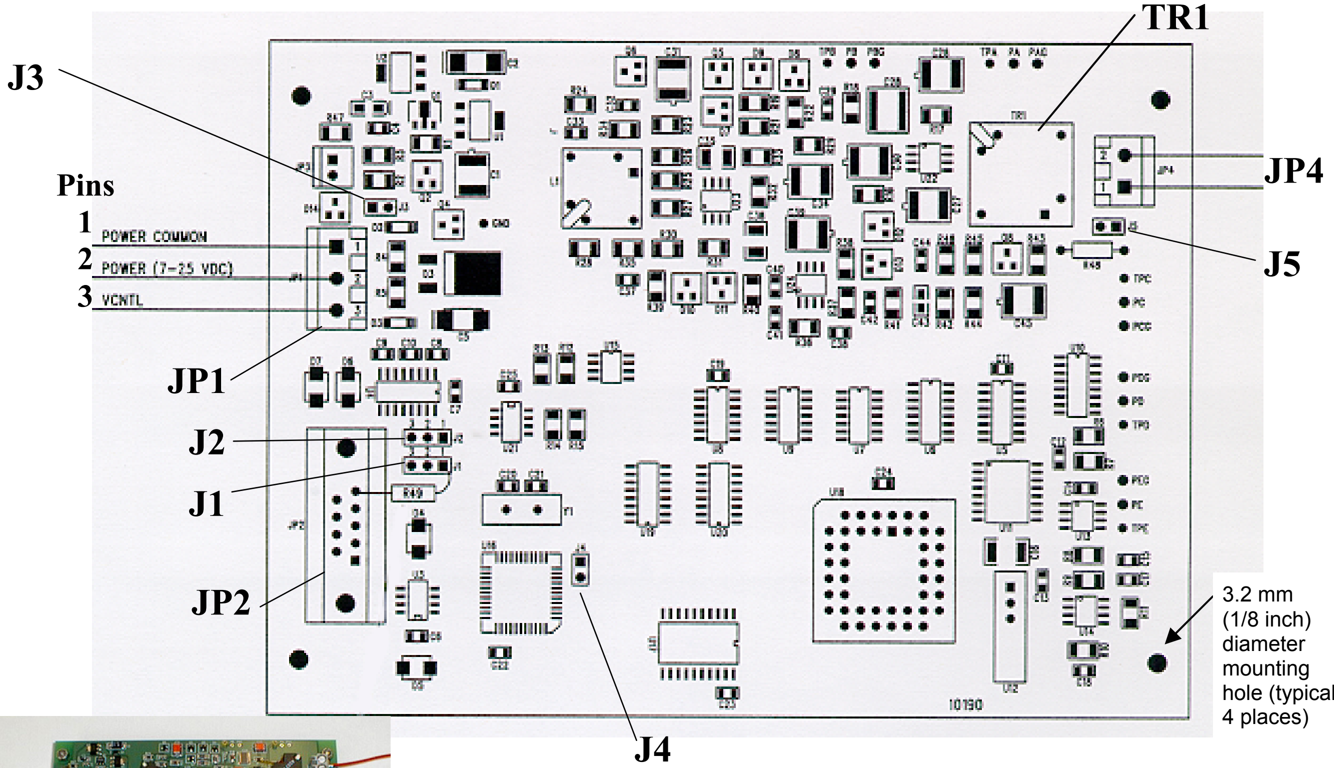
FUNCTION	CATEGORY	COMMAND	DESCRIPTION
MicroCAT Acquisition Microcontroller Commands (**ii** = MicroCAT ID)	**Status**	**#iiDS**	Display status.
	Setup	**#iiMMDDYY= mmddyy**	Set real-time clock month, day, year. Must follow with **#iiHHMMSS=**.
		#iiDDMMYY= ddmmyy	Set real-time clock day, month, year. Must follow with **#iiHHMMSS=**.
		#iiHHMMSS= hhmmss	Set real-time clock hour, minute, second.
		#iiFormat=x	**x=0**: output hex data, for diagnostic use or to increase speed of data upload. **x=1**: output converted data, date dd mmm yyyy, conductivity=S/m, temperature precedes conductivity. **x=2**: output converted data, date mm-dd-yyyy, conductivity=mS/cm, conductivity precedes temperature.
		#iiTxSampleNum=x	**x=Y**: Output six-character sample number with data from **Dataii**, **#iiTS**, **#iiSLT**, **#iiTSSTx**, **#iiSL**, **#iiSACG**, and **#iiSAC**. **x=N:** Do not output sample number.
		#iiRefPress=x	**x**= reference pressure (gauge) in decibars (used for conductivity computation for MicroCAT without pressure sensor).
		#iiPumpInstalled=x	**x=Y**: Not applicable to 37-IM. **x=N:** Internal pump not installed **(only valid setting for 37-IM)**.
	Autonomous Sampling (Logging)	**#iiInterval=x**	**x**= interval (seconds) between samples (10 - 32767). When commanded to start sampling with **#iiStartNow** or **#iiStartLater**, MicroCAT takes sample, stores data in FLASH memory, and powers down at **x** second intervals.
		#iiSampleNum=x	**x**= sample number for first sample when logging begins. After all previous data has been uploaded, set to 0 before starting to log to make entire memory available for recording. If not reset to 0, data stored after last sample.
		#iiStoreTime=x	**x=Y**: store date and time with each sample. **x=N**: do not store date and time.
		#iiStartNow	Start logging now, at rate defined by **#iiInterval**.
		#iiStartMMDDYY= mmddyy	Delayed logging start: month, day, year. Must follow with **#iiStartHHMMSS=**.
		#iiStartDDMMYY= ddmmyy	Delayed logging start: day, month, year. Must follow with **#iiStartHHMMSS=**.
		#iiStartHHMMSS= hhmmss	Delayed logging start: hour, minute, second.
		#iiStartLater	Start logging at delayed logging start time, at rate defined by **#iiInterval**.
		#iiStop	Stop logging or stop waiting to start logging. Press Connect on Toolbar to get S> prompt before entering **#iiStop**. Must send **#iiStop** before uploading data.

FUNCTION	CATEGORY	COMMAND	DESCRIPTION
Continued . . . **Acquisition Microcontroller Commands** (**ii** = MicroCAT ID)	Continued . . . **Autonomous Sampling (Logging)**	**#iiGA**	Start logging; take first sample after delay of (**#iiInterval**/2).
		#iiSACG	Output averaged converted data. Start new average.
		#iiSARG	Output averaged raw data. Start new average.
		#iiSAC	Output averaged converted data. Continue averaging.
		#iiSAR	Output averaged raw data. Continue averaging.
	Polled Sampling	**#iiTS**	Take sample and output converted data. Data not stored in FLASH memory.
		#iiTSR	Take sample and output raw data. Data not stored in FLASH memory.
		#iiSLT	Output converted data from last sample, and then take a new sample. Data not stored in FLASH memory.
		#iiSLTR	Output raw data from last sample, and then take new sample. Data not stored in FLASH memory.
		#iiTSSTx	Take sample, **store data in FLASH memory**, and output converted data.
		#iiSL	Output converted data from last sample taken with either polled sampling or logging command.
	Data Upload	**#iiDDb,e**	Upload data beginning with scan **b**, ending with scan **e**. Send **#iiStop** before sending **#iiDDb,e**.
		#iiDNx	Upload last **x** scans from memory.
	Testing	**#iiSS**	Send averaged raw data.
		#iiTT	Measure temperature for 30 samples, output converted data.
		#iiTC	Measure conductivity for 30 samples, output converted data.
		#iiTP	Measure pressure for 30 samples, output converted data.
		#iiTTR	Measure temperature for 30 samples, output raw data
		#iiTCR	Measure conductivity for 30 samples, output raw data.
		#iiTPR	Measure pressure for 30 samples, output raw data.
		#iiTR	Measure real-time clock frequency for 30 samples, output data.

Note:
Use Upload on the Toolbar or Upload Data in the Data menu to upload data that will be processed by SBE Data Processing. Manually entering the data upload command does not produce data with the required header information for processing by SBE Data Processing.

FUNCTION	CATEGORY	COMMAND	DESCRIPTION
Continued . . . **Acquisition Microcontroller Commands** (**ii** = MicroCAT ID)	**Coefficients** (F=floating point number; S=string with no spaces) Dates shown are when calibrations were performed. Calibration coefficients are initially factory-set and should agree with Calibration Certificates shipped with MicroCATs.	**#iiDC**	Display calibration coefficients; all coefficients and dates listed below are included in display. Use individual commands below to modify a particular coefficient or date.
		#iiTCalDate=S	**S**=Temperature calibration date.
		#iiTA0=F	**F**=Temperature A0.
		#iiTA1=F	**F**=Temperature A1.
		#iiTA2=F	**F**=Temperature A2.
		#iiTA3=F	**F**=Temperature A3.
		#iiCCalDate=S	**S**=Conductivity calibration date.
		#iiCG=F	**F**=Conductivity G.
		#iiCH=F	**F**=Conductivity H.
		#iiCI=F	**F**=Conductivity I.
		#iiCJ=F	**F**=Conductivity J.
		#iiWBOTC=F	**F**=Conductivity wbotc.
		#iiCTCOR=F	**F**=Conductivity ctcor.
		#iiCPCOR=F	**F**=Conductivity cpcor.
		#iiPCalDate=S	**S**=Pressure calibration date.
		#iiPA0=F	**F**=Pressure A0.
		#iiPA1=F	**F**=Pressure A1.
		#iiPA2=F	**F**=Pressure A2.
		#iiPTCA0=F	**F**=Pressure ptca0.
		#iiPTCA1=F	**F**=Pressure ptca1.
		#iiPTCA2=F	**F**=Pressure ptca2.
		#iiPTCB0=F	**F**=Pressure ptcb0.
		#iiPTCB1=F	**F**=Pressure ptcb1.
		#iiPTCB2=F	**F**=Pressure ptcb2.
		#iiPOffset=F	**F**=Pressure offset.
		#iiRCalDate=S	**S**=Real-time clock calibration date.
		#iiRTCA0=F	**F**=Real-time clock A0.
		#iiRTCA1=F	**F**=Real-time clock A1.
		#iiRTCA2=F	**F**=Real-time clock A2.

Appendix V: SIM Hookup and Configuration



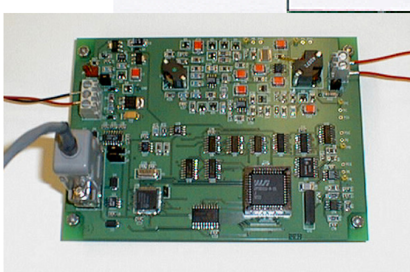


Photo shows SIM-Direct for use without Inductive Cable Coupler. SIM-Coupled for use with Inductive Cable Coupler is similar, but does not include TR1.

Dimensions:
PCB: 109 mm x 147.5 mm (4 1/4 x 5 3/4 inches)
Mounting holes: 90.5 mm x 138.1 mm (3 9/16 x 5 7/16 inches)

Power Connection

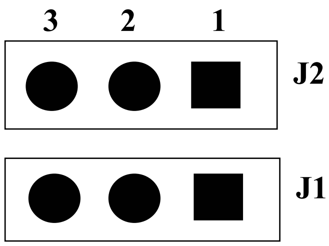
The SIM can be configured to power up in either of the following two modes:

- **Normal Power Switching (factory setting)** – The SIM runs when power is applied. Set up the SIM as follows:
  1. Connect Power Common to JP1 pin 1.
  2. Connect 7-25 VDC to JP1 pin 2.
  3. Verify there is no connection to JP1 pin 3.
  4. Verify jumper is across J3.

- **Logic Level Controlled Power Switching** – Power is always applied to JP1, pins 1 and 2. Voltage applied to JP1 pin 3 (VCNTL) switches power to the SIM. Set up the SIM as follows:
  1. Connect Power Common to JP1 pin 1.
  2. Connect 7-25 VDC to JP1 pin 2.
  3. Remove jumper on J3.

> **Note:**
> If VCNTL < 1 volt, SIM is Off (consuming < 100 microamps).
> If VCNTL > 2 volts, SIM is On.

Interface Option Connection (J1, J2, and J4)

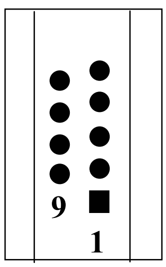


The SIM can be configured to accept RS-232 or RS-485:

- **RS-232 (factory setting)**
  1. Verify jumper is on J1 pins 2 and 3.
  2. Verify jumper is on J2 pins 2 and 3.
  3. Remove jumper on J4.

- **RS-485**
  1. Install jumper on J1 pins 1 and 2.
  2. Install jumper on J2 pins 1 and 2.
  3. Install jumper on J4.

I/O Connector Wiring (JP2)



Connect wires to JP2 as follows:

- **RS-232**
  1. **Pin 2** – RS-232 transmit from SIM to computer
  2. **Pin 3** – RS-232 transmit from computer to SIM
  3. **Pin 5** – Power Common

- **RS-485**
  1. **Pin 4** – RS-485 ‘A’
  2. **Pin 5** – Power Common
  3. **Pin 6** – RS-485 ‘B’

Inductive Mooring Cable Connection (JP4)

Note:
ICC version 4 may have 3 wires in the cable. If you ordered the ICC with a pigtail termination, solder the white and white/black wires together and attach to 1 terminal of JP4. Attach the white/red wire to the other terminal.

- **MicroCAT installed with Inductive Cable Coupler (ICC)** - Connect wires from the ICC to JP4 on SIM-Coupled.

- **MicroCAT installed without Inductive Cable Coupler** - Connect wires from the mooring cable and seawater ground to JP4 on SIM-Direct.

Normal Deployed Operation (J5)

- **Normal Deployed Operation** – Ensure jumper on J5 is installed.

- **Instrument Setup and Lab Testing** - Remove jumper on J5. Removing the jumper on J5 inserts a 1K resistor in series with the inductive loop, reducing the signal amplitude. This prevents the MicroCATs in close proximity from responding to commands, which is especially important when sending ***ID=**.

Appendix VI: AF24173 Anti-Foulant Device

AF24173 Anti-Foulant Devices supplied for user replacement are supplied in polyethylene bags displaying the following label:

AF24173 ANTI-FOULANT DEVICE

FOR USE ONLY IN SEA-BIRD ELECTRONICS' CONDUCTIVITY SENSORS TO CONTROL THE GROWTH OF AQUATIC ORGANISMS WITHIN ELECTRONIC CONDUCTIVITY SENSORS.

ACTIVE INGREDIENT:

Bis(tributyltin) oxide…………..……………………………....	53.0%
OTHER INGREDIENTS: …………………………………....	47.0%
Total…………………………………………………………....	100.0%

DANGER

See the complete label within the Conductivity Instrument Manual for Additional Precautionary Statements and Information on the Handling, Storage, and Disposal of this Product.

Net Contents: Two anti-foulant devices
Sea-Bird Electronics, Inc.
1808 - 136th Place Northeast
Bellevue, WA 98005

EPA Registration No. 74489-1
EPA Establishment No. 74489-WA-1

AF24173 Anti-Foulant Device

FOR USE ONLY IN SEA-BIRD ELECTRONICS' CONDUCTIVITY SENSORS TO CONTROL THE GROWTH OF AQUATIC ORGANISMS WITHIN ELECTRONIC CONDUCTIVITY SENSORS.

ACTIVE INGREDIENT:
Bis(tributyltin) oxide…………..…………………………..... 53.0%
OTHER INGREDIENTS: ……………………………….... 47.0%
Total……………………………………………………….... 100.0%

DANGER
See Precautionary Statements for additional information.

FIRST AID	
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for15-20 minutes. • Call a poison control center or doctor for treatment advice.
If swallowed	• Call poison control center or doctor immediately for treatment advice. • Have person drink several glasses of water. • Do not induce vomiting. • Do not give anything by mouth to an unconscious person.
If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
HOT LINE NUMBER	
Note to Physician	Probable mucosal damage may contraindicate the use of gastric lavage.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. For further information call National Pesticide Telecommunications Network (NPTN) at 1-800-858-7378.	

Net Contents: Two anti-foulant devices

Sea-Bird Electronics, Inc.
1808 - 136th Place Northeast
Bellevue, WA 98005

EPA Registration No. 74489-1
EPA Establishment No. 74489-WA-1

PRECAUTIONARY STATEMENTS

HAZARD TO HUMANS AND DOMESTIC ANIMALS

DANGER

Corrosive - Causes irreversible eye damage and skin burns. Harmful if swallowed. Harmful if absorbed through the skin or inhaled. Prolonged or frequently repeated contact may cause allergic reactions in some individuals. Wash thoroughly with soap and water after handling.

PERSONAL PROTECTIVE EQUIPMENT

USER SAFETY RECOMMENDATIONS

Users should:

- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Wear protective gloves (rubber or latex), goggles or other eye protection, and clothing to minimize contact.
- Follow manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.
    - Wash hands with soap and water before eating, drinking, chewing gum, using tobacco or using the toilet.

ENVIRONMENTAL HAZARDS

Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of EPA. This material is toxic to fish. Do not contaminate water when cleaning equipment or disposing of equipment washwaters.

PHYSICAL OR CHEMICAL HAZARDS

Do not use or store near heat or open flame. Avoid contact with acids and oxidizers.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling. For use only in Sea-Bird Electronics' conductivity sensors. Read installation instructions in the applicable Conductivity Instrument Manual.

STORAGE AND DISPOSAL

PESTICIDE STORAGE: Store in original container in a cool, dry place. Prevent exposure to heat or flame. Do not store near acids or oxidizers. Keep container tightly closed.

PESTICIDE SPILL PROCEDURE: In case of a spill, absorb spills with absorbent material. Put saturated absorbent material to a labeled container for treatment or disposal.

PESTICIDE DISPOSAL: Pesticide that cannot be used according to label instructions must be disposed of according to Federal or approved State procedures under Subtitle C of the Resource Conservation and Recovery Act.

CONTAINER DISPOSAL: Dispose of in a sanitary landfill or by other approved State and Local procedures.

Sea-Bird Electronics/label revised 01-31-05

Appendix VII: Replacement Parts

Part Number	Part	Application Description	Quantity in MicroCAT
50243 / 50243.1	Lithium battery set (6 sticks)	Power MicroCAT	1
801542	AF24173 Anti-Foulant Device	Bis(tributyltin) oxide device inserted into anti-foulant device cup	1 (set of 2)
231459	Anti-foulant device cup	Holds AF24173 Anti-Foulant Device	2
231505	Anti-foulant device cap	Secures AF24173 Anti-Foulant Device in cup	2
30984	Plug	Seals end of anti-foulant cap when not deployed, keeping dust and aerosols out of conductivity cell during storage	2
30411	Triton X-100	Octyl Phenol Ethoxylate – Reagent grade non-ionic cleaning solution for conductivity cell (supplied in 100% strength; dilute as directed)	1
50087.1	Conductivity cell filling & storage device with hose barb caps	For cleaning and storing conductivity cell	-
30507	Parker 2-206N674-70 O-ring	Between end of conductivity cell and anti-foulant device cup	2
60033	Spare hardware/ O-ring kit	Assorted hardware and O-rings, including: • 30149 Machine screw, 6-32 x 5/8 PH, stainless steel (secures battery pack assembly to battery pylon) • 30243 Washer, #6 split ring lock, stainless steel (for 30149) • 30544 Machine screw, 8-32 x ½, FH, titanium (secures conductivity cell guard to housing) • 30357 Machine screw, 2-56 x 1/4 PH, stainless steel (secures battery pack's upper PCB to brass sleeve) • 30986 Washer, #2 split ring lock, stainless steel (for 30357) • 30900 Bolt, 1/4-20 x 2" hex head, titanium (secures mounting clamp) • 30633 Washer, ¼" split ring lock, titanium (for 30900) • 30634 Washer ¼" flat, titanium (for 30900) • 31019 O-ring 2-008 N674-70 (for 30900) • 30857 Parker 2-033E515-80 O-ring (modem end cap and sensor end cap o-ring) • 30859 Machine screw, 8-32 x 3/8" FH, titanium (secures housing to modem end cap)	-

Continued on next page

Continued from previous page

Part Number	Part	Application Description	Quantity in MicroCAT
171887	9-pin DB-9P to 9-pin DB-9S I/O cable, 3 m (10 ft)	From SIM to computer	1
17188	25-pin DB-25S to 9-pin DB-9P cable adapter	For sue with computer with DB-25 connector	-

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S

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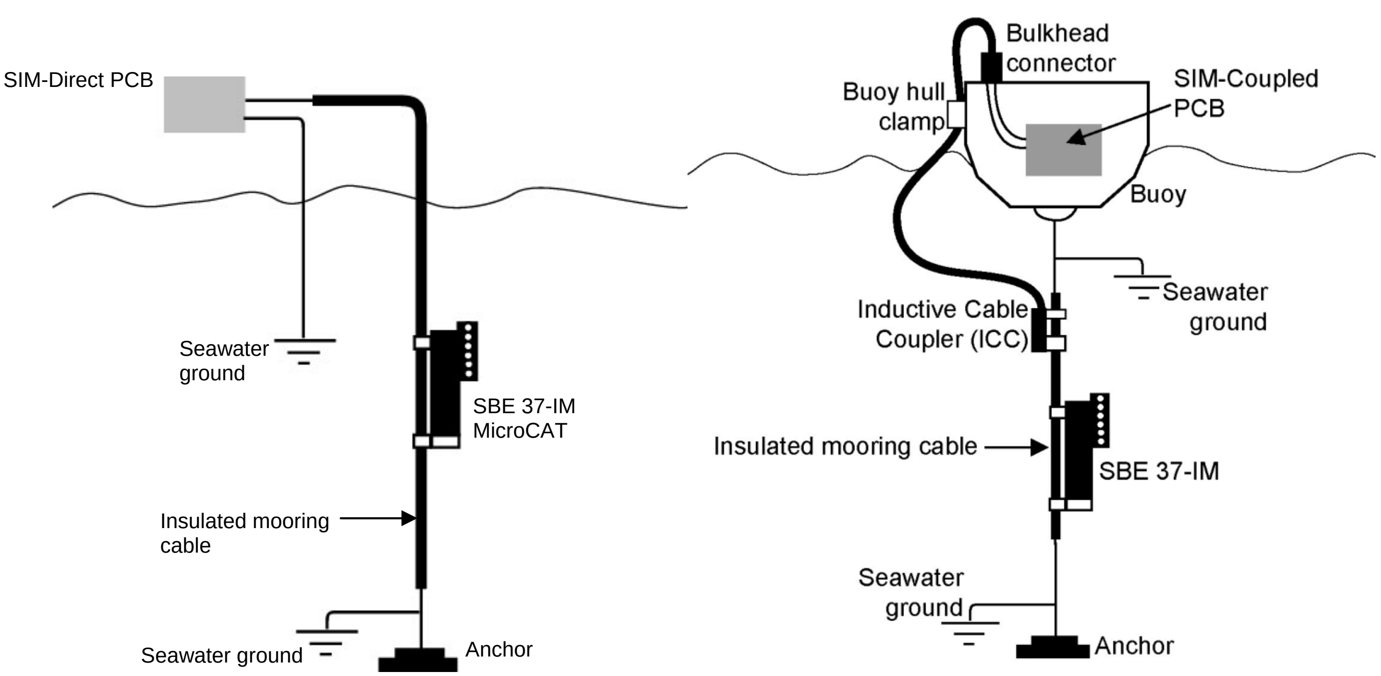
W

SBE 37-IM MicroCAT Reference Sheet
(see SBE 37-IM MicroCAT User's Manual for complete details)

Sampling Modes
- **Polled –** On command, MicroCAT wakes up, takes one sample, transmits data, and goes to sleep.
- **Autonomous** – At pre-programmed intervals, MicroCAT wakes up, samples, stores data in FLASH memory, and goes to sleep.
- **Combo** – On command, last Autonomous sampling data is transmitted.
- **Averaging** – On command, average of Autonomous sampling data since last request is calculated and transmitted.

Communication Setup Parameters
1. Double click on SeaTerm.exe.
2. Once main screen appears, in Configure menu select SBE 37. Click on COM Settings tab in dialog box. Input:
   - Comm Port: COM1 through COM10 are available
   - Baud Rate: 1200, 2400, 4800, or 9600
   - Data Bits: 8
   - Parity: No Parity
   - Mode: Inductive Modem
   - Modem/RS-485 ID:
     Pre-deployment testing: Automatically get ID
     Deployment with multiple MicroCATs: Prompt ID

Deployment
1. Batteries:
   A. *Remove modem end cap*: Wipe dry housing/end cap seam. Remove 2 flat Phillips-head screws from end cap. Pull end cap out. Disconnect Molex connector connecting end cap to battery pack. Wipe O-ring mating surfaces in housing with lint-free cloth.
   B. *Remove battery pack and install batteries*: Remove large screw/washer from upper PCB. Lift battery pack out of housing, using handle. Remove 2 small screws/washers from upper PCB. Lift upper PCB off brass sleeve. Insert batteries onto lower PCB. Press upper PCB onto batteries, mating plugs and aligning screw holes. Refasten with two small screws/washers.
   C. *Reinstall battery pack and modem end cap*: Align D-shaped opening and notch. Lower battery pack into housing; push gently to mate. Reinstall large screw/washer in upper PCB. Remove water from O-rings and mating surfaces with lint-free cloth. Inspect O-rings and mating surfaces for dirt, nicks, and cuts. Clean as necessary. Apply light coat of O-ring lubricant to O-ring and mating surfaces. Plug Molex connector together. Fit end cap into housing. Reinstall 2 flat Phillips-head screws to secure.
2. Attach MicroCAT to insulated mooring cable with Sea-Bird mounting brackets. Install (optional) ICC on mooring cable.
3. SIM wiring and configuration:
   A. *Power* – Normal Setting: Power common to JP1 pin 1, 7-25 VDC to JP1 pin 2, jumper on J3.
   B. *Interface* – Connect I/O cable to JP2 and to computer serial port.
   RS-232: J1 pins 2 and 3, J2 pins 2 and 3, J4 no jumper. RS-485: J1 pins 1 and 2, J2 pins 1 and 2, J4 jumper.
   C. *Inductive Cable Connection* –
   With ICC: Connect ICC to JP4; Without ICC: Connect mooring cable and seawater ground to JP4.
   D. *Deployed Operation* – Jumper J5 *Instrument Setup and Lab Testing* – No jumper on J5.



Direct Connection

Connection with Inductive Cable Coupler (ICC)

Command Instructions and List

- Input commands in upper or lower case letters and register commands by pressing Enter key.
- MicroCAT sends `?CMD` if invalid command is entered.
- If system does not return S> prompt after executing a command, press Enter key to get S> prompt.
- If new command is not received within 2 minutes after completion of a command, MicroCAT returns to quiescent (sleep) state.
- If in quiescent (sleep) state, re-establish communications by clicking Connect on Toolbar or entering **PWRON** command to get S> prompt.

Shown below are the commands used most commonly in the field. See the Manual for complete listing and detailed descriptions.

FUNCTION	CATEGORY	COMMAND	DESCRIPTION
SIM Commands	-	**PWRON**	Send wakeup tone to **all** MicroCATs.
		PWROFF	Send power off command to **all** MicroCATs. MicroCATs enter quiescent (sleep) state. Data logging and memory retention unaffected.
		DS	Display SIM firmware version and status.
		BAUD=x	**x=** baud from SIM to computer (1200, 2400, 4800, or 9600). Default 9600.
		DATANNMAX=x	**x=** timeout that applies to **DATAii**; default 1000 milliseconds.
		RELAYMAX=x	**x=** timeout that applies to all other commands; default 20 seconds.
		ECHOON	Echo characters received from computer.
		ECHOOFF	Do not echo characters received from computer.
MicroCAT Communications Microcontroller Commands	**Global**	**MMDDYY=mmddyy**	Set **all** real-time clocks: month, day, year. Must follow with **HHMMSS=**.
		DDMMYY=ddmmyy	Set **all** real-time clocks: day, month, year. Must follow with **HHMMSS=**.
		HHMMSS=hhmmss	Set **all** real-time clocks: hour, minute, second.
		RESUMELOGGING	Simultaneously command **all** MicroCATs to start logging.
		GDATA	Command **all** MicroCAT communication microcontrollers to get average data from acquisition units and start next averaging cycle. Communication microcontrollers hold averaged data in buffer until receiving **DATAii**.
		STAYON	Command **all** MicroCATs to reset counting for 2-minute timeout.
	Get data	**DATAii**	Get data obtained with **GDATA** from MicroCAT with ID=**ii**.
	MicroCAT ID	**ID?**	Get MicroCAT ID (0-99).
		***ID=ii**	Set MicroCAT ID to **ii** (ii=0-99). Only 1 MicroCAT can be on line when setting ID or all MicroCATs will have same ID. Must be sent twice, because computer responds by requesting verification.
	Firmware	**!iiDS**	Display MicroCAT communication microcontroller firmware version.
MicroCAT Acquisition Microcontroller Commands (**ii** = MicroCAT ID)	**Status**	**#iiDS**	Display status.
	Setup	**#iiMMDDYY=mmddyy**	Set real-time clock month, day, year. Must follow with **#iiHHMMSS=**.
		#iiDDMMYY=ddmmyy	Set real-time clock day, month, year. Must follow with **#iiHHMMSS=**.
		#iiHHMMSS=hhmmss	Set real-time clock hour, minute, second.
		#iiFORMAT=x	**x=0**: output hex data, for diagnostic use or to increase speed of data upload. **x=1**: output converted data, date dd mmm yyyy, C=S/m, T precedes C. **x=2**: output converted data, date mm-dd-yyyy, C=mS/cm, C precedes T.
		#iiTXSAMPLENUM=x	**x=Y**: Output sample number with data from **DATAii**, **#iiTS**, **#iiSLT**, **#iiTSSTX**, **#iiSL**., **#iiSACG**, and **#iiSAC**.
		#iiREFPRESS=x	**x** = reference pressure (decibars) (for MicroCAT without pressure sensor).
		#iiPUMPINSTALLED=x	**x=N**: Internal pump not installed (only valid setting for 37-IM).
	Autonomous Sampling (Logging)	**#iiINTERVAL=x**	**x** = interval between samples (10 - 32767 seconds).
		#iiSAMPLENUM=x	**x=** sample number for first sample when logging begins. After uploading data, set to 0 before starting to log to make entire memory available for recording. If not set to 0, data stored after last sample.
		#iiSTORETIME=x	**x=Y**: store date and time with each sample. **x=N**: do not
		#iiSTARTNOW	Start logging now. Data stored in FLASH memory.
		#iiSTARTMMDDYY= mmddyy	Delayed logging start: month day year. Must follow with **#iiSTARTHHMMSS=**.
		#iiSTARTDDMMYY= ddmmyy	Delayed logging start: day month year. Must follow with **#iiSTARTHHMMSS=**.
		#iiSTARTHHMMSS =hhmmss	Delayed logging start: hour, minute, second.
		#iiSTARTLATER	Start logging at delayed start time. Data stored in FLASH memory.
		#iiSTOP	Stop logging or waiting to log. Press Connect on Toolbar to get S> prompt before entering this. Must send **#iiSTOP** before uploading data.
	Polled Sampling	**#iiTS**	Take sample, output converted data.
		#iiTSR	Take sample, output raw data.
		#iiSLT	Output converted data from last sample, then take new sample.
		#iiSLTR	Output raw data from last sample, then take new sample.
		#iiTSSTX	Take sample, **store in FLASH memory**, output converted data.
		#iiSL	Output last sample taken with either polled or autonomous sampling.
	Data Upload	**#iiDDb,e**	Upload data from scan **b** to **e**. Send **#iiSTOP** before sending **#iiDDb,e**.
		#iiDNx	Upload last **x** scans from memory.
	Coefficients	**#iiDC**	Display calibration coefficients.

CALIBRATION SHEETS

CALIBRATION SHEETS

CALIBRATION SHEETS

SBE37-IM MicroCAT

Conductivity & Temperature Recorder
with Inductive Modem

Instrument Configuration:

Serial Number	37IM46716-5427
Pressure Sensor	110 dbar Druck, SN 2461397
Firmware Version	2.3b
Memory	2048Kb
Conductivity Range	0-7 S/m
Microcat ID#	01
DPSK Baud Rate	1200 (Microcat <-> SIM)
SIM Baud Rate	9600, 8 data bits, 1 stop bit, no parity
Maximum Depth	**100 meters**

CAUTION - The maximum deployment depth will be limited by the measurement range of the optional pressure sensor, if installed.

