

SBE 37-SM MicroCAT

*Conductivity and Temperature Recorder
with RS-232 Interface*



Configuration and Calibration Manual

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SBE 37-SM MICROCAT OPERATING AND REPAIR MANUAL

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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-SM MicroCAT

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User's Manual

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**Manual Version #021, 02/03/04
Firmware Version 2.5 and later**

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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-SM MicroCAT Conductivity and Temperature Recorder (pressure optional) with **RS-232** interface.

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. Install batteries and test power and communications (*Section 3: Preparing MicroCAT for Deployment*).
2. Deploy the MicroCAT (*Section 4: Deploying and Operating MicroCAT*):
 - A. Install new batteries if necessary.
 - B. Ensure all data has been uploaded, and then set **SAMPLENUM=0** to make entire memory available for recording if desired.
 - C. Set date and then time.
 - D. Establish setup and logging parameters.
 - E. Set MicroCAT to start logging now or in the future.
 - F. Remove protective plugs from anti-foulant device cups, and verify AF24173 Anti-Foulant Devices are installed. Leave protective plugs off for deployment.
 - G. Install dummy plug or cable connector, and locking sleeve.
 - H. Deploy MicroCAT, using Sea-Bird or customer-supplied hardware.

Unpacking MicroCAT

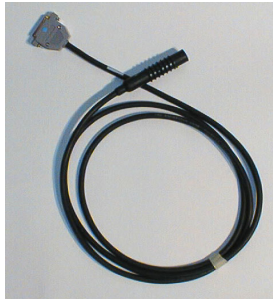
Shown below is a typical MicroCAT shipment.



SBE 37-SM MicroCAT



Batteries



I/O Cable



25-pin to 9-pin adapter
(for use with computer
with DB-25 connector)



Spare hardware
and o-ring kit



Cell cleaning solution
(Triton-X)



MicroCAT User Manual



Software, and Electronic Copies of
Software Manuals and User Manual

Shipping Precautions



Assembled
battery pack

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

The MicroCAT was shipped from the factory with the batteries packaged separately within the shipping box (not inside the MicroCAT). Before attempting to communicate with the MicroCAT, the batteries must be installed following the instructions in *Section 3: Preparing MicroCAT for Deployment*.

IMPORTANT NOTE:

Depending on their classification, the shipment of lithium batteries is subject to safety regulation concerning Dangerous Goods or Hazardous Material imposed by the U.S. Department of Transportation (DOT) and the International Air Transportation Association (IATA). Other countries may also have their own regulations. The MicroCAT uses a lithium battery pack comprised of six parallel 9-volt batteries. The total lithium contained in each 9-volt battery is less than 2 grams. In this form, the batteries are not considered Dangerous/Hazardous Goods, and may be shipped without restriction if they are **NOT** connected together and they are packaged to prevent accidental shorting of the battery contacts.

When two or more 9-volt battery sticks are assembled into the instrument's battery pack (either inside or outside the instrument housing), they are connected in parallel and **ARE** classified as **Dangerous/Hazardous Goods**. The *assembled battery pack* does not comply with DOT and IATA regulations requiring battery packaging test documentation and therefore **MUST NOT BE SHIPPED VIA COMMERCIAL AIRCRAFT** (those governed by DOT or IATA), **INCLUDING PASSENGER AIRLINES, OR CARGO CARRIERS SUCH AS FEDEX, DHL, UPS, ETC.**



Batteries packed
for shipment
by commercial
aircraft

Note:

All data and setup information is preserved when the batteries are removed. However, the real-time clock does not run. Accordingly, time and date must be reset after final assembly and before deployment. See *Section 4: Deploying and Operating MicroCAT*.

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 recalibration or repair.

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 to prevent accidental shorting of the battery contacts.

Section 2: Description of MicroCAT

This section describes the functions and features of the SBE 37-SM MicroCAT, including specifications and dimensions.

System Description



The SBE 37-SM MicroCAT is a high-accuracy conductivity and temperature recorder (pressure optional) with internal battery and non-volatile memory, and a standard RS-232 serial interface. 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.

Communication with the MicroCAT is over an internal, 3-wire, RS-232C link. 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:

- **Autonomous sampling** – At pre-programmed intervals, the MicroCAT wakes up, samples, stores data in its FLASH memory, and powers off. If desired, real-time data can also be transmitted.
- **Polled sampling** – On command, the MicroCAT takes one sample and transmits the data. Polled sampling is useful for integrating the MicroCAT with satellite, radio, or wire telemetry equipment.
- **Serial line sync** – The MicroCAT wakes up, samples, transmits real-time data, and powers off in response to a pulse on the serial line. This provides an easy method for synchronizing MicroCAT sampling with other instruments such as Acoustic Doppler Current Profilers (ADCPs) or current meters, without drawing on their battery or memory resources.

The MicroCAT can be deployed in two ways:

- **Cable installed** – The MicroCAT can be remotely controlled, allowing for polled sampling or serial line sync, or for periodic requests of data from the MicroCAT memory. If desired, data can be periodically uploaded while the MicroCAT remains deployed.
- **Dummy plug installed** – The MicroCAT cannot be remotely controlled. Autonomous sampling is programmed before deployment, and data is uploaded after recovery.

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). Electrical isolation of the conductivity electronics eliminates any possibility of ground-loop noise.

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.

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

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.

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

Specifications

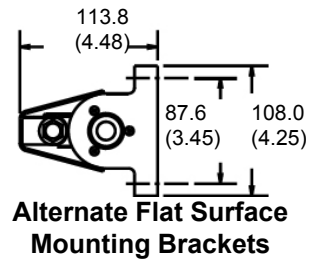
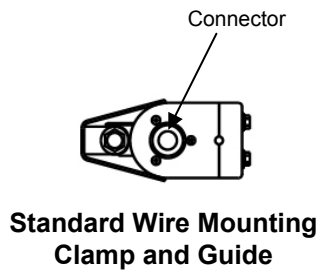
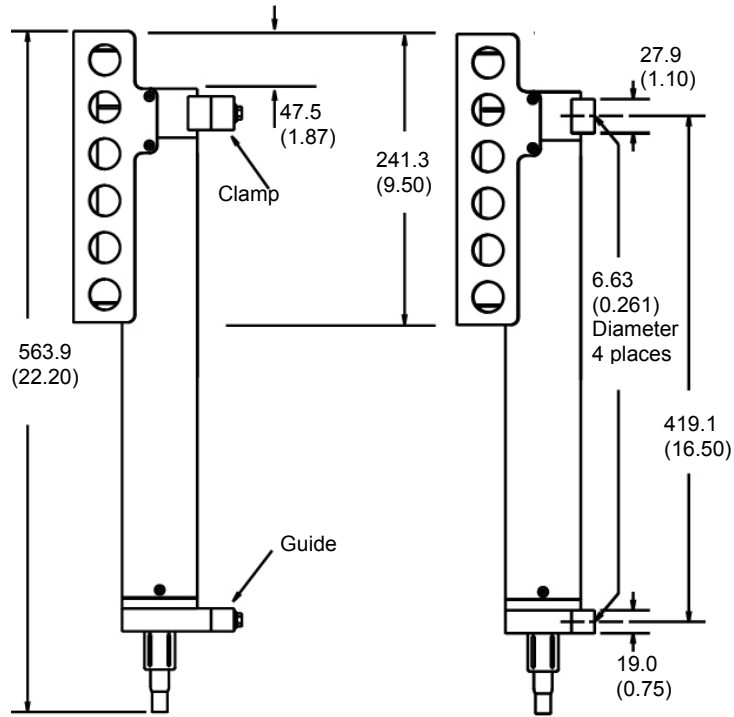
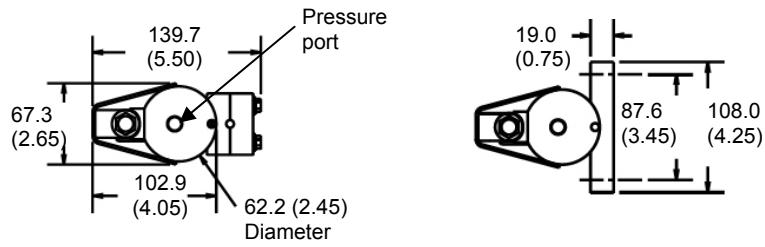
Note:

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 / 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. <table border="1" style="margin-left: 20px;"> <thead> <tr> <th><u>Recorded Parameters</u></th> <th><u>Memory Space - Total Number of Samples</u></th> </tr> </thead> <tbody> <tr> <td>C and T</td> <td>410,000</td> </tr> <tr> <td>C, T, and P</td> <td>290,000</td> </tr> <tr> <td>C, T, and time</td> <td>225,000</td> </tr> <tr> <td>C, T, P, and time</td> <td>185,000</td> </tr> </tbody> </table>			<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
<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. Provides sufficient capacity for more than 175,000 samples. When removed from MicroCAT and battery pack, and batteries packed separately, batteries can be shipped without hazardous material restrictions.												
External Input Power (optional)	40 ma at 9-24 VDC (to avoid draining the internal batteries, use an external voltage greater than 10 VDC)												
Power Requirements	Quiescent Current: 10 microamps. Sampling Current: 25 milliamps. Acquisition Time: 1 - 3 seconds per sample (depending on sampling mode and inclusion of pressure sensor) for 1 measurement per sample (NAV=1).												
Housing	Titanium pressure case rated at 7000 meters (23,000 feet)												
Weight (without pressure sensor)	In water: 2.3 kg (5.1 lbs) In air: 3.8 kg (8.3 lbs)												

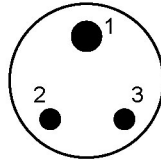
Dimensions

Dimensions in millimeters (inches)



End Cap Connector

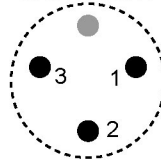
Standard
XSG-3-BCL-HP-SS



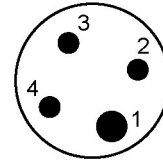
3-pin Connector

Pin	Signal
1	Common
2	RS-232 data receive
3	RS-232 data transmit

Optional
Wet-Pluggable
MCBH-3MTI



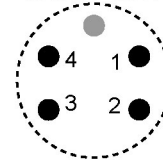
Optional
XSG-4-BCL-HP-SS



Optional 4-pin Connector

Pin	Signal
1	Common
2	RS-232 data receive
3	RS-232 data transmit
4	9-24 VDC (optional external power)

Optional
Wet-Pluggable
MCBH-4MTI



Sample Timing

Notes:

- If date and time are stored with the data, time is the time at the **start** of the sample.
- Acquisition time shown does not include time to transmit real-time data, which is dependent on cable length and baud rate.

Sample timing is dependent on several factors, including:

- Sampling mode – autonomous, polled, or serial line sync
- Inclusion of optional pressure sensor in MicroCAT
- Number of measurements taken per sample (**NAVG**)

Autonomous Sampling

Power on time for each sample while logging:

- **With pressure:** 1.55 seconds + (**NAVG** * 1.26 seconds)
- **Without pressure:** 1.44 seconds + (**NAVG** * 0.86 seconds)

The MicroCAT goes into quiescent (sleep) state for at least 2 seconds between each sample. If **NAVG** is large, the time required to sample plus the quiescent time may be more than the interval between samples (**INTERVAL**); the MicroCAT will then internally set the sampling rate to **INTERVAL** plus the actual required sampling time.

Example 1: INTERVAL=10, NAVG=2, MicroCAT has no pressure sensor
 Sampling time = 1.44 seconds + (**NAVG** * 0.86 seconds) = 1.44 + (2 * 0.86) = 3.16 seconds
 3.16 seconds + 2 seconds (for quiescent state) = 5.16 seconds < 10 second sample interval, OK.

Example 2: INTERVAL=10, NAVG=8, MicroCAT has no pressure sensor
 Sampling time = 1.44 seconds + (**NAVG** * 0.86 seconds) = 1.44 + (8 * 0.86) = 8.32 seconds
 8.32 seconds + 2 seconds (for quiescent state) = 10.32 seconds > 10 second sample interval.
 Therefore, the MicroCAT internally sets the sampling rate to:
 (**INTERVAL** + actual required sampling time) = 10 seconds + 8.32 seconds = 18.32 seconds

Polled Sampling

Time from receipt of take sample command to beginning of reply:

- **With pressure:** 0.45 seconds + (**NAVG** * 1.26 seconds)
- **Without pressure:** 0.35 seconds + (**NAVG** * 0.86 seconds)

Minimum time (approximate) required from beginning of one sample to beginning of next sample, if **NAVG=1**:

- After **TS** command – 2 seconds
- After **TSSON** command – 3 seconds
- After **TSS** command – 5 seconds

Serial Line Sync Sampling

Power on time for each sample:

- **With pressure:** 1.55 seconds + (**NAVG** * 1.26 seconds)
- **Without pressure:** 1.44 seconds + (**NAVG** * 0.86 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 amp-hours. For planning purposes, Sea-Bird recommends using a conservative value of 5 amp-hours.

Current consumption is as follows:

- Sampling (acquisition) current is 25 milliamps.
- Quiescent current is less than 10 microamps (0.09 AH per year).

The time required for each sample is dependent on the user-programmed sampling mode, number of measurements per sample, and inclusion of a pressure sensor in the MicroCAT (see *Sample Timing* above). So, battery endurance is highly dependent on the application. Two examples follow.

Example 1: A MicroCAT with no pressure sensor is set up to sample autonomously every 10 minutes (6 samples/hour), taking 1 measurement per sample (**NAVG=1**). How long can it be deployed?

Sampling time = 1.44 seconds + (**NAVG** * 0.86 seconds) = 1.44 + (1 * 0.86) = 2.3 seconds

Sampling current consumption = 0.025 amps * 2.3 seconds = 0.06 amp-seconds/sample

In 1 hour, sampling current consumption = 6 * 0.06 amp-seconds/sample = 0.36 amp-seconds/hour

Quiescent current = 10 microamps = 0.01 mA

In 1 hour, quiescent current consumption ≈ 0.01 mA * 3600 seconds/hour = 0.036 amp-seconds/hour

Total current consumption / hour = 0.36 + 0.036 = 0.4 amp-seconds/hour

Capacity = (5 amp-hours * 3600 seconds/hr) / (0.4 amp-seconds/hour) = 45000 hours = 1875 days = 5.1 years

However, Sea-Bird recommends that batteries should not be expected to last longer than 2 years in the field.