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

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

SBE Pressure Test Certificate

Test Date: **5/31/2007** Description **SBE-37 Microcat**

Job Number: **46716** Customer Name **UW/APL**

SBE Sensor Information:

Model Number: **37**
Serial Number: **5427**

Pressure Sensor Information:

Sensor Type: **Druck**
Sensor Serial Number: **2461397**
Sensor Rating: **160**

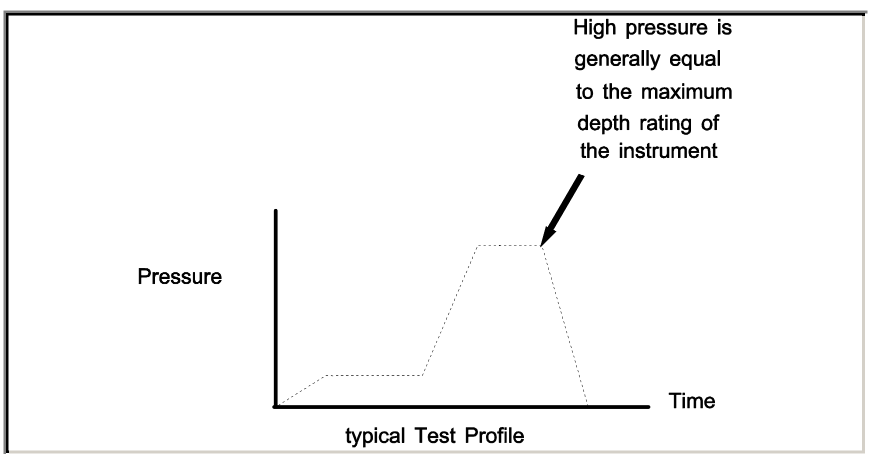
Pressure Test Protocol:

Low Pressure Test: **50** PSI Held For **15** Minutes

High Pressure Test: **160** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: PCC



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

SENSOR SERIAL NUMBER: 5427
CALIBRATION DATE: 06-Jun-07

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

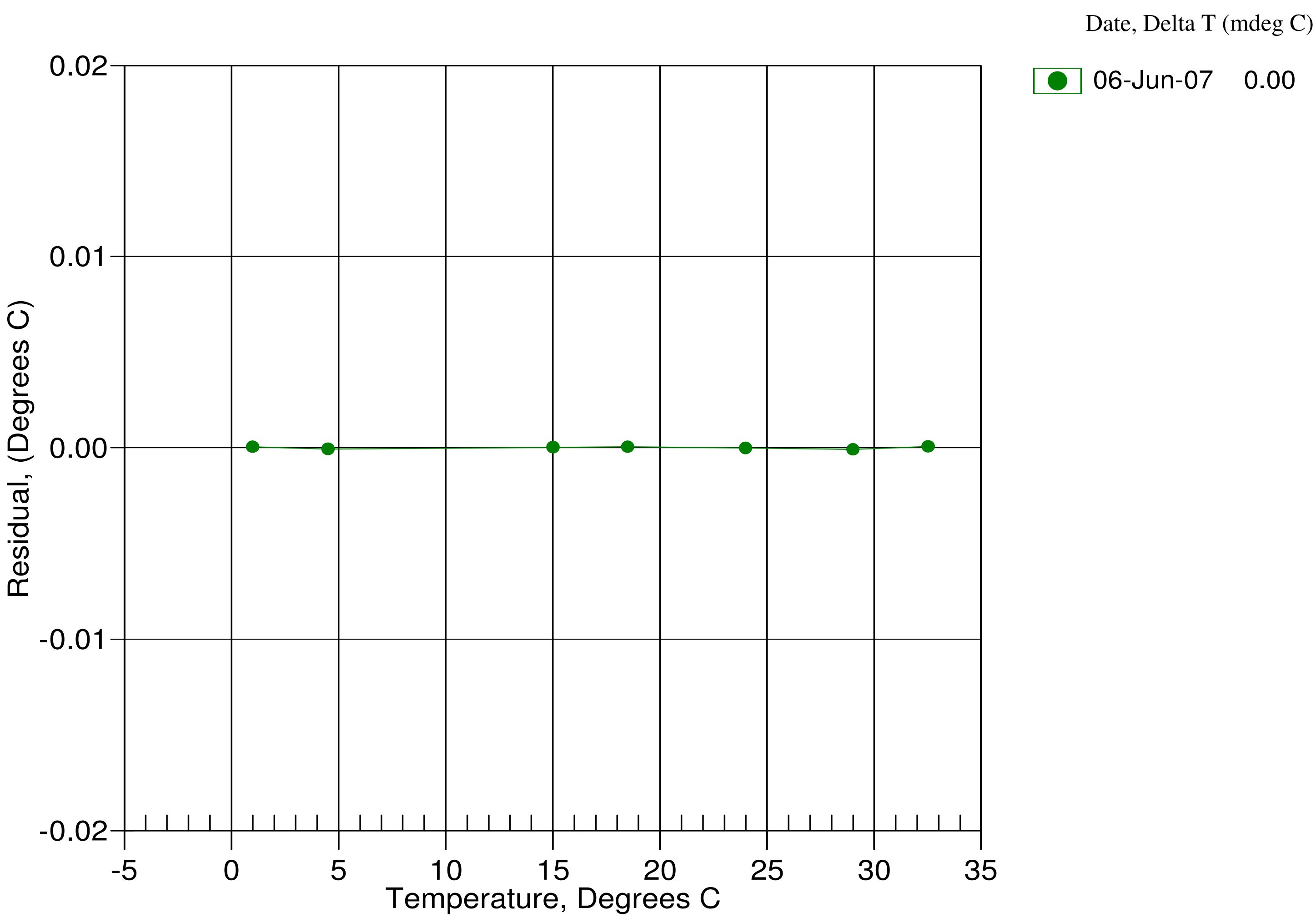
ITS-90 COEFFICIENTS

a0 = -1.450359e-005
a1 = 2.840380e-004
a2 = -3.063809e-006
a3 = 1.699366e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	653926.7	0.9999	0.0000
4.4999	558897.8	4.4998	-0.0001
15.0000	355788.6	15.0000	0.0000
18.5000	307964.3	18.5001	0.0001
24.0000	246923.1	24.0000	-0.0000
29.0000	203224.4	28.9999	-0.0001
32.5000	177909.1	32.5001	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



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

SENSOR SERIAL NUMBER: 5427
CALIBRATION DATE: 06-Jun-07

SBE 37 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.000507e+000
h = 1.554362e-001
i = -9.653908e-005
j = 3.439914e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 2.0140e-005

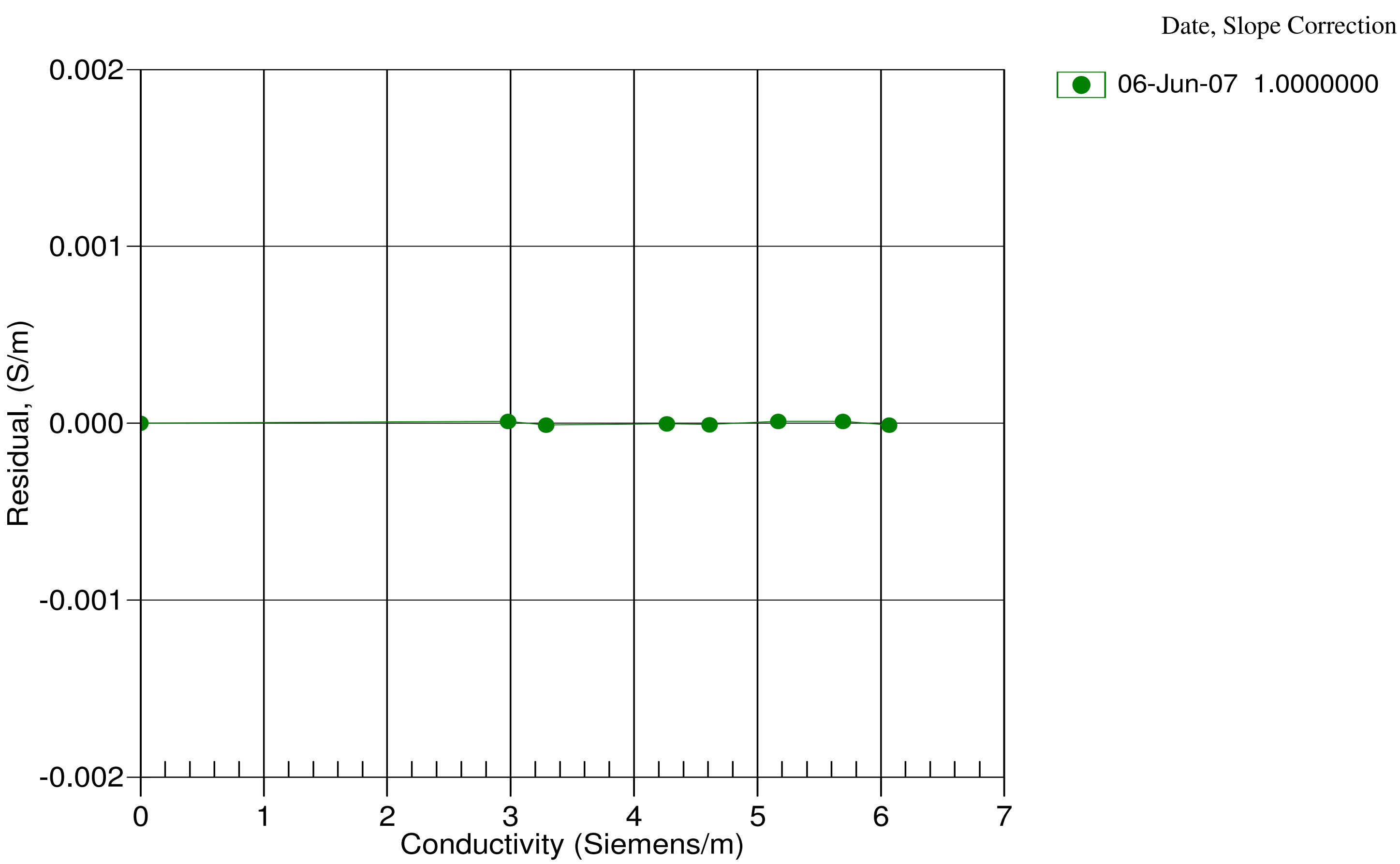
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2536.71	0.00000	0.00000
0.9999	34.8367	2.97753	5052.55	2.97754	0.00001
4.4999	34.8171	3.28478	5243.04	3.28477	-0.00001
15.0000	34.7752	4.26710	5809.47	4.26710	-0.00000
18.5000	34.7666	4.61249	5995.61	4.61248	-0.00001
24.0000	34.7573	5.17082	6284.55	5.17083	0.00001
29.0000	34.7523	5.69301	6542.89	5.69302	0.00001
32.5000	34.7499	6.06572	6720.99	6.06571	-0.00001

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



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SENSOR SERIAL NUMBER: 5427
CALIBRATION DATE: 06-Jun-07

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

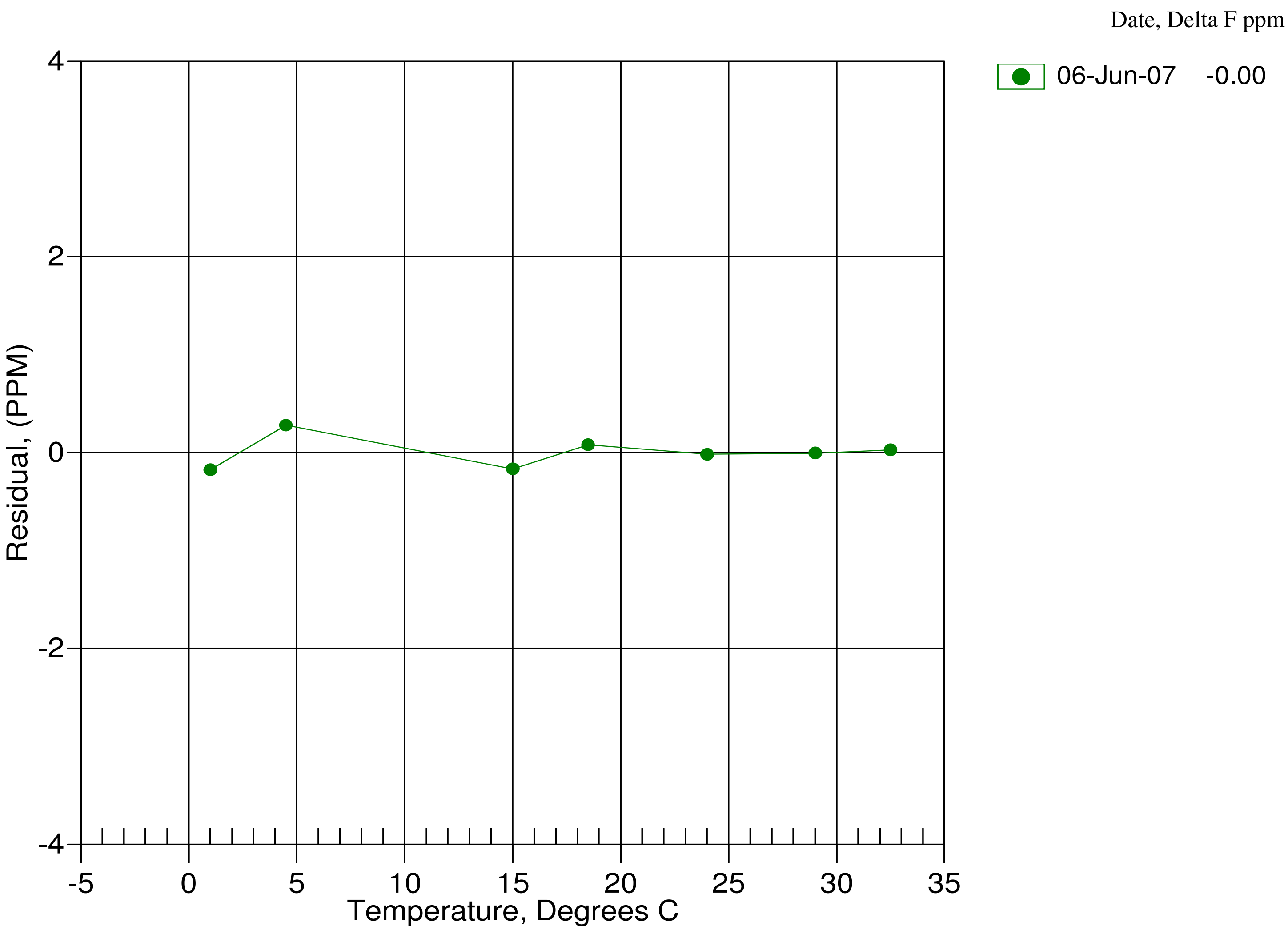
COEFFICIENTS:

```
rtca0 =  9.999771e-001
rtca1 =  1.739700e-006
rtca2 = -3.278544e-008
```

BATH TEMP (ITS-90)	RTC FREQ (Hz)	COMPUTED FREQ (Hz)	RESIDUAL (PPM)
0.9999	0.9999790	0.9999788	-0.2
4.4999	0.9999840	0.9999843	0.3
15.0000	0.9999960	0.9999958	-0.2
18.5000	0.9999980	0.9999981	0.1
24.0000	1.0000000	1.0000000	-0.0
29.0000	1.0000000	1.0000000	-0.0
32.5000	0.9999990	0.9999990	0.0

RTC frequency = rtca0 + rtca1 * t + rtca2 * t^2

Residual = (Computed RTC frequency - Measured RTC frequency) * 1e6



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

SENSOR SERIAL NUMBER: 5427
CALIBRATION DATE: 01-Jun-07

SBE 37 PRESSURE CALIBRATION DATA
160 psia S/N 2461397

COEFFICIENTS:

PA0 = -4.717393e-001
PA1 = 7.552805e-003
PA2 = -1.124524e-009

PTCA0 = -3.010563e+001
PTCA1 = -2.006447e+000
PTCA2 = -2.644156e-002
PTCB0 = 2.503837e+001
PTCB1 = -9.250000e-004
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	TEMP ITS90	COMPUTED PRESSURE	ERROR %FS
14.57	1897.9	23.7	14.57	0.00
29.88	3925.0	23.9	29.89	0.00
59.88	7897.8	23.9	59.86	-0.01
94.86	12541.8	23.9	94.86	-0.00
124.85	16526.9	23.9	124.86	0.00
159.86	21183.8	23.8	159.86	-0.00
124.85	16527.1	23.8	124.85	0.00
94.86	12542.3	23.8	94.86	-0.00
59.88	7901.3	23.8	59.89	0.01
29.93	3930.3	23.7	29.92	-0.00
14.57	1897.6	23.7	14.57	-0.00

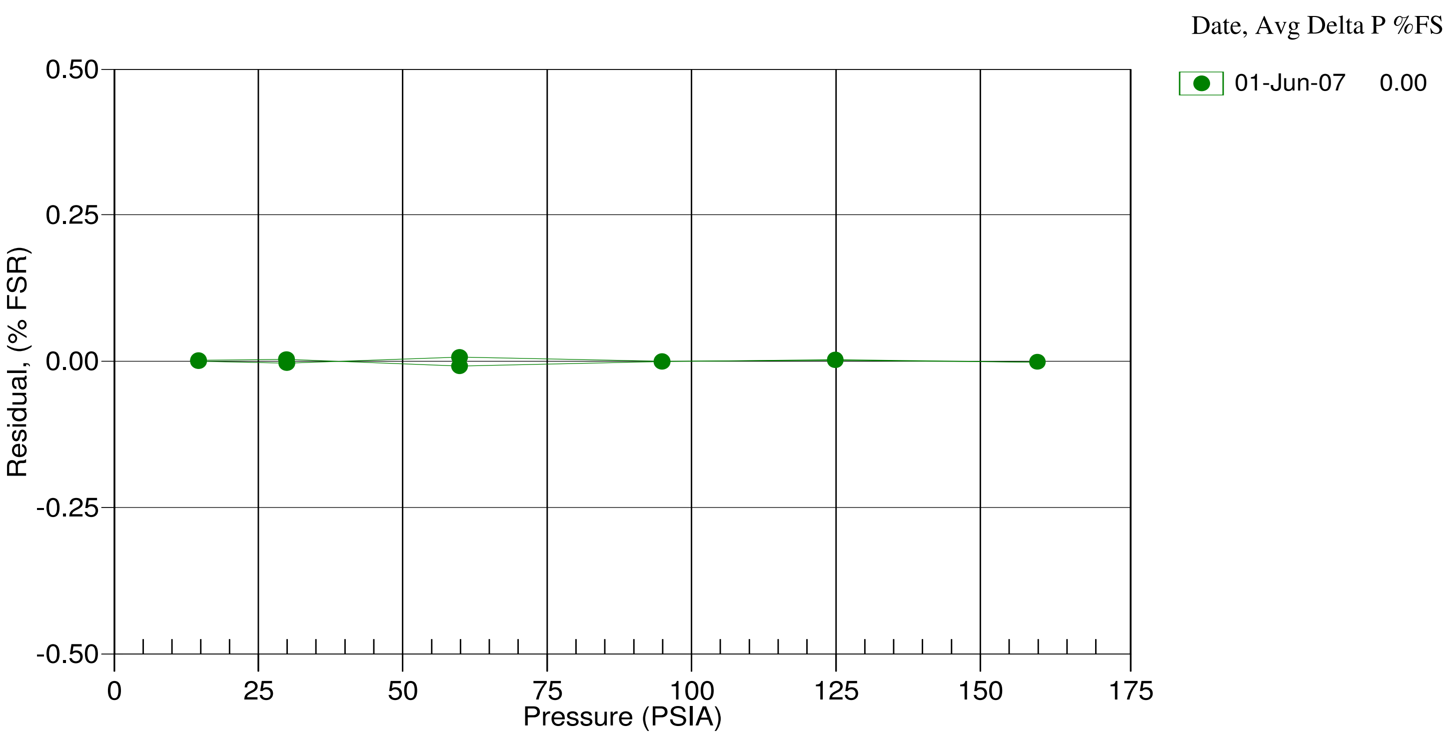
THERMAL CORRECTION

TEMP ITS90	INST OUTPUT	TEMP ITS90	SPAN MV
32.50	1984.50	-5.00	25.04
29.00	1996.10	35.00	25.01
24.00	2013.30		
18.50	2031.10		
15.00	2041.40		
4.50	2067.60		
1.00	2074.90		

x = pressure output - PTCA0 - PTCA1 * t - PTCA2 * t^2

n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)

pressure (psia) = PA0 + PA1 * n + PA2 * n^2



SBE37-IM MicroCAT

Conductivity & Temperature Recorder with Inductive Modem

Instrument Configuration:

Serial Number	37IM46716-5428
Pressure Sensor	110 dbar Druck, SN 2461398
Firmware Version	2.3b
Memory	2048Kb
Conductivity Range	0-7 S/m
Microcat ID#	02
DPSK Baud Rate	1200 (Microcat <-> SIM)
SIM Baud Rate	9600, 8 data bits, 1 stop bit, no parity
Maximum Depth	**100 meters**

CAUTION - The maximum deployment depth will be limited by the measurement range of the optional pressure sensor, if installed.

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

SBE Pressure Test Certificate

Test Date: **5/31/2007** Description **SBE-37 Microcat**

Job Number: **46716** Customer Name **UW/APL**

SBE Sensor Information:

Model Number: **37**
Serial Number: **5428**

Pressure Sensor Information:

Sensor Type: **Druck**
Sensor Serial Number: **2461398**
Sensor Rating: **160**

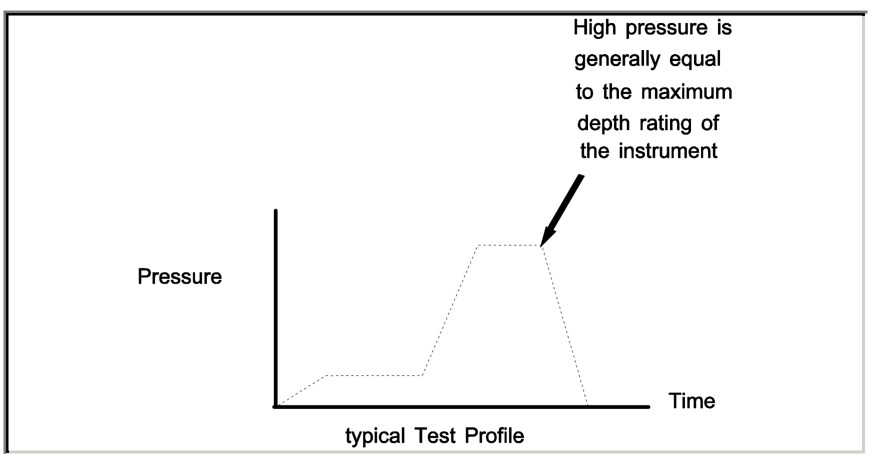
Pressure Test Protocol:

Low Pressure Test: **50** PSI Held For **15** Minutes

High Pressure Test: **160** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: PCC



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

SENSOR SERIAL NUMBER: 5428
CALIBRATION DATE: 06-Jun-07

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

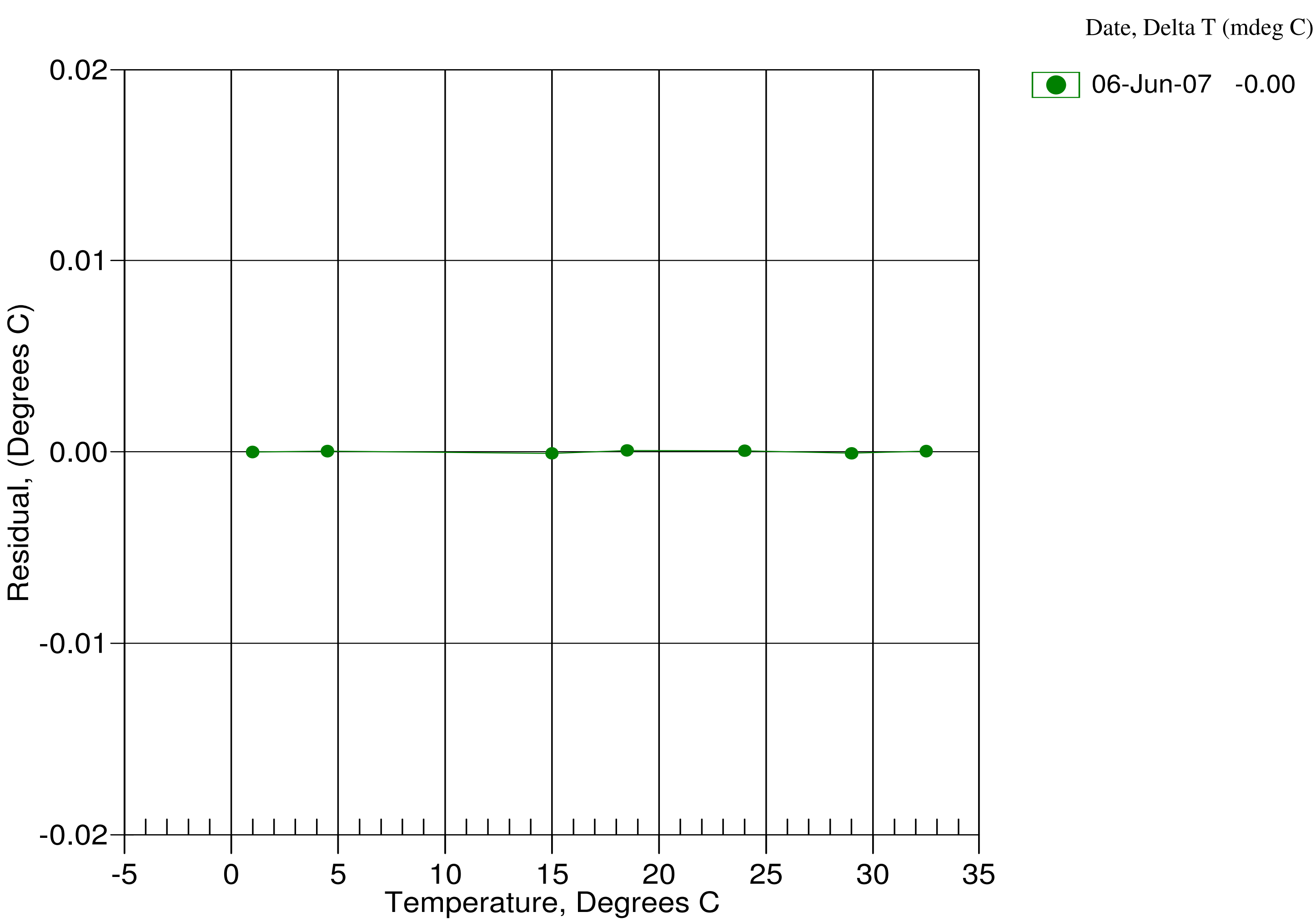
ITS-90 COEFFICIENTS

```
a0 = -5.423053e-005
a1 =  2.831930e-004
a2 = -2.992116e-006
a3 =  1.662459e-007
```

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	767796.8	0.9999	-0.0000
4.4999	656316.3	4.4999	0.0000
15.0000	417992.4	14.9999	-0.0001
18.5000	361855.7	18.5001	0.0001
24.0000	290194.1	24.0000	0.0000
29.0000	238882.3	28.9999	-0.0001
32.5000	209151.7	32.5000	0.0000

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

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 5428
CALIBRATION DATE: 06-Jun-07

SBE 37 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.024822e+000
h = 1.576798e-001
i = -9.353335e-005
j = 3.403442e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 2.2301e-005

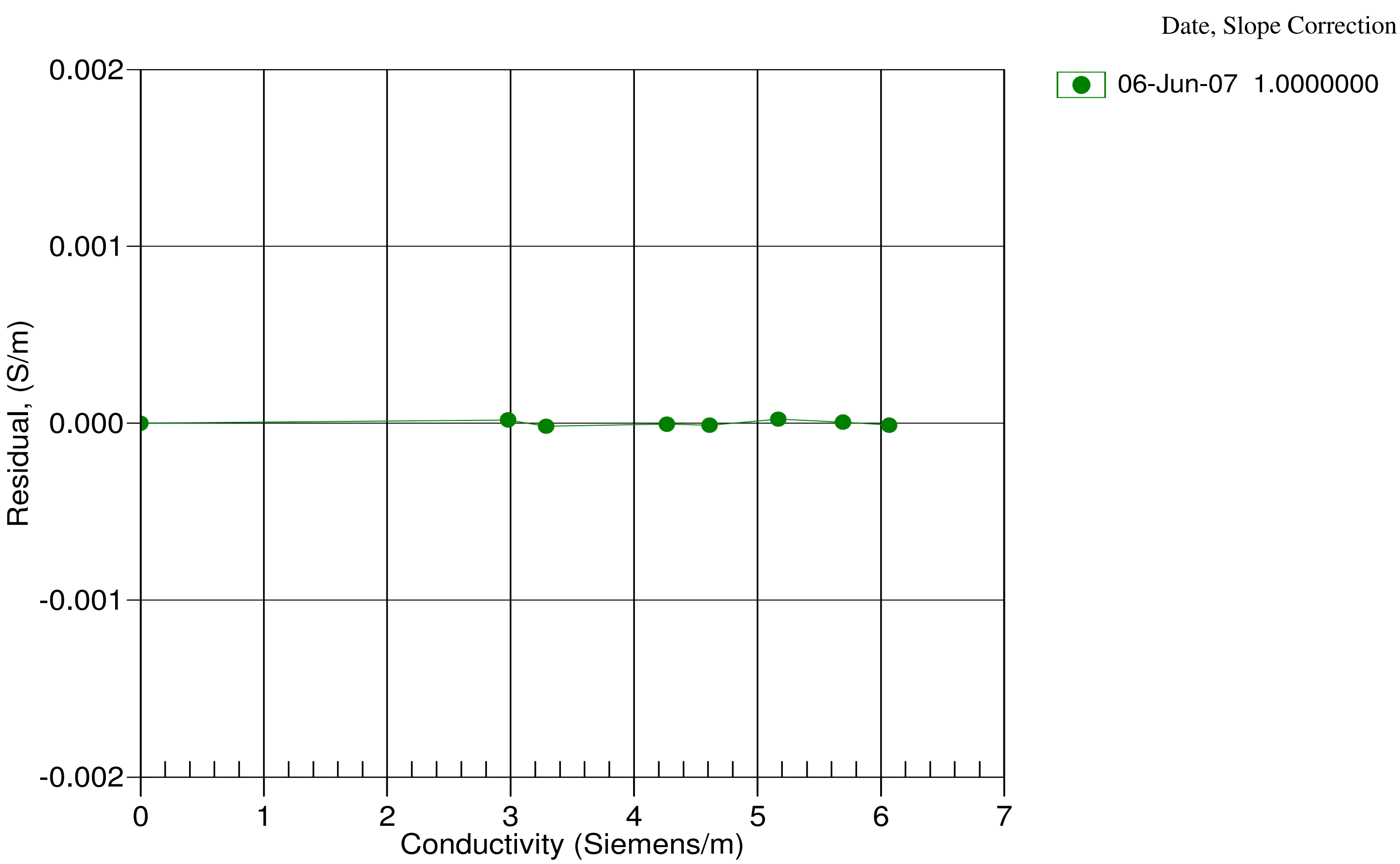
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2548.90	0.00000	0.00000
0.9999	34.8367	2.97753	5031.86	2.97755	0.00002
4.4999	34.8171	3.28478	5220.43	3.28477	-0.00002
15.0000	34.7752	4.26710	5781.41	4.26710	-0.00001
18.5000	34.7666	4.61249	5965.82	4.61247	-0.00001
24.0000	34.7573	5.17082	6252.14	5.17084	0.00002
29.0000	34.7523	5.69301	6508.17	5.69302	0.00001
32.5000	34.7499	6.06572	6684.71	6.06571	-0.00001

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



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SENSOR SERIAL NUMBER: 5428
CALIBRATION DATE: 06-Jun-07

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

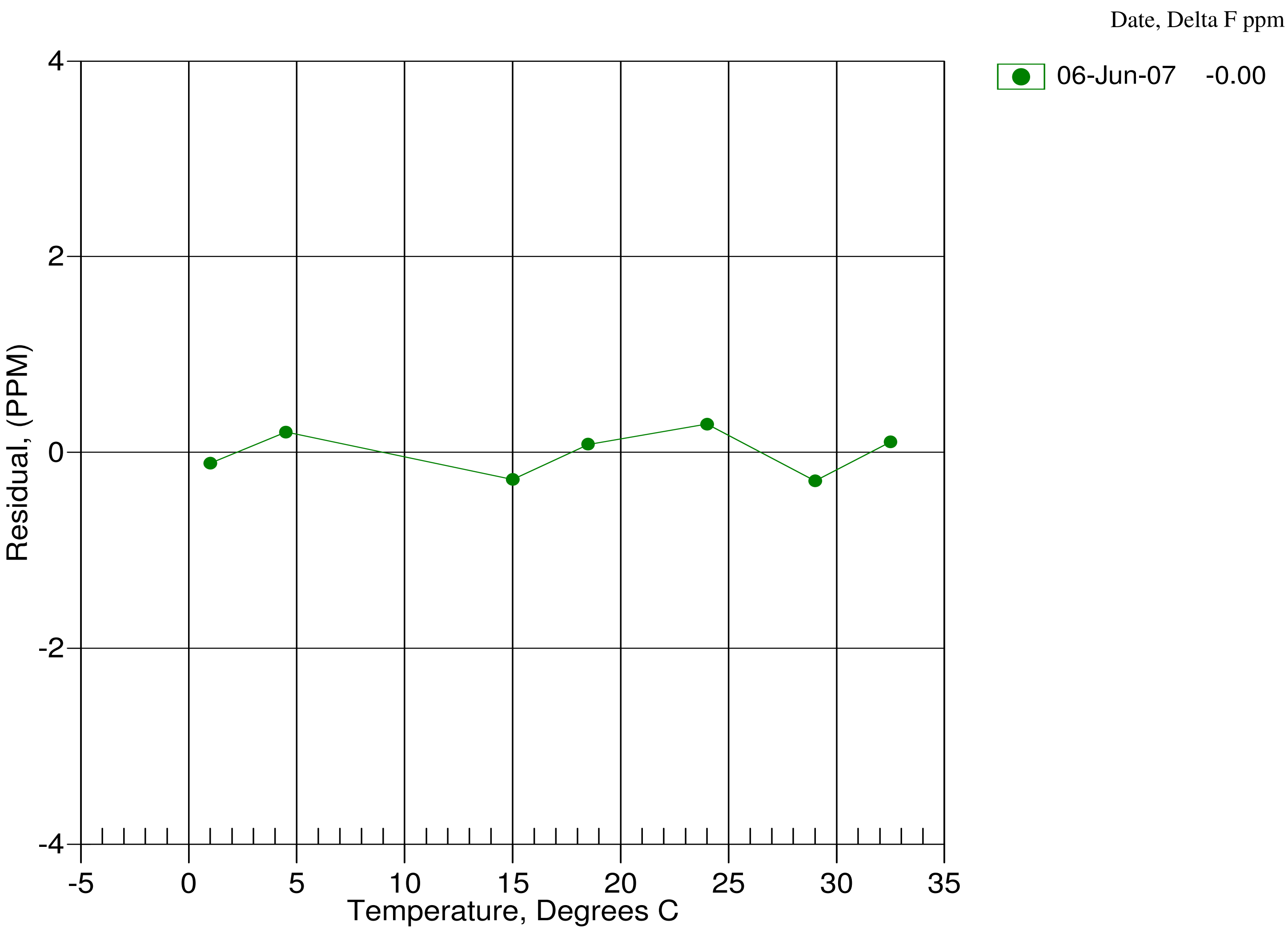
COEFFICIENTS:

rtca0 = 9.999972e-001
rtca1 = 1.686116e-006
rtca2 = -3.022712e-008

BATH TEMP (ITS-90)	RTC FREQ (Hz)	COMPUTED FREQ (Hz)	RESIDUAL (PPM)
0.9999	0.9999990	0.9999989	-0.1
4.4999	1.0000040	1.0000042	0.2
15.0000	1.0000160	1.0000157	-0.3
18.5000	1.0000180	1.0000181	0.1
24.0000	1.0000200	1.0000203	0.3
29.0000	1.0000210	1.0000207	-0.3
32.5000	1.0000200	1.0000201	0.1

RTC frequency = rtca0 + rtca1 * t + rtca2 * t^2

Residual = (Computed RTC frequency - Measured RTC frequency) * 1e6



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

SENSOR SERIAL NUMBER: 5428
CALIBRATION DATE: 01-Jun-07

SBE 37 PRESSURE CALIBRATION DATA
160 psia S/N 2461398

COEFFICIENTS:

PA0 = -4.640623e-001
PA1 = 7.559894e-003
PA2 = -1.110806e-009

PTCA0 = -7.672184e+001
PTCA1 = -1.793500e+000
PTCA2 = -3.176585e-002
PTCB0 = 2.495725e+001
PTCB1 = -7.500000e-004
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	TEMP ITS90	COMPUTED PRESSURE	ERROR %FS
14.56	1848.6	24.0	14.56	-0.00
29.89	3878.2	24.0	29.90	0.01
59.87	7846.0	24.0	59.87	-0.00
94.85	12484.0	24.0	94.85	-0.00
124.85	16465.9	24.0	124.84	-0.00
159.85	21119.2	24.0	159.85	0.00
124.85	16466.9	23.9	124.85	-0.00
94.85	12484.9	23.9	94.85	0.00
59.86	7846.9	23.9	59.87	0.00
29.93	3881.3	23.9	29.92	-0.01
14.56	1848.6	23.9	14.56	-0.00

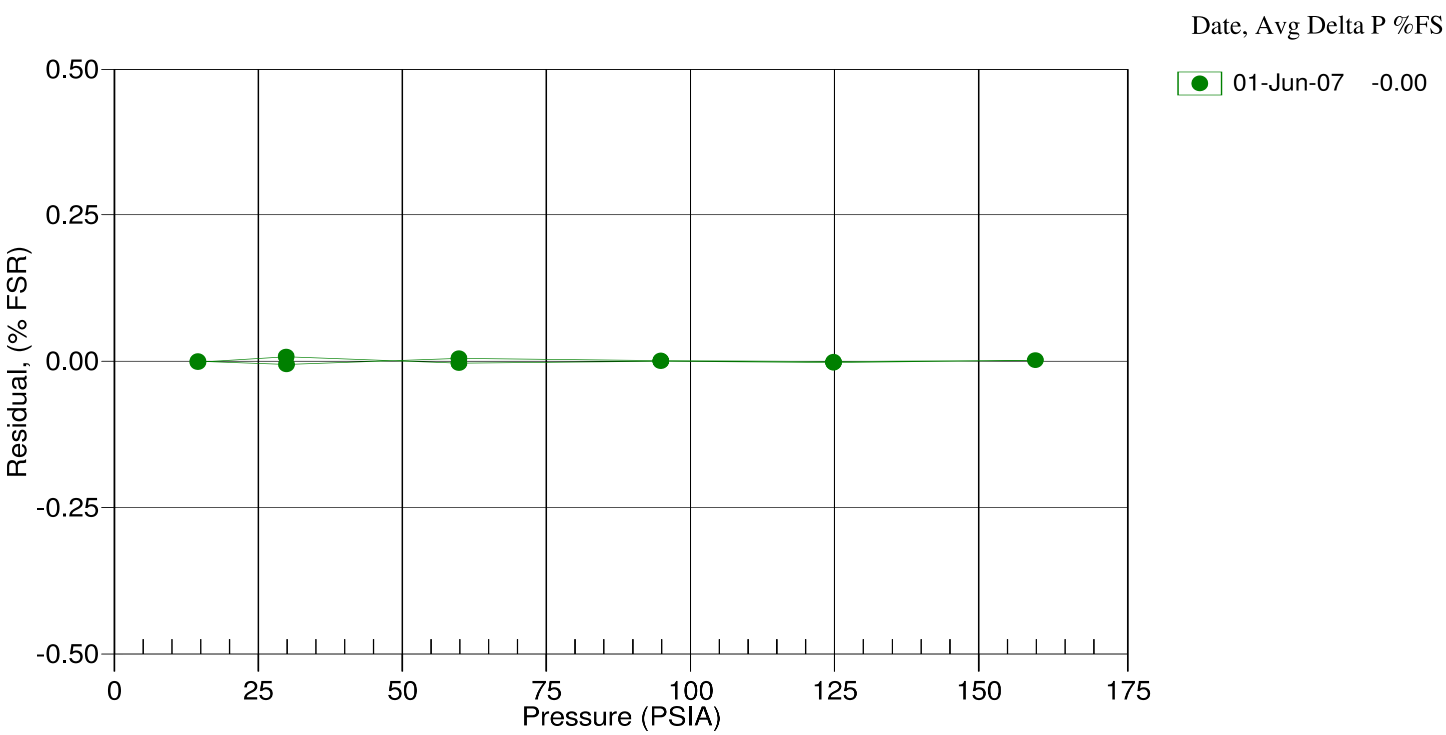
THERMAL CORRECTION

TEMP ITS90	INST OUTPUT	TEMP ITS90	SPAN MV
32.50	1936.10	-5.00	24.96
29.00	1948.00	35.00	24.93
24.00	1965.70		
18.50	1983.50		
15.00	1993.50		
4.50	2019.00		
1.00	2025.20		

$x = \text{pressure output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)$

$\text{pressure (psia)} = PA0 + PA1 * n + PA2 * n^2$



SBE37-IM MicroCAT

Conductivity & Temperature Recorder
with Inductive Modem

Instrument Configuration:

Serial Number	37IM46716-5429
Pressure Sensor	110 dbar Druck, SN 2461399
Firmware Version	2.3b
Memory	2048Kb
Conductivity Range	0-7 S/m
Microcat ID#	03
DPSK Baud Rate	1200 (Microcat <-> SIM)
SIM Baud Rate	9600, 8 data bits, 1 stop bit, no parity
Maximum Depth	**100 meters**

CAUTION - The maximum deployment depth will be limited by the measurement range of the optional pressure sensor, if installed.

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Email: seabird@seabird.com

SBE Pressure Test Certificate

Test Date: **5/31/2007** Description **SBE-37 Microcat**

Job Number: **46716** Customer Name **UW/APL**

SBE Sensor Information:

Model Number: **37**

Serial Number: **5429**

Pressure Sensor Information:

Sensor Type: **Druck**

Sensor Serial Number: **2461399**

Sensor Rating: **160**

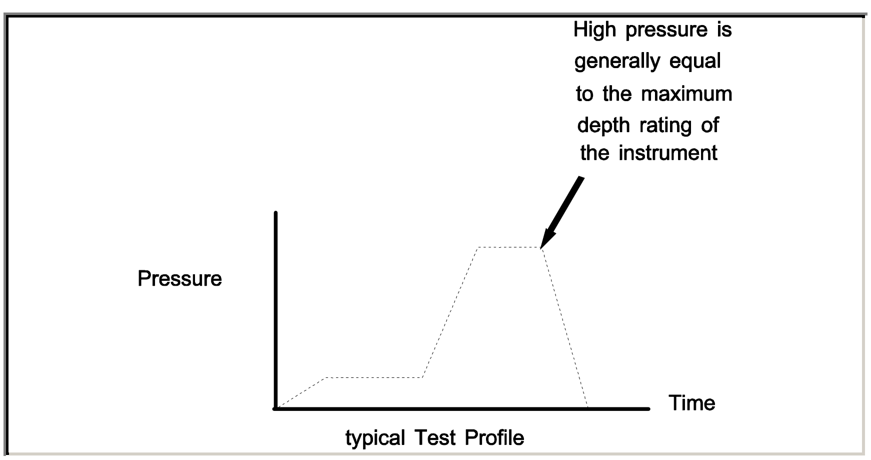
Pressure Test Protocol:

Low Pressure Test: **50** PSI Held For **15** Minutes

High Pressure Test: **160** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: PCC



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: 5429
CALIBRATION DATE: 06-Jun-07

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

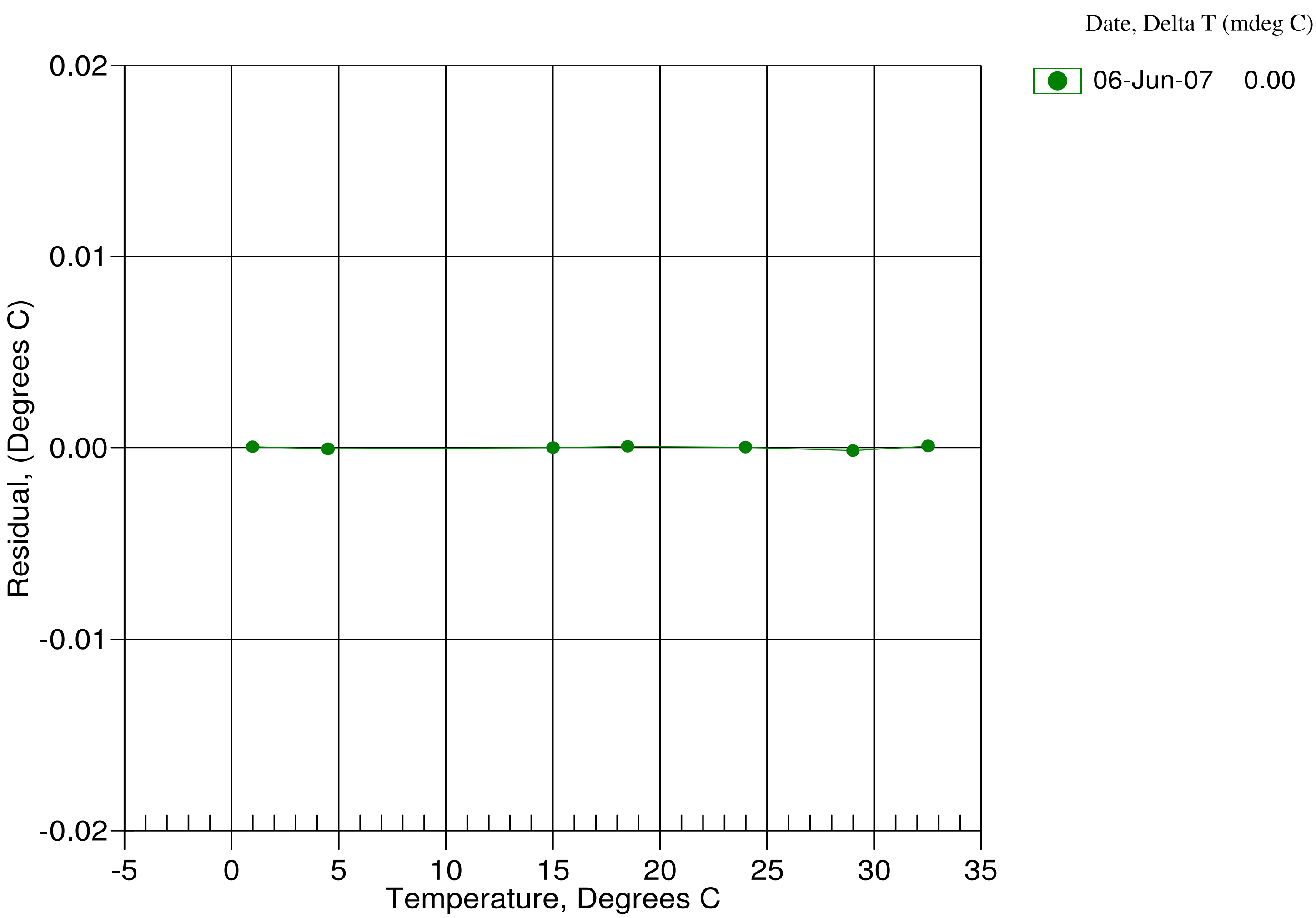
ITS-90 COEFFICIENTS

a0 = 4.208696e-005
a1 = 2.764711e-004
a2 = -2.496279e-006
a3 = 1.554851e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	605939.3	0.9999	0.0000
4.4999	517687.6	4.4998	-0.0001
15.0000	329202.6	15.0000	0.0000
18.5000	284855.0	18.5001	0.0001
24.0000	228275.7	24.0000	0.0000
29.0000	187791.4	28.9999	-0.0001
32.5000	164346.2	32.5001	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



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SENSOR SERIAL NUMBER: 5429
CALIBRATION DATE: 06-Jun-07

SBE 37 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.897058e-001
h = 1.539787e-001
i = -8.543930e-005
j = 3.327776e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 2.2064e-005

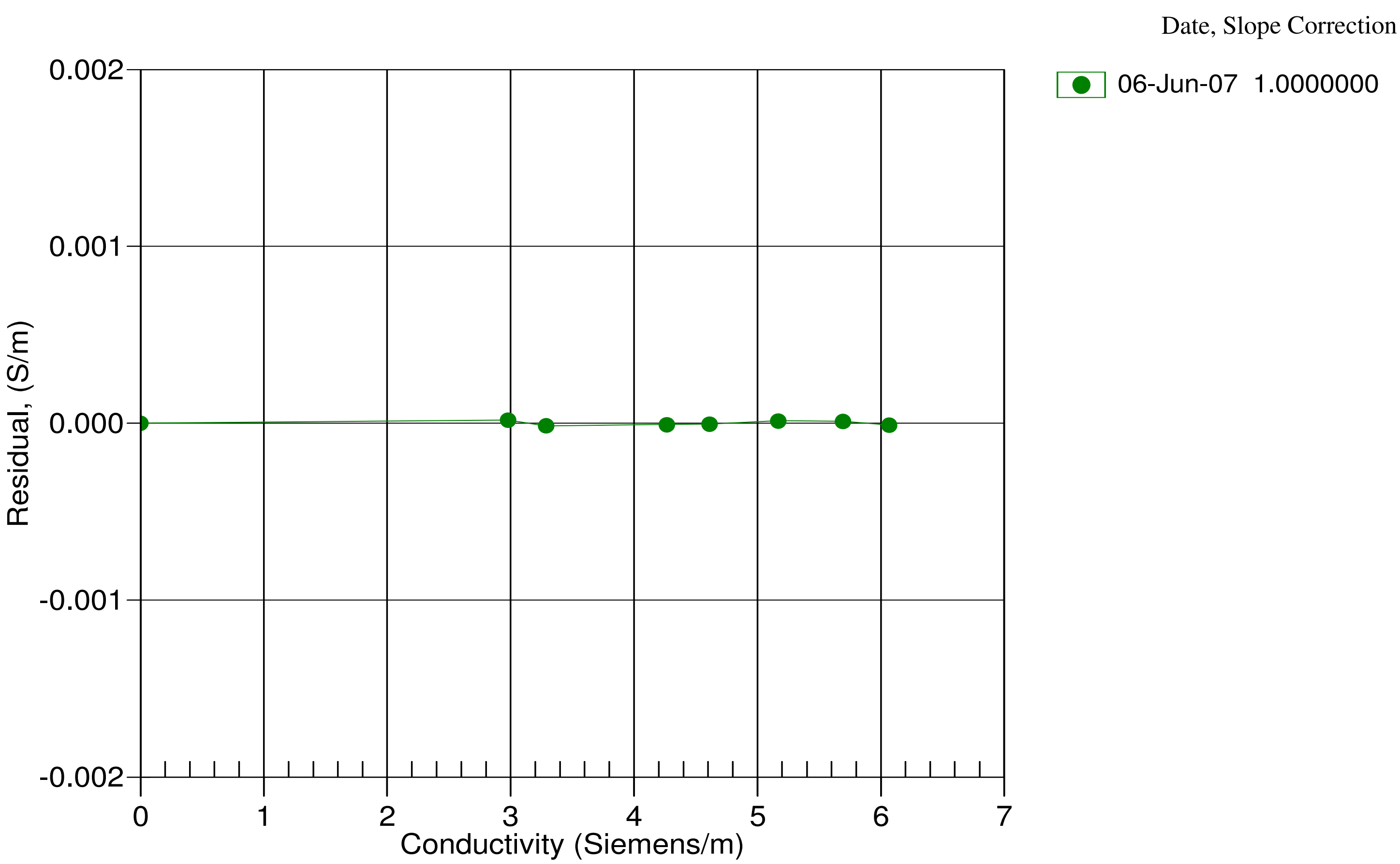
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2534.67	0.00000	0.00000
0.9999	34.8367	2.97753	5068.93	2.97755	0.00002
4.4999	34.8171	3.28478	5260.51	3.28477	-0.00002
15.0000	34.7752	4.26710	5830.10	4.26710	-0.00001
18.5000	34.7666	4.61249	6017.25	4.61248	-0.00001
24.0000	34.7573	5.17082	6307.73	5.17083	0.00001
29.0000	34.7523	5.69301	6567.42	5.69302	0.00001
32.5000	34.7499	6.06572	6746.44	6.06571	-0.00001

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



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SENSOR SERIAL NUMBER: 5429
CALIBRATION DATE: 06-Jun-07

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

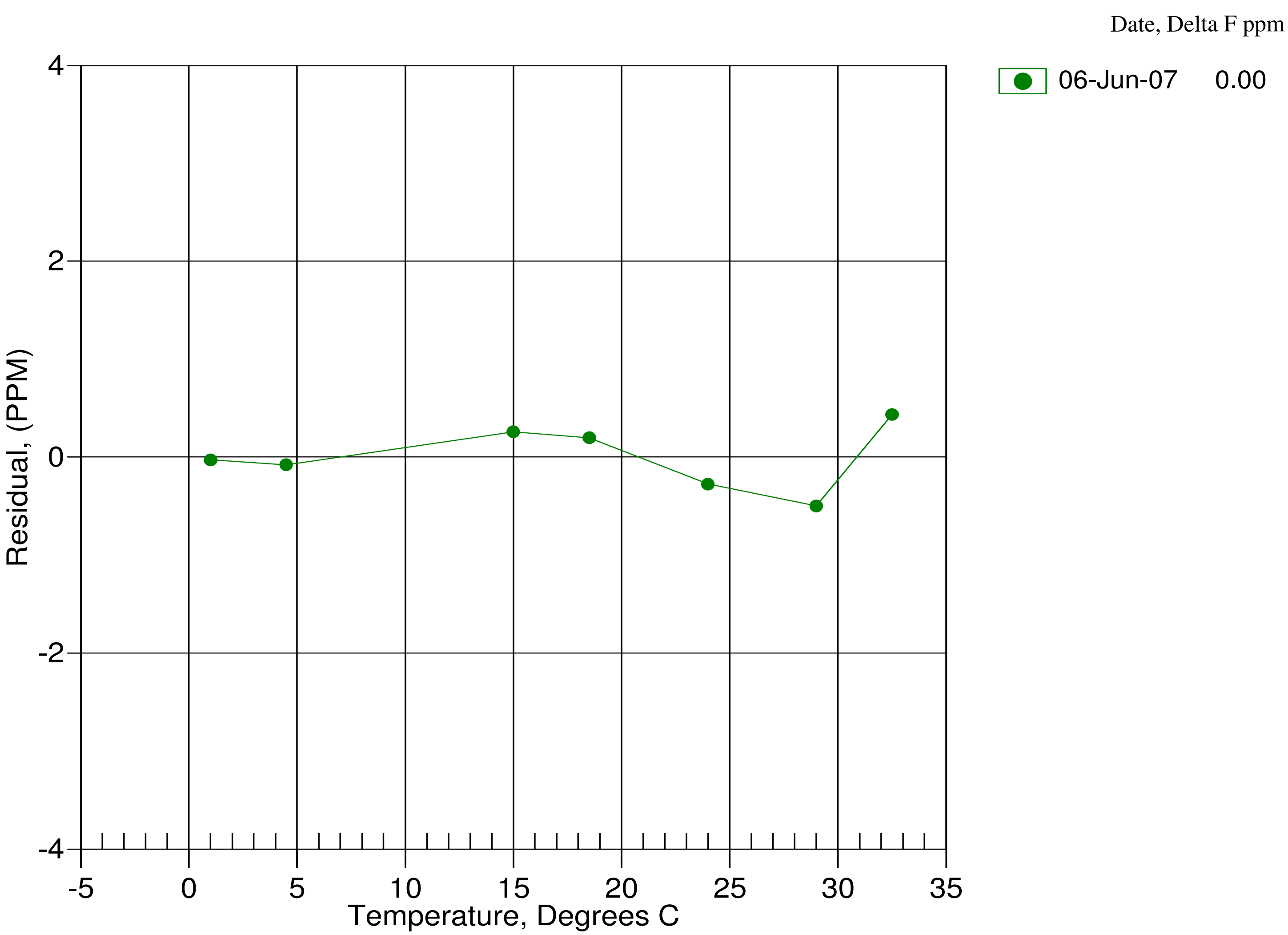
COEFFICIENTS:

rtca0 = 9.999794e-001
rtca1 = 1.583127e-006
rtca2 = -3.071162e-008

BATH TEMP (ITS-90)	RTC FREQ (Hz)	COMPUTED FREQ (Hz)	RESIDUAL (PPM)
0.9999	0.9999810	0.9999810	-0.0
4.4999	0.9999860	0.9999859	-0.1
15.0000	0.9999960	0.9999963	0.3
18.5000	0.9999980	0.9999982	0.2
24.0000	1.0000000	0.9999997	-0.3
29.0000	1.0000000	0.9999995	-0.5
32.5000	0.9999980	0.9999984	0.4

RTC frequency = rtca0 + rtca1 * t + rtca2 * t^2

Residual = (Computed RTC frequency - Measured RTC frequency) * 1e6



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SENSOR SERIAL NUMBER: 5429
CALIBRATION DATE: 01-Jun-07

SBE 37 PRESSURE CALIBRATION DATA
160 psia S/N 2461399

COEFFICIENTS:

PA0 = -4.669164e-001
PA1 = 7.575713e-003
PA2 = -8.262800e-010

PTCA0 = 7.267865e+001
PTCA1 = -1.739623e+000
PTCA2 = -3.262809e-002
PTCB0 = 2.503613e+001
PTCB1 = -1.575000e-003
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	TEMP ITS90	COMPUTED PRESSURE	ERROR %FS
14.56	1991.5	24.3	14.56	-0.00
29.87	4011.0	24.3	29.87	-0.00
59.85	7967.4	24.2	59.84	-0.00
94.84	12589.4	24.2	94.83	-0.00
124.84	16556.7	24.2	124.84	-0.00
159.86	21191.6	24.2	159.86	0.00
124.84	16556.8	24.2	124.84	-0.00
94.84	12590.9	24.2	94.85	0.00
59.86	7970.1	24.2	59.86	0.00
29.92	4018.1	24.2	29.92	0.00
14.55	1991.9	24.2	14.56	0.00

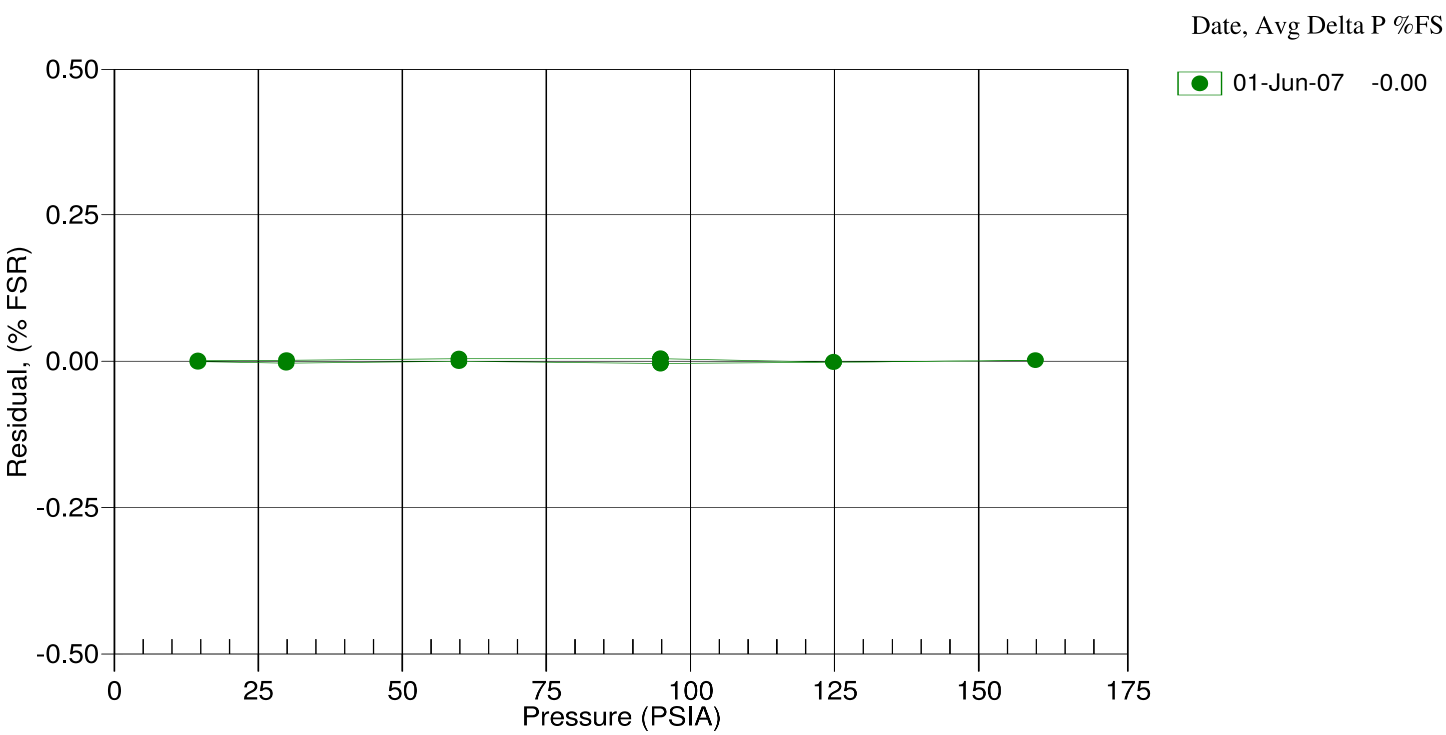
THERMAL CORRECTION

TEMP ITS90	INST OUTPUT	TEMP ITS90	SPAN MV
32.50	2078.30	-5.00	25.04
29.00	2090.20	35.00	24.98
24.00	2107.80		
18.50	2125.60		
15.00	2135.60		
4.50	2160.30		
1.00	2166.80		

x = pressure output - PTCA0 - PTCA1 * t - PTCA2 * t^2

n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)

pressure (psia) = PA0 + PA1 * n + PA2 * n^2



SBE37-IM MicroCAT

***Conductivity & Temperature Recorder
with Inductive Modem***

Instrument Configuration:

Serial Number	37IM46716-5430
Pressure Sensor	110 dbar Druck, SN 2461400
Firmware Version	2.3b
Memory	2048Kb
Conductivity Range	0-7 S/m
Microcat ID#	04
DPSK Baud Rate	1200 (Microcat <-> SIM)
SIM Baud Rate	9600, 8 data bits, 1 stop bit, no parity
Maximum Depth	**100 meters**

CAUTION - The maximum deployment depth will be limited by the measurement range of the optional pressure sensor, if installed.

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SBE Pressure Test Certificate

Test Date: **5/31/2007** Description **SBE-37 Microcat**

Job Number: **46716** Customer Name **UW/APL**

SBE Sensor Information:

Model Number: **37**
Serial Number: **5430**

Pressure Sensor Information:

Sensor Type: **Druck**
Sensor Serial Number: **2461400**
Sensor Rating: **160**

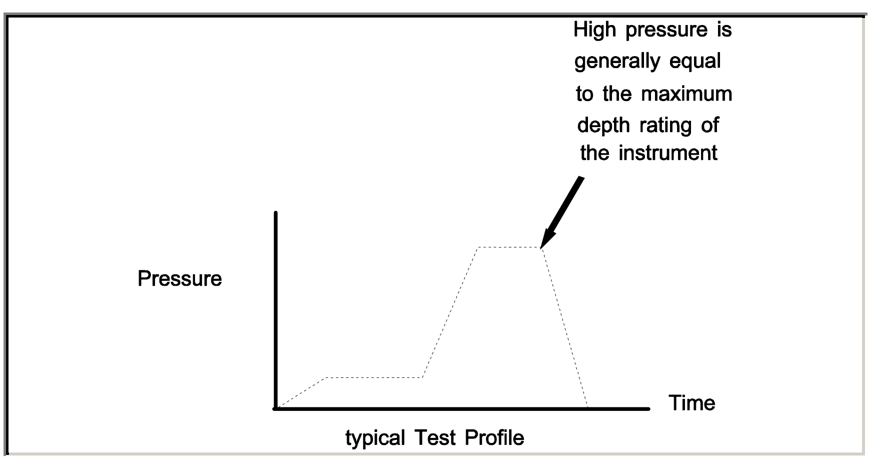
Pressure Test Protocol:

Low Pressure Test: **50** PSI Held For **15** Minutes

High Pressure Test: **160** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: PCC



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SENSOR SERIAL NUMBER: 5430
CALIBRATION DATE: 06-Jun-07

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

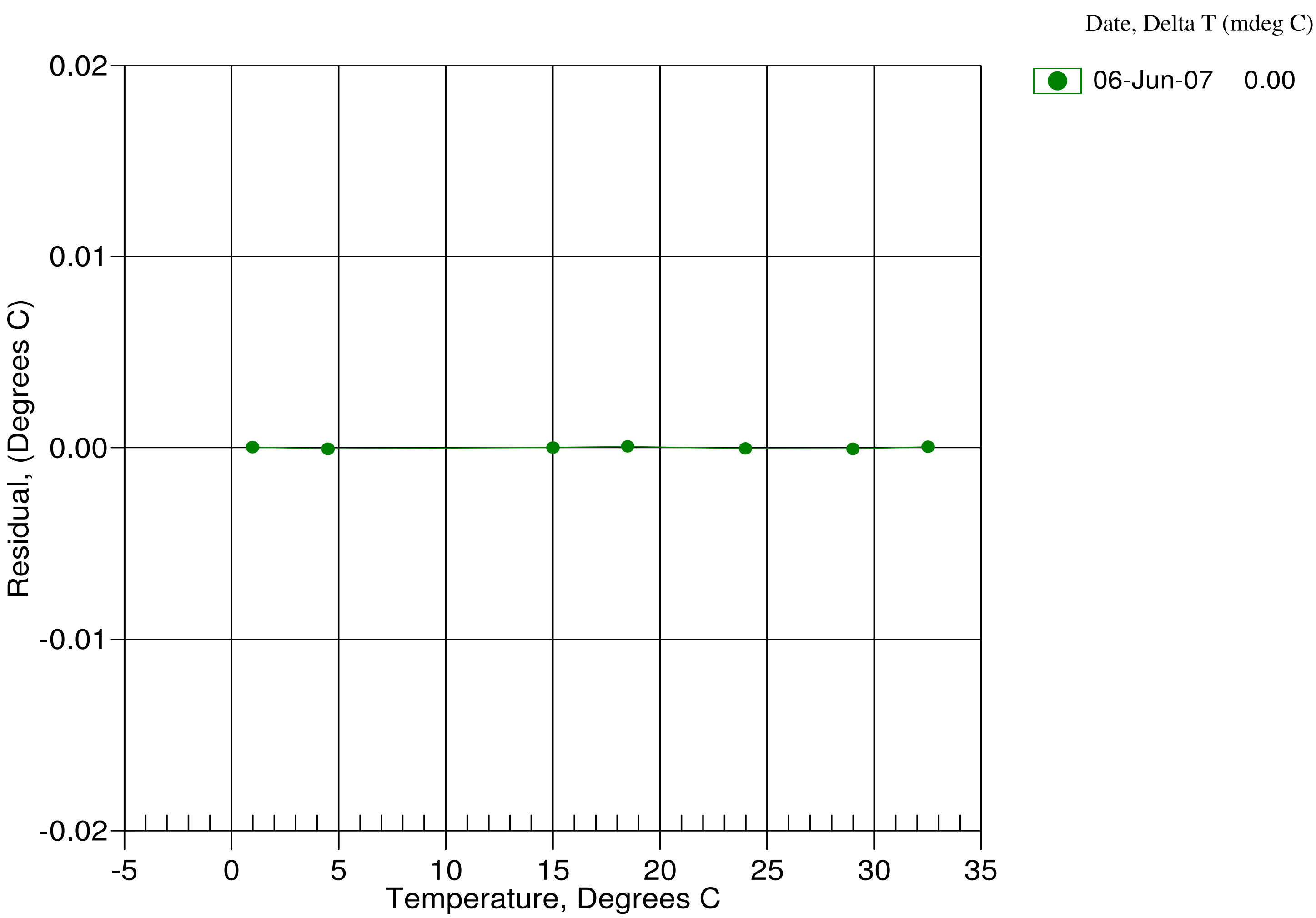
ITS-90 COEFFICIENTS

a0 = -2.586517e-005
a1 = 2.815942e-004
a2 = -2.888975e-006
a3 = 1.636328e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	719282.5	0.9999	0.0000
4.4999	614609.7	4.4998	-0.0001
15.0000	390993.4	15.0000	0.0000
18.5000	338365.5	18.5001	0.0001
24.0000	271212.6	24.0000	-0.0000
29.0000	223152.2	28.9999	-0.0001
32.5000	195317.7	32.5000	0.0000

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

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 5430
CALIBRATION DATE: 06-Jun-07

SBE 37 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.925588e-001
h = 1.548408e-001
i = -1.261837e-004
j = 3.713640e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 2.2583e-005

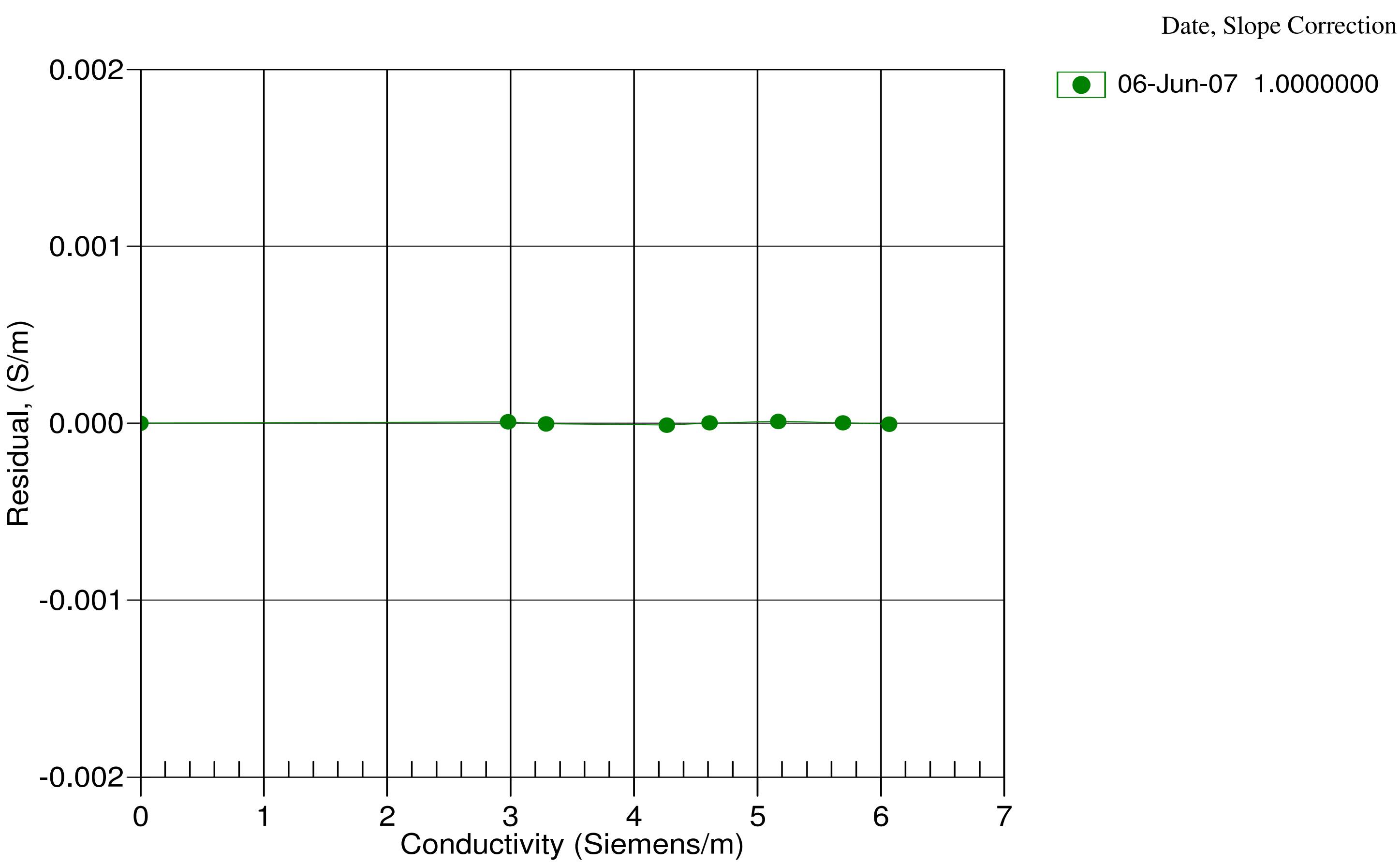
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2531.87	0.00000	0.00000
0.9999	34.8367	2.97753	5058.44	2.97754	0.00001
4.4999	34.8171	3.28478	5249.51	3.28478	-0.00000
15.0000	34.7752	4.26710	5817.53	4.26709	-0.00001
18.5000	34.7666	4.61249	6004.17	4.61249	0.00000
24.0000	34.7573	5.17082	6293.84	5.17083	0.00001
29.0000	34.7523	5.69301	6552.80	5.69302	0.00000
32.5000	34.7499	6.06572	6731.32	6.06571	-0.00001

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



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

SENSOR SERIAL NUMBER: 5430
CALIBRATION DATE: 06-Jun-07

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

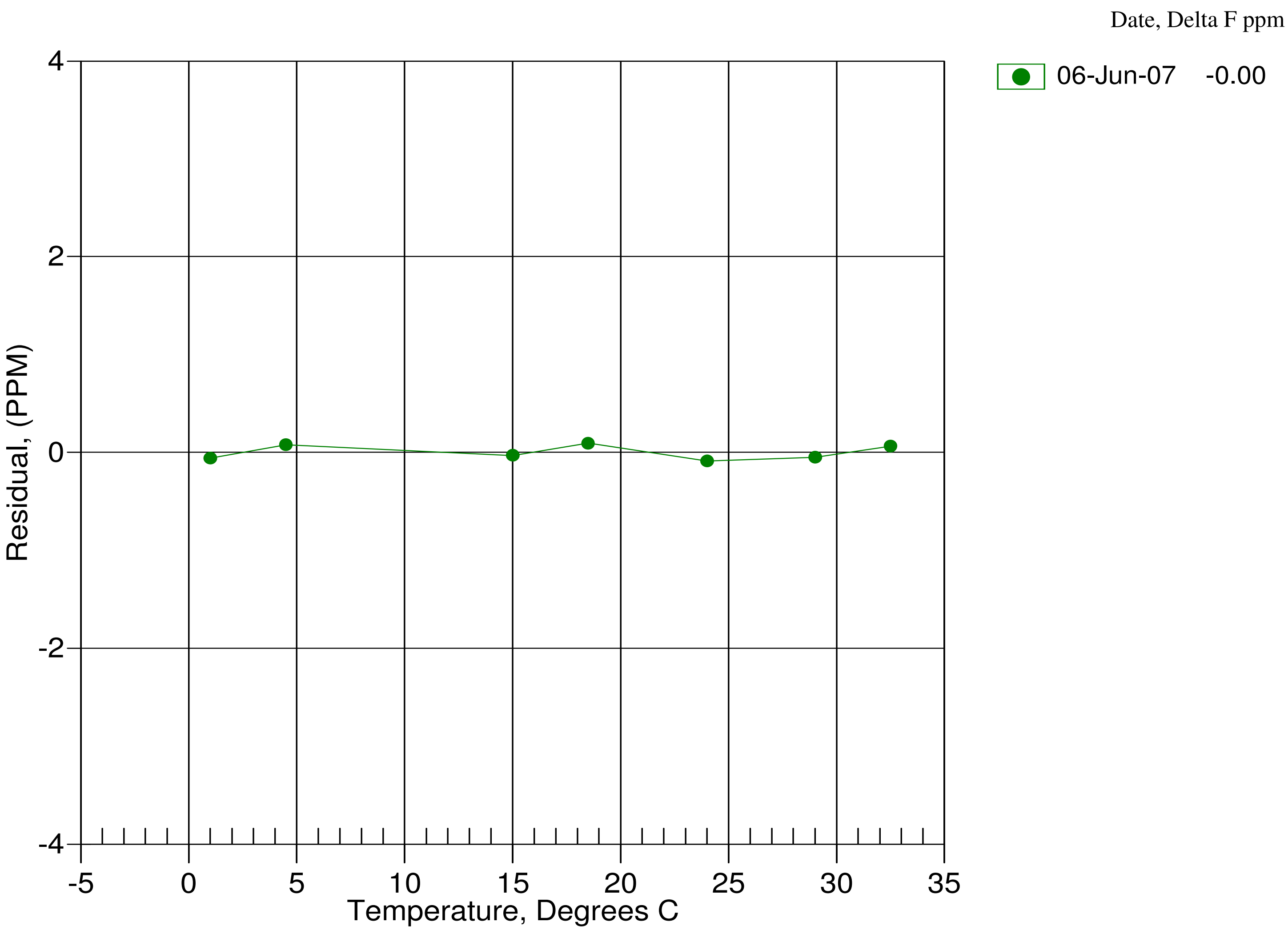
COEFFICIENTS:

rtca0 = 9.999723e-001
rtca1 = 1.636608e-006
rtca2 = -3.073084e-008

BATH TEMP (ITS-90)	RTC FREQ (Hz)	COMPUTED FREQ (Hz)	RESIDUAL (PPM)
0.9999	0.9999740	0.9999739	-0.1
4.4999	0.9999790	0.9999791	0.1
15.0000	0.9999900	0.9999900	-0.0
18.5000	0.9999920	0.9999921	0.1
24.0000	0.9999940	0.9999939	-0.1
29.0000	0.9999940	0.9999940	-0.0
32.5000	0.9999930	0.9999931	0.1