Example 2: Same as above, but taking 20 measurements per sample (**NAVG=20**). How long can it be deployed?

Sampling time = 1.44 seconds + (**NAVG** * 0.86 seconds) = 1.44 + (20 * 0.86) = 18.64 seconds

Sampling current consumption = 0.025 amps * 18.64 seconds = 0.47 amp-seconds/sample

In 1 hour, sampling current consumption = 6 * 0.47 amp-seconds/sample = 2.82 amp-seconds/hour

Quiescent current = 10 microamps = 0.01 mA

In 1 hour, quiescent current consumption ≈ 0.01 mA * 3600 seconds/hour = 0.036 amp-seconds/hour

Total current consumption / hour = 2.82 + 0.036 = 2.86 amp-seconds/hour

Capacity = (5 amp-hours * 3600 seconds/hr) / (2.86 amp-seconds/hour) = 6294 hours = 262 days = 0.7 years

External Power (optional)

The MicroCAT can be ordered with an optional ability to be powered from an external source. The internal lithium pack is diode-OR'd with the external source, so power is drawn from whichever voltage source is higher. The MicroCAT can also be operated from the external supply without having the lithium batteries installed. Electrical isolation of conductivity is retained in units with the external power option, preventing ground loop noise contamination in the conductivity measurement.

Cable Length and Optional External Power

Note:

See *Real-Time Data Acquisition* in *Section 4: Deploying and Operating MicroCAT* for baud rate limitations on cable length if transmitting real-time data.

There are two issues to consider if powering the MicroCAT externally:

- Limiting the IR loss to 1 volt **if transmitting real-time data**; higher IR loss will prevent the instrument from transmitting real-time data because of the difference in ground potential.
- Supplying enough power at the power source so that sufficient power is available at the instrument after considering IR loss.

Looking at each issue separately:

Limiting IR Loss to 1 Volt if Transmitting Real-Time Data

The limit to cable length is typically reached when the maximum current times the power common wire resistance is more than 1 volt, because the difference in ground potential of the MicroCAT and ground controller prevents the MicroCAT from transmitting real-time data.

$$V_{\text{limit}} = 1 \text{ volt} = IR_{\text{limit}}$$

Where I is the current required by the MicroCAT (25 milliamps; see *Specifications* in *Section 2: Description of MicroCAT*).

$$\text{Maximum cable length} = R_{\text{limit}} / \text{wire resistance per foot}$$

Note:

Common wire resistances:

Gauge	Resistance (ohms/foot)
12	0.0016
14	0.0025
16	0.0040
18	0.0064
19	0.0081
20	0.0107
22	0.0162
24	0.0257
26	0.0410
28	0.0653

Example 1 – For 24 gauge wire, what is the maximum distance to transmit power to the MicroCAT?

For 25 milliamp current, $R_{\text{limit}} = V_{\text{limit}} / I = 1 \text{ volt} / 0.025 \text{ amps} = 40 \text{ ohms}$

For 24 gauge wire, resistance is 0.0257 ohms/foot.

Therefore, maximum cable length is $40 \text{ ohms} / 0.0257 \text{ ohms/foot} = 1556 \text{ feet} = 474 \text{ meters}$

Example 2 – Same as above, but there are 4 MicroCATs powered from the same power supply.

For 25 milliamp current, $R_{\text{limit}} = V_{\text{limit}} / I = 1 \text{ volt} / (0.025 \text{ amps} * 4 \text{ MicroCATs}) = 10 \text{ ohms}$

For 24 gauge wire, resistance is 0.0257 ohms/foot.

Therefore, maximum cable length is $10 \text{ ohms} / 0.0257 \text{ ohms/foot} = 389 \text{ feet} = 118 \text{ meters}$ (this is the cable length to the MicroCAT furthest from the power source).

Supplying Enough Power to MicroCAT

Another consideration in determining maximum cable length is supplying enough power at the power source so that sufficient voltage is available, after IR loss in the cable, to power the MicroCAT without drawing battery power.

Example 1 – For 24 gauge wire, what is the maximum distance to transmit power to the MicroCAT if using a 10.5 volt power source to supply power?

The MicroCAT's input power specification is 9 – 24 volts, with a recommendation of 10 volts minimum to avoid drawing power from the batteries. Therefore, a 0.5 volt IR drop (10.5 volts – 10 volts) would still provide enough power to the MicroCAT.

$$V = IR \quad 0.5 \text{ volts} = (0.025 \text{ amps}) * (0.0257 \text{ ohms/foot} * \text{cable length}) \quad \text{Cable length} = 778 \text{ ft} = 237 \text{ meters}$$

Note that 237 meters < 474 meters (maximum distance if MicroCAT is transmitting real-time data), so the IR drop in power is the controlling factor for this example. Using a higher voltage power supply or a different wire gauge would increase the allowable cable length.

Example 2 – Same as above, but there are 4 MicroCATs powered from the same power supply.

$$V = IR \quad 0.5 \text{ volts} = (0.025 \text{ amps} * 4 \text{ MicroCATs}) * (0.0257 \text{ ohms/foot} * \text{cable length}) \quad \text{Cable length} = 194 \text{ ft} = 59 \text{ meters}$$

(this is the cable length to the MicroCAT furthest from the power source)

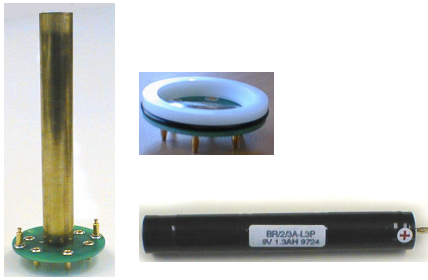
Section 3: Preparing MicroCAT for Deployment

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

Battery Installation

WARNING!

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



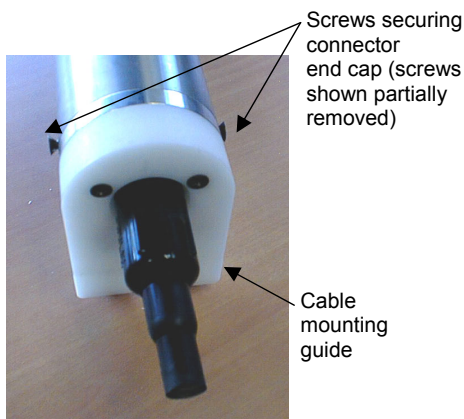
Description of Batteries and Battery Pack

Sea-Bird supplies six 9-volt batteries, shipped with the MicroCAT in a separate bag. Since they use solid-cathode cells and the total lithium contained in each 9-volt battery is less than 2 grams, these batteries are not *hazardous material* as defined by IATA or the US DOT. They are free of shipping restrictions, but shipment of the *assembled* battery pack is governed by the Hazardous Material Regulations.

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

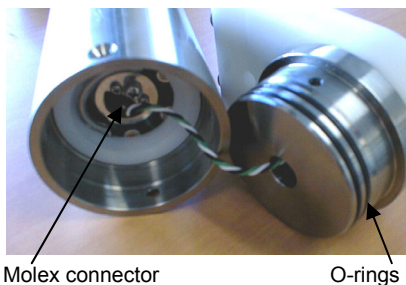
- a brass sleeve with lower printed circuit board (PCB) containing banana jacks
- upper PCB containing banana plugs

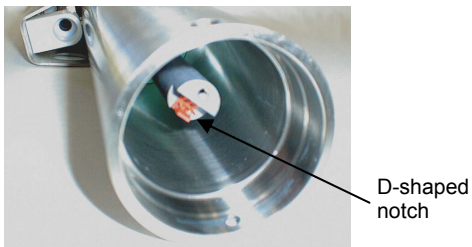
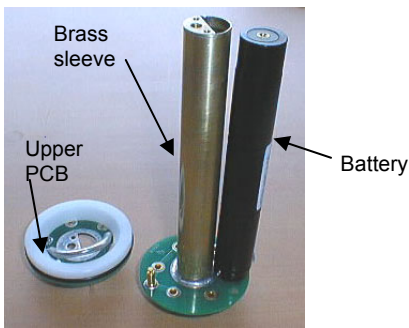
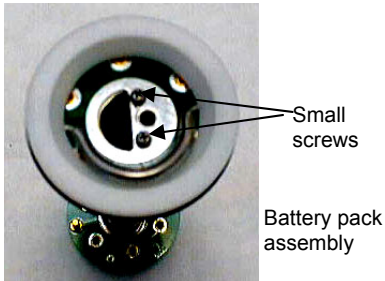
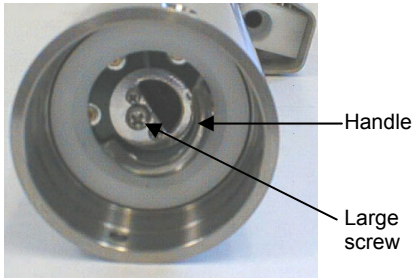
No soldering is required when assembling the battery pack because the batteries use the banana plugs and jacks as (+) and (-) terminals.



Installing Batteries

1. Remove the I/O connector end cap:
 - A. Wipe the outside of the I/O 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 I/O end cap by pulling firmly and steadily on the plastic cable mounting guide. 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 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 I/O connector 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 the O-rings and mating surfaces.
 - B. Plug the female end of the 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

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

Note:

It is possible to use the MicroCAT without SEATERM by sending direct commands from a dumb terminal or terminal emulator, such as Windows HyperTerminal.

If not already installed, install SEATERM and other Sea-Bird software programs on your computer using the supplied software CD: :

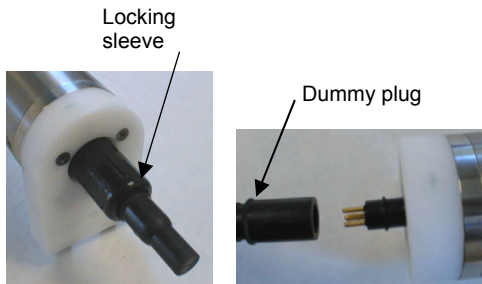
1. Insert the CD in your CD drive.
2. Double click on **Seasoft-Win32.exe**.
3. Follow the dialog box directions to install the software.

The default location for the software is c:/Program Files/Sea-Bird. Within that folder is a sub-directory for each program.

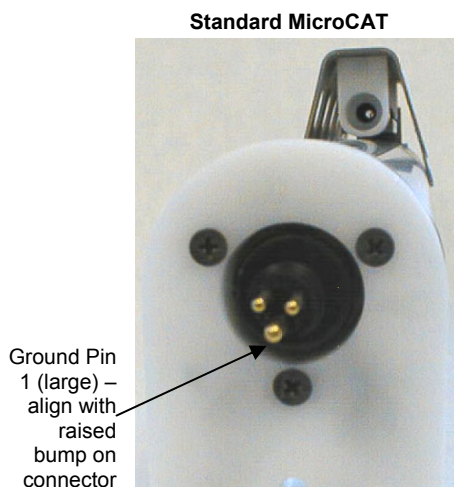
Power and Communications Test

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

Test Setup



1. Remove dummy plug (if applicable):
 - A. By hand, unscrew the locking sleeve from the MicroCAT's bulkhead connector. If you must use a wrench or pliers, be careful not to loosen the bulkhead connector instead of the locking sleeve.
 - B. Remove the dummy plug from the MicroCAT's I/O bulkhead connector by pulling the plug firmly away from the connector.



2. **Standard Connector** - Install the I/O cable connector, aligning the raised bump on the side of the connector with the large pin (pin 1 - ground) on the MicroCAT. **OR**
MCBH Connector - Install the I/O cable connector, aligning the pins.

3. Connect the I/O cable to your computer's serial port.

Note:

See SEATERM's help files for detailed information on the use of the program.

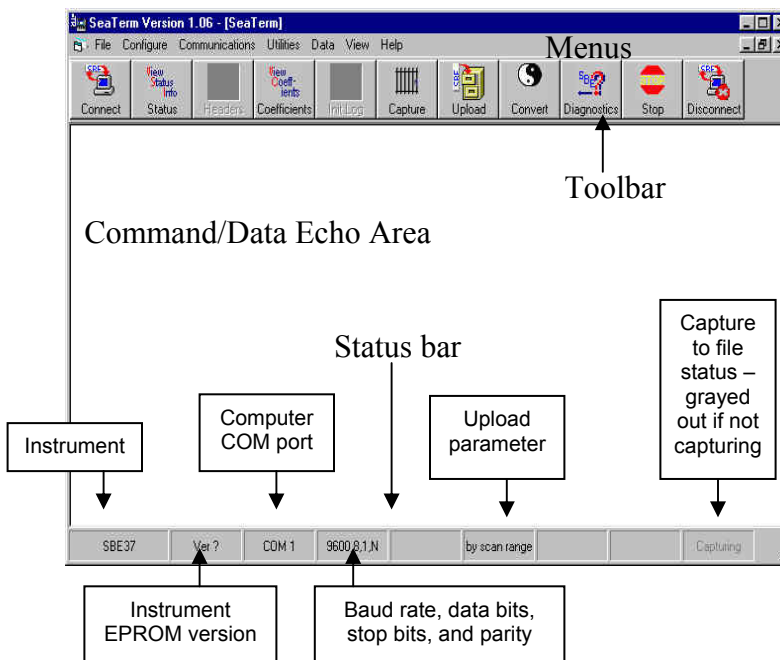
Test

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:

**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.

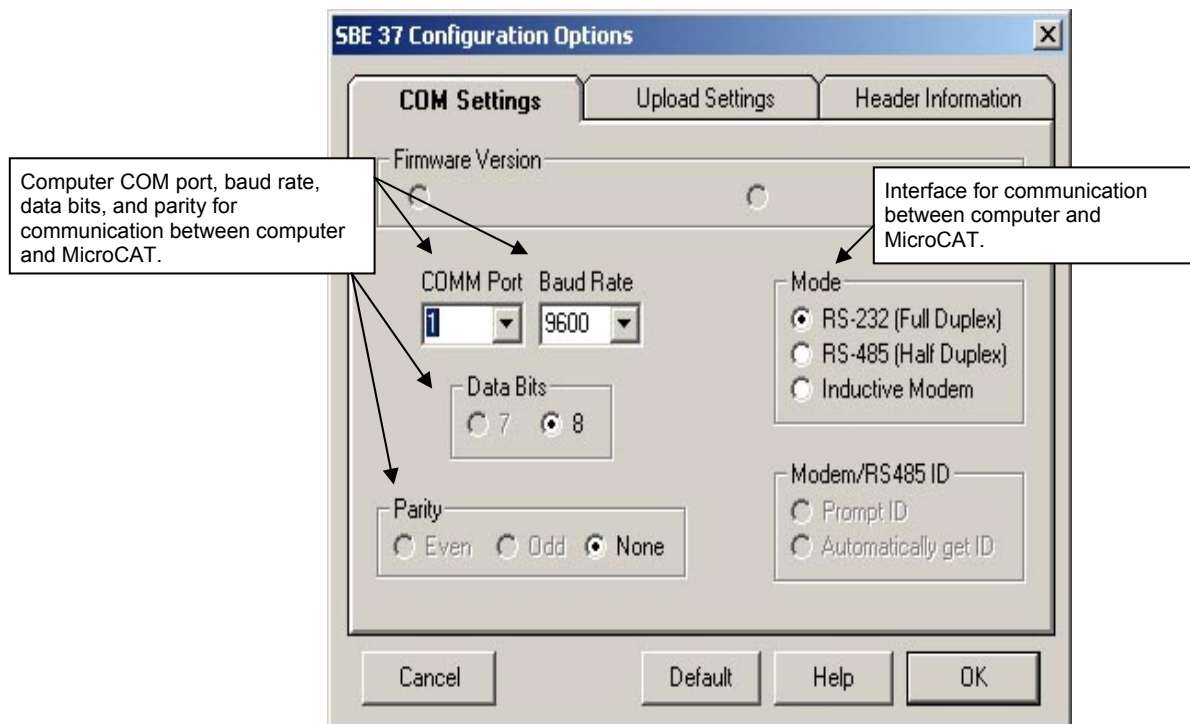
- **Menus** – Contains tasks and frequently executed instrument commands.
- **Toolbar** – Contains buttons for frequently executed tasks and instrument commands. All tasks and commands accessed through the Toolbar are also available in the Menus. To display or hide the Toolbar, select View Toolbar in 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.