RTC frequency = rtca0 + rtca1 * t + rtca2 * t^2

Residual = (Computed RTC frequency - Measured RTC frequency) * 1e6



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

SENSOR SERIAL NUMBER: 5430
CALIBRATION DATE: 04-Jun-07

SBE 37 PRESSURE CALIBRATION DATA
160 psia S/N 2461400

COEFFICIENTS:

PA0 = -4.654130e-001
PA1 = 7.568839e-003
PA2 = -9.246081e-010

PTCA0 = -1.802526e+002
PTCA1 = -2.135760e+000
PTCA2 = -1.837826e-002
PTCB0 = 2.478938e+001
PTCB1 = 8.750000e-004
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	TEMP ITS90	COMPUTED PRESSURE	ERROR %FS
14.58	1748.0	23.9	14.58	0.00
29.91	3776.3	23.9	29.91	-0.00
59.87	7744.2	23.9	59.87	0.00
94.86	12381.8	24.0	94.85	-0.01
124.86	16363.0	24.1	124.86	-0.00
159.86	21013.3	24.1	159.86	0.00
124.86	16363.7	24.1	124.86	0.00
94.87	12383.9	24.2	94.87	0.00
59.88	7745.0	24.1	59.88	-0.00
29.93	3779.3	23.9	29.93	0.00
14.58	1747.8	23.9	14.58	-0.00

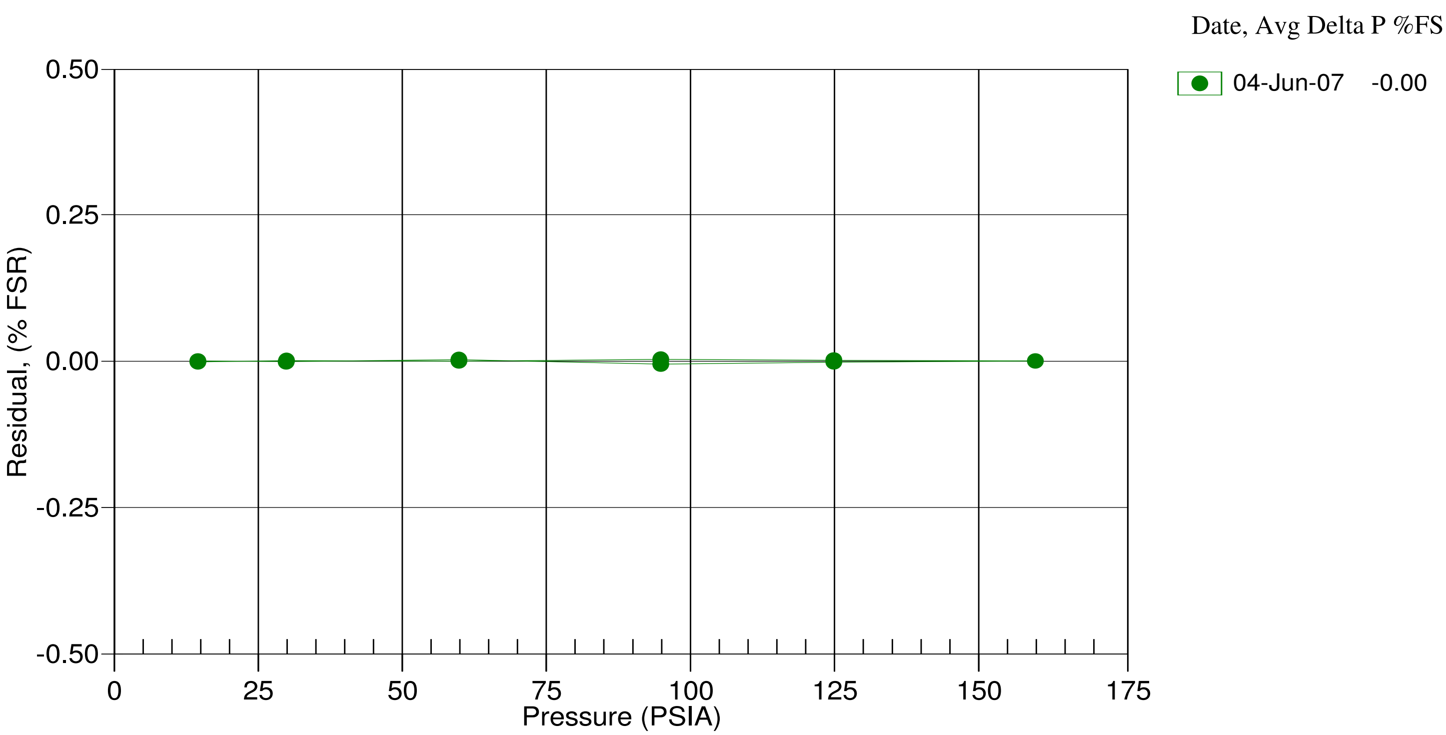
THERMAL CORRECTION

TEMP ITS90	INST OUTPUT	TEMP ITS90	SPAN MV
32.50	1836.40	-5.00	24.79
29.00	1846.60	35.00	24.82
24.00	1862.40		
18.50	1879.00		
15.00	1888.90		
4.50	1914.60		
1.00	1922.40		

x = pressure output - PTCA0 - PTCA1 * t - PTCA2 * t^2

n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)

pressure (psia) = PA0 + PA1 * n + PA2 * n^2



SBE37-IM MicroCAT

Conductivity & Temperature Recorder
with Inductive Modem

Instrument Configuration:

Serial Number	37IM46716-5431
Pressure Sensor	110 dbar Druck, SN 2461541
Firmware Version	2.3b
Memory	2048Kb
Conductivity Range	0-7 S/m
Microcat ID#	05
DPSK Baud Rate	1200 (Microcat <-> SIM)
SIM Baud Rate	9600, 8 data bits, 1 stop bit, no parity
Maximum Depth	**100 meters**

CAUTION - The maximum deployment depth will be limited by the measurement range of the optional pressure sensor, if installed.

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Email: seabird@seabird.com

SBE Pressure Test Certificate

Test Date: **5/31/2007** Description **SBE-37 Microcat**

Job Number: **46716** Customer Name **UW/APL**

SBE Sensor Information:

Model Number: **37**
Serial Number: **5431**

Pressure Sensor Information:

Sensor Type: **Druck**
Sensor Serial Number: **2461541**
Sensor Rating: **160**

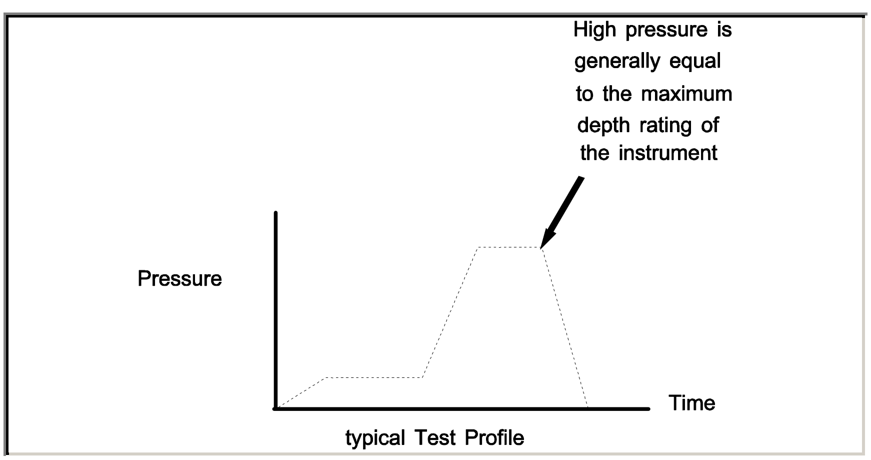
Pressure Test Protocol:

Low Pressure Test: **50** PSI Held For **15** Minutes

High Pressure Test: **160** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: PCC



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SENSOR SERIAL NUMBER: 5431
CALIBRATION DATE: 06-Jun-07

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

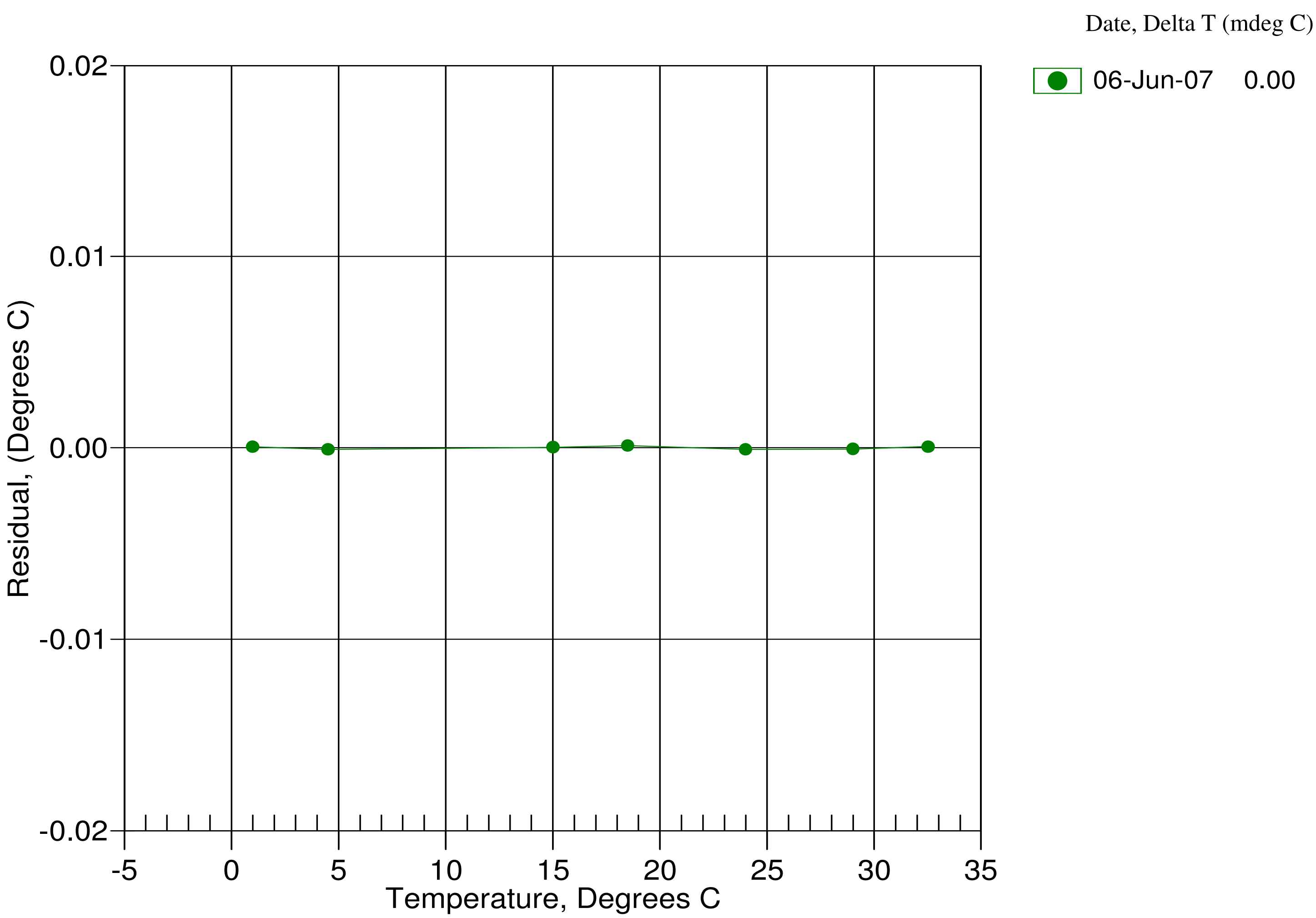
ITS-90 COEFFICIENTS

a0 = -4.501185e-005
a1 = 2.816667e-004
a2 = -2.888513e-006
a3 = 1.629915e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	769204.0	1.0000	0.0001
4.4999	657350.7	4.4998	-0.0001
15.0000	418333.3	15.0000	0.0000
18.5000	362066.3	18.5001	0.0001
24.0000	290261.0	23.9999	-0.0001
29.0000	238861.0	28.9999	-0.0001
32.5000	209088.4	32.5001	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



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SENSOR SERIAL NUMBER: 5431
CALIBRATION DATE: 06-Jun-07

SBE 37 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g = -1.011591e+000
h =  1.554766e-001
i = -9.683388e-005
j =  3.466596e-005

CPcor = -9.5700e-008
CTcor =  3.2500e-006
WBOTC =  1.8430e-005
```

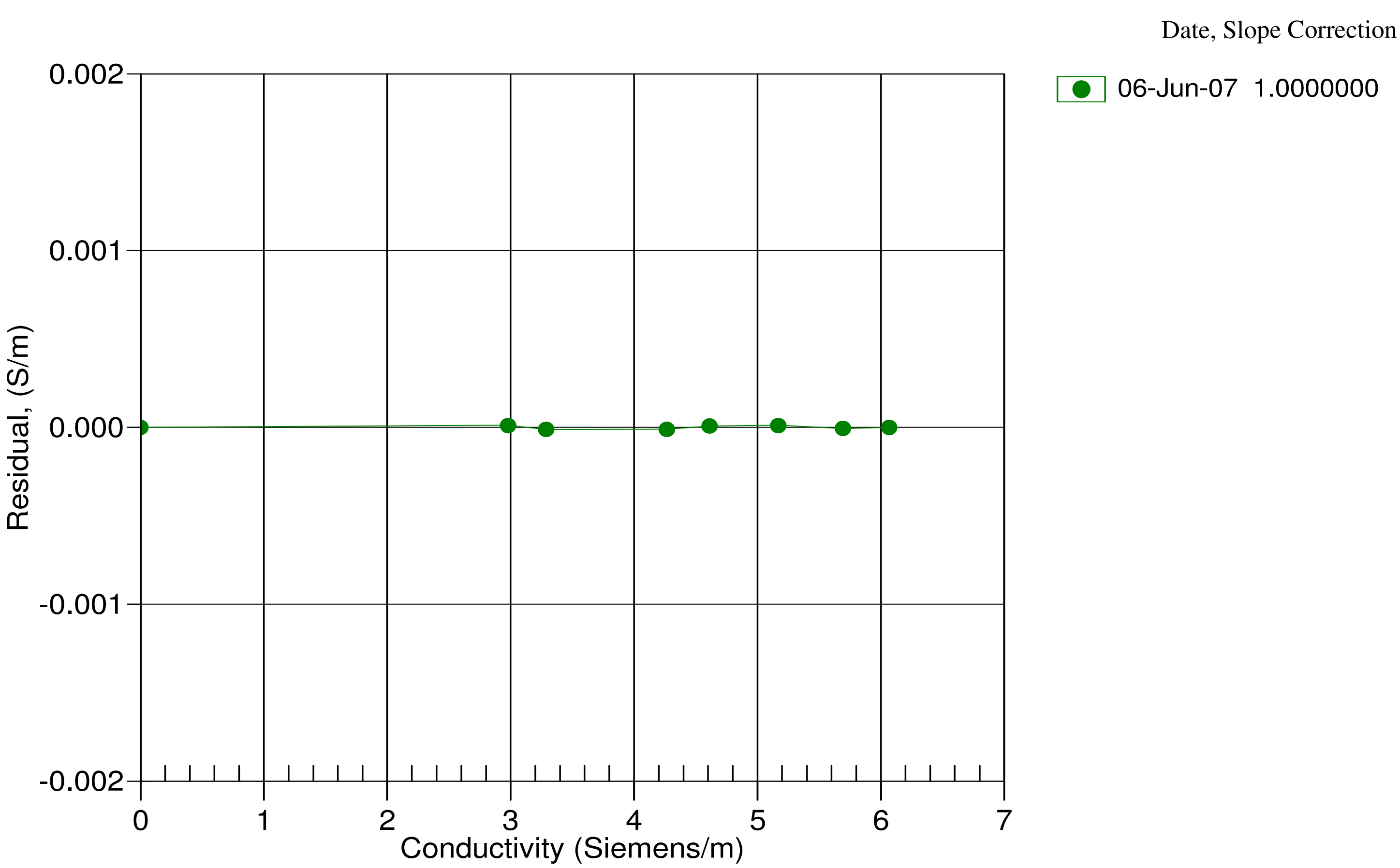
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2550.42	0.00000	0.00000
0.9999	34.8367	2.97753	5058.82	2.97755	0.00001
4.4999	34.8171	3.28478	5249.03	3.28477	-0.00001
15.0000	34.7752	4.26710	5814.73	4.26709	-0.00001
18.5000	34.7666	4.61249	6000.67	4.61249	0.00001
24.0000	34.7573	5.17082	6289.30	5.17083	0.00001
29.0000	34.7523	5.69301	6547.38	5.69301	-0.00001
32.5000	34.7499	6.06572	6725.33	6.06572	-0.00000

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

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

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

Residual = instrument conductivity - bath conductivity



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

SENSOR SERIAL NUMBER: 5431
CALIBRATION DATE: 06-Jun-07

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

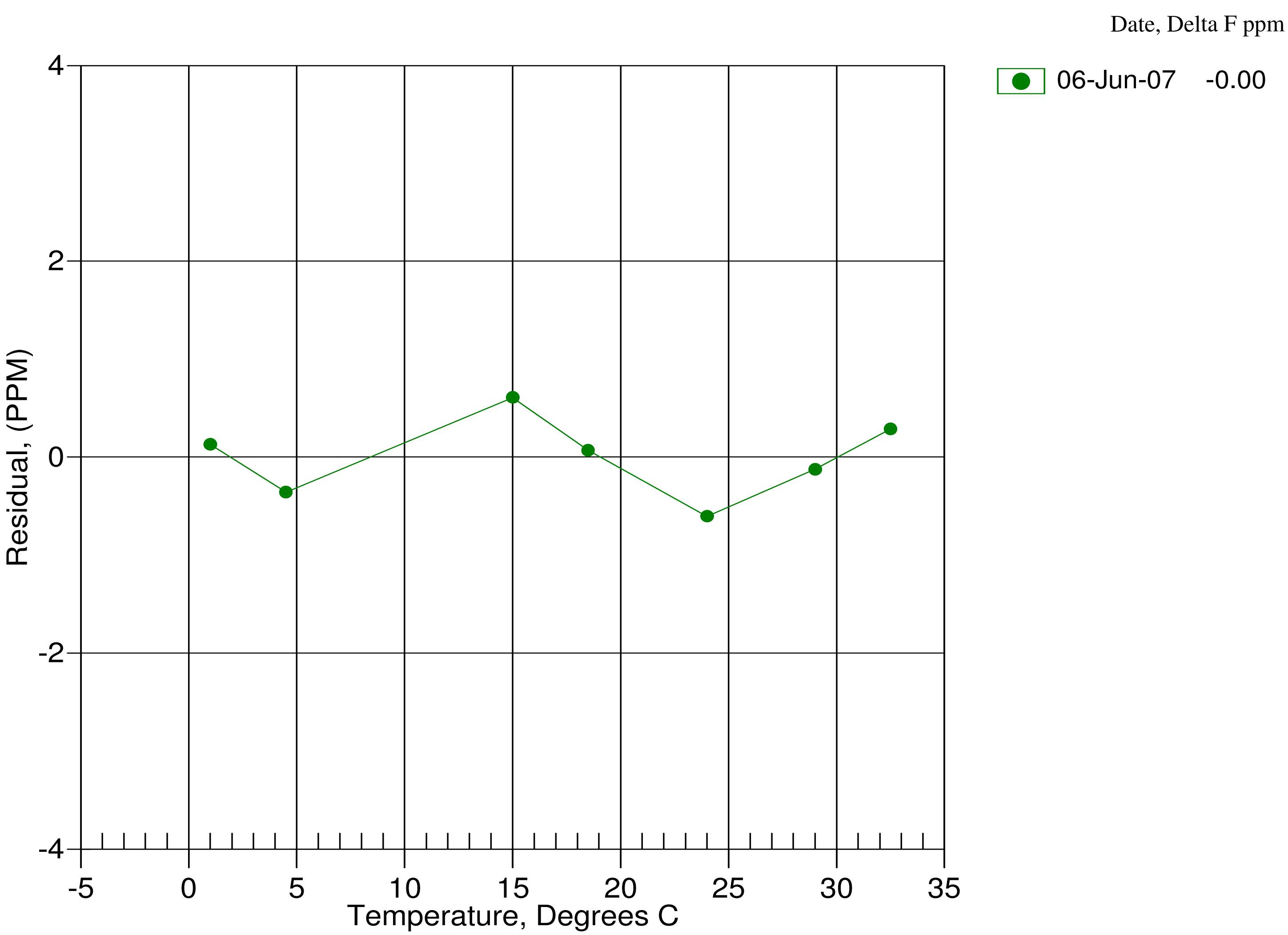
COEFFICIENTS:

rtca0 = 9.999944e-001
rtca1 = 1.746916e-006
rtca2 = -3.115016e-008

BATH TEMP (ITS-90)	RTC FREQ (Hz)	COMPUTED FREQ (Hz)	RESIDUAL (PPM)
0.9999	0.9999960	0.9999961	0.1
4.4999	1.0000020	1.0000016	-0.4
15.0000	1.0000130	1.0000136	0.6
18.5000	1.0000160	1.0000161	0.1
24.0000	1.0000190	1.0000184	-0.6
29.0000	1.0000190	1.0000189	-0.1
32.5000	1.0000180	1.0000183	0.3

RTC frequency = rtca0 + rtca1 * t + rtca2 * t^2

Residual = (Computed RTC frequency - Measured RTC frequency) * 1e6



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: 5431
CALIBRATION DATE: 04-Jun-07

SBE 37 PRESSURE CALIBRATION DATA
160 psia S/N 2461541

COEFFICIENTS:

```
PA0 =   -2.996809e-002
PA1 =    7.571584e-003
PA2 =   -6.086937e-010

PTCA0 = -2.226045e+001
PTCA1 =  2.051295e-001
PTCA2 = -1.560152e-002
PTCB0 =  2.501338e+001
PTCB1 = -7.250000e-004
PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	TEMP ITS90	COMPUTED PRESSURE	ERROR %FS
14.57	1898.6	23.8	14.55	-0.01
29.88	3919.9	23.8	29.86	-0.01
59.88	7885.6	23.9	59.88	0.00
94.87	12509.8	24.0	94.86	-0.01
124.87	16479.3	24.1	124.87	-0.00
159.86	21113.2	24.1	159.87	0.00
124.87	16479.6	24.1	124.87	0.00
94.88	12511.6	24.1	94.87	-0.00
59.87	7884.7	24.1	59.87	-0.00
29.88	3931.2	24.0	29.95	0.04
14.57	1899.1	23.9	14.56	-0.01

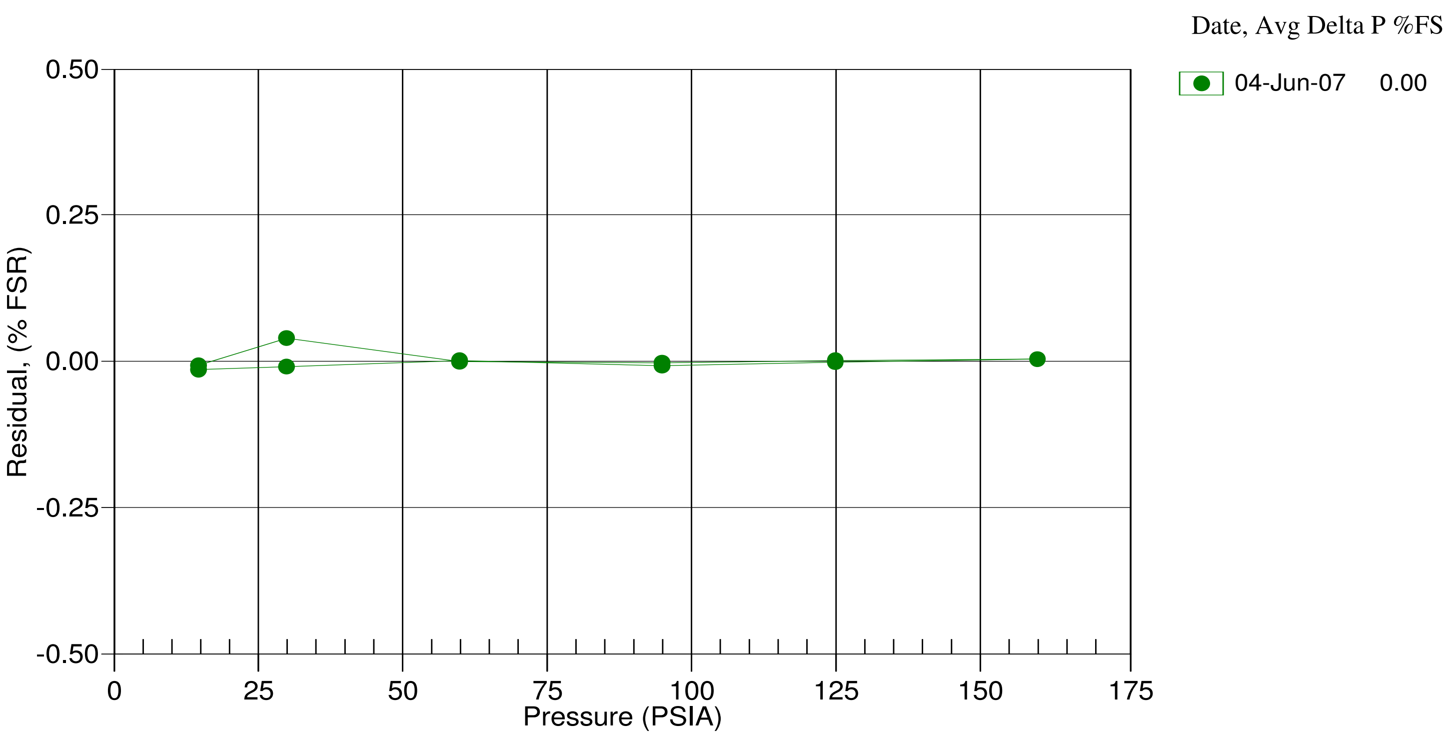
THERMAL CORRECTION

TEMP ITS90	INST OUTPUT	TEMP ITS90	SPAN MV
32.50	2010.40	-5.00	25.02
29.00	2012.10	35.00	24.99
24.00	2015.60		
18.50	2018.40		
15.00	2019.60		
4.50	2020.30		
1.00	2020.00		

x = pressure output - PTCA0 - PTCA1 * t - PTCA2 * t^2

n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)

pressure (psia) = PA0 + PA1 * n + PA2 * n^2



SBE37-IM MicroCAT

Conductivity & Temperature Recorder
with Inductive Modem

Instrument Configuration:

Serial Number	37IM46716-5432
Pressure Sensor	110 dbar Druck, SN 2461542
Firmware Version	2.3b
Memory	2048Kb
Conductivity Range	0-7 S/m
Microcat ID#	06
DPSK Baud Rate	1200 (Microcat <-> SIM)
SIM Baud Rate	9600, 8 data bits, 1 stop bit, no parity
Maximum Depth	**100 meters**

CAUTION - The maximum deployment depth will be limited by the measurement range of the optional pressure sensor, if installed.

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SBE Pressure Test Certificate

Test Date: **5/31/2007** Description **SBE-37 Microcat**

Job Number: **46716** Customer Name **UW/APL**

SBE Sensor Information:

Model Number: **37**
Serial Number: **5432**

Pressure Sensor Information:

Sensor Type: **Druck**
Sensor Serial Number: **2461542**
Sensor Rating: **160**

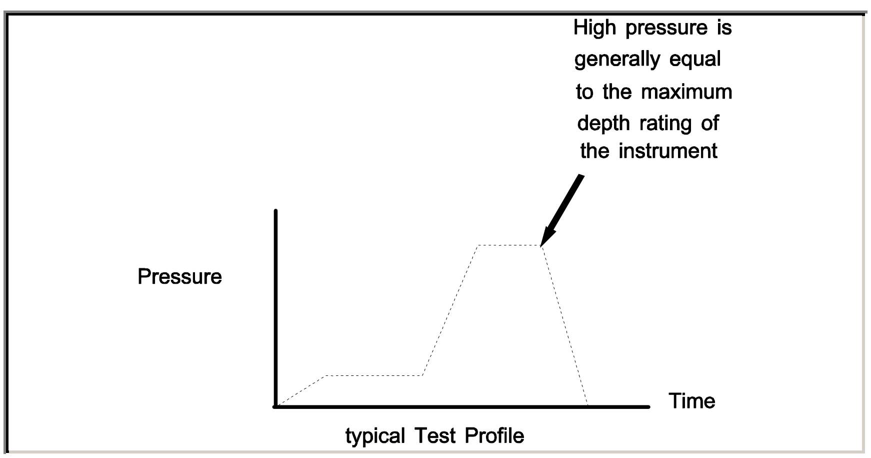
Pressure Test Protocol:

Low Pressure Test: **50** PSI Held For **15** Minutes

High Pressure Test: **160** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: PCC



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SENSOR SERIAL NUMBER: 5432
CALIBRATION DATE: 06-Jun-07

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

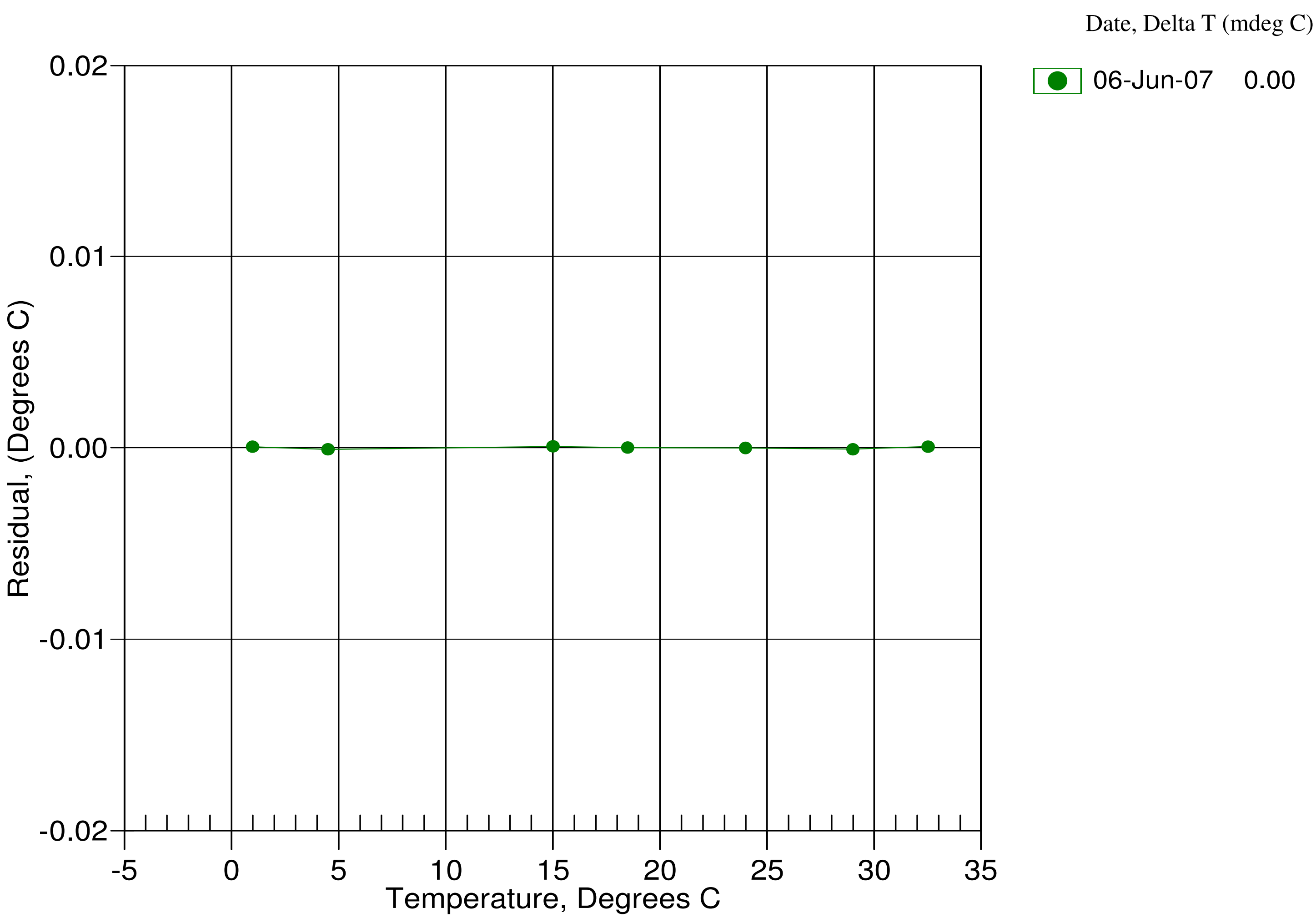
ITS-90 COEFFICIENTS

a0 = -1.249018e-005
a1 = 2.772707e-004
a2 = -2.560610e-006
a3 = 1.546404e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	737365.0	0.9999	0.0000
4.4999	629998.7	4.4998	-0.0001
15.0000	400671.2	15.0001	0.0001
18.5000	346712.4	18.5000	0.0000
24.0000	277865.1	24.0000	-0.0000
29.0000	228599.2	28.9999	-0.0001
32.5000	200068.5	32.5001	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



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SENSOR SERIAL NUMBER: 5432
CALIBRATION DATE: 06-Jun-07

SBE 37 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.903173e-001
h = 1.522336e-001
i = -8.786392e-005
j = 3.329664e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 2.0951e-005

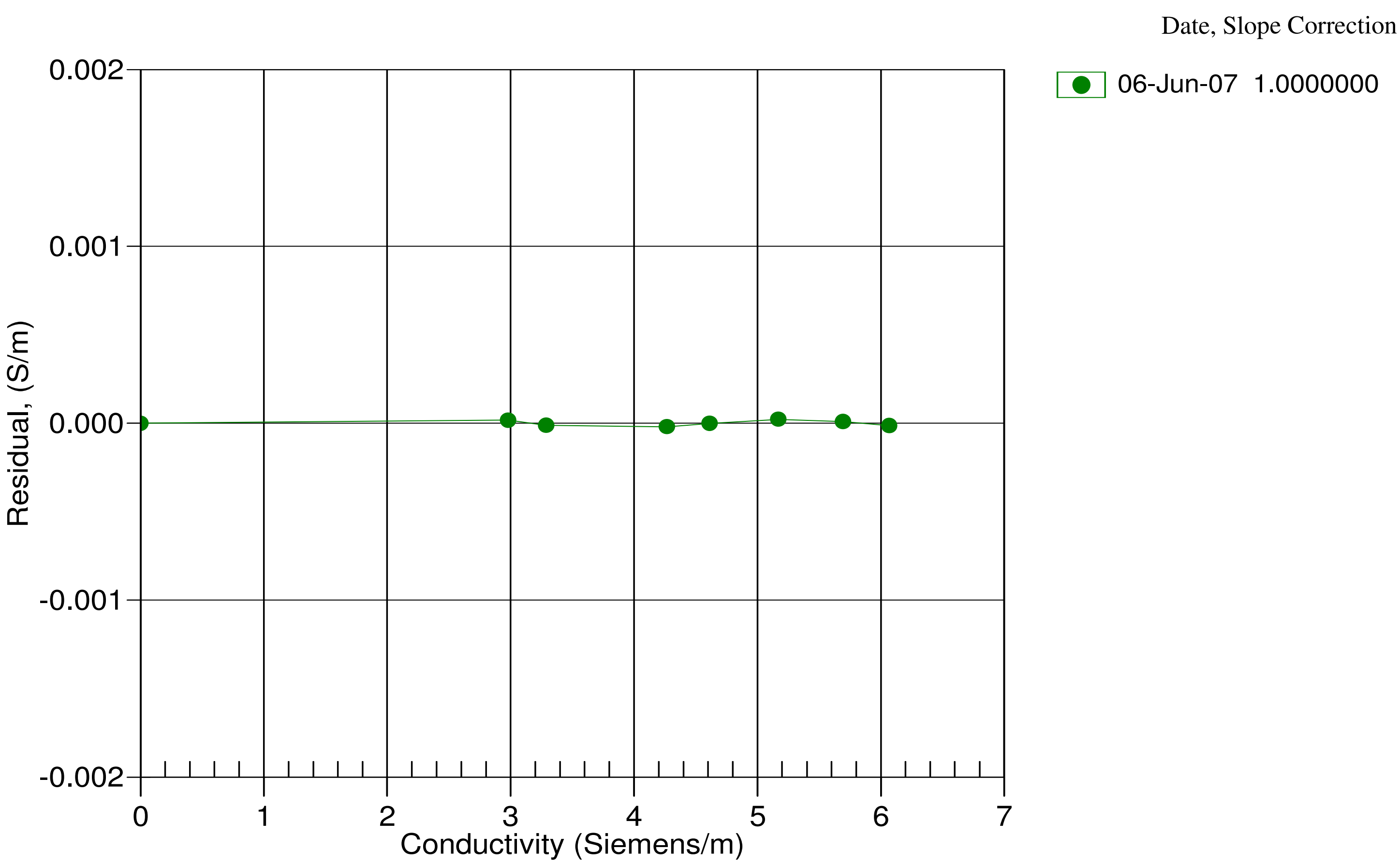
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2550.01	0.00000	0.00000
0.9999	34.8367	2.97753	5098.29	2.97755	0.00002
4.4999	34.8171	3.28478	5290.95	3.28477	-0.00001
15.0000	34.7752	4.26710	5863.73	4.26708	-0.00002
18.5000	34.7666	4.61249	6051.94	4.61249	-0.00000
24.0000	34.7573	5.17082	6344.05	5.17084	0.00002
29.0000	34.7523	5.69301	6605.19	5.69302	0.00001
32.5000	34.7499	6.06572	6785.21	6.06571	-0.00001

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



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SENSOR SERIAL NUMBER: 5432
CALIBRATION DATE: 06-Jun-07

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

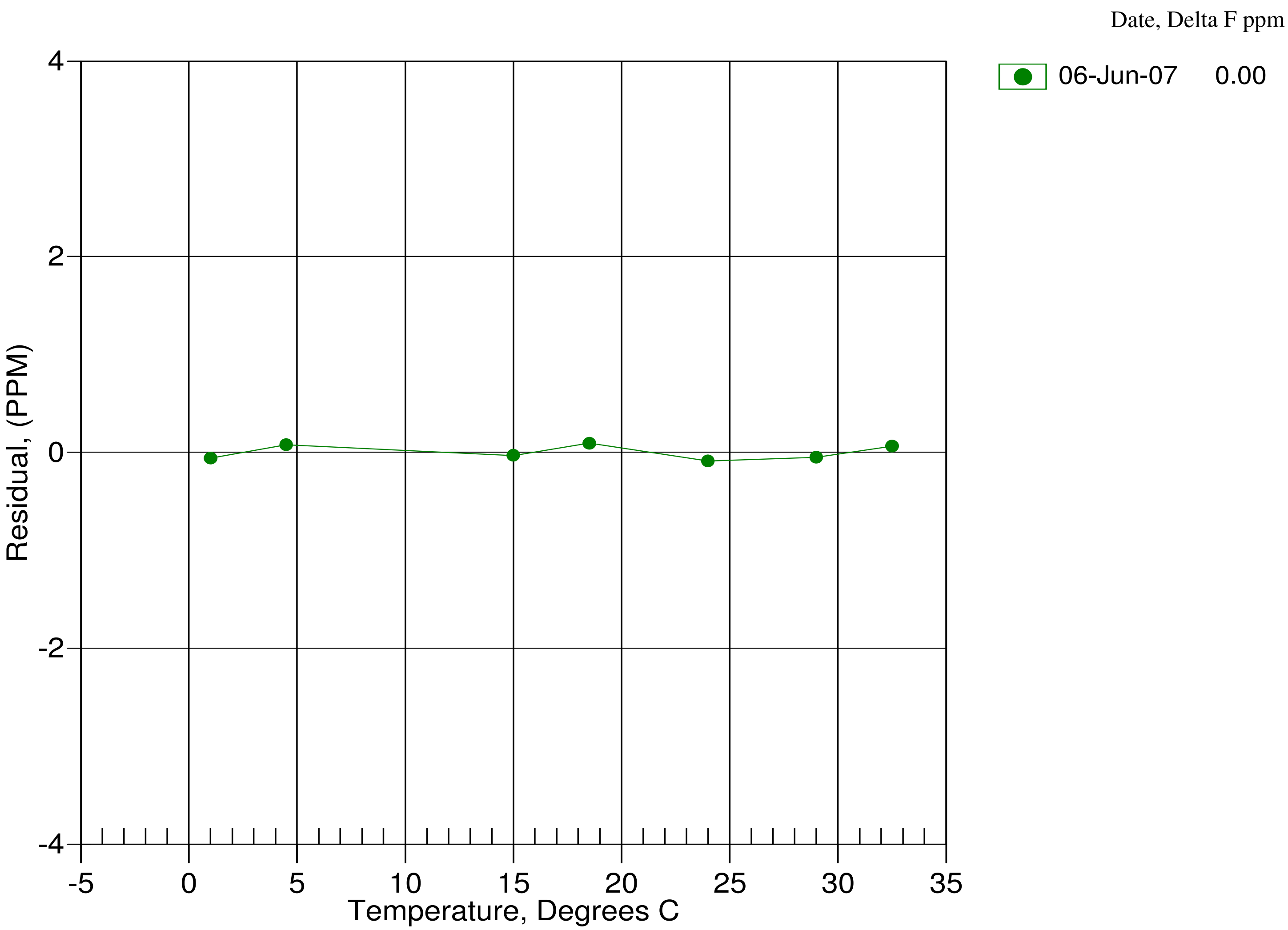
COEFFICIENTS:

rtca0 = 9.999743e-001
rtca1 = 1.636608e-006
rtca2 = -3.073084e-008

BATH TEMP (ITS-90)	RTC FREQ (Hz)	COMPUTED FREQ (Hz)	RESIDUAL (PPM)
0.9999	0.9999760	0.9999759	-0.1
4.4999	0.9999810	0.9999811	0.1
15.0000	0.9999920	0.9999920	-0.0
18.5000	0.9999940	0.9999941	0.1
24.0000	0.9999960	0.9999959	-0.1
29.0000	0.9999960	0.9999960	-0.0
32.5000	0.9999950	0.9999951	0.1

RTC frequency = rtca0 + rtca1 * t + rtca2 * t^2

Residual = (Computed RTC frequency - Measured RTC frequency) * 1e6



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SENSOR SERIAL NUMBER: 5432
CALIBRATION DATE: 04-Jun-07

SBE 37 PRESSURE CALIBRATION DATA
160 psia S/N 2461542

COEFFICIENTS:

PA0 = -6.508068e-001
PA1 = 7.577668e-003
PA2 = -8.500007e-010

PTCA0 = -6.231881e+000
PTCA1 = -3.206477e+000
PTCA2 = -2.117979e-002
PTCB0 = 2.503000e+001
PTCB1 = -1.200000e-003
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	TEMP ITS90	COMPUTED PRESSURE	ERROR %FS
14.57	1912.6	23.2	14.55	-0.01
29.88	3933.5	23.5	29.88	0.01
59.87	7889.6	23.6	59.86	-0.00
94.85	12511.6	23.8	94.85	-0.00
124.85	16478.5	23.9	124.85	-0.00
159.86	21113.9	23.9	159.86	0.00
124.85	16478.9	23.9	124.85	-0.00
94.86	12512.0	23.9	94.85	-0.00
59.86	7889.9	23.8	59.87	0.01
29.92	3938.8	23.8	29.93	0.01
14.57	1911.6	23.8	14.57	-0.00

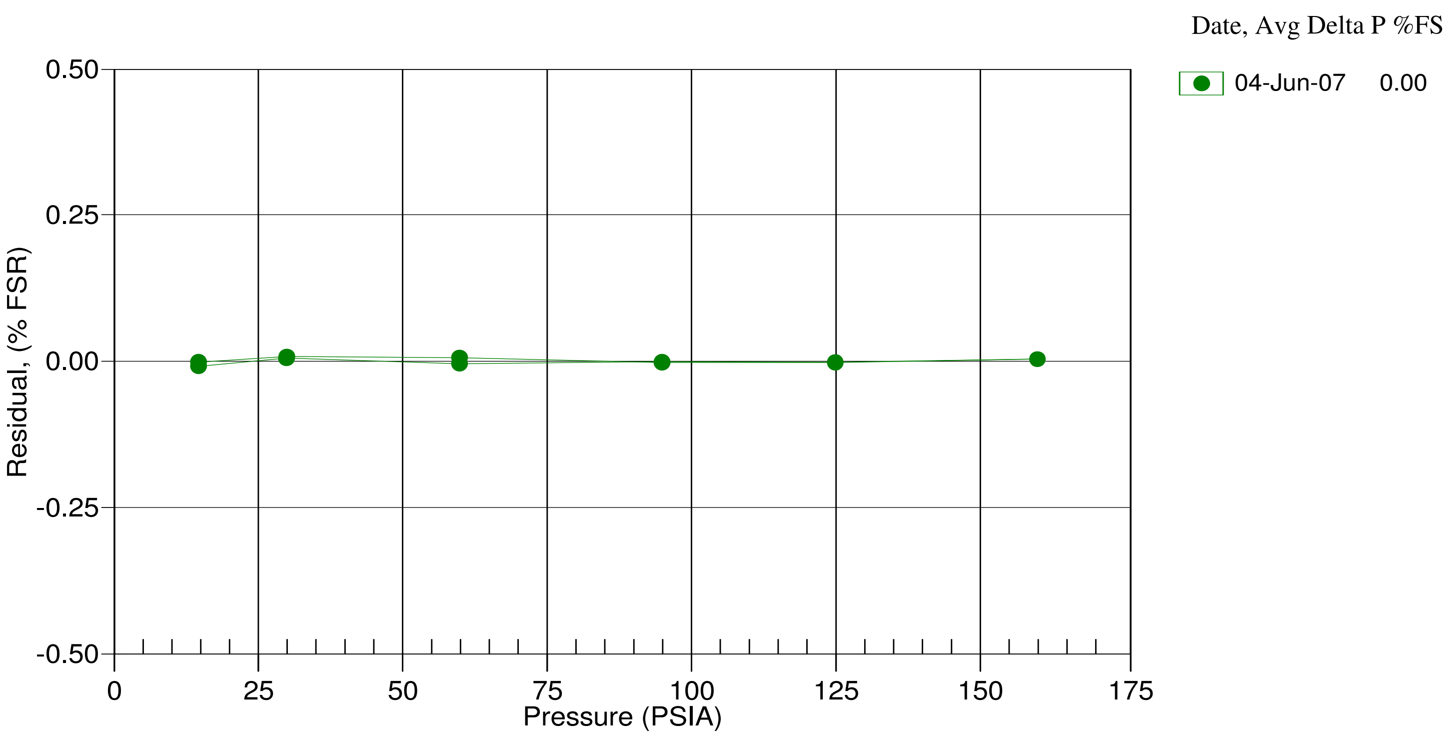
THERMAL CORRECTION

TEMP ITS90	INST OUTPUT	TEMP ITS90	SPAN MV
32.50	1988.70	-5.00	25.04
29.00	2003.40	35.00	24.99
24.00	2025.50		
18.50	2048.50		
15.00	2062.20		
4.50	2099.70		
1.00	2111.70		

$x = \text{pressure output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)$

$\text{pressure (psia)} = PA0 + PA1 * n + PA2 * n^2$



MicroCAT C-T Recorder (Inductive Modem)

SBE 37-IM

The SBE 37-IM MicroCAT is a high-accuracy conductivity and temperature sensor/recorder (pressure optional) with internal battery, non-volatile memory, and built-in **I**nductive **M**odem. The modem provides reliable, low-cost, real-time data transmission for up to 100 instruments — all MicroCATs or a mix of MicroCATs and other IM instruments — using a single, plastic-coated, steel mooring cable. IM instruments clamp anywhere along the inherently rugged mooring cable; expensive and potentially unreliable multiconductor cables are not required.

IM moorings are easily reconfigured to meet changing deployment scenarios. Instrument positions can be altered (or instruments added/deleted) simply by sliding and re-clamping the sensors up or down the cable; there is no need to design and purchase a new mooring cable with different breakout locations.

Because data can be telemetered from instruments located anywhere along the mooring cable, inductive modem systems are far more efficient and flexible than acoustic modems, which place serious demands on battery capacity and can return data from a single underwater position only.

At the surface (typically in a buoy), a corresponding **S**urface **I**nductive **M**odem (SIM) completes the communication link between the underwater instruments and a computer or data logger. Data from the instrument string can be stored and transmitted via satellite link, cell phone, or radio telemetry. As insurance against loss of the real-time data, the MicroCAT simultaneously backs up the data in its non-volatile internal memory.

Standard titanium housing; optional plastic (ShallowCAT) housing also available

SENSORS AND INTERFACE ELECTRONICS

The MicroCAT retains the temperature and conductivity sensors used in our time-proven SEACAT products; however, new acquisition techniques provide increased accuracy and resolution while reducing power consumption. Calibration coefficients are stored in EEPROM, allowing the MicroCAT to transmit data in engineering units. Sea-Bird's unique internal-field conductivity cell permits the use of expendable anti-foulant devices. The aged and pressure-protected thermistor has a long history of exceptional accuracy and stability.

Temperature is acquired by applying an AC excitation to a hermetically sealed VISHAY reference resistor and an ultra-stable aged thermistor (drift rate typically less than 0.002 °C per year). The ratio of thermistor resistance to reference resistance is determined by a 24-bit A/D converter; this A/D also processes the pressure sensor signal. Conductivity is acquired using an ultra-precision Wien-Bridge oscillator. A high-stability reference crystal with a drift rate of less than 2 ppm/year is used to count the frequency from the oscillator.

The optional pressure sensor, developed by Druck, Inc., has a superior new design that is entirely different from conventional 'silicon' types in which the deflection of a metallic diaphragm is detected by epoxy-bonded silicon strain gauges. The Druck sensor employs a micro-machined *silicon diaphragm* into which the strain elements are implanted using semiconductor fabrication techniques. Unlike metal diaphragms, silicon's crystal structure is perfectly elastic, so the sensor is essentially free of pressure hysteresis. Compensation of the temperature influence on pressure offset and scale is performed by the MicroCAT's CPU.

COMMUNICATIONS AND INTERFACING

The bottom of the insulated mooring wire is grounded to seawater, typically via a padeye swaged to its steel core; a second padeye at the top completes a conductive loop through the water. A coupling transformer — similar to the one built into the MicroCAT but clamped to the mooring cable just under the buoy — connects to the SIM board (SIM and coupling transformer available separately). Communication with the SIM is via full-duplex RS-232C. Commands and data are transmitted half-duplex between the SIM and MicroCAT using DPSK (differential-phase-shift-keyed) telemetry. Full ocean-depth mooring cables can be used. DPSK telemetry provides a high degree of immunity from *fishbite* or other cable degradation. Lab diagnostics, setup, and data extraction may be performed by simply looping any insulated wire through the inductive core and connecting the wire ends to the SIM.

Each MicroCAT (or other sensor compatible with the Sea-Bird inductive modem) has a programmable address. Upon receipt of a wake-up command, the SIM sends a tone for two seconds, waking all the MicroCATs on the cable. When a MicroCAT receives a command, it replies and then returns to listening for commands. A global power-off command returns all the MicroCATs to a quiescent, standby state. The MicroCATs automatically return to quiescent state if there is no line activity for two minutes.

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MicroCAT C-T Recorder (Inductive Modem) SBE 37-IM

OPERATING MODES

User-selectable operating modes include:

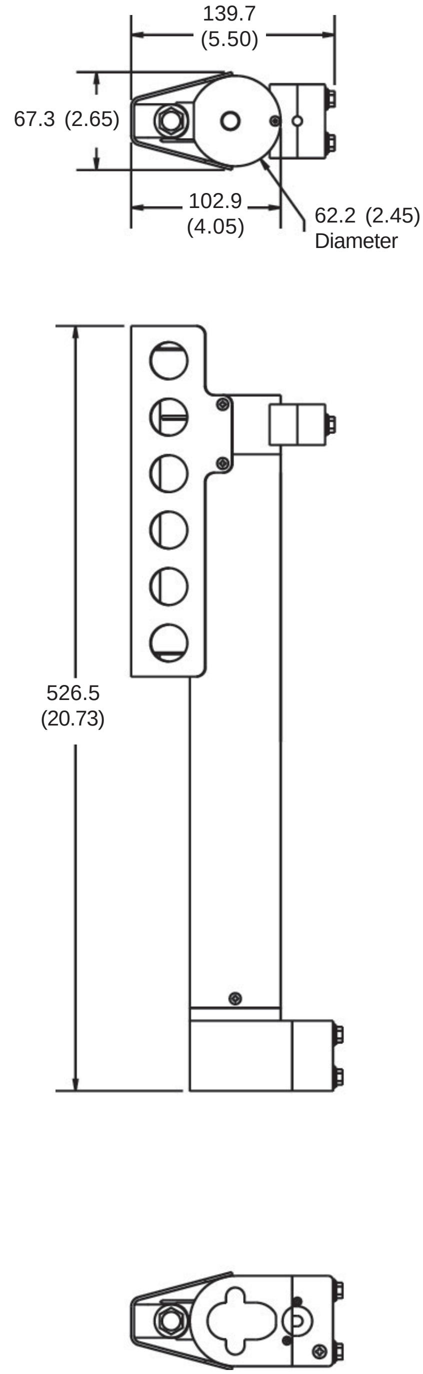
- Polled — On command, MicroCAT takes one sample and transmits the data.
- Autonomous — MicroCAT samples at pre-programmed intervals, storing the data in FLASH memory.
- Combo — Data at pre-programmed intervals is stored in FLASH memory and the SIM can request the last stored data.
- Averaging — Data at pre-programmed intervals is stored in FLASH memory. The SIM can periodically request the average of the individual samples acquired since its last request.

SOFTWARE

The MicroCAT is supplied with a powerful Windows 95/98/NT/2000/XP software package, SEASOFT©-Win32, which includes:

- SEATERM© – terminal program for easy communication and data retrieval.
- SBE Data Processing© – programs for calculation, display, and plotting of conductivity, temperature, pressure (optional), and derived variables such as salinity and sound velocity.

Dimensions in mm (inches)



DATA STORAGE AND BATTERY ENDURANCE

Temperature and conductivity are stored 5 bytes/sample, time 4 bytes/sample, and optional pressure 2 bytes/sample; memory capacity is in excess of 185,000 samples. The MicroCAT is powered by a 7.2 Ampere-Hour (nominal) battery pack consisting of six 9-volt lithium batteries which, when removed from the MicroCAT, can be shipped via commercial aircraft. The pack provides sufficient internal battery capacity for more than 100,000 samples.

SPECIFICATIONS

Measurement Range

Conductivity:	0 - 7 S/m (0 - 70 mS/cm)
Temperature:	-5 to 35 °C
Optional Pressure:	20/100/350/600/1000/2000/3500/7000 m (meters of deployment depth capability)

Initial Accuracy

Conductivity:	0.0003 S/m (0.003 mS/cm)
Temperature:	0.002 °C
Optional Pressure:	0.1% of full scale range

Typical Stability *(per month)*

Conductivity:	0.0003 S/m (0.003 mS/cm)
Temperature:	0.0002 °C
Optional Pressure:	0.004% of full scale range

Resolution

Conductivity:	0.00001 S/m (0.0001 mS/cm)
Temperature:	0.0001 °C
Optional Pressure:	0.002% of full scale range

Time Resolution	1 second
Clock Accuracy	13 seconds/month
Power Supply	9 volt 7.2 A-H (nominal) battery
Quiescent Current	< 100 microamps
Communications Current	5.0 milliamps
Communications Time	0.5 seconds/sample
Acquisition Current	30 milliamps
Acquisition Time	3 seconds/sample

Housing, Depth Rating, & Weight (with standard mooring guide & clamp, without pressure)

Standard	Titanium housing; 7000 m (23,000 ft) Weight in air: 4.0 kg (8.8 lbs) Weight in water 2.4 kg (5.3 lbs)
Optional ShallowCAT	Plastic housing; 250 m (820 ft) Weight in air: 2.9 kg (6.4 lbs) Weight in water 1.3 kg (2.9 lbs)

11/06

SBE
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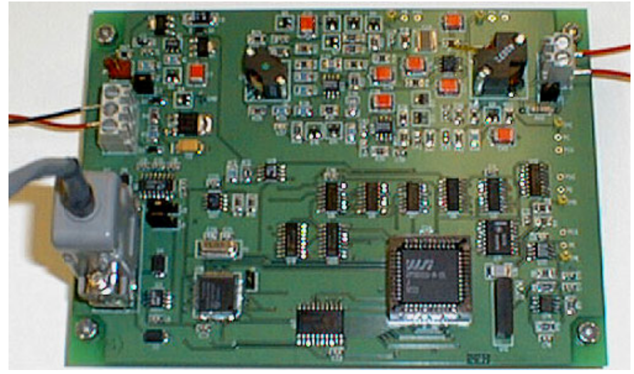
Surface Inductive Modem SIM



The Surface Inductive Modem (SIM) is a vital link in Sea-Bird's inductive modem (IM) telemetry systems, which provide data communications without the need for underwater electrical connections. Each system requires:

- **SIM**, housed in a buoy or on land. The SIM provides the link between the underwater IM instruments and computer / buoy controller. Communication with the computer / buoy controller is via RS-232 (optional RS-485).
- **Underwater IM instruments**. The SIM can link to up to 100 inductively coupled instruments on a jacketed mooring wire. Compatible instruments include:
  - SBE 37-IMP (or 37-IM) MicroCAT C-T (optional pressure) Recorder.
  - SBE 39-IM Temperature (optional pressure) Recorder
  - SBE 16*plus*-IM SEACAT C-T Recorder (optional pressure), which can acquire additional data from optional auxiliary sensors (oxygen, fluorescence, etc.).
  - SBE 44 Underwater IM, which links to a current meter, Doppler profiler, etc. with a standard serial interface.
  - Instruments by other manufacturers with built-in Sea-Bird underwater IMs.

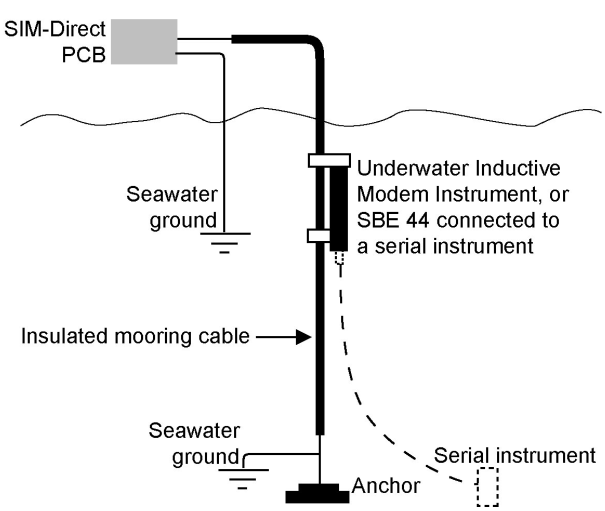
The SIM (a modem is a *modulator/demodulator*) impresses (*modulates*) the mooring cable with a DPSK signal that is encoded with the commands received from the user's computer/controller. The encoded signal is *demodulated* by underwater inductive modem instruments coupled to the mooring cable. The underwater inductive modem instrument interprets the commands and transmits replies via the mooring cable, which are *demodulated* by the SIM. The DPSK communication link between the SIM and underwater modem is half-duplex, so talking and listening is sequential only. Although the data link between the SIM and the user's computer/controller is established at 1200, 2400, 4800, or 9600 baud, the DPSK modem communication between SIM and underwater modem operates at 1200 baud.

SIM VERSIONS

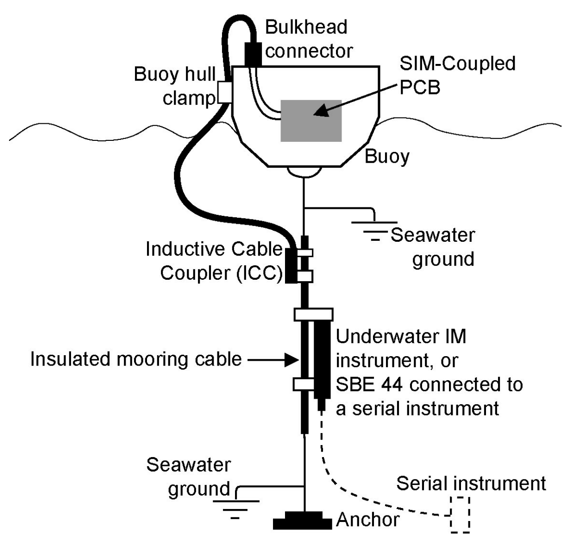
The SIM is available in two models, SIM-Direct and SIM-Coupled:

SIM-Direct: In a direct connection (typical cable to shore applications), the bottom end of the wire is grounded to seawater, and the top end remains insulated all the way to the connection to the SIM. A second wire from the SIM connects to seawater ground, completing the circuit.

SIM-Coupled: In typical surface buoys it is often preferable to connect the jacketed mooring wire to the buoy with a length of chain, grounding the jacketed wire to seawater at each end. An Inductive Cable Coupler (ICC) connects the SIM to the jacketed wire above the uppermost underwater inductive instrument and below the point where the wire is grounded.



SIM-Direct: Direct Connection



SIM-Coupled: ICC Connection

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Surface Inductive Modem SIM

DPSK (Differential Phase Shift Keyed) DATA TRANSMISSION

Sea-Bird's Inductive Modem telemetry system uses a DPSK data transmission method that overcomes most of the disadvantages of Frequency Shift Keyed (FSK) transmission, resulting in superior transmission efficiency and much lower error rates. The Sea-Bird system uses a carrier frequency of 4800 Hz, permitting four cycles of carrier frequency during the time allotted to each data bit (i.e., 1200 baud).

The encoding scheme is straightforward: if the next bit is a one, the phase of the carrier is inverted (shifted 180 degrees); if the next bit is a zero, the carrier phase does not change. With DPSK, both the modulation and demodulation hardware are extremely simple. Modulation requires only an OR gate and flip-flop, and demodulation is inherently coherent (bit energy is averaged rather than spot-sampled) using minimal hard logic, a shift register implementing a one-bit delay being the principle component. Further advantages are that the transmission of all zeros creates a single coherent frequency (4800 Hz) that is readily detected in inductive modem instruments as the *wake up* signal, and that - unlike FSK - the connection polarity of the transformers used for coupling does not matter.

COMMANDS

Commands sent to the SIM can be directed to the SIM, the underwater inductive modem, or the serial instrument connected to the underwater modem (if applicable). The commands below apply only to the SIM – see the appropriate underwater inductive modem manual for its commands.

COMMAND	DESCRIPTION
PWRON	Send wakeup tone to **all** underwater modems.
PWROFF	Send power off command to **all** underwater modems, and turn off transmitter. Underwater modems enter quiescent (sleep) state. Any data in underwater modem buffer is erased.
DS	Display SIM firmware version and status.
BAUD=x	**x** = baud rate between SIM and computer/controller (1200, 2400, 4800, 9600). Default 9600.
DATANNMAX=x	**x** = timeout that applies to **DATAii** only. If no reply received within **x** (0-65535 milliseconds), control returned to computer and other commands can be sent. Default 1000 milliseconds.
RELAYMAX=x	**x** = timeout that applies to all other commands. If no reply received within **x** (0-3276 seconds), control returned to computer and other commands can be sent. Default 20 seconds.
BINARYGAP=x	**x** = termination timeout (0 – 65535 milliseconds) that applies to commands requesting binary response from SBE 44. Gap of **x** since last byte received acts as termination character. Bytes sent after gap are ignored; control is returned to computer and other commands can be sent. Default 1000 milliseconds.
AUTOPWRON=x	**x=Y** (default): Send **PWRON** to underwater modems when power applied to SIM. This wakes up all UIMs on line. **x=N**: Do not send **PWRON** to underwater modems when power applied to SIM.
ECHOON	Echo characters received from computer (default).
ECHOOFF	Do not echo characters received from computer.

Note:
When using RS-232 communication from the computer to the SIM, control of the SIM can be re-established sooner than the timeout by pressing the Esc key and then the Enter key. When the `S>` prompt is displayed, new commands can be sent.

SPECIFICATIONS

SIM Specifications

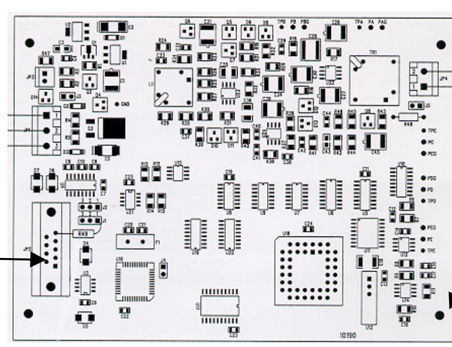
Sensor Interface to computer or buoy controller:
Standard: RS-232C; 1200, 2400, 4800, or 9600 baud; 8 data bits; no parity; echoing or no echoing of characters
Optional: RS-485

Current: 30 mA when communicating, 27 mA in quiescent state (**PWROFF**).
With control line, < 10 microamps when turned off.

Power: 7-25 VDC

Underwater Inductive Modem Instrument Specifications –
See SBE 37-IMP, 37-IM, 39-IM, 16*plus*-IM, and 44 datasheets

ICC Specifications –
See Inductive Cable Coupler datasheet



Dimensions:
PCB: 109 mm x 147.5 mm (4 1/4 x 5 3/4 inches)
Mounting holes: 90.5 mm x 138.1 mm (3 9/16 x 5 7/16 inches)

04/05

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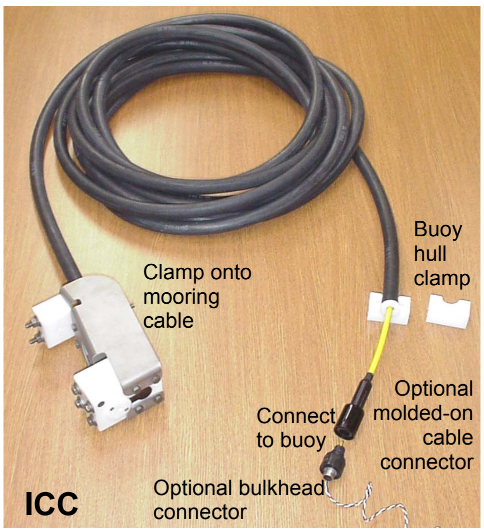
Inductive Cable Coupler (Version 4) ICC

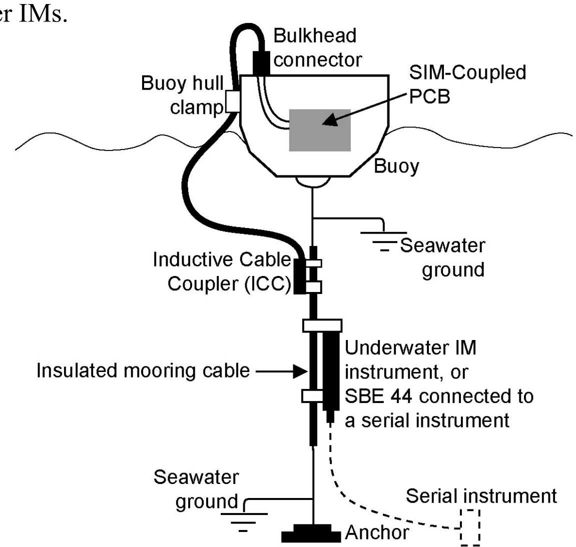
The ICC is a link in Sea-Bird's inductive modem (IM) telemetry systems. The ICC is used in applications where the plastic-jacketed wire termination is grounded to seawater (at a chain, for example). The ICC clamps to the jacketed mooring wire, and makes electrical connection with the Surface Inductive Modem (SIM) via a cable housed in reinforced-rubber conduit. The conduit's upper end is fixed to the buoy hull with the provided clamps. The conduit/cable must be long enough to prevent buoy motion from pulling it completely straight and putting tension on the ICC.

An IM telemetry system typically includes:

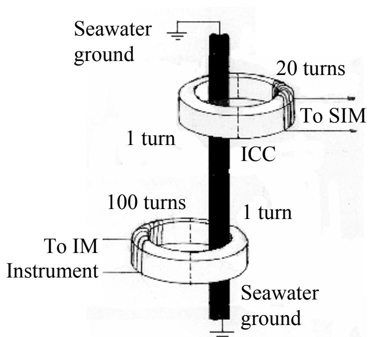
- **Surface Inductive Modem (SIM)**, housed in a buoy or on land. The SIM provides the link between the underwater IM instruments and computer / buoy controller.
- **Inductive Cable Coupler (ICC)**, which links the underwater IM and SIM *for typical buoy applications*.
- **Underwater IM instruments**, up to 100 inductively coupled instruments on a jacketed mooring wire. Compatible instruments include:
  - SBE 37-IMP (or 37-IM) MicroCAT C-T (optional pressure) Recorder.
  - SBE 39-IM Temperature (optional pressure) Recorder
  - SBE 16*plus*-IM SEACAT C-T (optional pressure) Recorder, which can acquire additional data from optional auxiliary sensors (oxygen, fluorescence, etc.).
  - SBE 44 Underwater IM, which links to a current meter, Doppler profiler, etc. with a standard serial interface.
  - Instruments by other manufacturers with built-in Sea-Bird underwater IMs.



Note: ICC includes pigtail cable, conduit, and buoy hull clamp; molded-on cable connector and bulkhead connector optional.



Inductive Modem System



PRINCIPLES OF INDUCTIVE COUPLING

A transformer has two or more coils that share a magnetic field. Materials such as ferrite can be used to form a transformer *core* that ensures the necessary sharing of magnetic fields.

When using the ICC with Sea-Bird's IM telemetry system, the ends of the mooring cable are grounded to the seawater. This causes a current to flow through the mooring wire and seawater. The ICC senses this current, providing a voltage for presentation to the SIM.

ICC CONFIGURATION CHOICES

- Mooring cable diameter - 1/4 inch, 5/16 inch, 3/8 inch, 1/2 inch, 6 mm, 8 mm, 10 mm, 12 mm, or 16 mm (5/8 inch)
- Cable length specified up to 10 meters (32.8 feet); longer lengths available – over 50 meters (164 feet) not recommended
- ICC comes with pigtail cable, conduit, and buoy hull clamp. Optional molded-on cable connector and matching bulkhead connector can be ordered; consult factory for availability.

ICC DEPTH RATING

To 7000 meters (23,000 ft).

ADDITIONAL INFORMATION

See SBE 37-IMP, SBE 37-IM, SBE 39-IM, SBE 16*plus*-IM, SBE 44, and SIM datasheets.

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APPLICATION NOTES

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APPLICATION NOTE NO. 2D **Revised October 2006**

Instructions for Care and Cleaning of Conductivity Cells

This application note presents new recommendations, based on our recent research, for cleaning and storing conductivity sensors. In the past, Sea-Bird had recommended cleaning and storing conductivity sensors with a Triton X-100 solution, and cleaning conductivity sensors with an acid solution. **Our latest research leads us to recommend adding the use of a dilute bleach solution to eliminate growth of bio-organisms, and eliminating the use of acid in most cases**.

The application note is divided into three sections:
- General discussion
- Rinsing, cleaning, and storage procedures
- Cleaning materials

General Discussion

Since any conductivity sensor's output reading is proportional to its cell dimensions, it is important to keep the cell clean of internal coatings. Also, cell electrodes contaminated with oil, biological growths, or other foreign material will cause low conductivity readings. A desire to provide better control of growth of bio-organisms in the conductivity cell led us to develop revised rinsing and cleaning recommendations.