Following are the Toolbar buttons applicable to the MicroCAT:

Toolbar Buttons	Description	Equivalent Command*
Connect	Re-establish communications with MicroCAT. Computer responds with S> prompt. MicroCAT goes to sleep after 2 minutes without communication from computer have elapsed.	(press Enter key)
Status	Display instrument setup and status (logging, number of samples in memory, etc.).	DS
Coefficients	Display calibration coefficients.	DC
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: <ul style="list-style-type: none"> • Configure upload and header parameters in Configure menu. • Send STOP to stop logging. 	DDb,e (use Upload key 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.	DS, DC, TS, and TSR
Stop	Interrupt and end current activity, such as logging, uploading, or diagnostic test.	—
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.

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



Notes:

- SEATERM's baud rate must be the same as the MicroCAT 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, 39, 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.

Make the selections in the Configuration Options dialog box:

- COMM Port:** COM 1 through COM 10, as applicable
- Baud Rate:** 9600 (documented on Configuration page of this manual)
- Data Bits:** 8
- Parity:** None
- Mode:** RS-232 (Full Duplex)

Click OK to save the settings.

- In the Communications menu, select *Options / Cycle baud when connecting*.
- Click Connect on the Toolbar. SEATERM tries to connect to the MicroCAT at the baud set in Step 3. If it cannot, it cycles through all other possible baud rates to try to connect. When it connects, the display looks like this:

```
. . . Communication Established
S>
```

This shows that correct communications between the computer and the MicroCAT has been established.

If the system does not respond with the S> prompt:

- Click Connect again or press the Enter key twice.
- 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 page of this manual.
- Check cabling between the computer and MicroCAT.

Note:

The MicroCAT has a 2 minute timeout algorithm 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, click Connect on the Toolbar to reestablish communications.

6. Display MicroCAT status information by clicking Status on the Toolbar.

The display looks like this:

```
SBE37-SM V 2.5 SERIAL NO. 2165 20 Nov 2003 08:49:08
logging not started
sample interval = 30 seconds
samplenum = 52, free = 190598
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
serial sync mode disabled
wait time after serial sync sampling = 120 seconds
temperature = 7.54 deg C
```

7. Command the MicroCAT to take a sample by typing **TS** and pressing the Enter key. The display looks like this (if optional pressure sensor installed, **FORMAT=1**, and not outputting salinity or sound velocity):

```
23.7658,0.00019, 0.062, 20 Nov 2003, 08:49:10
```

where 23.7658 = temperature in degrees Celsius
 0.00019 = conductivity in S/m
 0.062 = pressure in decibars
 20 Nov 2003 = date
 08:49:10 = 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).

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

The MicroCAT is ready for programming and deployment.

Section 4:

Deploying and Operating MicroCAT

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

Sampling Modes

The MicroCAT has three basic sampling modes for obtaining data:

- Polled Sampling – On command, the MicroCAT takes one sample.
- Autonomous Sampling – At pre-programmed intervals, the MicroCAT wakes up, samples, stores data in memory, and powers off.
- Serial Line Synchronization – In response to a pulse on the serial line, the MicroCAT wakes up, samples, stores data in memory, and powers off.

Commands can be used in various combinations to provide a high degree of operating flexibility.

Descriptions and examples of the sampling modes follow. Note that the MicroCAT's response to each command is not shown in the examples. Review the operation of the basic sampling modes and the commands described in *Command Descriptions* before setting up your system.

Polled Sampling

On command, the MicroCAT takes **NAVIG** measurements, averages the measurements, and sends the averaged data to the computer. Storing of data in the MicroCAT's FLASH memory is dependent on the particular command used.

Example: Polled Sampling (user input in bold)

Wake up MicroCAT. Set the number of measurements per sample to 4. Command MicroCAT to take a sample, and send converted data to computer (do not store data in MicroCAT's memory). Send power-off command to MicroCAT.

(click Connect on Toolbar to wake up.)

S>**NAVIG=4**

S>**TS**

S>**QS**

Autonomous Sampling (Logging commands)

At pre-programmed intervals the MicroCAT wakes up, samples data (taking **NAVG** measurements for each sample and averaging the measurements), stores the averaged data in its FLASH memory, and goes to sleep (enters quiescent state). Logging is started with **STARTNOW** or **STARTLATER**, and is stopped with **STOP**. Transmission of real-time averaged data to the computer is dependent on **TXREALTIME**.

Note:

Use **STOP** to:

- stop logging
- stop waiting to start logging (after **STARTLATER** has been sent)

Once **STOP** 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 waiting to start logging (**STARTLATER** has been sent, but logging has not started yet), the MicroCAT will only accept the following commands: **DS**, **DC**, **TS**, **TSR**, **SL**, **SLT**, **SLTR**, **QS**, and **STOP**.

Additionally, if the MicroCAT is logging, **it cannot be interrupted during measurements** to accept any commands. If the MicroCAT is logging and appears unresponsive, it may be in the middle of taking measurements; continue to try to establish communications. Note that if **NAVG** is large in comparison to **INTERVAL**, there will only be a very short period of time between samples when the MicroCAT can be interrupted; this may make it difficult to interrupt or stop sampling.

Example: Autonomous Sampling (user input in bold).

Wake up MicroCAT. Set sample number to 0 to overwrite previous data in memory. Set up to sample every 60 seconds, with 4 measurements averaged per sample. Store time and date with samples, and do not transmit real-time data to computer. Set up to automatically start logging on 10 January 2004 at 12:00:00. Send power-off command after all parameters are entered – system will automatically wake up and power down for each sample.

(click Connect on Toolbar to wake up.)

```
S>SAMPLENUM=0
S>INTERVAL=60
S>NAVG=4
S>STORETIME=Y
S>TXREALTIME=N
S>STARTMMDDYY=011004
S>STARTHHMMSS=120000
S>STARTLATER
S>QS
```

After logging begins, look at data from last sample to check results, and then power down:

(click Connect on Toolbar to wake up.)

```
S>SL
S>QS
```

When ready to upload all data to computer, wake up MicroCAT, stop sampling, upload data, and then power down:

(click Connect on Toolbar to wake up.)

```
S>STOP
```

(Click Upload on Toolbar – program leads you through screens to define data to be uploaded and where to store it)

```
S>QS
```

Serial Line Synchronization (Serial Line Sync)

Serial Line Sync allows a simple pulse on the RS-232 line to initiate a sample. This mode provides easy integration with ADCPs or current meters, which can synchronize MicroCAT sampling with their own without drawing on their battery or memory resources.

Note:
Use **DS** to view Serial Line Sync enable/disable status.

If this mode is enabled (**SYNCMODE=Y**) and the MicroCAT is powered down, setting the RS-232 RX line high (3 –10 VDC) for 1 to 1000 milliseconds wakes up the MicroCAT and executes a Take Sample command:

- Take sample (consisting of **NAVG** measurements)
- Store averaged data in **FLASH** memory
- Output real-time converted averaged data

After executing the Take Sample command, the MicroCAT checks the RS-232 line and **SYNCWAIT**. These determine whether to power down immediately or accept commands from the computer, and whether to leave the serial line sync mode enabled or disable it:

- **SYNCWAIT=0** and **Mark State** (RS-232 RX line less than 0.5 volts)
MicroCAT immediately powers down. Serial line sync mode remains enabled (**SYNCMODE=Y**).
- **SYNCWAIT=0** and **Space State** (RS-232 RX line greater than 3 volts)
MicroCAT monitors the RS-232 line for a time equivalent to 25 characters (actual length of time is dependent on the baud rate):
 - Line remains in space state - MicroCAT disables serial line sync mode (sets **SYNCMODE** to **N**) at end of time. Once serial line sync mode is disabled, you can communicate with the MicroCAT using the full range of commands (polled sampling commands, logging commands, upload command, etc.).
 - Line returns to mark state - MicroCAT immediately powers down. Serial line sync mode remains enabled (**SYNCMODE=Y**).
- **SYNCWAIT>0**
MicroCAT monitors the RS-232 line for **SYNCWAIT** seconds. Each time a carriage return (Enter key) is detected, the time-out clock is reset to 2 minutes. Within that time period, you can communicate with the MicroCAT using the full range of commands (polled sampling commands, logging commands, uploading command, etc.). While the MicroCAT is monitoring:
 - More than 25 break characters are received - MicroCAT disables serial line sync mode (sets **SYNCMODE** to **N**). Once serial line sync mode is disabled, you can communicate with the MicroCAT using the full range of commands (polled sampling commands, logging commands, upload command, etc.).
 - Less than 25 break characters are received - MicroCAT powers down when the time-out clock runs down. Serial line sync mode remains enabled (**SYNCMODE=Y**).

In summary, to disable serial line sync mode after executing the take sample command:

- **SYNCWAIT = 0**
Put RS-232 line in space state (greater than 3 volts) for time equivalent to 25 characters.
- **SYNCWAIT > 0**
 - Send 25 break characters, or
 - If **SYNCWAIT** is greater than 5 seconds, send **SYNCMODE=N** after waiting at least 3 seconds after executing the take sample command.

Note:
If running **SEATERM**, select *Send 5 second break* in the Communications menu to hold the RS-232 RX line in space state for 5 seconds. This will always be more than 25 break characters, and will cause the MicroCAT to exit serial line sync mode.

Example: Serial Line Sync (user input in bold)

Wake up MicroCAT. Set sample number to 0 to overwrite previous data in memory. Set **NAVG=4** to take 4 measurements per sample. Set **SYNCWAIT** to 25 seconds and enable serial line sync mode. Send power off command.

(click Connect on Toolbar to wake up.)

S>**SAMPLENUM=0**

S>**NAVG=4**

S>**SYNCWAIT=25**

S>**SYNCMODE=Y**

S>**QS**

Take samples using serial line sync mode:

(Set RS-232 RX line high [3-10 VDC] for 1-1000 milliseconds.

MicroCAT takes 4 measurements, stores averaged data in memory, and outputs converted averaged data. Do not send any characters – MicroCAT powers down after 25 seconds.)

(Repeat this process at periodic intervals as desired.)

When ready to upload all data to computer, disable serial line sync mode, and then upload data and power down:

(Set RS-232 RX line high [3-10 VDC] for 1-1000 milliseconds.

MicroCAT takes 4 measurements, stores averaged data in memory, and outputs converted averaged data.)

(Within 25 seconds [**SYNCWAIT** timeout], select *Send 5 second break* in Communications menu to disable serial line sync mode.)

(Press Enter key to get S> prompt.)

S>**DS** (to verify MicroCAT is communicating)

(Click Upload on Toolbar – program leads you through screens to define data to be uploaded and where to store it)

S>**QS**

Real-Time Data Acquisition

Notes:

- Baud rate is set with **BAUD=**. Set **TXREALTIME=Y** to output real-time data. See *Command Descriptions* in this section for command details.
- If using external power, see *External Power (optional)* in *Section 2: Description of MicroCAT* for power limitations on cable length.

The length of cable that the MicroCAT can drive is dependent on the baud rate. The allowable combinations are:

Maximum Cable Length (meters)	Maximum Baud Rate
1600	600
800	1200
400	2400
200	4800
100	9600
50	19200
25	38400

If acquiring real-time data, click Capture on SEATERM's Toolbar before you begin logging. The data displayed in SEATERM will be saved to the designated file. Process the data as desired. Note that this real-time data file **cannot be processed by SBE Data Processing, as it does not have the required headers and format**. To process data with SBE Data Processing, upload the data from the MicroCAT's memory.

Timeout Description

The MicroCAT has a timeout algorithm. If the MicroCAT does not receive a command for two minutes, it powers down its communication circuits to prevent exhaustion of the batteries. **To re-establish control (wake up), click Connect on the Toolbar or press the Enter key.** The system responds with the S> prompt.

Command Descriptions

This section describes commands and provides sample outputs. See *Appendix III: 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 returns to the quiescent (sleep) state.
- If in quiescent state, re-establish communications by clicking Connect on the Toolbar or pressing the Enter key to get an S> prompt.