- A dilute bleach solution is extremely effective in controlling the growth of bio-organisms in the conductivity cell. Lab testing at Sea-Bird over the past year indicates no damaging effect from use of a dilute bleach solution in cleaning the conductivity cell. Sea-Bird now recommends cleaning the conductivity sensor in a bleach solution.
- Triton X-100 is a mild, non-ionic surfactant (detergent), valuable for removal of surface and airborne oil ingested into the CTD plumbing as the CTD is removed from the water and brought on deck. Sea-Bird had previously recommended, and continues to recommend, rinsing and cleaning the conductivity sensor in a Triton solution.
- Sea-Bird had previously recommended acid cleaning for eliminating bio-organisms or mineral deposits on the inside of the cell. However, bleach cleaning has proven to be effective in eliminating growth of bio-organisms; bleach is much easier to use and to dispose of than acid. Furthermore, data from many years of use shows that mineral deposits are an unusual occurrence. Therefore, Sea-Bird now recommends that, in most cases, acid should not be used to clean the conductivity sensor. ***In rare instances***, acid cleaning may still be required for mineral contamination of the conductivity cell. ***Sea-Bird recommends that you return the equipment to the factory for this cleaning if it is necessary***.

Sea-Bird had previously recommended storing the conductivity cell filled with water to keep the cell wetted, unless the cell was in an environment where freezing is a possibility (the cell could break if the water freezes). However, no adverse affects have been observed as a result of dry storage, if the cell is rinsed with fresh, clean water before storage to remove any salt crystals. This leads to the following revised conductivity cell storage recommendations:
- Short term storage (less than 1 day, typically between casts): If there is no danger of freezing, store the conductivity cell with a dilute bleach solution in Tygon tubing looped around the cell. If there is danger of freezing, store the conductivity cell dry, with Tygon tubing looped around the cell.
- Long term storage (longer than 1 day): Since conditions of transport and long term storage are not always under the control of the user, we now recommend storing the conductivity cell dry, with Tygon tubing looped around the cell ends. Dry storage eliminates the possibility of damage due to unforeseen freezing, as well as the possibility of bio-organism growth inside the cell. Filling the cell with a Triton X-100 solution for 1 hour before deployment will *rewet* the cell adequately.

Note that the Tygon tubing looped around the ends of the conductivity cell, whether dry or filled with a bleach or Triton solution, has the added benefit of keeping air-borne contaminants (abundant on most ships) from entering the cell.

Rinsing, Cleaning, and Storage Procedures

Note: See *Cleaning Materials* below for discussion of appropriate sources / concentrations of water, Triton X-100, bleach, and tubing.

CAUTIONS:

- The conductivity cell is primarily glass, and can break if mishandled. Use the correct size Tygon tubing; using tubing with a smaller ID will make it difficult to remove the tubing, and the cell end may break if excessive force is used. **The correct size tubing for use in cleaning / storing all conductivity cells produced since 1980 is 7/16" ID, 9/16" OD**. Instruments shipped prior to 1980 had smaller retaining ridges at the ends of the cell, and 3/8" ID tubing is required for these older instruments.
- **Do not put a brush or object (e.g., Q-Tip) inside the conductivity cell to clean it or dry it.** Touching and bending the electrodes can change the calibration; large bends and movement of the electrodes can damage the cell.
- **If an SBE 43 dissolved oxygen (DO) sensor is plumbed to the CTD** - Before soaking the conductivity cell for more than 1 minute in Triton X-100 solution, **disconnect the tubing between the conductivity cell and DO sensor** to prevent extended Triton contact with the DO sensor membrane (extended Triton contact can damage the membrane). See *Application Note 64* for rinsing, cleaning, and storage recommendations for the SBE 43.

Active Use (after each cast)

1. Rinse: Remove the plumbing (Tygon tubing) from the exhaust end of the conductivity cell. **Flush** the cell with a **0.1% Triton X-100** solution. **Rinse** thoroughly with **fresh, clean water** and drain.
   - If not rinsed between uses, salt crystals may form on the conductivity cell platinized electrode surfaces. When the instrument is used next, sensor accuracy may be temporarily affected until these crystals dissolve.
2. Store: The intent of these storage recommendations is to keep contamination from aerosols and spray/wash on the ship deck from harming the sensor's calibration.
   - ***No danger of freezing***: **Fill** the cell with a **500 – 1000 ppm bleach** solution, using a length of Tygon tubing attached to each end of the conductivity sensor to close the cell ends.
   - ***Danger of freezing***: Remove larger droplets of water by blowing through the cell. **Do not use compressed air**, which typically contains oil vapor. Attach a length of Tygon tubing to each end of the conductivity cell to close the cell ends.

Routine Cleaning (no visible deposits or marine growths on sensor)

1. **Agitate** a **500 – 1000 ppm Bleach** solution warmed to 40 °C through the cell in a washing action (this can be accomplished with Tygon tubing and a syringe kit – see *Application Note 34*) for **2 minutes**. **Drain and flush** with warm (not hot) fresh, clean water for **5 minutes**.
2. **Agitate** a **1%-2% Triton X-100** solution warmed to 40 °C through the cell many times in a washing action (this can be accomplished with Tygon tubing and a syringe kit). Fill the cell with the solution and let it **soak** for **1 hour**. **Drain and flush** with warm (not hot) fresh, clean water for **5 minutes**.

Cleaning Severely Fouled Sensors (visible deposits or marine growths on sensor)

Repeat the *Routine Cleaning* procedure up to 5 times.

Long-Term Storage (after field use)

1. Rinse: Remove the plumbing (Tygon tubing) from the exhaust end of the conductivity cell. **Flush** the cell with a **0.1% Triton X-100** solution. **Rinse** thoroughly with **fresh, clean water** and drain. Remove larger droplets of water by blowing through the cell. **Do not use compressed air**, which typically contains oil vapor.
2. Store: Attach a length of Tygon tubing to each end of the conductivity cell to close the cell ends. The loop prevents any contaminants from entering the cell.
   - Storing the cell dry prevents the growth of any bio-organisms, thus preserving the calibration.
3. When ready to deploy again: **Fill** the cell with a **0.1% Triton X-100** solution for **1 hour** before deployment. Drain the Triton X-100 solution; there is no need to rinse the cell.

Cleaning Materials

Water

De-ionized (DI) water, commercially distilled water, or fresh, clean, tap water is recommended for rinsing, cleaning, and storing sensors.

- On ships, **fresh water is typically made in large quantities by a distillation process, and stored in large tanks. This water may be contaminated with small amounts of oil, and should not be used for rinsing, cleaning, or storing sensors**.

Where fresh water is in extremely limited supply (for example, a remote location in the Arctic), you can substitute **clean seawater** for rinsing and cleaning sensors. If not immediately redeploying the instrument, follow up with a **brief fresh water rinse** to eliminate the possibility of salt crystal formation (salt crystal formation could cause small shifts in calibration).

- **The seawater must be extremely clean, free of oils that can coat the conductivity cell. To eliminate any bio-organisms in the water, Sea-Bird recommends boiling the water or filtering it with a 0.5 micron filter.**

Triton X-100

Triton X-100 is Octyl Phenol Ethoxylate, a mild, non-ionic surfactant (detergent). Triton X-100 is included with every CTD shipment and can be ordered from Sea-Bird, but may be available locally from a chemical supply or lab products company. It is manufactured by Mallinckrodt Baker (see http://www.mallbaker.com/changecountry.asp?back=/Default.asp for local distributors). Other liquid detergents can probably be used, but scientific grades (with no colors, perfumes, glycerins, lotions, etc.) are required because of their known composition. It is better to use a non-ionic detergent, since conductivity readings taken immediately after use are less likely to be affected by any residual detergent left in the cell.

100% Triton X-100 is supplied by Sea-Bird; dilute the Triton as directed in *Rinsing, Cleaning, and Storage Procedures*.

Bleach

Bleach is a common household product used to whiten and disinfect laundry. Commercially available bleach is typically 4 % - 7% (40,000 – 70,000 ppm) sodium hypochlorite (Na-O-Cl) solution that includes stabilizers. Some common commercial product names are Clorox (U.S.) and eau de Javel (French).

Dilute to 500 – 1000 ppm. For example, if starting with 5% (50,000 ppm) sodium hypochlorite, diluting 50 to 1 (50 parts water to 1 part bleach) yields a 1000 ppm (50,000 pm / 50 = 1000 ppm) solution.

Tygon Tubing

Sea-Bird recommends use of Tygon tubing, because it remains flexible over a wide temperature range and with age. Tygon is manufactured by Saint-Gobain (see *www.tygon.com*). It is supplied by Sea-Bird, but may be available locally from a chemical supply or lab products company.

Keep the Tygon in a clean place (so that it does not pick up contaminants) while the instrument is in use.

Acid

In rare instances, acid cleaning is required for mineral contamination of the conductivity cell. ***Sea-Bird recommends that you return the equipment to the factory for this cleaning***. Information below is provided if you cannot return the equipment to Sea-Bird.

CAUTIONS:

- **SBE 37-IMP, 37-SMP, or 37-SIP MicroCAT; SBE 49 FastCAT; or other instruments with an integral, internal pump - Do not perform acid cleaning.** Acid cleaning may damage the internal, integral pump. Return these instruments to Sea-Bird for servicing if acid cleaning is required.
- **SBE 9*plus* or SBE 25 CTD** – Remove the SBE 4 conductivity cell from the CTD and remove the TC Duct before performing the acid cleaning procedure.
- **All instruments which include AF24173 Anti-Foulant Devices** – Remove the AF24173 Anti-Foulant Devices before performing the acid cleaning procedure. See the instrument manual for details and handling precautions when removing AF24173 Anti-Foulant Devices.

WARNING! Observe all precautions for working with strong acid. Avoid breathing acid fumes. Work in a well-ventilated area.

The acid cleaning procedure for the conductivity cell uses approximately 50 - 100 cc of acid. Sea-Bird recommends using a 20% concentration of HCl. However, acid in the range of 10% to full strength (38%) is acceptable.

If starting with a strong concentration of HCl that you want to dilute:
For each 100 cc of concentrated acid, to get a 20% solution, mix with this amount of water -
Water = [(conc% / 20%) – 1] * [100 + 10 (conc% / 20%)] cc
Always add acid to water; never add water to acid.

Example -- concentrated solution 31.5% that you want to dilute to 20%:
[(31.5% / 20%) – 1] * [100 + 10 (31.5% / 20%)] = 66.6 cc of water.
So, adding 100 cc of 31.5% HCl to 66.6 cc of water provides 166.6 cc of the desired concentration.
For 100 cc of solution:
100 cc * (100 / 166.6) = 60 cc of 31.5% HCl   66.6 cc * (100 / 166.6) = 40 cc of water

For acid disposal, dilute the acid heavily or neutralize with bicarbonate of soda (baking soda).

1. Prepare for cleaning:
   A. Place a 0.6 m (2 ft) length of Tygon tubing over the end of the cell.
   B. Clamp the instrument so that the cell is vertical, with the Tygon tubing at the bottom end.
   C. Loop the Tygon tubing into a U shape, and tape the open end of the tubing in place at the same height as the top of the glass cell.
2. Clean the cell:
   A. Pour **10% to 38% HCl** solution into the open end of the tubing until the cell is nearly filled. **Let it soak for 1 minute only.**
   B. Drain the acid from the cell and flush for 5 minutes with warm (not hot), clean, de-ionized water.
   C. Rinse the exterior of the instrument to remove any spilled acid from the surface.
   D. Fill the cell with a **1% Triton X-100** solution and let it stand for 5 minutes.
   E. Drain and flush with warm, clean, de-ionized water for 1 minute.
   F. Carefully remove the 0.6 m (2 ft) length of Tygon tubing.
3. Prepare for deployment, **or** follow recommendations above for storage.

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APPLICATION NOTE NO. 10 **Revised July 2005**

COMPRESSIBILITY COMPENSATION OF SEA-BIRD CONDUCTIVITY SENSORS

Sea-Bird conductivity sensors provide precise characterization of deep ocean water masses. To achieve the accuracy of which the sensors are capable, an accounting for the effect of hydrostatic loading (pressure) on the conductivity cell is necessary. Conductivity calibration certificates show an equation containing the appropriate pressure-dependent correction term, which has been derived from mechanical principles and confirmed by field observations. The form of the equation varies somewhat, as shown below:

SBE 4, 9, 9*plus*, 16, 19, 21, 25, 26, 26*plus*, and 53 BPR

$$\text{Conductivity (Siemens/meter)} = \text{slope}\ \frac{(g + h f^2 + i f^3 + j f^4) / 10}{1 + [\text{CTcor}]\, t + [\text{CPcor}]\, p} + \text{offset} \qquad (\textbf{recommended})$$

or

$$\text{Conductivity (Siemens/meter)} = \text{slope}\ \frac{(a f^m + b f^2 + c + dt) / 10}{1 + [\text{CPcor}]\, p} + \text{offset}$$

SBE 16*plus*, 19*plus*, 37, 45, 49, and 52-MP

$$\text{Conductivity (Siemens/meter)} = \text{slope}\ \frac{g + h f^2 + i f^3 + j f^4}{1 + [\text{CTcor}]\, t + [\text{CPcor}]\, p} + \text{offset}$$

where

- a, b, c, d, m, and CPcor are the calibration coefficients used for older sensors (prior to January 1995). Sea-Bird continues to calculate and print these coefficients on the calibration sheets for use with old software, but recommends use of the g, h, i, j, CTcor, CPcor form of the equation for most accurate results.
- g, h, i, j, CTcor, and CPcor are the calibration coefficients used for newer sensors.
  Note: The SBE 26, 26*plus*, and 53 BPR use the SBE 4 conductivity sensor, so both sets of calibration coefficients are reported on the calibration sheet. *SEASOFT for Waves* **for DOS**, which can be used with the SBE 26 only, only supports use of the a, b, c, d, CTcor, and CPcor coefficients. The current processing software for these instruments, *SEASOFT for Waves* **for Windows**, only supports use of the g, h, i, j, CTcor, CPcor coefficients.
- **CPcor is the correction term for pressure effects on conductivity (see below for discussion)**
- slope and offset are correction coefficients used to make corrections for sensor drift between calibrations; set to 1.0 and 0 respectively on initial calibration by Sea-Bird (see Application Note 31 for details on calculating slope and offset)
- f is the instrument frequency (kHz) for all instruments except the SBE 52-MP.
  For the SBE 52-MP, $f = \text{instrument frequency (kHz)} * (1.0 + \text{WBOTC} * t)^{0.5} / 1000.00$
- t is the water temperature (°C).
- p is the water pressure (decibars).

Sea-Bird CTD data acquisition, display, and post-processing software *SEASOFT for Waves* (for SBE 26, 26*plus*, and 53 only) and *SEASOFT* (for all other instruments) automatically implement these equations.

DISCUSSION OF PRESSURE CORRECTION

Conductivity cells do not measure the specific conductance (the desired property), but rather the conductance of a *specific geometry* of water. The ratio of the cell's length to its cross-sectional area (*cell constant*) is used to relate the measured conductance to specific conductance. Under pressure, the conductivity cell's length and diameter are reduced, leading to a lower indicated conductivity. The magnitude of the effect is not insignificant, reaching 0.0028 S/m at 6800 dbars.

The compressibility of the borosilicate glass used in the conductivity cell (and all other homogeneous, noncrystalline materials) can be characterized by E (Young's modulus) and ν (Poisson's ratio). For the Sea-Bird conductivity cell, $E = 9.1 \times 10^6$ psi, $\nu = 0.2$, and the ratio of indicated conductivity divided by true conductivity is:

$1 + s$
where $s = (\text{CPcor})(\text{p})$
Typical value for CPcor is -9.57×10^{-8} for pressure in decibars **or** -6.60×10^{-8} for pressure in psi

Note: This equation, and the mathematical derivations below, deals only with the pressure correction term, and does not address the temperature correction term.

MATHEMATICAL DERIVATION OF PRESSURE CORRECTION

For a cube under hydrostatic load:

$\Delta L / L = s = -p\,(1 - 2\nu) / E$
where
- p is the hydrostatic pressure
- E is Young's modulus
- ν is Poisson's ratio
- $\Delta L / L$ and s are strain (change in length per unit length)

Since this relationship is linear in the forces and displacements, the relationship for strain also applies for the length, radius, and wall thickness of a cylinder.

To compute the effect on conductivity, note that $R_0 = \rho L / A$, where R_0 is resistance of the material at 0 pressure, ρ is volume resistivity, L is length, and A is cross-sectional area. For the conductivity cell $A = \pi r^2$, where r is the cell radius. Under pressure, the new length is $L\,(1 + s)$ and the new radius is $r\,(1 + s)$. If R_p is the cell resistance under pressure:

$$R_p = \rho L\,(1 + s) / (\pi r^2 [1 + s]^2) = \rho L / \pi r^2 (1 + s) = R_0 / (1 + s)$$

Since conductivity is 1/R:

$C_p = C_0 (1 + s)$ and $C_0 = C_p / (1 + s) = C_p / (1 + [\text{Cpcor}]\,[\text{p}])$
where
- C_0 is conductivity at 0 pressure
- C_p is conductivity measured at pressure

A less rigorous determination may be made using the material's bulk modulus. For small displacements in a cube:

$\Delta V / V = 3\Delta L / L = -3p\,(1 - 2\nu) / E$ or $\Delta V/V = -p / K$
where
- $\Delta V / V$ is the change in volume per volume or volume strain
- K is the bulk modulus. K is related to E and ν by $K = E / 3\,(1 - 2\nu)$.

In this case, $\Delta L / L = -p / 3K$.

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APPLICATION NOTE NO. 14 **January 1989**

1978 PRACTICAL SALINITY SCALE

Should you not be already familiar with it, we would like to call your attention to the January 1980 issue of the IEEE Journal of Oceanic Engineering, which is dedicated to presenting the results of a multi-national effort to obtain a uniform repeatable Practical Salinity Scale, based upon electrical conductivity measurements. This work has been almost universally accepted by researchers, and all instruments delivered by Sea-Bird since February 1982 have been supplied with calibration data based upon the new standard.

The value for conductivity at 35 ppt, 15 degrees C, and 0 pressure [C(35,15,0)] was not agreed upon in the IEEE reports -- Culkin & Smith used 42.914 mmho/cm (p 23), while Poisson used 42.933 mmho/cm (p 47). It really does not matter which value is used, provided that the same value is used during data reduction that was used to compute instrument calibration coefficients. Our instrument coefficients are computed using C(35,15,0) = 42.914 mmho/cm.

The PSS 1978 equations and constants for computing salinity from *in-situ* measurements of conductivity, temperature, and pressure are given in the 'Conclusions' section of the IEEE journal (p 14) and are reproduced back of this note. In the first equation, 'R' is obtained by dividing the conductivity value measured by your instrument by C(35,15,0), or 42.914 mmho/cm. Note that the PSS equations are based upon conductivity in units of mmho/cm, which are equal in magnitude to units of mS/cm. **If you are working in conductivity units of Siemens/meter (S/m), multiply your conductivity values by 10 before using the PSS 1978 equations**.

Also note that the equations assume pressure relative to the sea-surface. Absolute pressure gauges (as used in all Sea-Bird CTD instruments) have a vacuum on the reference side of their sensing diaphragms and indicate atmospheric pressure (nominally 10.1325 dBar) at the sea-surface. This reading must be subtracted to obtain pressure as required by the PSS equations. The pressure reading displayed when using Sea-Bird's SEASOFT CTD acquisition, display, and post-processing software is the corrected sea-surface pressure and is used by SEASOFT to compute salinity, density, etc in accordance with the PSS equations.

1978 PRACTICAL SALINITY SCALE EQUATIONS, from IEEE Journal of Oceanic Engineering, Vol. OE-5, No. 1, January 1980, page 14.

CONCLUSIONS

Using Newly generated data, a fit has been made giving the following algorithm for the calculation of salinity from data of the form:

$$R = \frac{C(S,T,P)}{C(35,15,0)}$$

T in °C (IPTS '68), P in decibars.

$$R_T = \frac{R}{R_P r_T};\ R_P = 1 + \frac{P \times (A_1 + A_2 P + A_3 P^2)}{1 + B_1 T + B_2 T^2 + B_3 R + B_4 R T}$$

$$r_T = c_0 + c_1 T + c_2 T^2 + c_3 T^3 + c_4 T^4$$

$A_1 = 2.070 \times 10^{-5}$ $\quad B_1 = 3.426 \times 10^{-2}$

$A_2 = -6.370 \times 10^{-10}$ $\quad B_2 = 4.464 \times 10^{-4}$

$A_3 = 3.989 \times 10^{-15}$ $\quad B_3 = 4.215 \times 10^{-1}$

$B_4 = -3.107 \times 10^{-3}$

$c_0 = 6.766097 \times 10^{-1}$

$c_1 = 2.00564 \times 10^{-2}$

$c_2 = 1.104259 \times 10^{-4}$

$c_3 = -6.9698 \times 10^{-7}$

$c_4 = 1.0031 \times 10^{-9}$

$$S = \sum_{j=0}^{5} a_j R_T^{j/2} + \frac{(T-15)}{1 + k(T-15)} \sum_{j=0}^{5} b_j R_T^{j/2}$$

$a_0 = 0.0080$ $\quad b_0 = 0.0005$ $\quad k = 0.0162.$

$a_1 = -0.1692$ $\quad b_1 = -0.0056$

$a_2 = 25.3851$ $\quad b_2 = -0.0066$

$a_3 = 14.0941$ $\quad b_3 = -0.0375$

$a_4 = -7.0261$ $\quad b_4 = 0.0636$

$a_5 = 2.7081$ $\quad b_5 = -0.0144$

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APPLICATION NOTE 27Druck **Revised July 2005**

Minimizing Strain Gauge Pressure Sensor Errors

The following Sea-Bird instruments use strain gauge pressure sensors manufactured by GE Druck:

- SBE 16*plus* and 16*plus*-IM SEACAT (not 16*) with optional strain gauge pressure sensor
- SBE 19*plus* SEACAT Profiler (not 19*)
- SBE 25 SEALOGGER CTD, which uses SBE 29 Strain-Gauge Pressure Sensor (built after March 2001)
- SBE 26*plus* SEAGAUGE Wave and Tide Recorder with optional strain gauge pressure sensor in place of Quartz pressure sensor
- SBE 37 MicroCAT (-IM, -IMP, -SM, -SMP, -SI, and -SIP) with optional pressure sensor (built after September 2000)
- SBE 39 Temperature Recorder with optional pressure sensor (built after September 2000) and 39-IM Temperature Recorder with optional pressure sensor
- SBE 49 FastCAT CTD Sensor
- SBE 50 Digital Oceanographic Pressure Sensor
- SBE 52-MP Moored Profiler CTD and DO Sensor

*** Note:** SBE 16 and SBE 19 SEACATs were originally supplied with other types of pressure sensors. However, a few of these instruments have been retrofitted with Druck sensors.

The Druck sensors are designed to respond to pressure in nominal ranges 0 - 20 meters, 0 - 100 meters, 0 - 350 meters, 0 – 600 meters, 0 – 1000 meters, 0 – 2000 meters, 0 – 3500 meters, and 0 – 7000 meters (with pressures expressed in meters of deployment depth capability). The sensors offer an initial accuracy of 0.1% of full scale range.

DEFINITION OF PRESSURE TERMS

The term *psia* means *pounds per square inch, absolute* (*absolute* means that the indicated pressure is referenced to a vacuum).

For oceanographic purposes, pressure is most often expressed in *decibars* (1 dbar = 1.4503774 psi). A dbar is 0.1 bar; a bar is approximately equal to a standard atmosphere (1 atmosphere = 1.01325 bar). For historical reasons, pressure at the water surface (rather than absolute or total pressure) is treated as the reference pressure (0 dbar); this is the value required by the UNESCO formulas for computation of salinity, density, and other derived variables.

Some oceanographers express pressure in Newtons/meter^2 or *Pascals* (the accepted SI unit). A Pascal is a very small unit (1 psi = 6894.757 Pascals), so the mega-Pascal (MPa = 10^6 Pascals) is frequently substituted (1 MPa = 100 dbar).

Since the pressure sensors used in Sea-Bird instruments are *absolute* types, their raw data inherently indicate atmospheric pressure (about 14.7 psi) when in air at sea level. Sea-Bird outputs pressure in one of the following ways:

- CTDs that output **raw data** (**SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, and 49**) and are supported by SEASOFT's SEASAVE (real-time data acquisition) and SBE Data Processing (data processing) software – In SEASOFT, user selects pressure output in psi (*not* psia) or dbar. SEASOFT subtracts 14.7 psi from the raw absolute reading and outputs the remainder as psi or converts the remainder to dbar.
- **SBE 26*plus*** – Real-time wave and tide data is output in psia. Wave and tide data stored in memory is processed using SEASOFT for Waves' Convert Hex module, and output in psia. Tide data can be converted to psi by subtracting a barometric pressure file using SEASOFT for Waves' Merge Barometric Pressure module.
- **SBE 50** – User selects pressure output in psia (including atmospheric pressure) or dbar. Calculation of dbar is as described above.
- All other instruments that can output **converted data in engineering units** (**SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 39-IM, 49, and 52-MP**) – Instrument subtracts 14.7 psi from the raw absolute reading and converts the remainder to dbar.

Note: SBE 16*plus*, 16*plus*-IM, 19*plus*, 49, and 52-MP can output raw **or** converted data.

RELATIONSHIP BETWEEN PRESSURE AND DEPTH

Despite the common nomenclature (CTD = **C**onductivity - **T**emperature - **D**epth), all CTDs measure *pressure*, which is not quite the same thing as depth. The relationship between pressure and depth is a complex one involving water density and compressibility as well as the strength of the local gravity field, but it is convenient to think of a decibar as essentially equivalent to a meter, an approximation which is correct within 3% for almost all combinations of salinity, temperature, depth, and gravitational constant.

SEASOFT (most instruments)

SEASOFT offers two methods for estimating depth from pressure.

- For oceanic applications, salinity is presumed to be 35 PSU, temperature to be 0^{o} C, and the compressibility of the water (with its accompanying density variation) is taken into account. This is the method recommended in UNESCO Technical Paper No. 44 and is a logical approach in that by far the greatest part of the deep-ocean water column approximates these values of salinity and temperature. Since pressure is also proportional to gravity and the major variability in gravity depends on latitude, the user's latitude entry is used to estimate the magnitude of the local gravity field.
  - SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, and 49 - User is prompted to enter latitude if Depth [salt water] is selected as a display variable in SEASAVE or as an output variable in the Data Conversion or Derive module of SBE Data Processing.
  - SBE 37-SM, 37-SMP, 37-IM, and 37-IMP - User is prompted to enter latitude if Depth [salt water] is selected as an output variable in the Derive module of SBE Data Processing.
  - SBE 37-SI, 37-SIP, and 50 - Latitude is entered in the instrument's EEPROM using the **LATITUDE=** command in SEASOFT's SEATERM (terminal program) software.
  - SBE 39 and 39-IM – User is prompted to enter latitude if conversion of pressure to depth is requested when converting an uploaded .asc file to a .cnv file in SEATERM.
- For fresh water applications, compressibility is not significant in the shallow depths encountered and is ignored, as is the latitude-dependent gravity variation. Fresh water density is presumed to be 1 gm/cm, and depth (in meters) is calculated as 1.019716 * pressure (in dbars). No latitude entry is required for the following:
  - SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, and 49 - If Depth [fresh water] is selected as a display variable in SEASAVE or as an output variable in the Data Conversion or Derive module of SBE Data Processing.
  - SBE 37-SM, 37-SMP, 37-IM, and 37-IMP - If Depth [fresh water] is selected as an output variable in the Derive module of SBE Data Processing.

SEASOFT for Waves (SBE 26plus SEAGAUGE Wave and Tide Recorder)

SEASOFT for Waves' Merge Barometric Pressure module subtracts a user-input barometric pressure file from the tide data file, and outputs the remainder as pressure in psi or as depth in meters. When converting to depth, the compressibility of the water is taken into account by prompting for user-input values for average density and gravity. See the SBE 26*plus* manual's appendix for the formulas for conversion of pressure to depth.

CHOOSING THE RIGHT SENSOR

Initial accuracy and resolution are expressed as a percentage of the full scale range for the pressure sensor. The initial accuracy is 0.1% of the full scale range. Resolution is 0.002% of full scale range, except for the SBE 25 (0.015% resolution). For best accuracy and resolution, select a pressure sensor full scale range to correspond to no more than the greatest depths to be encountered. The effect of this choice on CTD accuracy and resolution is shown below:

Range (meters)	Maximum Initial Error (meters)	SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 39-IM, 49, 50, and 52-MP - Resolution (meters)	SBE 25 - Resolution (meters)
0 – 20	0.02	0.0004	0.003
0 – 100	0.10	0.002	0.015
0 – 350	0.35	0.007	0.052
0 – 600	0.60	0.012	0.090
0 – 1000	1.0	0.02	0.15
0 - 2000	2.0	0.04	0.30
0 - 3500	3.5	0.07	0.52
0 - 7000	7.0	0.14	1.05

Note: See the SBE 26*plus* manual or data sheet for its resolution specification; 26*plus* resolution is a function of integration time as well as pressure sensor range.

The meaning of *accuracy*, as it applies to these sensors, is that the indicated pressure will conform to true pressure to within ± *maximum error* (expressed as equivalent depth) throughout the sensor's operating range. Note that a 7000-meter sensor reading + 7 meters at the water surface is operating within its specifications; the same sensor would be expected to indicate 7000 meters ± 7 meters when at full depth.

Resolution is the magnitude of indicated increments of depth. For example, a 7000-meter sensor on an SBE 25 (resolution 1.05 meters) subjected to slowly increasing pressure will produce readings approximately following the sequence *0, 1.00, 2.00, 3.00* (meters). Resolution is limited by the design configuration of the CTD's A/D converter. For the SBE 25, this restricts the possible number of discrete pressure values for a given sample to somewhat less than 8192 (13 bits); an approximation of the ratio 1 : 7000 is the source of the SBE 25's 0.015% resolution specification.

Note: SEASOFT (and other CTD software) presents temperature, salinity, and other variables as a function of depth or pressure, so the CTD's pressure resolution limits the number of plotted data points in the profile. For example, an SBE 25 with a 7000-meter sensor might acquire several values of temperature and salinity during the time required to descend from 1- to 2-meters depth. However, all the temperature and salinity values will be graphed in clusters appearing at either 1 or 2 meters on the depth axis.

High-range sensors used in shallow water generally provide better accuracy than their *absolute* specifications indicate. With careful use, they may exhibit *accuracy* approaching their *resolution* limits. For example, a 3500-meter sensor has a nominal accuracy (irrespective of actual operating depth) of ± 3.5 meters. Most of the error, however, derives from variation over time and temperature of the sensor's *offset*, while little error occurs as a result of changing *sensitivity*.

MINIMIZING ERRORS

Offset Errors

Note: Follow the procedures below for all instruments except the SBE 26*plus* (see the 26*plus* manual for details).

The primary *offset* error due to drift over time can be eliminated by comparing CTD readings in air before beginning the profile to readings from a barometer. Follow this procedure:

1. Allow the instrument to equilibrate in a reasonably constant temperature environment for at least 5 hours. Pressure sensors exhibit a transient change in their output in response to changes in their environmental temperature; allowing the instrument to equilibrate before starting will provide the most accurate calibration correction.

2. Place the instrument in the orientation it will have when deployed.

3. Set the pressure offset to 0.0:
   - In the .con file, using SEASAVE or SBE Data Processing (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, or 49).
   - In the CTD's EEPROM, using the appropriate command in SEATERM (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 39-IM, 49, 50, or 52-MP).

4. Collect pressure data from the instrument using SEASAVE or SEATERM (see instrument manual for details). If the instrument is not outputting data in decibars, convert the output to decibars.

5. Compare the instrument output to the reading from a good barometer placed at the same elevation as the pressure sensor. Calculate *offset* (decibars) = barometer reading (converted to decibars) – instrument reading (decibars).

6. Enter calculated offset (positive or negative) in decibars:
   - In the .con file, using SEASAVE or SBE Data Processing (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, or 49).
   - In the CTD's EEPROM, using the appropriate command in SEATERM (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 39-IM, 49, 50, or 52-MP).

Note: For instruments that store calibration coefficients in EEPROM and also use a .con file (SBE 16*plus*, 16*plus*-IM, 19*plus*, and 49), set the pressure offset (Steps 3 and 6 above) in both the EEPROM and in the .con file.

Offset Correction Example
Absolute pressure measured by a barometer is 1010.50 mbar. Pressure displayed from instrument is -2.5 dbars.
Convert barometer reading to dbars using the relationship: mbar * 0.01 = dbars
Barometer reading = 1010.50 mbar *0.01 = 10.1050 dbars
Instrument's internal calculations and/or our processing software output gage pressure, using an assumed value of 14.7 psi for atmospheric pressure. Convert instrument reading from gage to absolute by adding 14.7 psia to instrument output: - 2.5 dbars + (14.7 psi * 0.689476 dbar/psia) = - 2.5 + 10.13 = 7.635 dbars
Offset = 10.1050 – 7.635 = + 2.47 dbar
Enter offset in .con file (if applicable) and in instrument EEPROM (if applicable).

Another source of *offset* error results from temperature-induced drifts. Because Druck sensors are carefully temperature compensated, errors from this source are small. Offset errors can be estimated for the conditions of your profile, and eliminated when post-processing the data in SBE Data Processing by the following procedure:

1. **Immediately** before beginning the profile, take a pre-cast *in air* pressure reading.

2. **Immediately** after ending the profile, take a post-cast *in air* pressure reading with the instrument at the same elevation and orientation. This reading reflects the change in the instrument temperature as a result of being submerged in the water during the profile.

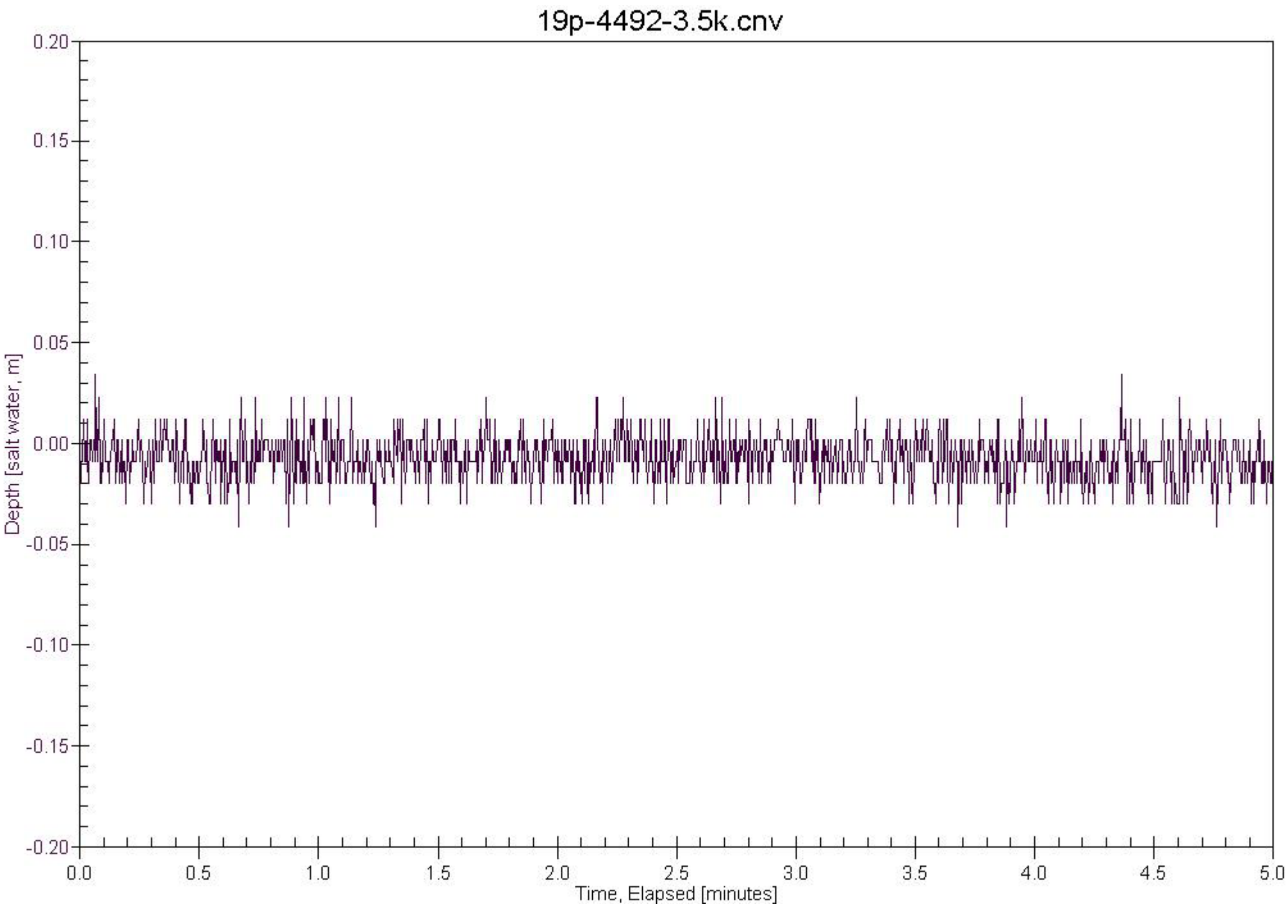
3. Calculate the average of the pre- and post-cast readings. Enter the negative of the average value (in decibars) as the *offset* in the .con file.

Hysteresis Errors

Hysteresis is the term used to describe the failure of pressure sensors to repeat previous readings after exposure to other (typically higher) pressures. The Druck sensor employs a micro-machined silicon diaphragm into which the strain elements are implanted using semiconductor fabrication techniques. Unlike metal diaphragms, silicon's crystal structure is perfectly elastic, so the sensor is essentially free of pressure hysteresis.

Power Turn-On Transient

Druck pressure sensors exhibit virtually no power turn-on transient. The plot below, for a 3500-meter pressure sensor in an SBE 19*plus* SEACAT Profiler, is representative of the power turn-on transient for all pressure sensor ranges.



Thermal Transient

Pressure sensors exhibit a transient change in their output in response to changes in their environmental temperature, so the thermal transient resulting from submersion in water must be considered when deploying the instrument.

During calibration, the sensors are allowed to *warm-up* before calibration points are recorded. Similarly, for best depth accuracy the user should allow the CTD to *warm-up* for several minutes before beginning a profile; this can be part of the *soak* time in the surface water. *Soaking* also allows the CTD housing to approach thermal equilibrium (minimizing the housing's effect on measured temperature and conductivity) and permits a Beckman- or YSI-type dissolved oxygen sensor (if present) to polarize.

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APPLICATION NOTE NO. 42 **Revised September 2001**

ITS-90 TEMPERATURE SCALE

Beginning January 1995, Sea-Bird temperature calibration certificates list a new set of coefficients labeled *g*, *h*, *i*, *j*, and *F0*. These coefficients correspond to ITS90 (T90) temperatures and should be entered by those researchers working with SEASOFT-DOS Versions 4.208 and higher (and all versions of SEASOFT-Win32). For the convenience of users who prefer to use older SEASOFT versions, the new certificates also list *a*, *b*, *c*, *d*, and *F0* coefficients corresponding to IPTS68 (T68) temperatures as required by SEASOFT-DOS versions older than 4.208.

It is important to note that the international oceanographic research community will continue to use T68 for computation of salinity and other seawater properties. Therefore, following the recommendations of Saunders (1990) and as supported by the Joint Panel on Oceanographic Tables and Standards (1991), SEASOFT-DOS 4.200 and later and all versions of SEASOFT-Win32 convert between T68 and T90 according to the linear relationship:

$$\mathbf{T_{68} = 1.00024 * T_{90}}$$

The use of T68 for salinity and other seawater calculations is automatic in all SEASOFT programs. However, when selecting **temperature** as a display/output variable, you will be prompted to specify which standard (T90 or T68) is to be used to compute temperature. SEASOFT recognizes whether you have entered T90 or T68 coefficients in the configuration (.con) file, and computes T90 temperature directly or calculates it from the Saunders linear approximation, depending on which coefficients were used and which display variable type is selected.

For example, if *g, h, i, j, F0* coefficients (T90) are entered in the .con file and you select temperature variable type as T68, SEASOFT computes T90 temperature directly and multiplies it by 1.00024 to display T68. Conversely, if *a, b, c, d,* and *F0* coefficients (T68) are entered in the .con file and you select temperature variable type as T90, SEASOFT computes T68 directly and divides by 1.00024 to display T90.

Note: The CTD configuration (.con) file is edited using the Configure menu (in SEASAVE or SBE Data Processing in our SEASOFT-Win32 suite of programs) or SEACON (in SEASOFT-DOS).

Also beginning January 1995, Sea-Bird's own temperature metrology laboratory (based upon water triple-point and gallium melt cell, SPRT, and ASL F18 Temperature Bridge) converted to T90. These T90 standards are now employed in calibrating *all* Sea-Bird temperature sensors, and as the reference temperature used in conductivity calibrations. Accordingly, all calibration certificates show T90 (g, h, i, j) coefficients that result directly from T90 standards, and T68 coefficients (a, b, c, d) computed using the Saunders linear approximation.

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APPLICATION NOTE NO. 68 Revised **November 2006**

Using USB Ports to Communicate with Sea-Bird Instruments

Most Sea-Bird instruments use the RS-232 protocol for transmitting setup commands to the instrument and receiving data from the instrument. However, many newer PCs and laptop computers have USB port(s) instead of RS-232 serial port(s).

USB serial adapters are available commercially. These adapters plug into the USB port, and allow one or more serial devices to be connected through the adapter. Sea-Bird tested USB serial adapters from three manufacturers on desktop computers at Sea-Bird, and verified compatibility with our instruments. These manufacturers and the tested adapters are:

- **IOGEAR** (www.iogear.com) –
  USB 1.1 to Serial Converter Cable (model # GUC232A).
  Note: This adapter can also be purchased from Sea-Bird, as Sea-Bird part # 20163.

- **Keyspan** (www.keyspan.com) -
  USB 4-Port Serial Adapter (part # USA-49WLC, replacing part # USA-49W)

- **Edgeport** (www.ionetworks.com) -
  Standard Serial Converter Edgeport/2 (part # 301-1000-02)

Other USB adapters from these manufacturers, and adapters from other manufacturers, **may** also be compatible with Sea-Bird instruments.

We have one report from a customer that he could not communicate with his instrument using a notebook computer and the Keyspan adapter listed above. He was able to successfully communicate with the instrument using an XH8290 DSE Serial USB Adapter (www.dse.co.nz).

We recommend testing any adapters, *including those listed above*, with the instrument and the computer you will use it with before deployment, to verify that there is no problem.

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APPLICATION NOTE NO. 69 **July 2002**

Conversion of Pressure to Depth

Sea-Bird's SEASOFT software can calculate and output depth, if the instrument data includes pressure. Additionally, some Sea-Bird instruments (such as the SBE 37-SI or SBE 50) can be set up by the user to internally calculate depth, and to output depth along with the measured parameters.

Sea-Bird uses the following algorithms for calculating depth:

Fresh Water Applications

Because most fresh water applications are shallow, and high precision in depth not too critical, Sea-Bird software uses a very simple approximation to calculate depth:

$$\text{depth (meters)} = \text{pressure (decibars)} * 1.019716$$

Seawater Applications

Sea-Bird uses the formula in UNESCO Technical Papers in Marine Science No. 44. This is an empirical formula that takes compressibility (that is, density) into account. An ocean water column at 0 °C (t = 0) and 35 PSU (s = 35) is assumed.

The gravity variation with latitude and pressure is computed as:

$$g\ (\text{m/sec}^2) = 9.780318 * [\ 1.0 + (\ 5.2788\text{x}10^{-3} + 2.36\text{x}10^{-5} * x) * x\ ] + 1.092\text{x}10^{-6} * p$$

where
$x = [\sin(\text{latitude} / 57.29578)\ ]^2$
p = pressure (decibars)

Then, depth is calculated from pressure:

$$\text{depth (meters)} = [(((-1.82\text{x}10^{-15} * p + 2.279\text{x}10^{-10}) * p - 2.2512\text{x}10^{-5}) * p + 9.72659) * p] / g$$

where
p = pressure (decibars)
g = gravity (m/sec^2)

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APPLICATION NOTE NO. 71 **Revised July 2005**

Desiccant Use and Regeneration (drying)

This application note applies to all Sea-Bird instruments intended for underwater use. The application note covers:

- When to replace desiccant
- Storage and handling of desiccant
- Regeneration (drying) of desiccant
- Material Safety Data Sheet (MSDS) for desiccant

When to Replace Desiccant Bags

Before delivery of the instrument, a desiccant package is placed in the housing, and the electronics chamber is filled with dry Argon. These measures help prevent condensation. To ensure proper functioning:

1. Install a new desiccant bag each time you open the housing and expose the electronics.
2. If possible, dry gas backfill each time you open the housing and expose the electronics. If you cannot, wait at least 24 hours before redeploying, to allow the desiccant to remove any moisture from the chamber.

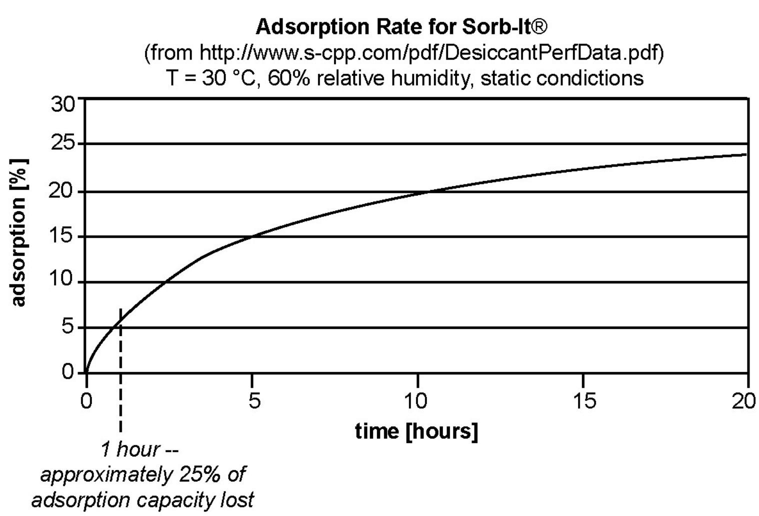
What do we mean by *expose the electronics*?

- For most battery-powered Sea-Bird instruments (such as SBE 16, 16*plus*, 16*plus*-IM, 17*plus*, 19, 19*plus*, 25, 26, 26*plus*, 37-SM, 37-SMP, 37-IM, 37-IMP, 44, 53; Auto Fire Module [AFM]), there is a bulkhead between the battery and electronics compartments. Battery replacement does not affect desiccation of the electronics, as the batteries are removed without removing the electronics and no significant gas exchange is possible through the bulkhead. Therefore, opening the battery compartment to replace the batteries does not expose the electronics; you do not need to install a new desiccant bag in the electronics compartment each time you open the battery compartment. For these instruments, install a new desiccant bag if you open the electronics compartment to access the printed circuit boards.
- For the SBE 39, 39-IM, and 48, the electronics must be removed or exposed to access the battery. Therefore, install a new desiccant bag each time you open the housing to replace a battery.

Storage and Handling

Testing by Süd-Chemie (desiccant's manufacturer) at 60% relative humidity and 30 °C shows that approximately 25% of the desiccant's adsorbing capacity is used up after only 1 hour of exposure to a constantly replenished supply of moisture in the air. In other words, if you take a bag out of a container and leave it out on a workbench for 1 hour, one-fourth of its capacity is gone before you ever install it in the instrument. Therefore:

- Keep desiccant bags in a tightly sealed, impermeable container until you are ready to use them. Open the container, remove a bag, and quickly close the container again.
- Once you remove the bag(s) from the sealed container, rapidly install the bag(s) in the instrument housing and close the housing. **Do not use the desiccant bag(s) if exposed to air for more than a total of 30 minutes.**



Regeneration (drying) of Desiccant

Replacement desiccant bags are available from Sea-Bird:

- PN 60039 is a metal can containing 25 1-gram desiccant bags and 1 humidity indicator card. The 1-gram bags are used in our smaller diameter housings, such as the SBE 3 (*plus*, F, and S), 4 (M and C), 5T, 37 (-SI, -SIP, -SM, -SMP, -IM, and –IMP), 38, 39, 39-IM, 43, 44, 45, 48, 49, and 50.
- PN 31180 is a 1/3-ounce desiccant bag, used in our SBE 16*plus*, 16*plus*-IM, 19*plus*, 21, and 52-MP.
- PN 30051 is a 1-ounce desiccant bag. The 1-ounce bags are used in our larger diameter housings, such as the SBE 9*plus*, 16, 17*plus*, 19, 25, 26, 26*plus*, 32, 53 BPR, AFM, and PDIM.

However, if you run out of bags, you can regenerate your existing bags using the following procedure provided by the manufacturer (Süd-Chemie Performance Packaging, a Division of United Catalysts, Inc.):

MIL-D-3464 Desiccant Regeneration Procedure

Regeneration of the United Desiccants' Tyvek Desi Pak® or Sorb-It® bags or United Desiccants' X-Crepe Desi Pak® or Sorb-It® bags can be accomplished by the following method:

1. Arrange the bags on a wire tray in a single layer to allow for adequate air flow around the bags during the drying process. The oven's inside temperature should be room or ambient temperature (25 – 29.4 °C [77 – 85 °F]). **A convection, circulating, forced-air type oven is recommended for this regeneration process. Seal failures may occur if any other type of heating unit or appliance is used.**

2. When placed in forced air, circulating air, or convection oven, allow a minimum of 3.8 to 5.1 cm (1.5 to 2.0 inches) of air space between the top of the bags and the next metal tray above the bags. If placed in a radiating exposed infrared-element type oven, shield the bags from direct exposure to the heating element, giving the closest bags a minimum of 40.6 cm (16 inches) clearance from the heat shield. Excessive surface film temperature due to infrared radiation will cause the Tyvek material to melt and/or the seals to fail. Seal failure may also occur if the temperature is allowed to increase rapidly. This is due to the fact that the water vapor is not given sufficient time to diffuse through the Tyvek material, thus creating internal pressure within the bag, resulting in a seal rupture. Temperature should not increase faster than 0.14 to 0.28 °C (0.25 to 0.50 °F) per minute.

3. Set the temperature of the oven to 118.3 °C (245 °F), and allow the bags of desiccant to reach equilibrium temperature. **WARNING**: Tyvek has a melt temperature of 121.1 – 126.7 °C (250 – 260 °F) (Non MIL-D-3464E activation or reactivation of both silica gel and Bentonite clay can be achieved at temperatures of 104.4 °C [220 °F]).

4. Desiccant bags should be allowed to remain in the oven at the assigned temperature for 24 hours. At the end of the time period, the bags should be immediately removed and placed in a desiccator jar or dry (0% relative humidity) airtight container for cooling. If this procedure is not followed precisely, any water vapor driven off during reactivation may be re-adsorbed during cooling and/or handling.

5. After the bags of desiccant have been allowed to cool in an airtight desiccator, they may be removed and placed in either an appropriate type polyliner tightly sealed to prevent moisture adsorption, or a container that prevents moisture from coming into contact with the regenerated desiccant.

NOTE: Use only a metal or glass container with a tight fitting metal or glass lid to store the regenerated desiccant. Keep the container lid **closed tightly** to preserve adsorption properties of the desiccant.

SÜD-CHEMIE
Creating Performance Technology

ISO 9002 CERTIFIED

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MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

SECTION I -- PRODUCT IDENTIFICATION

Trade Name and Synonyms:	Silica Gel, Synthetic Amorphous Silica, Silicon, Dioxide
Chemical Family:	Synthetic Amorphous Silica
Formula:	$SiO_2.x\ H_2O$

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

COMPONENT	CAS No	%	ACGIH/TLV (PPM)	OSHA-(PEL)
Amorphous Silica	63231-67-4	>99	PEL - 20 (RESPIRABLE), TLV – 5	LIMIT – NONE, HAZARD - IRRITANT

Synthetic amorphous silica is not to be confused with crystalline silica such as quartz, cristobalite or tridymite or with diatomaceous earth or other naturally occurring forms of amorphous silica that frequently contain crystalline forms.

This product is in granular form and packed in bags for use as a desiccant. Therefore, no exposure to the product is anticipated under normal use of this product. Avoid inhaling desiccant dust.

SECTION III -- PHYSICAL DATA

Appearance and Odor:	White granules; odorless.
Melting Point:	>1600 Deg C; >2900 Deg F
Solubility in Water:	Insoluble.
Bulk Density:	>40 lbs./cu. ft.
Percent Volatile by Weight @ 1750 Deg F:	<10%.

SÜD-CHEMIE
Creating Performance Technology

ISO 9002 CERTIFIED

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MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

SECTION IV -- FIRE EXPLOSION DATA

Fire and Explosion Hazard - Negligible fire and explosion hazard when exposed to heat or flame by reaction with incompatible substances.

Flash Point - Nonflammable.

Firefighting Media - Dry chemical, water spray, or foam. For larger fires, use water spray fog or foam.

Firefighting - Nonflammable solids, liquids, or gases: Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in enclosed area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of the tank due to fire.

SECTION V -- HEALTH HAZARD DATA

Health hazards may arise from inhalation, ingestion, and/or contact with the skin and/or eyes. Ingestion may result in damage to throat and esophagus and/or gastrointestinal disorders. Inhalation may cause burning to the upper respiratory tract and/or temporary or permanent lung damage. Prolonged or repeated contact with the skin, in absence of proper hygiene, may cause dryness, irritation, and/or dermatitis. Contact with eye tissue may result in irritation, burns, or conjunctivitis.

First Aid (Inhalation) - Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep affected person warm and at rest. Get medical attention immediately.

First Aid (Ingestion) - If large amounts have been ingested, give emetics to cause vomiting. Stomach siphon may be applied as well. Milk and fatty acids should be avoided. Get medical attention immediately.

First Aid (Eyes) - Wash eyes immediately and carefully for 30 minutes with running water, lifting upper and lower eyelids occasionally. Get prompt medical attention.

First Aid (Skin) - Wash with soap and water.

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MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

NOTE TO PHYSICIAN: This product is a desiccant and generates heat as it adsorbs water. The used product can contain material of hazardous nature. Identify that material and treat accordingly.

SECTION VI -- REACTIVITY DATA

Reactivity - Silica gel is stable under normal temperatures and pressures in sealed containers. Moisture can cause a rise in temperature which may result in a burn.

SECTION VII --SPILL OR LEAK PROCEDURES

Notify safety personnel of spills or leaks. Clean-up personnel need protection against inhalation of dusts or fumes. Eye protection is required. Vacuuming and/or wet methods of cleanup are preferred. Place in appropriate containers for disposal, keeping airborne particulates at a minimum.

SECTION VIII -- SPECIAL PROTECTION INFORMATION

Respiratory Protection - Provide a NIOSH/MSHA jointly approved respirator in the absence of proper environmental control. Contact your safety equipment supplier for proper mask type.

Ventilation - Provide general and/or local exhaust ventilation to keep exposures below the TLV. Ventilation used must be designed to prevent spots of dust accumulation or recycling of dusts.

Protective Clothing - Wear protective clothing, including long sleeves and gloves, to prevent repeated or prolonged skin contact.

Eye Protection - Chemical splash goggles designed in compliance with OSHA regulations are recommended. Consult your safety equipment supplier.

SECTION IX -- SPECIAL PRECAUTIONS

Avoid breathing dust and prolonged contact with skin. Silica gel dust causes eye irritation and breathing dust may be harmful.

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MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

* No Information Available

HMIS (Hazardous Materials Identification System) for this product is as follows:

Health Hazard	0
Flammability	0
Reactivity	0
Personal Protection	HMIS assigns choice of personal protective equipment to the customer, as the raw material supplier is unfamiliar with the condition of use.

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APPLICATION NOTE NO. 73 **Revised July 2005**

Using Instruments with Pressure Sensors at Elevations Above Sea Level

This application note covers use of a Sea-Bird instrument that includes a pressure sensor at elevations above sea level, such as in a mountain lake or stream.

Background

Sea-Bird pressure sensors are absolute sensors, so their raw output includes the effect of atmospheric pressure. As shown on the Calibration Sheet that accompanies the instrument, our calibration (and resulting calibration coefficients) is in terms of psia. However, when outputting pressure in engineering units, most of our instruments output pressure relative to the ocean surface (i.e., at the surface the output pressure is 0 decibars). Sea-Bird uses the following equation in our instruments and/or software to convert psia to decibars:

Pressure (db) = [pressure (psia) – 14.7] * 0.689476
where 14.7 psia is the assumed atmospheric pressure (based on atmospheric pressure at sea level).

This conversion is based on the assumption that the instrument is being used in the ocean; the surface of the ocean water is by definition at sea level. However, if the instrument is used in a mountain lake or stream, the assumption of sea level atmospheric pressure (14.7 psia) in the instrument and/or software can lead to incorrect results. Procedures are provided below for measuring the pressure *offset* from the assumed sea level atmospheric pressure, and entering the offset in the instrument and/or software to make the appropriate correction.

- **Perform the correction procedure at the elevation at which the instrument will be deployed.** Allow the instrument to equilibrate in a reasonably constant temperature environment for at least 5 hours before starting. Pressure sensors exhibit a transient change in their output in response to changes in their environmental temperature. Sea-Bird instruments are constructed to minimize this by thermally decoupling the sensor from the body of the instrument. However, there is still some residual effect; allowing the instrument to equilibrate before starting will provide the most accurate calibration correction.

Inclusion of calibration coefficients in the instrument itself or in a file used by our software to interpret raw data varies, depending on the instrument. Commands used to program the instrument vary as well. Therefore, there are variations in the correction procedure, depending on the instrument. These instruments are addressed below:

- SBE **9*plus*** CTD and SBE **25** SEALOGGER CTD
- SBE **16*plus* (RS-232 version)** SEACAT C-T (pressure optional) Recorder, SBE **19*plus*** SEACAT Profiler CTD, and SBE **49** FastCAT CTD Sensor
- SBE **16*plus* (RS-485 version)** SEACAT C-T (pressure optional) Recorder and SBE **16*plus*-IM** SEACAT C-T (pressure optional) Recorder
- SBE **37** MicroCAT (all models – IM, IMP, SI, SIP, SM, SMP)
- SBE **50** Digital Oceanographic Pressure Sensor
- SBE **52-MP** Moored Profiler CTD and DO Sensor
- SBE **39-IM** Temperature (pressure optional) Recorder
- SBE **39** Temperature (pressure optional) Recorder
- SBE **26*plus*** SEAGAUGE Wave and Tide Recorder and SBE **53** BPR Bottom Pressure Recorder

SBE 9*plus* and 25

Sea-Bird software (SEASAVE or SBE Data Processing) uses calibration coefficients programmed in a configuration (.con) file to convert raw data from these instruments to engineering units.

Follow this procedure to correct the pressure:
1. With the instrument in the air, place it in the orientation it will have when deployed.
2. In SEASAVE, in the .con file, set the pressure offset to 0.0.
3. Acquire data in SEASAVE, and display the pressure sensor output in decibars.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the .con file.

Offset Correction Example:
Pressure displayed at elevation is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
Enter offset in .con file.

SBE 16*plus* (RS-232 version), 19*plus*, and 49

Sea-Bird software (SEASAVE or SBE Data Processing) uses calibration coefficients programmed in a configuration (.con) file to convert raw data from these instruments to engineering units. These instruments are also able to directly output data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the instrument.

Follow this procedure to correct the pressure:
1. With the instrument in the air, place it in the orientation it will have when deployed.
2. In SEASAVE, in the .con file, set the pressure offset to 0.0.
3. Acquire data in SEASAVE, and display the pressure sensor output in decibars.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the .con file.
6. Also enter the calculated offset in the instrument (use the **POFFSET=** command in SEATERM).

Offset Correction Example:
Pressure displayed at elevation is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
Enter offset in .con file and in instrument.

SBE 16*plus* (RS-485 version) and 16*plus*-IM

Sea-Bird software (SEASAVE or SBE Data Processing) uses calibration coefficients programmed in a configuration (.con) file to convert raw data from these instruments to engineering units. These instruments are also able to directly output data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the instrument.

Follow this procedure to correct the pressure:
1. With the instrument in the air, place it in the orientation it will have when deployed.
2. In SEATERM, set the pressure offset to 0.0 (**#iiPOFFSET=0**) and set the output format to converted data in decimal form (**#iiOUTPUTFORMAT=3**).
3. Acquire data using the **#iiTP** command.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the instrument (use **#iiPOFFSET=** in SEATERM).
6. Also enter the calculated offset in the .con file, using SBE Data Processing.

Offset Correction Example:
Pressure displayed at elevation is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
Enter offset in .con file and in instrument.

SBE 37 (all models)

The SBE 37 is able to directly output data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the instrument. The SBE 37 does not use a .con file.

Follow this procedure to correct the pressure:

1. With the SBE 37 in the air, place it in the orientation it will have when deployed.
2. In SEATERM, set the pressure offset to 0.0 and pressure sensor output to decibars. *
3. Acquire data. *
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the SBE 37 in SEATERM. *

   Offset Correction Example:
   Pressure displayed at elevation is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
   Enter offset in the SBE 37.

* NOTE: Commands for setting pressure offset, setting output format, and acquiring data vary:

Instrument	Pressure Offset Command	Output Format Command	Command to Acquire Data
SBE 37-IM and 37-IMP, and RS-485 version of SBE 37-SM, 37-SMP, 37-SI, and 37-SIP	**#iiPOFFSET=**	**#iiFORMAT=1** or **#iiFORMAT=2**	**#iiTP** (measures and outputs pressure 30 times)
RS-232 version of SBE 37-SM, 37-SMP, 37-SI, and 37-SIP	**POFFSET=**	**FORMAT=1** or **FORMAT=2**	**TP** (measures and outputs pressure 100 times)

SBE 50

The SBE 50 is able to directly output data that is already converted to engineering units (psia, decibars, or depth in feet or meters), using calibration coefficients that are programmed into the instrument. The SBE 50 does not use a .con file.

Follow this procedure to correct the pressure:

1. With the SBE 50 in the air, place it in the orientation it will have when deployed.
2. In SEATERM, set the pressure offset to 0.0 (**POFFSET=0**) and set the output format to the desired format (**OUTPUTFORMAT=**).
3. Acquire data using the **TS** command a number of times.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the SBE 50 (use **POFFSET=** in SEATERM). The offset must be entered in units consistent with **OUTPUTFORMAT=**. For example, if the output format is decibars (**OUTPUTFORMAT=2**), enter the offset in decibars.

   Offset Correction Example:
   Pressure displayed at elevation with **OUTPUTFORMAT=2** (db) is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
   Enter offset in the SBE 50.

SBE 52-MP

The SBE 52-MP is able to directly output data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the instrument. The SBE 52-MP does not use a .con file.

Follow this procedure to correct the pressure:
1. With the SBE 52-MP in the air, place it in the orientation it will have when deployed.
2. In SEATERM, set the pressure offset to 0.0 (**POFFSET=0**).
3. Acquire data using the **TP** command.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the SBE 52-MP (use **POFFSET=** in SEATERM).

   Offset Correction Example:
   Pressure displayed at elevation is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
   Enter offset in the SBE 52-MP.

SBE 39-IM

The SBE 39-IM directly outputs data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the SBE 39-IM. The SBE 39-IM does not use a .con file.

Follow this procedure to correct the pressure:
1. With the SBE 39-IM in the air, place it in the orientation it will have when deployed.
2. In SEATERM, set the pressure offset to 0.0 (**#iiPOFFSET=0**).
3. Acquire data using the **#iiTP** command.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the SBE 39-IM (use **#iiPOFFSET=** in SEATERM)

   Offset Correction Example:
   Pressure displayed at elevation is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
   Enter offset in the SBE 39-IM.

SBE 39

The SBE 39 directly outputs data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the SBE 39. The SBE 39 does not use a .con file. The SBE 39 is a special case, because its programmed calibration coefficients do not currently include a pressure offset term. The lack of a pressure offset term creates two difficulties when deploying at elevations above sea level:

- After the data is recorded and uploaded, you must perform post-processing to adjust for the pressure offset. Sea-Bird software cannot currently perform this adjustment for the SBE 39.
- Without adjusting the instrument range, internal calculation limitations prevent the SBE 39 from providing accurate data at high elevations. Specifically, if (0.1 * sensor range) < (decrease in atmospheric pressure from sea level to elevation), an error condition in the SBE 39's internal calculations occurs. The table below tabulates the atmospheric pressure and approximate elevation at which this calculation limitation occurs for different pressure sensor ranges.

Range (m or db) *	**Range (psi) = Range (db) / 0.689476**	**0.1 * Range (psi)**	**Atmospheric Pressure (psi) at elevation at which error occurs = [14.7 – 0.1 * Range (psi)]**	**Approximate Corresponding Elevation (m)**
20	29	2.9	11.8	1570
100	145	14.5	0.2	7885
350	507	50.7	-	-
1000	1450	145	-	-
2000	2900	290	-	-
3500	5076	507	-	-
7000	10152	1015	-	-

* Notes:

- Although decibars and meters are not strictly equal, this approximation is close enough for this Application Note. See Application Note 69 for conversion of pressure (db) to depth (m) for fresh or salt water applications.
- Equations used in conversions -
  As shown on page 1: pressure (db) = [pressure (psia) – 14.7] * 0.689476;
  Rearranging: pressure (psia) = [Pressure (db) / 0.689476] + 14.7
  Measuring relative to atmospheric: pressure (psi; relative to atmospheric pressure) = Pressure (db) / 0.689476

From the table, it is apparent that the only practical limitation occurs with a 20 meter pressure sensor. To use the SBE 39 in this situation, change the sensor range internally to 100 meters by entering **PRANGE=100** in the SBE 39 (using SEATERM). This changes the electronics' operating range, allowing you to record pressure data at high elevations, but slightly decreases resolution. After the data is recorded and uploaded, perform post-processing to adjust for the pressure offset. Note that Sea-Bird software cannot currently perform this adjustment for the SBE 39.

CAUTION: Changing **PRANGE** in the SBE 39 does not increase the actual maximum water depth at which the instrument can be used (20 meters) without damaging the sensor.

> *Example 1*: You want to deploy the SBE 39 with a 20 m pressure sensor in a mountain lake at 1400 meters (4590 feet). This is lower than 1570 meters shown in the table, so you do not need to adjust the sensor range. After the data is recorded and uploaded, perform post-processing to adjust for the pressure offset.
>
> *Example 2*: You want to deploy the SBE 39 with a 20 m pressure sensor in a mountain lake at 2000 meters (6560 feet). This is higher than 1570 meters shown in the table, so you need to adjust the sensor range. In SEATERM, set **PRANGE=100** to allow use of the SBE 39 at this elevation. After the data is recorded and uploaded, perform post-processing to adjust for the pressure offset.

SBE 26*plus* and 53

Unlike our other instruments that include a pressure sensor, the SBE 26*plus* and 53 output absolute pressure (i.e., at the surface the output pressure is atmospheric pressure at the deployment elevation). Therefore, no corrections are required when using these instruments above sea level. SBE 26*plus* / 53 software (SEASOFT for Waves) includes a module that can subtract measured barometric pressures from tide data, and convert the resulting pressures to water depths.

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APPLICATION NOTE NO. 83 **April 2006**

Deployment of Moored Instruments

This Application Note applies to Sea-Bird instruments intended to provide time series data on a mooring or fixed site:

- SBE 16*plus* and 16*plus*-IM SEACAT Conductivity and Temperature Recorder
- SBE 19*plus* SEACAT Profiler CTD (in moored mode)
- SBE 26*plus* SEAGAUGE Wave and Tide Recorder
- SBE 37 (-IM, -IMP, -SM, -SMP, -SI, -SIP) MicroCAT Conductivity and Temperature Recorder
- SBE 39 and 39-IM Temperature Recorder
- SBE 53 BPR Bottom Pressure Recorder

We have developed a check list to assist users in deploying moored instruments. **This checklist is intended as a guideline to assist you in developing a checklist specific to your operation and instrument setup.** The actual procedures and procedure order may vary, depending on such factors as:

- Instrument communication interface - RS-232, RS-485, or inductive modem
- Deployment interface for RS-232 or RS-485 - with an I/O cable for real-time data or with a dummy plug for self-contained operation
- Sampling initiation - using delayed start commands to set a date and time for sampling to automatically begin or starting sampling just before deploying the instrument
- Sensors included in your instrument –
  - Pressure is optional in the SBE 16*plus*, 16*plus*-IM, 37 (all), 39, and 39-IM.
  - Conductivity is optional in the SBE 26*plus* and 53, and is not provided in the SBE 39 and 39-IM.
  - Optional auxiliary sensors can be integrated with the SBE 16*plus*, 16*plus*-IM, and 19*plus*.

Deployment Summary

Instrument serial number	
Mooring number	
Date of deployment	
Depth of instrument	
Intended date of recovery	
Capture file printout(s) attached, or file name and location (showing status command, calibration coefficients command if applicable, any other applicable commands)	
Actual date of recovery	
Condition of instrument at recovery	
Notes	

Preparation for Deployment

Task	Completed?
If applicable, upload existing data in memory. Perform preliminary processing / analysis of data to ensure you have uploaded all data, that data was not corrupted in upload process, and that (if uploading converted data) instrument EEPROM was programmed with correct calibration coefficients. If there is a problem with data, you can try to upload again now. Once you record over data in next deployment, opportunity to correct any upload problem is gone.	
Initialize memory to make entire memory available for recording. If memory is not initialized, data will be stored after last recorded sample.	
Calculate battery endurance to ensure sufficient power for intended sampling scheme. See instrument manual for example calculations.	
Calculate memory endurance to ensure sufficient memory for intended sampling scheme. See instrument manual for example calculations.	
Install fresh batteries. Even if you think there is adequate battery capacity left for another deployment, cost of fresh batteries is small price to pay to ensure successful deployment.	
Establish setup / operating parameters. 1. Click Capture button in SEATERM and enter file name to record instrument setup, so you have complete record of communication with instrument. 2. Set current date and time. 3. Establish setup / operating parameters. 4. If desired, set date and time for sampling to automatically begin. 5. Send *Status* command (**DS** or **#iiDS**) to verify and provide record of setup. ** 6. Send *Calibration Coefficients* command (**DC**, **#iiDC**, **DCAL**, or **#iiDCAL**) to verify and provide record of calibration coefficients. **	
Get conductivity sensor ready for deployment: Remove protective plugs that were placed in Anti-Foulant Device caps **or** remove Tygon tubing that was looped end-to-end around conductivity cell to prevent dust / dirt from entering cell. *Note*: Deploying instrument with protective plugs or looped Tygon tubing in place will prevent instrument from measuring conductivity during deployment, and may destroy cell.	
Install fresh AF24173 Anti-Foulant Devices for conductivity sensor. Rate of anti-foul use varies greatly, depending on location and time of year. If you think there is adequate capability remaining, and previous deployment(s) in this location and at this time of year back up that assumption, you may not choose to replace Anti-Foulant Devices for every deployment. However, as for batteries, cost of fresh Anti-Foulant Devices is small price to pay to ensure successful deployment.	
For instrument with external pump (16*plus*, 16*plus*-IM, 19*plus*), verify that system plumbing is correctly installed. See instrument manual for configuration.	
Start sampling (if you did not set up instrument with a delayed start command), or verify that sampling has begun (if you set up instrument with a delayed start command). 1. Click Capture button in SEATERM and enter file name to record instrument setup, so you have a complete record of communication with instrument. 2. If you did not set up instrument with a delayed start command, send command to start sampling. 3. Send *Status* command (**DS** or **#iiDS**) to verify and provide record that instrument is sampling. ** 4. Send *Send Last* command (**SL** or **#iiSL**) to look at most recent sample and verify that output looks reasonable (i.e., ambient temperature, zero conductivity, atmospheric pressure). ** 5. If instrument has pressure sensor, record atmospheric pressure with barometer. You can use this information during data processing to check and correct for pressure sensor drift, by comparing to instrument's pressure reading in air (from Step 4). Note: For instrument with pump (external **or** integral), avoid running pump *dry* for extended period of time.	
If cable connectors or dummy plugs were unmated, reinstall cables or dummy plugs as described in *Application Note 57: I/O Connector Care and Installation*. Failure to correctly install cables may result in connector leaking, causing data errors as well as damage to bulkhead connector.	
Install mounting hardware on instrument. Verify that hardware is secure.	