Status Command

Note:

If the battery voltage is below 6.15 volts, the following displays in response to **DS**:

```
WARNING: LOW BATTERY
VOLTAGE!!  Replace the
batteries before continuing.
```

DS

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 [**MMDDYY=** or **DDMMYY=**, and **HHMMSS=**]
- logging status
- sample interval time [**INTERVAL=**]
- number of samples in memory and available sample space in memory
- data acquired with autonomous sampling to be transmitted real-time [**TXREALTIME=**]?
- output salinity with each sample [**OUTPUTSAL=**]?
- output sound velocity with each sample [**OUTPUTSV**]?
- store date and time with each sample acquired with autonomous sampling [**STORETIME=**]?
- number of measurements to average for each sample [**NAVG=**]
- reference pressure [**REFPRESS=**]; only displays if no pressure sensor installed
- serial sync mode state [**SYNCMODE=**]
- serial sync mode wait time [**SYNCWAIT=**]
- 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

Example: Display status for MicroCAT (user input in bold).

```
S>DS
SBE37-SM V 2.5  SERIAL NO. 2165  20 Nov 2003  08:49:08
logging data
sample interval = 30 seconds
splenumber = 52, free = 190598
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
reference pressure = 0.0 db
serial sync mode disabled
wait time after serial sync sampling = 120 seconds
temperature = 7.54 deg C
```

Setup Commands

Notes:

- **DDMMYY=** and **MMDDYY=** are equivalent. Either can be used to set the date.
- If the battery pack has been removed, date and then 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=** or **DDMMYY=**.

Notes:

The MicroCAT's baud rate (set with **BAUD=**) must be the same as SEATERM's baud rate (set in the Configure menu).

MMDDYY=mmddy

Set real-time clock month, day, and year. Must be followed by **HHMMSS=** to set time.

DDMMYY=ddmmyy

Set real-time clock day, month, and year. Must be followed by **HHMMSS=** to set time.

HHMMSS=hhmss

Set real-time clock hour, minute, second.

Example: Set current date and time to 10 January 2004 12:00:00 (user input in bold).

S>**MMDDYY=011004**

or

S>**DDMMYY=100104**S>**HHMMSS=120000**S>**HHMMSS=120000****BAUD=x**

x= baud rate (600, 1200, 2400, 4800, 9600, 19200, or 38400). Default 9600.

Length of cable that MicroCAT can drive when transmitting real-time data is dependent on baud. Allowable combinations:

Maximum Cable Length (meters)	Maximum Baud Rate
1600	600
800	1200
400	2400
200	4800
100	9600
50	19200
25	38400

Notes:

- The MicroCAT does not *store* salinity and sound velocity in memory if **OUTPUTSAL=Y** and **OUTPUTSV=Y**. It calculates and outputs the values real-time or as data is uploaded; therefore, outputting these parameters has no effect on the number of samples that can be stored in memory.
- Salinity and sound velocity can also be calculated from data uploaded from the MicroCAT's memory in SBE Data Processing.

OUTPUTSAL=x

x=Y: Calculate and output salinity (psu) with each sample.

x=N: Do not.

OUTPUTSV=x

x=Y: Calculate and output sound velocity (m/sec) with each sample, using Chen and Millero formula (UNESCO Technical Papers in Marine Science #44).

x=N: Do not.

Notes:

- See *Data Output Formats* below.
- Date and time are included in autonomous sampling data only if **STORETIME=Y**.
- Legend:
t = temperature (°C, ITS-90).
c = conductivity (Siemens/meter).
p = pressure (decibars); sent only if optional pressure sensor installed.
s = salinity (psu); sent only if **OUTPUTSAL=Y**.
v = sound velocity (m/sec); sent only if **OUTPUTSV=Y**.
dd mmm yyyy = day, month, year.
mm-dd-yyyy = month, day, year.
hh:mm:ss = hour, minute, second.

FORMAT=x

x=0: output raw hex data, for diagnostic use at Sea-Bird

x=1 (default): output converted data.
ttt.ttt,cc.ccccc, pppp.ppp, sss.ssss,
vvvv.vvv, dd mmm yyyy, hh:mm:ss

x=2: output converted data.
ttt.ttt,cc.ccccc, pppp.ppp, sss.ssss,
vvvv.vvv, mm-dd-yyyy, hh:mm:ss

Setup Commands (continued)

REFPRESS=x x = reference pressure (gauge) in decibars. MicroCAT without installed pressure sensor uses this reference pressure in conductivity (and optional salinity and sound velocity) calculations. Entry ignored if MicroCAT includes pressure sensor.

NAVG=x x= number of measurements (1 – 1000) to take and average for each sample. Default 1.

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

QS Quit session and place MicroCAT in quiescent (sleep) state. Main power is turned off. Data logging and memory retention are not affected.

Note:

Do not send SAMPLENUM=0 until all data has been uploaded. SAMPLENUM=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 **SAMPLENUM=x**, where **x** is your estimate of number of samples in memory.
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 file 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.

Logging Commands

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

INTERVAL=x x= interval (seconds) between samples (5 - 32767). When commanded to start sampling with **STARTNOW** or **STARTLATER**, at x second intervals MicroCAT takes **NAVG** measurements, stores averaged data in FLASH memory, transmits real-time averaged data (if **TXREALTIME=Y**), and goes to sleep (enters quiescent state).

STORETIME=x x=Y: Store date and time with each sample. This adds 4 bytes per scan.
x=N: Do not.

TXREALTIME=x x=Y: Output real-time data to computer. Averaged data is transmitted immediately after it is sampled. **This does not affect storing data to FLASH memory, but slightly increases current consumption and increases amount of time needed to sample (and then transmit) data.** If outputting real-time data, do not set **INTERVAL** to less than 10 seconds if **NAVG=1**; for larger values of **NAVG** increase **INTERVAL** (see *Sample Timing* in *Section 2: Description of MicroCAT*).
x=N: Do not.

Note:

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 sets the logging status to low battery.

Notes:

- **TXREALTIME** and **STORETIME** apply to autonomous sampling only.
- To capture real-time data to a file, do the following *before* starting logging:
 1. Click Capture on the Toolbar.
 2. Enter the desired file name in the dialog box. The *capture* status displays in the status bar at the bottom of the screen.

Logging Commands (continued)

STARTNOW Start logging now, at rate defined by **INTERVAL**. Data is stored in FLASH memory. Data is transmitted real-time if **TXREALTIME=Y**.

STARTMMDDYY=mmddy Set delayed logging start month, day, and year. Must be followed by **STARTHHMMSS=** to set delayed start time.

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

STARTHHMMSS=hmmss Set delayed logging start hour, minute, and second.

STARTLATER Start logging at time set with delayed start date and time commands, at rate defined by **INTERVAL**. Data is stored in FLASH memory. Data is transmitted real-time if **TXREALTIME=Y**.

Note:

STARTDDMMYY= and **STARTMMDDYY=** are equivalent. Either can be used to set the delayed start date.

Notes:

- After receiving **STARTLATER**, the MicroCAT displays not logging: waiting to start at in reply to the Display Status (**DS**) command. Once logging has started, the **DS** reply displays logging data.
- If the delayed start date and time has already passed when **STARTLATER** is received, the MicroCAT executes **STARTNOW**.

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

```
S>STARTMMDDYY=012004
S>STARTHHMMSS=120000
S>STARTLATER
```

or

```
S>STARTDDMMYY=200104
S>STARTHHMMSS=120000
S>STARTLATER
```

Note:

You may need to send **STOP** several times to get the MicroCAT to respond. This is most likely to occur if sampling with a small **INTERVAL** and transmitting real-time data (**TXREALTIME=Y**).

STOP

Stop logging (that was started with **STARTNOW** or **STARTLATER**) or stop waiting to start logging (if **STARTLATER** was sent but logging has not begun yet). Press Enter key to get **S>** prompt before entering **STOP**. **STOP** must be sent before uploading data using Upload on Toolbar, Upload Data in Data menu, or **DDb,e**.

Polled Sampling Commands

Note:

The MicroCAT has a buffer that stores the most recent data sample. Unlike data in the FLASH memory, data in the buffer is erased upon removal or failure of power.

These commands are used by an external controller to request a sample from the MicroCAT. Each sample consists of **NAV**G measurements, which are averaged and stored in the buffer. To interrupt taking a sample, press the Esc key.

TS	Take sample, output converted averaged data, and leave power on. Data is not stored in FLASH memory.
TSR	Take sample, output averaged raw data, and leave power on. Data is not stored in FLASH memory.
TSS	Take sample, store averaged data in FLASH memory , output converted averaged data, and turn power off. If MicroCAT is logging or waiting to log when TSS is sent, MicroCAT executes TS instead.
TSSON	Take sample, store averaged data in FLASH memory , output converted averaged data, and leave power on. If MicroCAT is logging or waiting to log when TSSON is sent, MicroCAT executes TS instead.
SLT	Output converted averaged data from last sample, then take new sample, and leave power on. Data is not stored in FLASH memory.
SLTR	Output raw averaged data from last sample, then take new sample, and leave power on. Data is not stored in FLASH memory.
SL	Output converted averaged data from last sample taken with either a Polled Sampling Command or with data logging (see <i>Logging Commands</i>), and leave power on.

Serial Line Sync Commands

Note:

See *Sampling Modes* above for complete details on the operation of serial line synchronization.

SYNCMODE=x	<p>x=Y: Enable serial line synchronization. When RS-232 RX line is high (3-10 VDC) for 1 to 1000 milliseconds, MicroCAT takes a sample consisting of NAVG measurements, stores averaged data in FLASH memory, transmits real-time averaged data, and powers down.</p> <p>x=N: Disable serial line synchronization.</p>
SYNCWAIT=x	<p>x= time (seconds) MicroCAT monitors RS-232 line for commands after taking a sample in serial line sync mode. Range 0 - 120 seconds; default 0.</p>

Notes:

- To save data to a file, click Capture on the Toolbar before entering **DDb,e**.
- See *Data Output Formats* after these *Command Descriptions*.
- **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 **DDb,e** does not produce data with the required header information and required format for processing by our software. This command is included here for reference for users who are writing their own software.

Data Upload Command

Send **STOP** before uploading data.

DDb,e

Upload data from scan b to scan e. First sample is number 1. 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.

Example: Upload samples 1 through 200 for MicroCAT to a file (user input in bold).
(Click Capture on Toolbar and enter desired filename in dialog box.)
S>**DD1 , 200**

Testing Commands

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

TT	Measure temperature 100 times or until Esc key is pressed, output converted data.
TC	Measure conductivity 100 times or until Esc key is pressed, output converted data.
TP	Measure pressure 100 times or until Esc key is pressed, output converted data.
TTR	Measure temperature 100 times or until Esc key is pressed, output raw data.
TCR	Measure conductivity 100 times or until Esc key is pressed, output raw data.
TPR	Measure pressure 100 times or until Esc key is pressed, output raw data.
TR	Measure real-time clock frequency 30 times or until Esc key is pressed, output data.

Calibration Coefficients Commands

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.

DC

Display calibration coefficients.
Equivalent to Coefficients on Toolbar.

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

```
S>DC
SBE37-SM V 2.5 2165
temperature:      19-may-03
TA0 = -9.420702e-05
TA1 =  2.937924e-04
TA2 = -3.739471e-06
TA3 =  1.909551e-07
conductivity:    19-may-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:             11-apr-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

TCALDATE=S	S=Temperature calibration date
TA0=F	F=Temperature A0
TA1=F	F=Temperature A1
TA2=F	F=Temperature A2
TA3=F	F=Temperature A3
CALDATE=S	S=Conductivity calibration date
CG=F	F=Conductivity G
CH=F	F=Conductivity H
CI=F	F=Conductivity I
CJ=F	F=Conductivity J
WBOTC=F	F=Conductivity wbotc
CTCOR=F	F=Conductivity ctcor
CPCOR=F	F=Conductivity cpcor
PCALDATE=S	S=Pressure calibration date
PA0=F	F=Pressure A0
PA1=F	F=Pressure A1
PA2=F	F=Pressure A2
PTCA0=F	F=Pressure ptca0
PTCA1=F	F=Pressure ptca1
PTCA2=F	F=Pressure ptca2
PTCB0=F	F=Pressure ptcb0
PTCB1=F	F=Pressure ptcb1
PTCB2=F	F=Pressure ptcb2
POFFSET=F	F=Pressure offset
RCALDATE=S	S=Real-time clock calibration date
RTCA0=F	F=Real-time clock A0
RTCA1=F	F=Real-time clock A1
RTCA2=F	F=Real-time clock A2

Data Output Formats

Notes (for **FORMAT=1** or **2**):

t = temperature (°C, ITS-90)

c = conductivity (S/m)

p = pressure (decibars); included only if optional pressure sensor installed

s = salinity (psu); sent only if

OUTPUTSAL=Y.

v = sound velocity (m/sec); sent only if

OUTPUTSV=Y.

dd mmm yyyy = day, month (Jan, Feb, Mar, etc.), year

mm-dd-yyyy = month, day, year

hh:mm:ss = hour, minute, second.

Note that time is the time at the **start** of the sample.

- There is a comma but no space between temperature and conductivity. All other data is separated with a comma and space.
- Date and time are included with autonomous sampling data only if **STORETIME=Y**.
- When **TXREALTIME=Y**, real-time autonomous data transmitted to the computer is preceded by a # sign and a space.
- 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>.

- **FORMAT=0**
Raw hex data, intended only for diagnostic use at Sea-Bird.
- **FORMAT=1** (default)
ttt.tttt,cc.cccccc, pppp.ppp, sss.ssss, vvvv.vvv, dd mmm yyyy, hh:mm:ss
Leading zeros are suppressed, except for one zero to the left of the decimal point.
- **FORMAT=2**
ttt.tttt,cc.cccccc, pppp.ppp, sss.ssss, vvvv.vvv, mm-dd-yyyy, hh:mm:ss
Leading zeros are suppressed, except for one zero to the left of the decimal point.

Example: Sample data output when pressure sensor is installed, **STORETIME=Y**, **OUTPUTSAL=Y**, **OUTPUTSV=Y**, and **FORMAT=1**:

```
4.1960, 3.53255, 2184.494, 36.9305, 1506.185,
07 Nov 2003, 14:28:00
(temperature,conductivity, pressure, salinity, sound velocity, date, time)
```

Setup for Deployment

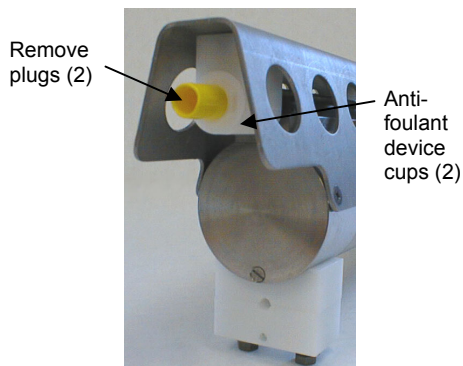
1. Install new batteries or ensure the existing battery pack has enough capacity to cover the intended deployment. See *Section 5: Routine Maintenance and Calibration* for details on installing new batteries.
2. Program the MicroCAT for the intended deployment (see *Section 3: Preparing MicroCAT for Deployment* for connection information; see information in this section on commands and sampling modes):
 - A. Ensure all data has been uploaded, and then set **SAMPLENUM=0** to make the entire memory available for recording. If **SAMPLENUM** is not reset to 0, data will be stored after the last recorded sample.
 - B. Set the date and then time.
 - C. Establish the setup and logging parameters.
 - D. Use **one** of the following command sequences to initiate sampling:
 - **STARTNOW** to start logging now, taking a sample consisting of **NAVG** measurements every **INTERVAL** seconds.
 - **STARTMMDDYY=**, **STARTRHHMMSS=**, and **STARTLATER** to start logging at the specified date and time, taking a sample consisting of **NAVG** measurements every **INTERVAL** seconds.
 - **SYNCMODE=Y** to place the MicroCAT in serial line sync mode, so that a simple pulse on the RS-232 line will initiate a sample consisting of **NAVG** measurements.

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=** or **DDMMYY=**.

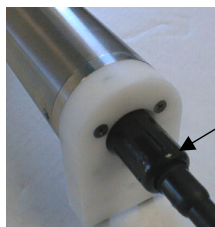
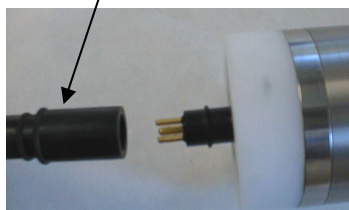
Deployment

The MicroCAT comes standard with a pre-installed Sea-Bird wire mounting clamp and guide.



CAUTION:
Do not use WD-40 or other petroleum-based lubricants, as they will damage the connectors.

Dummy plug or I/O cable connector
(as applicable)



Locking sleeve



Standard mounting clamp and guide –
loosen hardware to separate clamp/guide
halves and mount on
mooring cable

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. Install the dummy plug or I/O cable (for optional external power and/or serial communication during deployment):
 - A. Lightly lubricate the inside of the dummy plug or cable connector with silicone grease (DC-4 or equivalent).
 - B. **Standard Connector** (shown in photos) - Install the dummy plug or cable connector, aligning the raised bump on the side of the plug/connector with the large pin (pin 1 - ground) on the MicroCAT. Remove any trapped air by *burping* or gently squeezing the plug/connector near the top and moving your fingers toward the end cap. **OR**
MCBH Connector – Install the plug/cable connector, aligning the pins.
 - C. Place the locking sleeve over the plug/connector. Tighten the locking sleeve finger tight only. **Do not overtighten the locking sleeve and do not use a wrench or pliers.**
3. Attach the mounting clamp and guide to the mooring cable.
4. Verify that the hardware and external fittings are secure.
5. Deploy the MicroCAT.

Recovery

WARNING!

Pressure housings may flood under pressure due to dirty or damaged o-rings, or other failed seals, causing highly compressed air to be trapped inside. If this happens, a potentially life-threatening explosion can occur when the instrument is brought to the surface.

If the MicroCAT is unresponsive to commands or shows other signs of flooding or damage, carefully secure the instrument in a location away from people until it has been determined that abnormal internal pressure does not exist.

Contact Sea-Bird for assistance with procedures for safely relieving internal pressure.

Physical Handling

1. Rinse the 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 extracted. 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 state (**QS**), so that date and time are retained. Because the quiescent current required is only 10 microamps, the batteries can be left in place without significant loss of capacity (less than 2% loss per year).

Uploading Data

Note:

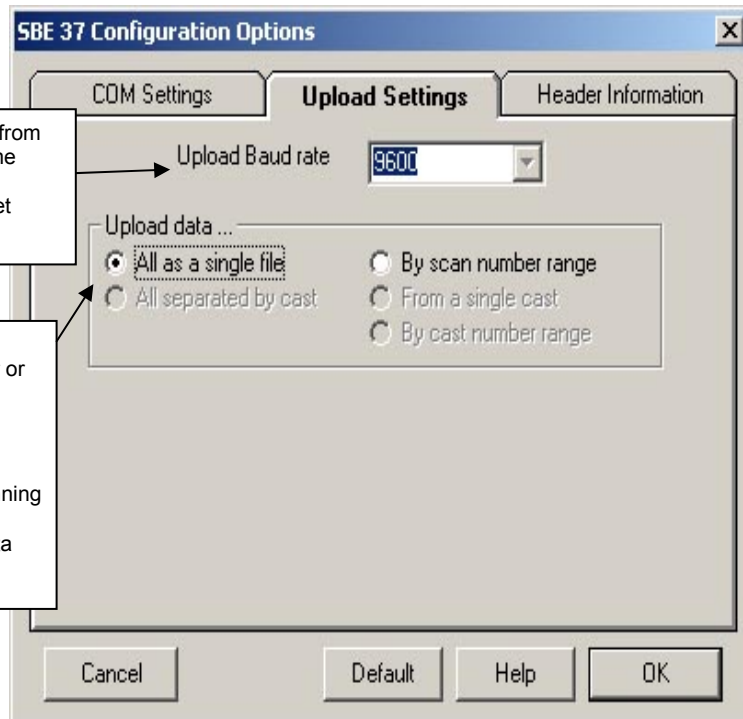
Data may be uploaded during deployment or after recovery. If uploading after recovery, connect the I/O cable as described in *Power and Communications Test* in *Section 3: Preparing MicroCAT for Deployment*.

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 uploading data from MicroCAT to computer is same as baud rate for general communication, which was set on COM Settings tab.

Defines data upload type when using Upload button 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.



Note:

Set up **Upload Settings**, **Header Information**, and/or **Header Form** (Steps 2 through 4):

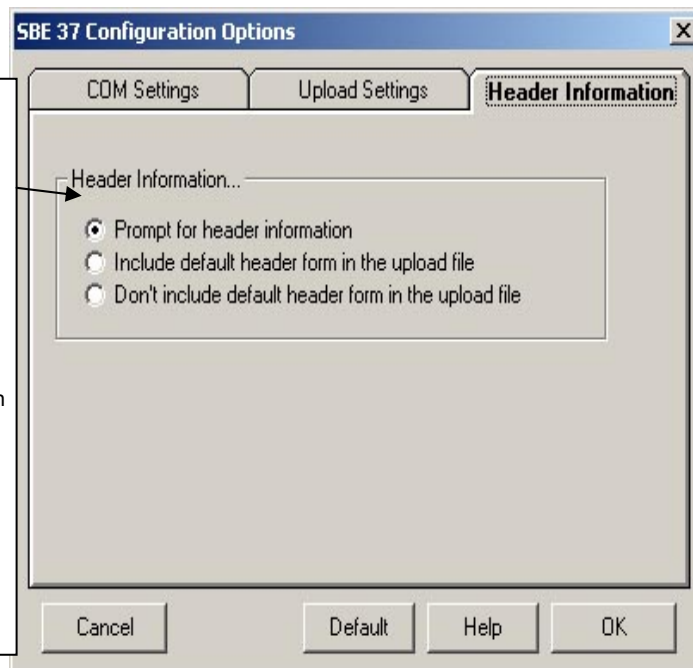
- The first time you upload data, and
- If you want to change upload or header parameters.

Make the selection for Upload Settings.

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.
- Do not 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:

- 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)
- 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:

```
. . . Communication Established
S>
```

This shows that correct communications between the computer and the MicroCAT has been established.

If the system does not respond as shown above:

- Click Connect again.
 - Check cabling between the computer and MicroCAT.
 - Verify the correct instrument was selected and the COM settings were entered correctly in the Configure menu.
6. If sampling autonomously, command the MicroCAT to stop logging by pressing the Enter key and sending **STOP**.

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