**** Note:** Actual instrument command is dependent on communication interface and instrument.

Recovery

Immediately upon recovery

Task	Completed?
Rinse instrument with fresh water.	
Remove locking sleeve on dummy plug or cable, slide it up cable (if applicable), and rinse connection (still mated) with fresh water.	
For instrument with pump (external or integral), stop sampling. Connect to instrument in SEATERM and send command to stop sampling (**STOP** or **#iiSTOP**). Stop sampling as soon as possible upon recovery to avoid running pump *dry* for an extended period of time. **	
If instrument has pressure sensor, record atmospheric pressure with barometer. You can use this information during data processing to check and correct for pressure sensor drift, by comparing to instrument's pressure reading in air.	
Gently rinse conductivity cell with clean de-ionized water, drain, and gently blow through cell to remove larger water droplets. • If cell is not rinsed between uses, salt crystals may form on platinized electrode surfaces. When instrument is used next, sensor accuracy may be temporarily affected until these crystals dissolve. • Note that **vigorous flushing is not recommended** if you will be sending instrument to Sea-Bird for post-deployment calibration to establish drift during deployment.	
For instrument with external pump (16*plus*, 16*plus*-IM, 19*plus*): Remove Tygon tubing from pump head's hose barbs, and rinse inside of pump head, pouring fresh water through a hose barb. If pump head is not rinsed between uses, salt crystals may form on impeller. Over time, this may *freeze* impeller in place, preventing pump from working.	
Install protective plugs in Anti-Foulant Device caps or loop Tygon tubing end-to-end around conductivity cell for *long term* storage. This will prevent dust / dirt from entering conductivity cell. *Note*: For short term (less than 1 day) storage, see *Application Note 2D: Instructions for Care and Cleaning of Conductivity Cells*.	
Upload data in memory. 1. Connect to instrument in SEATERM. 2. If you have not already done so, send command to stop sampling (**STOP** or **#iiSTOP**). ** 3. Upload data in memory, using Upload button in SEATERM. 4. Perform preliminary processing / data analysis to ensure you have uploaded all data, data was not corrupted in upload process, and (if uploading converted data) instrument EEPROM was programmed with correct calibration coefficients. If there is a problem with data, you can try to upload again now. Once you record over data in next deployment, opportunity to correct any upload problem is gone.	

** **Note:** Actual instrument command is dependent on communication interface and instrument.

Later

Task	Completed?
Clean conductivity cell, as needed: • Do not clean cell if you will be sending instrument to Sea-Bird for post-deployment calibration to establish drift during deployment. • Clean cell if you will not be performing a post-deployment calibration to establish drift. See cleaning instructions in instrument manual and *Application Note 2D: Instructions for Care and Cleaning of Conductivity Cells*.	
For instrument with external pump (16*plus*, 16*plus*-IM, 19*plus*): Clean pump as described in *Application Note 75: Maintenance of SBE 5T and 5M Pumps*.	
(Annually) Inspect and (if applicable) rinse pressure port. See instructions in instrument manual.	
Send instrument to Sea-Bird for calibrations / regular inspection and maintenance. We typically recommend that instrument be recalibrated once a year, but possibly less often if used only occasionally. We recommend that you return instrument to Sea-Bird for recalibration. In between laboratory calibrations, take field salinity samples to document conductivity cell drift. ***Notes:*** 1. We cannot place instrument in our calibration bath if heavily covered with biological material or painted with anti-foul paint. Remove as much material as possible before shipping to Sea-Bird; if we need to clean instrument before calibrating it, we will charge you for cleaning. To remove barnacles, plug ends of conductivity cell to prevent cleaning solution from getting into cell, then soak instrument in white vinegar *for a few minutes*. To remove anti-foul paint, use Heavy Duty Scotch-Brite pad or similar material. 2. If using lithium batteries, do not ship batteries installed in instrument. See http://www.seabird.com/customer_support/LithiumBatteriesRev2005.htm for shipping details.	

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APPLICATION NOTE NO. 84 **July 2006**

Using Instruments with Druck Pressure Sensors in Muddy or Biologically Productive Environments

This Application Note applies to Sea-Bird instruments with **Druck** pressure sensors, for moored applications or other long deployments that meet **either** of the following conditions:

- used in a **high-sediment (muddy)** environment, in a **pressure sensor end up** orientation
- used in a **biologically productive** environment, in **any** orientation

Standard pressure sensor port plug

At Sea-Bird, a pressure port plug with a small (0.042-inch diameter) vent hole in the center is inserted in the pressure sensor port. The vent hole allows hydrostatic pressure to be transmitted to the pressure sensor inside the instrument.

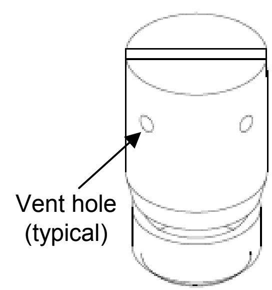
- If the instrument is deployed in a **high-sediment (muddy)** environment **with the pressure sensor end up**, the pressure port may partially fill with sediment (through the vent hole) over time, causing a delay in the pressure response.
- If the instrument is deployed in a **biologically productive** environment, the vent hole may be covered with biological growth over time, causing a delay in the pressure response, or in extreme cases completely blocking the pressure signal.

Note: Photo is for an SBE 37-SM. Pressure port details are similar for all instruments included in this application note.

Sea-Bird has developed a high-head pressure port plug for deployment in muddy and/or biologically productive environments. The high-head plug extends beyond the surface of the instrument end cap, and has *four* horizontal vent holes connecting *internally* to a vertical vent hole.

- The horizontal orientation of the external holes prevents the deposit of sediment inside the pressure port.
- Each of the four vent holes is larger (0.062-inch vs. 0.042-inch diameter) than the single vent hole in the standard pressure port plug, significantly reducing the possibility that biological growth will cover all of the hole(s).

To purchase the high-head pressure port plug, Part Number 233186, contact Sea-Bird.



High-Head
Pressure Port Plug,
Part Number 233186

High-Head Pressure Port Plug Installation

1. Unscrew the standard pressure port plug from the pressure port.
2. Rinse the pressure port with warm, de-ionized water to remove any particles, debris, etc. **Do not put a brush or any object in the pressure port;** doing so may damage or break the pressure sensor.
3. Install the *high-head* pressure port plug in the pressure port.

Note: Until several years ago, Sea-Bird filled the pressure port with silicon oil at the factory. For **Druck** pressure sensors, we determined that this was unnecessary, and no longer do so. It is not necessary to refill the oil in the field. However, for **Paine** or **Paroscientific Digiquartz** pressure sensors, the pressure port **does** need to be refilled with silicon oil. Please contact Sea-Bird with the serial number of your instrument if you are unsure of the type of pressure sensor installed in your instrument.

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APPLICATION NOTE NO. 85 — December 2006

Handling of Ferrite Core on Instruments with Inductive Modem Telemetry

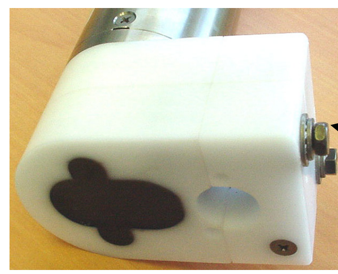
This Application Note applies to instruments and accessories that include a cable coupler for inductive modem telemetry:

- SBE 16*plus*-IM SEACAT C-T (optional pressure) Recorder
- SBE 37-IM MicroCAT C-T (optional pressure) Recorder
- SBE 37-IMP MicroCAT C-T (optional pressure) Recorder
- SBE 39-IM Temperature (optional pressure) Recorder
- SBE 44 Underwater Inductive Modem
- Inductive Cable Coupler (ICC) – clamps to the jacketed mooring wire, and makes electrical connection with the Surface Inductive Modem (SIM) or Inductive Modem Module (IMM) via a cable housed in reinforced-rubber conduit.

The ferrite modem core in these instruments and accessories is fragile, and must be handled with care. If you are having problems with inductive modem communications, check the core for misalignment or damage as follows.

Note*:* All photos are for an SBE 37-IMP, except as noted. Details are similar for all instruments included in this application note, except as noted.

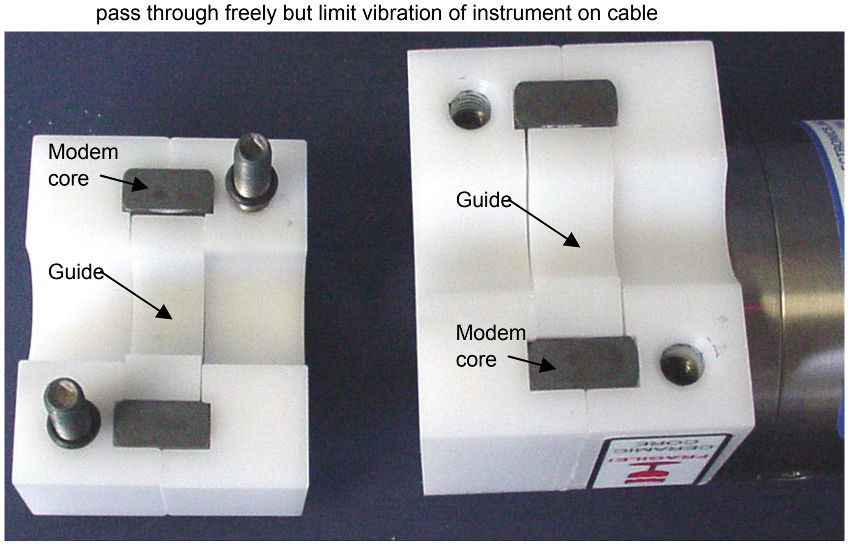
1. Open the mounting bracket by unthreading the large hex-head bolts.



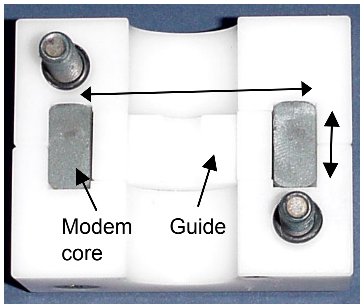
Unthread 2 hex head bolts (Note: ICC has 4 bolts)

Mounting guide / Inductive Modem Coupler Detail
Guide is sized ***slightly*** bigger than specified cable diameter, to allow cable to pass through freely but limit vibration of instrument on cable

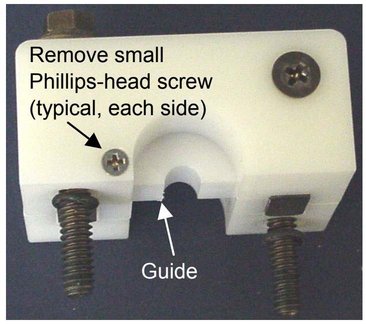
For proper communications, 2 halves of modem coupling toroid core must mate, with no gaps



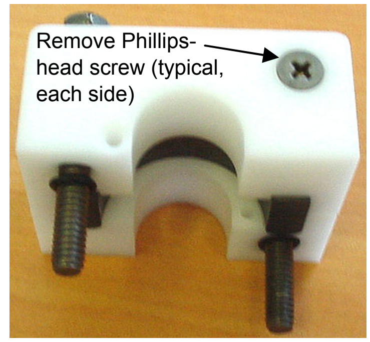
2. On the ***clamp*** side:
   A. Verify that the core provides a level surface for mating with the *instrument* side.
   B. Remove the two small Phillips-head screws securing the guide, and remove the guide.
   C. Remove the 2 larger Phillip-head screws and carefully pull the clamp apart.



Step 2A: Check that core is level in both directions shown

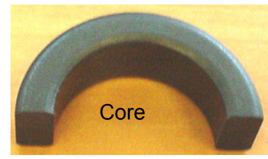


Step 2B: Remove guide



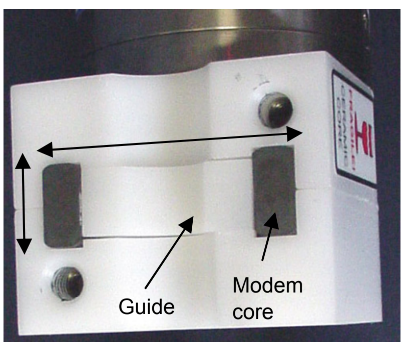
Step 2C: Pull clamp apart

   D. Examine the ferrite core for cracks or chips; replace if necessary.
   E. Reinstall the ferrite core in the two plastic pieces of the clamp, using the 2 Phillips-head screws, being careful to provide a level surface for mating with the *instrument* side.
   F. Reinstall the guide, using the 2 small Phillips-head screws.

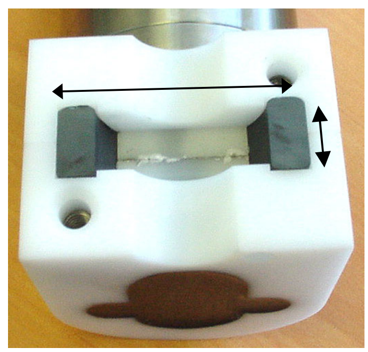


Step 2D: Examine core

3. On the ***instrument*** side:
   A. Verify that the core provides a level surface for mating with the *clamp* side.
   B. Remove the two small Phillips-head screws securing the guide, and remove the guide (similar to Step 2B).
   C. (SBE 16*plus*-IM, 37-IM, 37-IMP, 39-IM, and 44) The core cannot be removed for a complete inspection, because it is surrounded by potting compound. Inspect the visual portions of the core for damage; if damaged, the entire end cap assembly will have to be replaced at Sea-Bird.



Step 3A: Check that core is level in both directions shown


Check that core is level in both directions shown

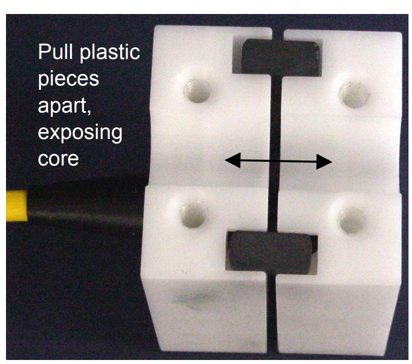
Step 3C: Examine visual portions of core

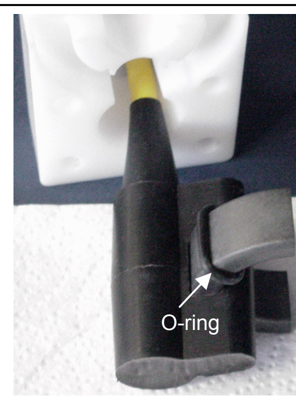
   D. (Inductive Cable Coupler) Remove the core as shown in the photos below. Examine the ferrite core for cracks or chips; replace if necessary. Reinstall the core, plastic, screws, etc.

Details for ICC Only

Remove 2 hex head screws with 2 washers and 2 nuts each; pull off bracket attaching cable to metal frame

Remove 4 hex head screws with 2 washers and 1 nut each; pull off bracket attaching to metal frame



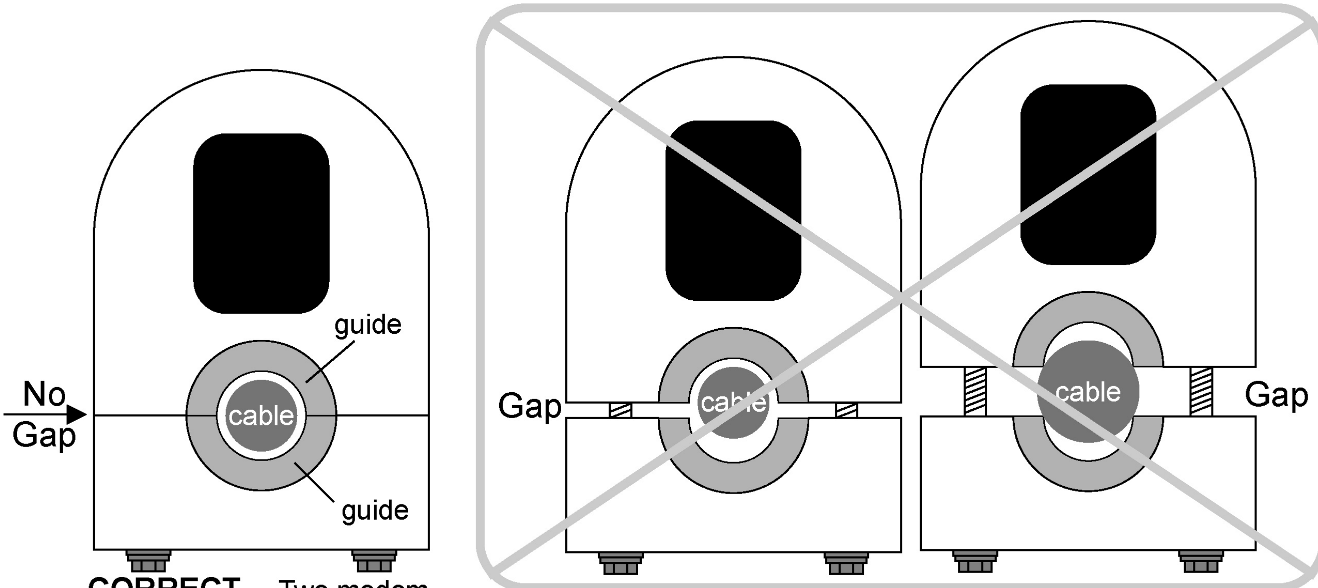


Remove o-rings from core, and slide core out of support

   E. Reinstall the guide, using the 2 small Phillips-head screws.

When installing the instrument or Inductive Cable Coupler on the cable, note the following:

Cable guide and clamp are sized at Sea-Bird to match cable size specified in your order.
If you will be using a different cable size, contact Sea-Bird to order new guide and clamp.

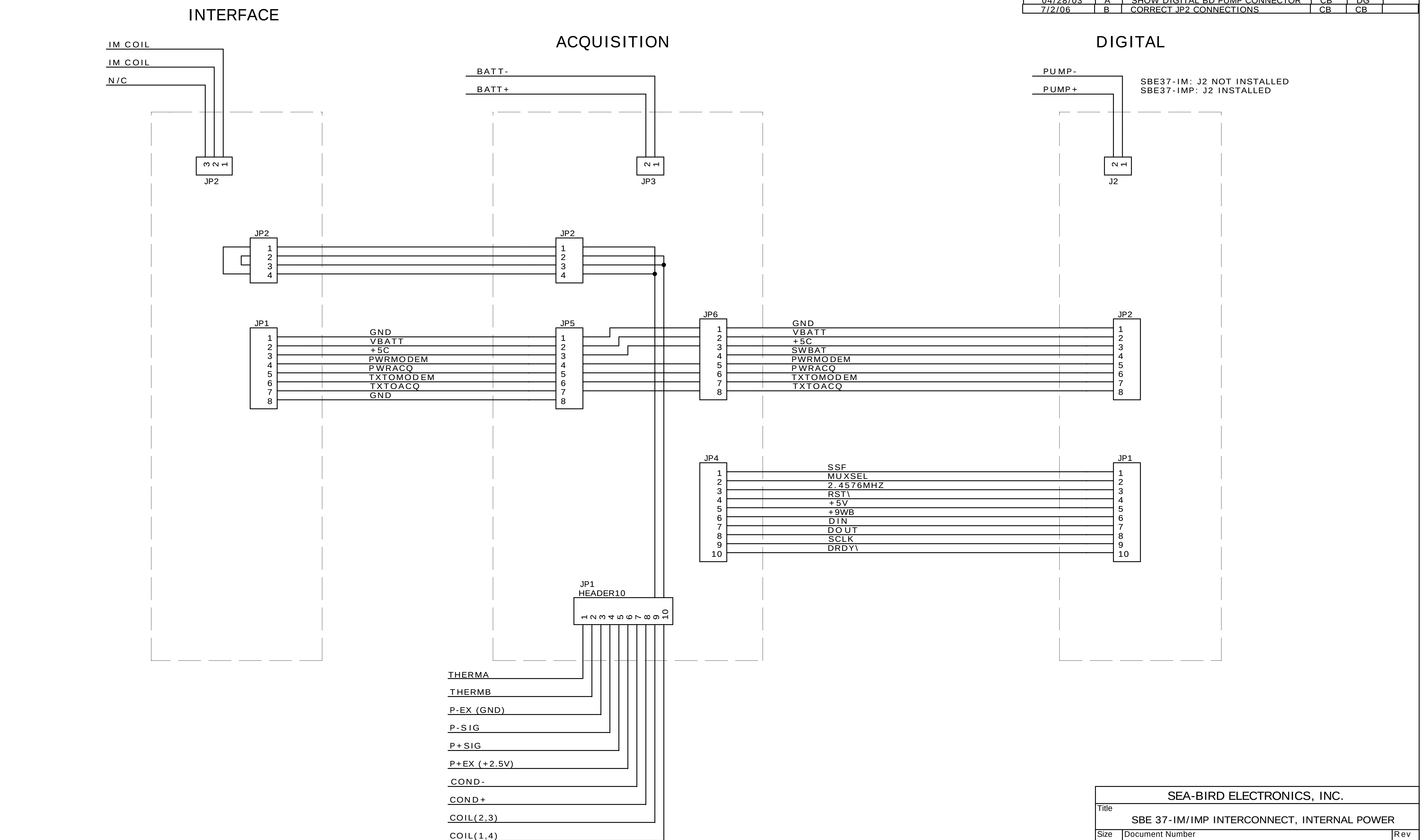


CORRECT -- Two modem halves mating closely (< 0.1 mm gap). Note that guide does not clamp cable.

INCORRECT -- Bolts not tightened completely, creating gap between modem halves. Hand-tighten bolts until snug.

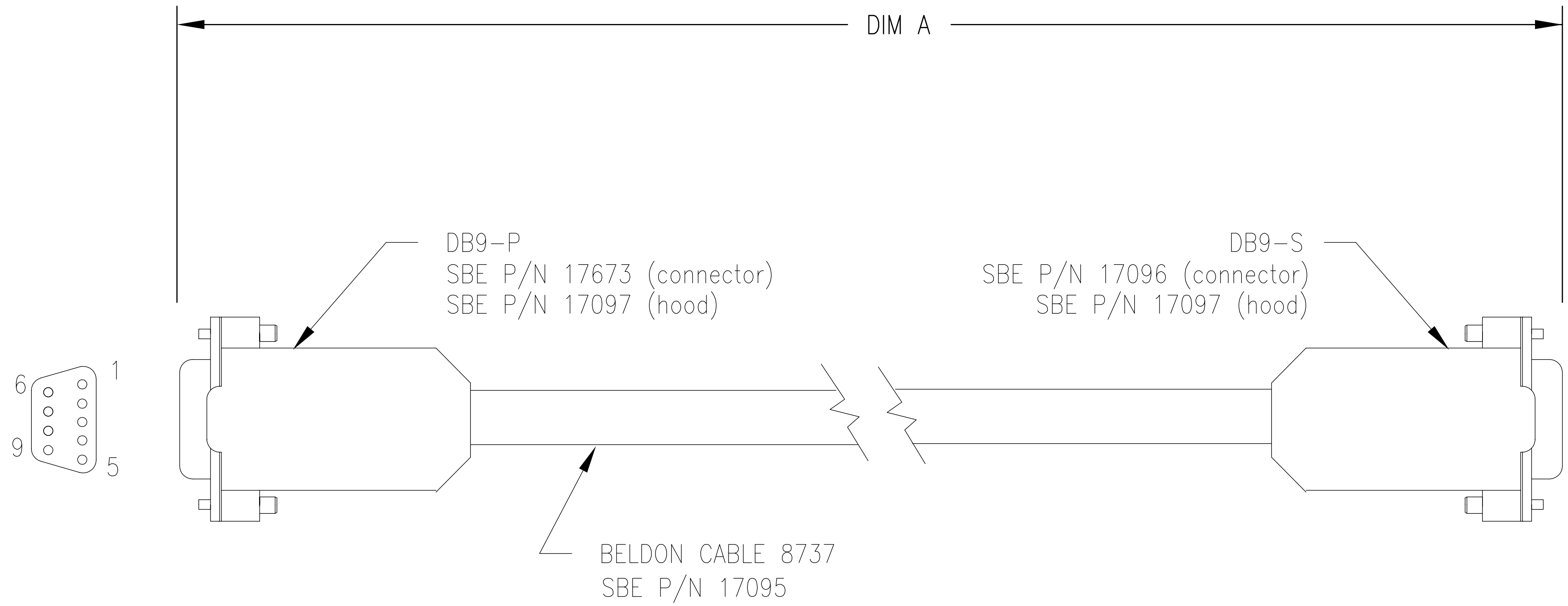
INCORRECT -- Guide hole too small for cable, creating gap between modem halves. May damage cable or modem if over-tightened.

DATE	SYM	REVISION RECORD	AUTH	DR	CK
04/28/03	A	SHOW DIGITAL BD PUMP CONNECTOR	CB	DG	
7/2/06	B	CORRECT JP2 CONNECTIONS	CB	CB	



SEA-BIRD ELECTRONICS, INC.		
Title: SBE 37-IM/IMP INTERCONNECT, INTERNAL POWER		
Size: B	Document Number: 31995	Rev: B
Date: Thursday, July 20, 2006	Sheet 1 of 1	

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.



P1 DB9-P	COLOR	P2 DB-9S
PIN 1		PIN 1
PIN 2	RED	PIN 2
PIN 3	BLACK	PIN 3
PIN 4		PIN 4
PIN 5	SHIELD	PIN 5
PIN 6		PIN 6
PIN 7		PIN 7
PIN 8		PIN 8
PIN 9		PIN 9

SBE PN	DIM A
801235	6 FT
801373	8 FT
801592	10 M

TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N SEE TABLE	SCALE NTS	DRAWN BY MJ APPROVED BY
DECIMAL	TITLE CABLE ASSY, SBE-21 OPTO I/O		
ANGULAR	DATE 07.00	DRAWING NUMBER 32431	REV

WARRANTY POLICY 2006

5-YEAR LIMITED WARRANTY (NEW PRODUCTS)

For a period of five years after the date of original shipment from our factory, products manufactured by Sea-Bird are warranted to function properly and be free of defects in materials and workmanship. Should a Sea-Bird instrument fail during the warranty period, return it freight pre-paid to our factory. We will repair it (or at our option, replace it) at no charge, and pay the cost of shipping it back to you. Certain products and components have modified coverage under this warranty as described below.

LIMITED WARRANTY ON SERVICE & REPAIRS

Service work, repairs, replacement parts and modifications are warranted to be free of defects in materials or workmanship for the remainder of the original 5-year warranty or one year from the date of shipment from our factory after repair or service, which ever is longer. Certain products and components have modified coverage under this warranty as described below.

MODIFICATIONS / EXCEPTIONS / EXCLUSIONS

1. The SBE 43 DO sensor is warranted to function properly for 5 years. Under normal use however, the electrolyte in an SBE 43 DO sensor will require replenishment after about 3 years. Purchase of an SBE 43 includes one free electrolyte replenishment (as necessitated by chemical depletion of electrolyte) anytime during the warranty period. To obtain the replenishment, return the sensor freight pre-paid to our factory. We will refurbish it for free (electrolyte refill, membrane replacement, and recalibration) and pay the cost of shipping it back to you. Membrane damage or depletion of electrolyte caused by membrane damage is not covered by this warranty.

2. Because pH and other dissolved oxygen (DO) electrodes have a limited life caused by the depletion of their chemical constituents during normal storage and use, our warranty applies differently to such electrodes. Electrodes in SBE 13Y and 23Y DO sensors, SBE 18 pH sensors, and SBE 27 pH/ORP sensors are covered under warranty for the first 90 days only. Other components of the sensor are covered for 5 years.

3. Equipment manufactured by other companies (e.g., fluorometers, transmissometers, PAR, optical backscatter sensors, altimeters, etc.) are warranted only to the limit of the warranties provided by their original manufacturers (typically 1 year).

4. Batteries, zinc anodes or other consumable/expendable items are not covered under this warranty.

5. Electrical cables and dummy plugs are warranted to function properly and be free of defects in materials and workmanship for 1 year.

6. This warranty is void if in our opinion the instrument has been damaged by accident, mishandled, altered, improperly serviced, or repaired by the customer where such treatment has affected its performance or reliability. In the event of such misuse/abuse by the customer, costs for repairs plus two-way freight costs will be borne by the customer. Instruments found defective should be returned to the factory carefully packed, as the customer will be responsible for freight damage.

7. Incidental or consequential damages or costs incurred as a result of product malfunction are not the responsibility of SEA-BIRD ELECTRONICS, INC

Warranty Administration Policy

Sea-Bird Electronics, Inc. and its authorized representatives or resellers provide warranty support only to the original purchaser. Warranty claims, requests for information or other support, and orders for post-warranty repair and service, by end-users that did not purchase directly from Sea-Bird or an authorized representative or reseller, must be made through the original purchaser. The intent and explanation of our warranty policy follows:

1. Warranty repairs are only performed by Sea-Bird.

2. Repairs or attempts to repair Sea-Bird products performed by customers (owners) shall be called *owner repairs*.

3. Our products are designed to be maintained by competent owners. Owner repairs of Sea-Bird products will NOT void the warranty coverage (as stated above) simply as a consequence of their being performed.

4. Owners may make repairs of any part or assembly, or replace defective parts or assemblies with Sea-Bird manufactured spares or authorized substitutes without voiding warranty coverage of the entire product, or parts thereof. Defective parts or assemblies removed by the owner may be returned to Sea-Bird for repair or replacement within the terms of the warranty, without the necessity to return the entire instrument. If the owner makes a successful repair, the repaired part will continue to be covered under the original warranty, as if it had never failed. Sea-Bird is not responsible for any costs incurred as a result of owner repairs or equipment downtime.

5. We reserve the right to refuse warranty coverage *on a claim by claim basis* based on our judgment and discretion. We will not honor a warranty claim if in our opinion the instrument, assembly, or part has been damaged by accident, mishandled, altered, or repaired by the customer *where such treatment has affected its performance or reliability*.

6. For example, if the CTD pressure housing is opened, a PC board is replaced, the housing is resealed, and then it floods on deployment, we do not automatically assume that the owner is to blame. We will consider a claim for warranty repair of a flooded unit, subject to our inspection and analysis. If there is no evidence of a fault in materials (e.g., improper or damaged o-ring, or seal surfaces) or workmanship (e.g., pinched o-ring due to improper seating of end cap), we would cover the flood damage under warranty.

7. In a different example, a defective PC board is replaced with a spare and the defective PC board is sent to Sea-Bird. We will repair or replace the defective PC board under warranty. The repaired part as well as the instrument it came from will continue to be covered under the original warranty.

8. As another example, suppose an owner attempts a repair of a PC board, but solders a component in backwards, causing the board to fail and damage other PC boards in the system. In this case, the evidence of the backwards component will be cause for our refusal to repair the damage under warranty. However, this incident will NOT void future coverage under warranty.

9. If an owner's technician attempts a repair, we assume his/her qualifications have been deemed acceptable to the owner. The equipment owner is free to use his/her judgment about who is assigned to repair equipment, and is also responsible for the outcome. The decision about what repairs are attempted and by whom is entirely up to the owner.

Service Request Form

To return your instrument for calibration or other service, please take a few moments to provide us with the information we need, so we can serve you better.

PLEASE:

1. **Get a Returned Material Authorization (RMA) number from Sea-Bird (*phone 425-643-9866, fax 425-643-9954, or email seabird@seabird.com*). Reference the RMA number on this form, on the outside shipping label for the equipment, and in all correspondence related to this service request.**
2. **Fill out 1 form for each type (model) of instrument.**
3. **Include this form when shipping the instrument to Sea-Bird for servicing.**
4. **Fax us a copy of this form on the day you ship.** ***FAX: (425) 643-9954***

RETURNED MATERIAL AUTHORIZATION (RMA) NUMBER: ____________________________

DATE EQUIPMENT REQUIRED BY: ____________________________

DO YOU REQUIRE A WRITTEN QUOTE? ____________________________

CONTACT INFORMATION

Your name: ____________________________

Institution/Organization/Company: ____________________________

Shipping/Delivery address for packages: ____________________________

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Telephone: ____________________ Fax: ____________________

e-mail: ____________________________

SERVICE INFORMATION

Date Shipped: ____________________________

Sea-Bird Model Number (for example, SBE 37-SM): ____________________________

Quantity: ____________________________

Serial Numbers: ____________________________

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(**Note**: **Specify instrument serial numbers below** if specific services are required for some instruments. For example, if 10 instruments are being returned for calibration, and 1 of the 10 also requires repairs, specify the serial number for the instrument requiring repairs in the appropriate section of the form.)

SEASOFT Version you have been using with this instrument(s): ____________________

[ ] **Calibration Services:**

____Calibration (includes basic diagnostic):

___Temperature ___Conductivity ___Pressure ___DO ___pH

(Please allow a minimum of 3 weeks after we receive the instrument(s) to complete calibration.)

____Other (specify): ____________________________

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[ ] **Internal Inspection and O-Ring Replacement (includes hydrostatic pressure test):**

Additional charges may apply.

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[ ] **System Upgrade or Conversion:**

Specify (include instrument serial number if multiple instruments are part of shipment): ____________

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[ ] **Diagnose and Repair Operational Faults:**

Please send a disk containing the raw data (.hex or .dat files) that shows the problems you describe. Also send the .con files you used to acquire or display the data.

Problem Description (continue on additional pages if needed; include instrument serial number if multiple instruments are part of shipment): ____________________________

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PAYMENT/BILLING INFORMATION

Credit Card: Sea-Bird accepts payment by VISA, MasterCard, or American Express.

[ ] MasterCard [ ] Visa [ ] American Express

Account Number: ______________________________ Expiration Date: __________

Credit Card Holder Name (printed or typed): ______________________________

Credit Card Holder Signature: ______________________________

Credit Card Billing Address (if different than shipping address):

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Invoice/Purchase Order: If you prefer us to invoice you, please complete the following or enclose a copy of your Purchase Order:

Purchase Order Number: ______________________________

Billing Address (if different than shipping address):

____

____

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Instructions for Returning Goods to Sea-Bird

1. **Domestic Shipments (USA)** - **Ship prepaid** (via UPS, FedEx, DHL, etc.) directly to:
   Sea-Bird Electronics, Inc.
   1808 136th Place NE
   Bellevue, WA 98005, USA
   Telephone: (425) 643-9866 Fax: (425) 643-9954
2. **International Shipments** –
   Option A. Ship via **PREPAID AIRFREIGHT to SEA-TAC International Airport (IATA Code "SEA")**:
   Sea-Bird Electronics, Inc.
   1808 136th Place NE
   Bellevue, WA 98005, USA
   Telephone: (425) 643-9866 Fax: (425) 643-9954 E-mail: seabird@seabird.com

   Notify: MTI Worldwide Logistics for Customs Clearance
   Seattle, WA, USA
   Telephone: (206) 431-4366 Fax: (206) 431-4374 E-mail: bill.keebler@mti-worldwide.com

   E-mail flight details and airway bill number to seabird@seabird.com and bill.keebler@mti-worldwide.com when your shipment is en-route. Include your RMA number in the e-mail.

   Option B. Ship via **EXPRESS COURIER directly to Sea-Bird Electronics**:
   If you choose this option, **we recommend shipping via UPS, FedEx, or DHL**. Their service is door-to-door, including customs clearance. It is not necessary to notify our customs agent, MTI Worldwide, if you ship using a courier service.

   E-mail the airway bill / tracking number to seabird@seabird.com when your shipment is en-route. Include your RMA number in the e-mail.

   For All International Shipments:
   Include a **commercial invoice** showing the description of the instruments, and **Value for Customs purposes only**.
   Include the following statement:
   "U.S. Goods Returned for Repair/Calibration. Country of Origin: USA. Customs Code: 9801001012."
   Failure to include this statement in your invoice will result in US Customs assessing duties on the shipment, which we will in turn pass on to the customer/shipper.

Note: Due to changes in regulations, if Sea-Bird receives an instrument from outside the U.S. in a crate containing non-approved (i.e., non-heat-treated) wood, we will return the instrument in a new crate that meets the requirements of ISPM 15 (see http://www.seabird.com/customer_support/retgoods.htm for details). We will charge for the replacement crate based on the dimensions of the crate we receive, determined as follows:

1. Multiply the crate length x width x height in centimeters (overall volume in cm^3, not internal volume).
2. Determine the price based on your calculated overall volume and the following chart:

Overall Volume (cm^3)	< 52,000	52,000 to < 65,000	65,000 to < 240,000	> 240,000
Example Instrument	37-SM MicroCAT	SEACAT, no cage	CTD in cage	--
Price (USD)	$45	$70	$125	consult factory

These prices are valid only for crate replacement required in conjunction with return of a customer's instrument after servicing, and only when the instrument was shipped in a crate originally supplied by Sea-Bird.