```
SBE37-SM V 2.5 SERIAL NO. 2165 20 Nov 2003 08:49:08
not logging: received stop command
sample interval = 30 seconds
samplenummer = 52, free = 190598
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
serial sync mode disabled
wait time after serial sync sampling = 120 seconds
temperature = 7.54 deg C
```

8. Click Upload on the Toolbar to upload stored data. SEATERM responds as follows:
- A. SEATERM sends the status (**DS**) command, displays the response, and writes the command and response to the upload file. This 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 (**DC**) command, displays the response, and writes the command and response to the upload file. This displays the 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 (**DDb,e**) command.
 - G. When the data has been uploaded, SEATERM shows the S> prompt.

9. 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 adds a pressure column to the data; the entered deployment pressure is 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 **REFPRESS=**. 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 than may have been available prior to deployment, for calculation of salinity and other parameters in SBE Data Processing.
- If your MicroCAT includes an optional pressure sensor, entering a deployment pressure has no effect on the data. Convert **does not overwrite the actual pressure data** in the file with the entered deployment pressure.

Notes:

To prepare for re-deployment:

1. After all data has been uploaded, send **SAMPLENUM=0**. If this 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 **QS** 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. Quiescent current is only 10 microamps, so the batteries can be left in place without significant loss of capacity.
 - Use **STARTNOW** to begin logging immediately.
 - Set a date and time for logging to start using **STARTMMDDYY=** or **STARTDDMMYY=**, **STARTHHMMSS=**, and **STARTLATER**.

- B. Use SBE Data Processing to process the .cnv data. See the software manual on CD-ROM or Help files for details.

Section 5: Routine Maintenance and Calibration

This section reviews corrosion precautions, connector mating and maintenance, conductivity cell cleaning and storage, 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 direct electrical connection of the MicroCAT housing to mooring or other dissimilar metal hardware should be avoided.

Connector Mating and Maintenance

A mated connector does not require periodic disassembly or other attention. Inspect a connector that is unmated for signs of corrosion product around the pins. When remating:

CAUTION:
Do not use **WD-40** or other petroleum-based lubricants, as they will damage the connectors.

1. Lightly lubricate the inside of the dummy plug/cable connector with silicone grease (DC-4 or equivalent).
2. **Standard Connector** - Install the plug/cable connector, aligning the raised bump on the side of the plug/cable connector with the large pin (pin 1 - ground) on the MicroCAT. Remove any trapped air by *burping* or gently squeezing the plug/connector near the top and moving your fingers toward the end cap. **OR**
MCBH Connector – Install the plug/cable connector, aligning the pins.
3. Place the locking sleeve over the plug/cable connector. Tighten the locking sleeve finger tight only. **Do not overtighten the locking sleeve and do not use a wrench or pliers.**

Verify that a cable or dummy plug is installed on the MicroCAT before deployment.

Conductivity Cell Maintenance

CAUTIONS:

- **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 conductivity cell if it is full of water.
- **Do not put a brush or any object inside the conductivity cell to clean it.** Putting an object inside the cell can damage and break the cell.

The MicroCAT's conductivity cell is shipped dry to prevent freezing in shipping.

Routine Rinsing after Recovery

After each recovery, rinse the cell with clean de-ionized water, drain and gently blow through the cell to remove larger water droplets. **Do not use compressed air**, which typically contains oil vapor. Re-insert the protective plugs in the anti-foulant device cups.

If the cell is not rinsed between uses, salt crystals may form on the platinized electrode surfaces. When the instrument is used next, sensor accuracy may be temporarily affected until these crystals dissolve.

Cleaning

Cell cleaning removes foreign material coating the inside of the cell, partially restoring the cell to the original factory calibration. Decide whether to clean the cell after a deployment based on the following:

- **Do not clean the cell** if you will be sending the MicroCAT to Sea-Bird for a post-cruise calibration to establish the drift during the cruise.
- **Clean the cell** if you will not be performing a post-cruise calibration to establish the drift.

Routine Cleaning (inside of cell not visibly dirty)

1. Heat a 1% - 2% solution of Triton X-100 (included with shipment) to less than 60 °C.
2. Agitate the warm solution through the cell many times in a washing action. This can be accomplished with Tygon tubing and a syringe kit.
3. Fill the cell with the solution and let it soak for 1 hour.
4. Drain and flush with warm, clean, de-ionized water for 1 minute. Then:
 - Prepare for deployment, **or**
 - If being stored – drain and gently blow through the cell to remove larger water droplets. **Do not use compressed air**, which typically contains oil vapor. Replace the protective plugs in the anti-foulant device cups.

Acid Cleaning (visible deposits or marine growth on inside of cell)

Do not clean with acid more than once per week.

Acid Concentration, Handling, and Disposal

The cleaning procedure 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 = $[(\text{conc}\% / 20\%) - 1] * [100 + 10 (\text{conc}\% / 20\%)]$ 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:

$100 \text{ cc} * (100 / 166.6) = 60$ cc of 31.5% HCl

$66.6 \text{ cc} * (100 / 166.6) = 40$ cc of water

Disposal

Dilute the acid heavily or neutralize with bicarbonate of soda (baking soda).

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.**

1. Remove the MicroCAT guard:
 - A. Remove the two screws attaching each anti-foulant device cup to the guard.
 - B. Remove the four Phillips-head screws attaching the guard to the housing and sensor end cap.
 - C. Gently lift the guard away.
2. Prepare for cleaning:
 - A. Remove the small section of Tygon tubing and anti-foulant device cup from one end of the cell.
 - B. Place a 0.6 m (2 ft) length of $7/16$ inch ID, $9/16$ inch OD Tygon tubing over the end of the cell.
 - C. Clamp the MicroCAT so that the cell is vertical, with the 0.6 m (2 ft) Tygon tubing at the bottom end.
 - D. 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.
3. Clean the cell:
 - A. Pour a **10% to 38% solution of HCL** 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%** solution of Triton X-100 (included with shipment) 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.

WARNING!

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

4. Reinstall the anti-foulant device cup and the guard:
 - A. Carefully reinstall the small section of Tygon tubing and anti-foulant device cup on the end of the glass cell.
 - B. Carefully place the guard over the housing, aligning all holes.
 - C. Reinstall the two screws attaching each anti-foulant device cup to the guard.
 - D. Reinstall the four Phillips-head screws attaching the guard to the housing and sensor end cap.
5. Prepare for deployment, **or**
 If being stored – gently blow through the cell to remove larger water droplets. **Do not use compressed air**, which typically contains oil vapor. Replace the protective plugs in the anti-foulant device cups.

Pressure Sensor (optional) Maintenance



Pressure sensor port plug

At the factory, the pressure sensor and pressure port were filled with a silicon oil, and a pressure port plug was used to retain the oil. The oil transmits hydrostatic pressure to the pressure sensor inside the instrument. Because of the viscosity of the silicone oil, the oil does not run out of the pressure sensor port plug. However, due to temperature and pressure cycling over long periods, it is normal for some oil to slowly leak out of the plug. **It is not necessary to refill the oil.**

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. The fitting may contain silicon oil from the factory, so there may be some spillage.
2. Rinse the pressure port with warm, de-ionized water to remove any particles, debris, etc.
3. Replace the pressure port plug.

CAUTION:

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

Replacing Batteries

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

1. Remove the I/O connector 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 IV) before proceeding.

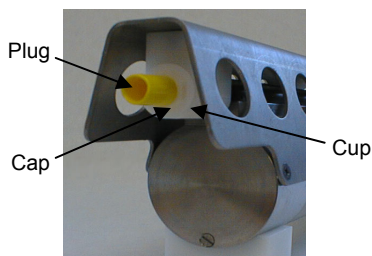
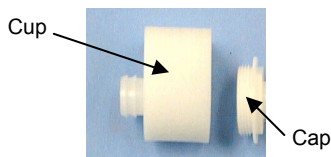
It is a violation of US Federal Law to use this product in a manner inconsistent with its labeling.

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 conductivity and temperature 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 sensor 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

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 the MicroCAT's 0.10% error specification with some allowance for aging and ambient-temperature induced drift.

Pressure sensors show most of their error as zero offset. A technique is provided below for making small corrections to the pressure sensor calibration using the *offset* (**POFFSET=**) 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 (**POFFSET=0**).
 - B. Send **TP** to measure the MicroCAT pressure 100 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 in the MicroCAT's EEPROM, using **POFFSET=** in SEATERM.

Offset Correction Example

Pressure measured by a barometer is 14.65 psia. Pressure displayed from MicroCAT is -2.5 dbars.
 Convert barometer reading to dbars using the relationship: $(\text{psia} - 14.7) * 0.6894759 = \text{dbars}$
 Barometer reading = $(14.65 - 14.7) * 0.6894759 = -0.034$ dbars
 Offset = $-0.034 - (-2.5) = +2.466$ dbar
 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.

Glossary

Battery pack – Six 9-volt (nominal 1.2 amp-hour) batteries, each containing lithium cells of the type commonly used in cameras. The 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. When converted to .cnv format, SBE Data Processing can be used to analyze and display data.

Fouling – Biological growth in the conductivity cell during deployment.

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 only, no internal battery or memory)
- SBE 37-SIP (**S**erial **I**nterface only, no internal battery or memory, integral **P**ump)

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

PCB – Printed Circuit Board.

SBE Data Processing - Sea-Bird's 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 (consisting of **NAV**G averaged measurements) containing temperature, conductivity, optional pressure, and optional date and time, as well as optional derived variables (salinity and sound velocity).

SEASOFT-DOS – Sea-Bird's complete DOS software package, which includes software for communication, real-time data acquisition, and data analysis and display.

SEASOFT-Win32 – Sea-Bird's complete Win 95/98/NT/2000/XP software 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 – Sea-Bird's WIN 95/98/NT/2000/XP software used to communicate with the MicroCAT.

TCXO – Temperature Compensated Crystal Oscillator.

Triton X-100 – Concentrated liquid non-ionic detergent, used for cleaning the conductivity cell.

Appendix I: Functional Description

Sensors

The MicroCAT embodies the same sensor elements (3-electrode, 2-terminal, borosilicate glass cell, and pressure-protected thermistor) previously employed in Sea-Bird's 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, 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 end cap and battery pack following instructions 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 198 mm (7.8 inch) threaded rod with Phillips-head.
 - B. Pull out the PCB assembly using the PVC pylon (post with Molex connector). The assembly will pull away from the 10-position edge connector used to connect to the sensors.

Reassembly

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 inch) 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 end cap following instructions in *Section 3: Preparing MicroCAT for Deployment*.

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.

Appendix III: Command Summary

CATEGORY	COMMAND	DESCRIPTION
Status	DS	Display status.
Setup	MMDDYY=mmddy	Set real-time clock month, day, year. Follow with HHMMSS= or it will not set date.
	DDMMYY=ddmmy	Set real-time clock day, month, year. Follow with HHMMSS= or it will not set date.
	HHMMSS=hhmss	Set real-time clock hour, minute, second.
	BAUD=x	x= baud rate (600, 1200, 2400, 4800, 9600, 19200, or 38400). Default 9600.
	OUTPUTSAL=x	x=Y: calculate and output salinity (psu) with each sample. x=N: do not.
	OUTPUTSV=x	x=Y: calculate and output sound velocity (m/sec) with each sample. x=N: do not.
	FORMAT=x	x=0: output raw hex data, for diagnostic use x=1: output converted data, date dd mmm yyyy x=2: output converted data, date mm-dd-yyyy
	REFPRESS=x	x= reference pressure (gauge) in decibars (used for conductivity computation when MicroCAT does not have pressure sensor).
	NAVg=x	x= number of measurements (1 – 1000) to take and average per sample. Default 1.
	SAMPLENUM=x	x= sample number for first sample when sampling begins. After all previous data has been uploaded, set to 0 before starting to sample to make entire memory available for recording. If not reset to 0, data stored after last sample.
QS	Enter quiescent (sleep) state. Main power turned off, but data logging and memory retention unaffected.	
Logging	INTERVAL=x	x= interval (seconds) between samples (5 - 32767). When commanded to start sampling with STARTNOW or STARTLATER, at x second intervals MicroCAT takes sample consisting of NAVG measurements, stores averaged data in FLASH memory, transmits real-time averaged data (if TXREALTIME=Y), and powers down.
	STORETIME=x	x=Y: store date and time with each sample. x=N: do not.
	TXREALTIME=x	x=Y: output real-time averaged data. x=N: do not.
	STARTNOW	Start logging now.
	STARTMMDDYY=mmddy	Delayed logging start: month, day, year. Must follow with STARTHHMMSS=.
	STARTDDMMYY=ddmmy	Delayed logging start: day, month, year. Must follow with STARTHHMMSS=.
	STARTHHMMSS=hhmss	Delayed logging start: hour, minute, second.
	STARTLATER	Start logging at delayed logging start time.
STOP	Stop logging or stop waiting to start logging. Press Enter key to get S> prompt before entering STOP. Must send STOP before uploading data.	

Note:

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

Note:

Do not set **INTERVAL** to less than 10 seconds if transmitting real-time data (**TXREALTIME=Y**).

CATEGORY	COMMAND	DESCRIPTION
Polled (All samples consist of NAVG measurements; averaged data is stored and/or output as applicable.)	TS	Take sample, output converted data, and leave power on. Data not stored in FLASH memory.
	TSR	Take sample, output raw data, and leave power on. Data not stored in FLASH memory.
	TSS	Take sample, store in FLASH memory , output converted data, and turn power off.
	TSSON	Take sample, store in FLASH memory , output converted data, and leave power on.
	SLT	Output converted data from last sample, then take new sample, and leave power on. Data not stored in FLASH memory.
	SLTR	Output raw data from last sample, then take new sample, and leave power on. Data not stored in FLASH memory.
	SL	Output converted data from last sample taken with either Polled Sampling or Logging Commands.
Serial Line Sync	SYNCMODE=x	x=Y : enable serial line sync mode. When RS-232 RX line is high (3-10 VDC) for 1-1000 milliseconds, MicroCAT takes a sample consisting of NAVG measurements, stores averaged data in FLASH memory, and transmits real-time averaged data. x=N : disable serial line sync mode.
	SYNCWAIT=x	x = time (seconds) MicroCAT monitors RS-232 line for commands after executing take sample command. Range 0 - 120 seconds; default 0 seconds.
Data Upload	DDb,e	Upload data beginning with scan b, ending with scan e. Send STOP before sending DDb,e .
Testing	TT	Measure temperature 100 times or until Esc key is pressed, output converted data.
	TC	Measure conductivity 100 times or until Esc key is pressed, output converted data.
	TP	Measure pressure 100 times or until Esc key is pressed, output converted data.
	TTR	Measure temperature 100 times or until Esc key is pressed, output raw data
	TCR	Measure conductivity 100 times or until Esc key is pressed, output raw data.
	TPR	Measure pressure 100 times or until Esc key is pressed, output raw data.
	TR	Measure real-time clock frequency 30 times or until Esc key is pressed, 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 **DDb,e** does not produce data with the required header information for processing by SBE Data Processing.

CATEGORY	COMMAND	DESCRIPTION
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 MicroCAT.	DC	Display calibration coefficients; all coefficients and dates listed below are included in display. Use individual commands below to modify a particular coefficient or date.
	TCALDATE=S	S=Temperature calibration date.
	TA0=F	F=Temperature A0.
	TA1=F	F=Temperature A1.
	TA2=F	F=Temperature A2.
	TA3=F	F=Temperature A3.
	CCALDATE=S	S=Conductivity calibration date.
	CG=F	F=Conductivity G.
	CH=F	F=Conductivity H.
	CI=F	F=Conductivity I.
	CJ=F	F=Conductivity J.
	WBOTC=F	F=Conductivity wbotc.
	CTCOR=F	F=Conductivity ctcor.
	CPCOR=F	F=Conductivity cpcor.
	PCALDATE=S	S=Pressure calibration date.
	PA0=F	F=Pressure A0.
	PA1=F	F=Pressure A1.
	PA2=F	F=Pressure A2.
	PTCA0=F	F=Pressure ptea0
	PTCA1=F	F=Pressure ptea1.
	PTCA2=F	F=Pressure ptea2.
	PTCB0=F	F=Pressure pteb0.
	PTCB1=F	F=Pressure pteb1.
	PTCB2=F	F=Pressure pteb2.
	POFFSET=F	F=Pressure offset.
	RCALDATE=S	S=Real-time clock calibration date.
	RTCA0=F	F=Real-time clock A0.
	RTCA1=F	F=Real-time clock A1.
RTCA2=F	F=Real-time clock A2.	

Appendix IV: AF24173 Anti-Foulant Device

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

AF24173 ANTIFOULANT 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:	<u>47.0%</u>
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 antifoulant devices (7.14 g)

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

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

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	<ul style="list-style-type: none"> • Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
If swallowed	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 (7.14 g)

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.

Appendix V: Replacement Parts

Part Number	Part	Application Description	Quantity in MicroCAT
801347	AF24173 Anti-Foulant Device	Bis(tributyltin) oxide device inserted into anti-foulant device cup	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
30507	Parker 2-206N674-70 O-ring	O-ring between end of conductivity cell and anti-foulant device cup	2
60035	37-SM / -SMP spare hardware/ O-ring kit	<p>Assorted hardware and O-rings, including:</p> <ul style="list-style-type: none"> • 30900 Machine screw, 1/4-20 x 2" hex head, titanium (secures mounting clamp) • 30633 Washer, 1/4" split ring lock, titanium (for screw 30900) • 30634 Washer 1/4" flat, titanium (for screw 30900) • 31019 O-ring 2-008 N674-70 (for screw 30900 – retains mounting clamp hardware) • 31040 Screw, 8-32 x 2 FH, TI (secures cable guide base to I/O connector end cap) • 30860 Machine screw, 6-32 x 1/2 FH TI (secures cable clamp half to flat area of sensor end cap) • 30859 Machine screw, 8-32 x 3/8" FH, PH, titanium (secures housing to I/O connector end cap) • 30857 Parker 2-033E515-80 O-ring (I/O connector end cap and sensor end cap O-ring) • 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 screw 30149) • 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 screw 30357) 	-

Continued on next page

Continued from previous page

Part Number	Part	Application Description	Quantity in MicroCAT
50243	Lithium battery set (6 sticks)	Power MicroCAT	1
30411	Triton X-100	Conductivity cell cleaning solution	1
801412	3-pin RMG-3FS to 9-pin DB-9S I/O cable, 2.4 m (8 ft) long *	From MicroCAT to computer	1
801366	3-pin MCIL-3FS (wet-pluggable connector) to 9-pin DB-9S I/O cable, 2.4 m (8 ft) long,	From MicroCAT to computer	1
801385	4-pin RMG-4FS to 9-pin DB-9S I/O cable with power leads, 2.4 m (8 ft) long *	From MicroCAT to computer, for MicroCAT with optional external power	1
801206	4-pin MCIL-4FS (wet-pluggable connector) to 9-pin DB-9S I/O cable with power leads, 2.4 m (8 ft) long	From MicroCAT to computer, for MicroCAT with optional external power	1
17043	Locking sleeve *	Locks I/O cable or dummy plug in place	1
171192	Locking sleeve (wet-pluggable connector)	Locks I/O cable or dummy plug in place	1
17045.1	3-pin RMG-3FSD-LP dummy plug with locking sleeve *	For when I/O cable not used	1
171500.1	3-pin MCDC-3-F dummy plug with locking sleeve, wet-pluggable connector	For when I/O cable not used	
17046.1	4-pin RMG-4FSD-LP dummy plug with locking sleeve (for external power option) *	For when I/O cable not used	1
171398.1	4-pin MCDC-4-F dummy plug with locking sleeve (for external power option), wet-pluggable connector	For when I/O cable not used	1
171888	25-pin DB-25S to 9-pin DB-9P cable adapter	For use with computer with DB-25 connector	1

* For standard XSG-type connector.

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SBE 37-SM (RS-232) MicroCAT Reference Sheet

(see SBE 37-SM MicroCAT User's Manual for complete details)

Sampling Modes

- **Autonomous sampling** – At pre-programmed intervals, MicroCAT wakes up, samples, stores data in FLASH memory, and powers off.
- **Polled sampling** – The MicroCAT takes one sample and sends data to computer. Polled sampling is useful for integrating MicroCAT with satellite, radio, or wire telemetry equipment.
- **Serial line sync**- The MicroCAT wakes up, samples, stores data in FLASH memory, sends data to computer, and powers off in response to a pulse on serial line. This provides an easy method for synchronizing MicroCAT sampling with other instruments such as Acoustic Doppler Current Profilers (ADCPs) or current meters, without drawing on their battery or memory resources.

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:
 - Serial Port: COM1 through COM10 are available
 - Baud Rate: 9600 (or other if applicable)
 - Data Bits: 8
 - Parity: No Parity
 - Mode: RS-232 (Full Duplex)

Deployment

1. Batteries:
 - A. *Remove I/O connector 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 dry 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 I/O connector 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. Program MicroCAT for intended deployment (see other side of this sheet for *Command Instructions and List*):
 - A. Set time and date.
 - B. Establish logging parameters.
 - C. Ensure all data has been uploaded, and then set **SAMPLENUM=0** to make entire memory available for recording. If **SAMPLENUM** is not reset to zero, data will be stored after last recorded sample.
 - D. Use one of following sequences to initiate logging:
 - **STARTNOW** to start logging now, taking a sample consisting of **NAVG** measurements every **INTERVAL** seconds.
 - **STARTMDDYY=**, **STARTHHMSS=**, and **STARTLATER** to start logging at specified date and time, taking a sample consisting of **NAVG** measurements every **INTERVAL** seconds.
 - **SYNCMODE=Y** to place MicroCAT in serial line sync mode, so that a simple pulse on RS-232 line will initiate a sample consisting of **NAVG** measurements.
3. Wiring to MicroCAT – deploy with dummy plug or I/O cable (for optional external power and/or serial communication during deployment):
 - A. Standard connector: Align raised bump on side of dummy plug/connector with large pin on MicroCAT.
 - B. Install locking sleeve.
4. Mount MicroCAT, using Sea-Bird or customer-supplied hardware.

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 pressing Enter key to get S> prompt.

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

CATEGORY	COMMAND	DESCRIPTION
Status	DS	Display status.
Setup	MMDDYY=mmddy	Set real-time clock month, day, year. Must follow with HHMMSS=.
	DDMMYY=ddmmy	Set real-time clock day, month, year. Must follow with HHMMSS=.
	HHMMSS=hhmss	Set real-time clock hour, minute, second.
	BAUD=x	x= baud rate (600, 1200, 2400, 4800, 9600, 19200, 38400). Default 9600.
	OUTPUTSAL=x	x=Y: calculate and output salinity (psu) with each sample. x=N: do not.
	OUTPUTSV=x	x=Y: calculate and output sound velocity (m/sec) with each sample. x=N: do not.
	FORMAT=x	x=0: output raw hex data, for diagnostic use. x=1 (default): output converted data, date dd mmm yyyy x=2: output converted data, date mm-dd-yyyy
	REFPRESS=x	x = reference pressure (decibars) (used when MicroCAT has no pressure sensor).
	NAVG=x	x= number of measurements (1 - 1000) to take and average per sample. Default 1.
	SAMPLENUM=x	x= sample number for first sample when sampling begins. After uploading data, set to 0 before starting to sample again to make entire memory available for recording. If not reset to 0, data stored after last sample.
	QS	Quit session and place MicroCAT in quiescent (sleep) state. Data logging and memory retention are not affected.
Logging	INTERVAL=x	x = interval between samples (5 - 32767 seconds). When commanded to start sampling with STARTNOW or STARTLATER, at x second intervals MicroCAT takes sample consisting of NAVG measurements, stores averaged data in FLASH memory, transmits real-time averaged data (if TXREALTIME=Y), and powers down.
	STORETIME=x	x=Y: store date and time with each sample. x=N: do not.
	TXREALTIME=x	x=Y: output real-time data as it is sampled. Does not affect storing data to memory. Do not set INTERVAL to less than 10 seconds if transmitting real-time data. x=N: do not.
	STARTNOW	Start logging now.
	STARTMMDDYY=mmddy	Delayed logging start: month, day, year. Must follow with STARTHHMMSS=.
	STARTDDMMYY=ddmmy	Delayed logging start: day, month, year. Must follow with STARTHHMMSS=.
	STARTHHMMSS=hhmss	Delayed logging start: hour, minute, second.
	STARTLATER	Start logging at delayed start time.
	STOP	Stop logging or stop waiting to start logging. Press Enter key to get S> prompt before entering STOP. Must send STOP before uploading data.
Polled (All samples consist of NAVG measurements; averaged data is stored and/or output.)	TS	Take sample, output converted data. Data not stored in FLASH memory.
	TSR	Take sample, output raw data. Data not stored in FLASH memory.
	TSS	Take sample, store in FLASH memory , output converted data. Turn power off.
	TSSON	Take sample, store in FLASH memory , output converted data.
	SLT	Output converted data from last sample, then take new sample. Data not stored in FLASH memory.
	SLTR	Output raw data from last sample, then take new sample. Data not stored in FLASH memory.
	SL	Output data from last sample taken with either Polled or Logging Command.
Serial Line Sync	SYNCMODE=x	x=Y: enable serial line sync mode. When RS-232 RX line is high (3-10 VDC) for 1-1000 milliseconds, MicroCAT takes sample consisting of NAVG measurements, stores averaged data in FLASH memory, transmits real-time averaged data, and powers down. x=N: disable serial line sync mode.
	SYNCWAIT=x	x= time (in seconds) MicroCAT monitors RS-232 line for commands after taking a sample in serial line sync mode. Range 0 - 120 seconds; default 0 seconds.
Data Upload	DDB,e	Upload data from scan b to e . Send STOP before sending this command.
Coefficients	DC	Display calibration coefficients.

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SBE37-SM MicroCAT

*Conductivity & Temperature Recorder
with RS-232 Serial Interface*

Instrument Configuration:

Serial Number	37SM36540-3526
Pressure Sensor	None.
Firmware Version	2.5
Memory	2048Kb
Interface Type	RS-232
Conductivity Range	0-7 S/m
Baud Rate	9600
Maximum Depth	7000m

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

FAX: (425) 643-9954

Email: seabird@seabird.com

SBE Pressure Test Certificate

Test Date: 3/19/2004 Description SBE-37 Microcat

Job Number: 36540

Customer Name NOAA/OLYMPIC

SBE Sensor Information:

Model Number: 37

Serial Number: 3526

Pressure Sensor Information:

Sensor Type: None

Sensor Serial Number: None

Sensor Rating: 0

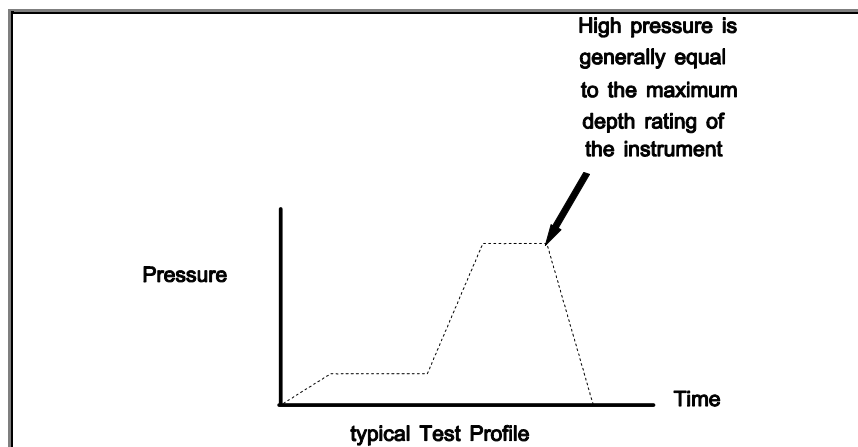
Pressure Test Protocol:

Low Pressure Test: 50 PSI Held For 15 Minutes

High Pressure Test: 10000 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: 3526
CALIBRATION DATE: 16-Jun-04

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = -1.763479e-004

a1 = 3.078888e-004

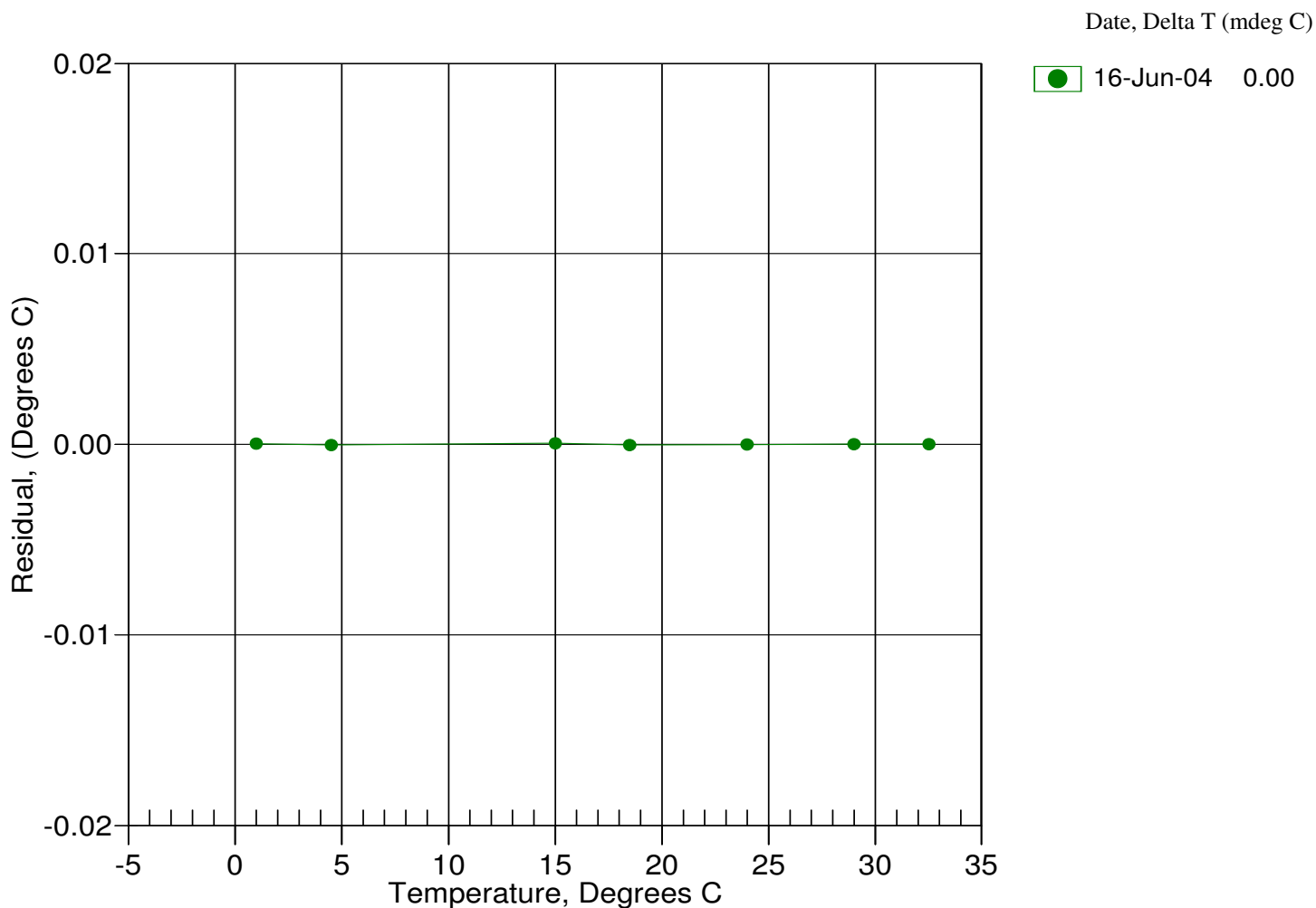
a2 = -4.437235e-006

a3 = 2.064047e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0001	656478.3	1.0001	0.0000
4.5000	563058.7	4.5000	-0.0000
15.0000	362118.7	15.0001	0.0001
18.5000	314480.2	18.5000	-0.0000
23.9999	253432.7	23.9999	-0.0000
28.9999	209526.4	28.9999	0.0000
32.5000	183998.5	32.5000	0.0000

Temperature ITS-90 = $1 / \{ a_0 + a_1[\ln(n)] + a_2[\ln^2(n)] + a_3[\ln^3(n)] \} - 273.15$ (°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: 3526
CALIBRATION DATE: 16-Jun-04

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

COEFFICIENTS:

g = -1.032525e+000 CPcor = -9.5700e-008
h = 1.423927e-001 CTcor = 3.2500e-006
i = -1.269920e-004 WBOTC = -1.2245e-005
j = 3.121209e-005

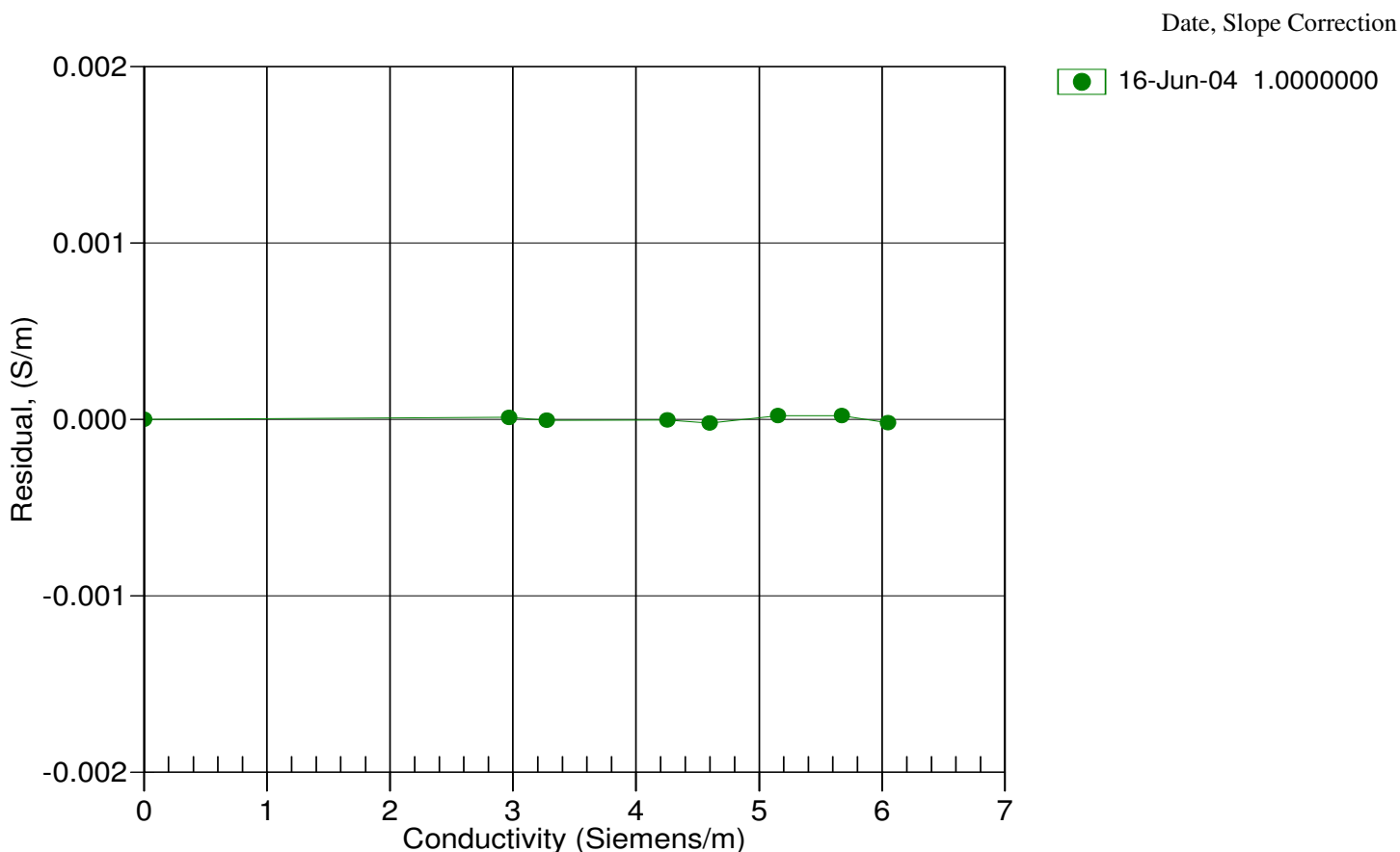
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2694.27	0.00000	0.00000
1.0001	34.7175	2.96833	5296.96	2.96834	0.00001
4.5000	34.6967	3.27455	5495.27	3.27454	-0.00001
15.0000	34.6518	4.25356	6085.39	4.25356	-0.00000
18.5000	34.6421	4.59775	6279.43	4.59773	-0.00002
23.9999	34.6316	5.15417	6580.81	5.15419	0.00002
28.9999	34.6260	5.67464	6850.40	5.67466	0.00002
32.5000	34.6228	6.04605	7036.29	6.04603	-0.00002

$$f = \text{INST FREQ} * \text{sqrt}(1.0 + \text{WBOTC} * t) / 1000.0$$

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

$$t = \text{temperature}[^{\circ}\text{C}]; p = \text{pressure}[\text{decibars}]; \delta = \text{CTcor}; \epsilon = \text{CPcor};$$

$$\text{Residual} = \text{instrument conductivity} - \text{bath conductivity}$$



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

SENSOR SERIAL NUMBER: 3526
CALIBRATION DATE: 16-Jun-04

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

rtca0 = 9.999831e-001
rtca1 = 1.736568e-006
rtca2 = -3.351996e-008

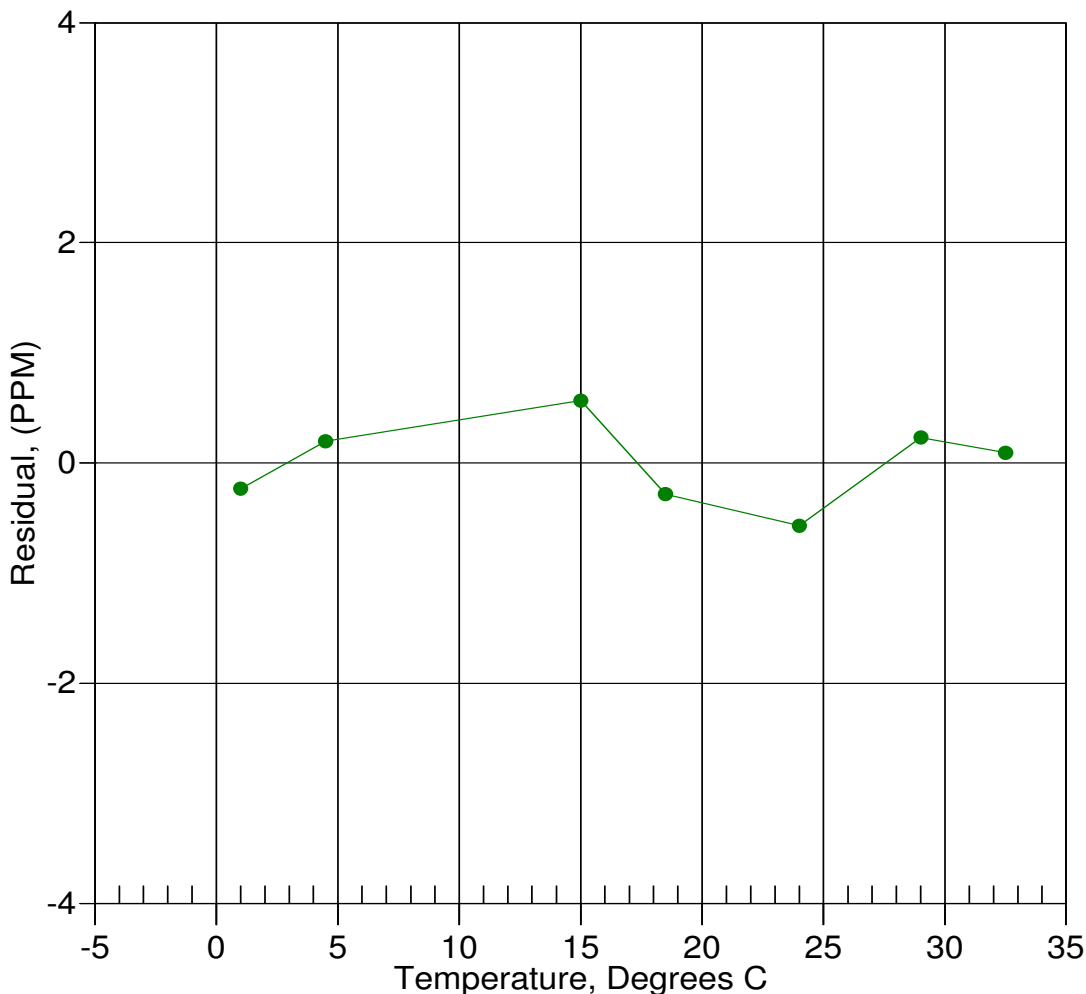
BATH TEMP (ITS-90)	RTC FREQO (Hz)	COMPUTED FREQO (Hz)	RESIDUAL (PPM)
1.0001	0.9999850	0.9999848	-0.2
4.5000	0.9999900	0.9999902	0.2
15.0000	1.0000010	1.0000016	0.6
18.5000	1.0000040	1.0000037	-0.3
23.9999	1.0000060	1.0000054	-0.6
28.9999	1.0000050	1.0000052	0.2
32.5000	1.0000040	1.0000041	0.1

$$\text{RTC frequency} = \text{rtca0} + \text{rtca1} * t + \text{rtca2} * t^2$$

$$\text{Residual} = (\text{Computed RTC frequency} - \text{Measured RTC frequency}) * 1e6$$

Date, Delta F ppm

16-Jun-04 -0.00



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SBE37-SM MicroCAT

*Conductivity & Temperature Recorder
with RS-232 Serial Interface*

Instrument Configuration:

Serial Number	37SM36540-3596
Pressure Sensor	None.
Firmware Version	2.5
Memory	2048Kb
Interface Type	RS-232
Conductivity Range	0-7 S/m
Baud Rate	9600
Maximum Depth	7000m

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



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 Website: <http://www.seabird.com>

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

SBE Pressure Test Certificate

Test Date: 4/6/2004 Description SBE-37 Microcat

Job Number: 36540 Customer Name NOAA/OLYMPIC

SBE Sensor Information:

Model Number: 37

Serial Number: 3596

Pressure Sensor Information:

Sensor Type: None

Sensor Serial Number: None

Sensor Rating: 0

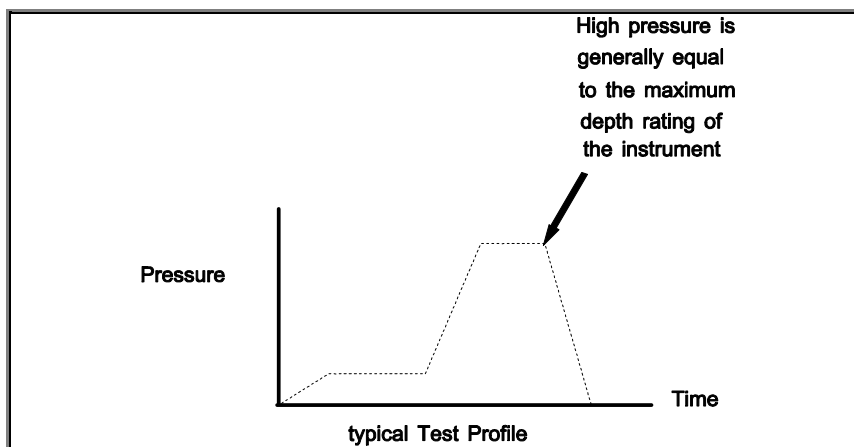
Pressure Test Protocol:

Low Pressure Test: 50 PSI Held For 15 Minutes

High Pressure Test: 10000 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: 3596
CALIBRATION DATE: 16-Jun-04

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = -2.351946e-004

a1 = 3.090708e-004

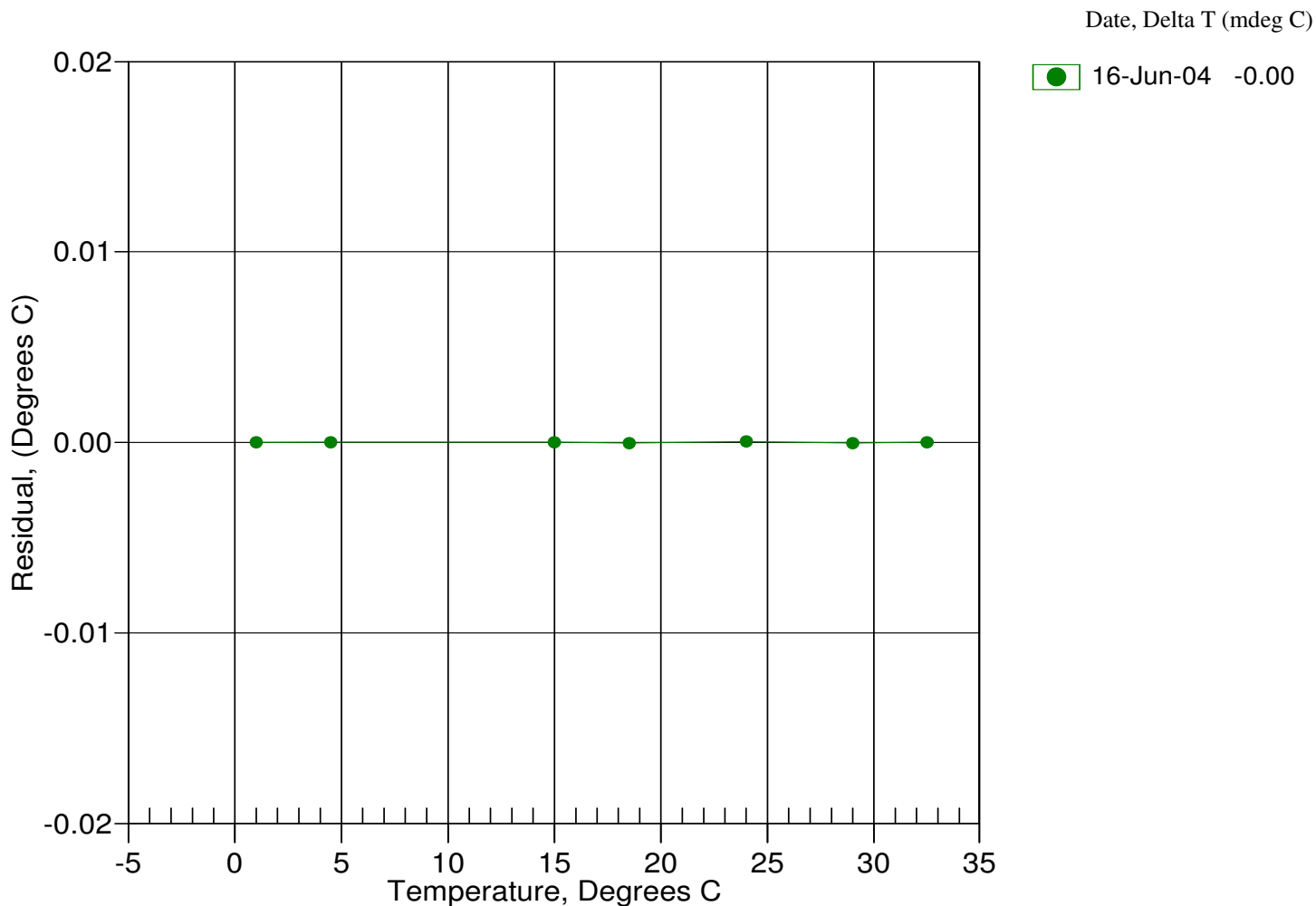
a2 = -4.528129e-006

a3 = 2.057073e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0001	804905.5	1.0001	-0.0000
4.5000	690333.8	4.5000	0.0000
15.0000	443918.3	15.0000	0.0000
18.5000	385501.4	18.5000	-0.0000
23.9999	310644.9	23.9999	0.0000
28.9999	256811.5	28.9999	-0.0000
32.5000	225512.0	32.5000	0.0000

Temperature ITS-90 = $1/\{a_0 + a_1[\ln(n)] + a_2[\ln^2(n)] + a_3[\ln^3(n)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 3596
CALIBRATION DATE: 16-Jun-04

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

COEFFICIENTS:

g = -1.033405e+000 CPcor = -9.5700e-008
h = 1.397437e-001 CTcor = 3.2500e-006
i = -1.228946e-004 WBOTC = -1.3442e-005
j = 2.933850e-005

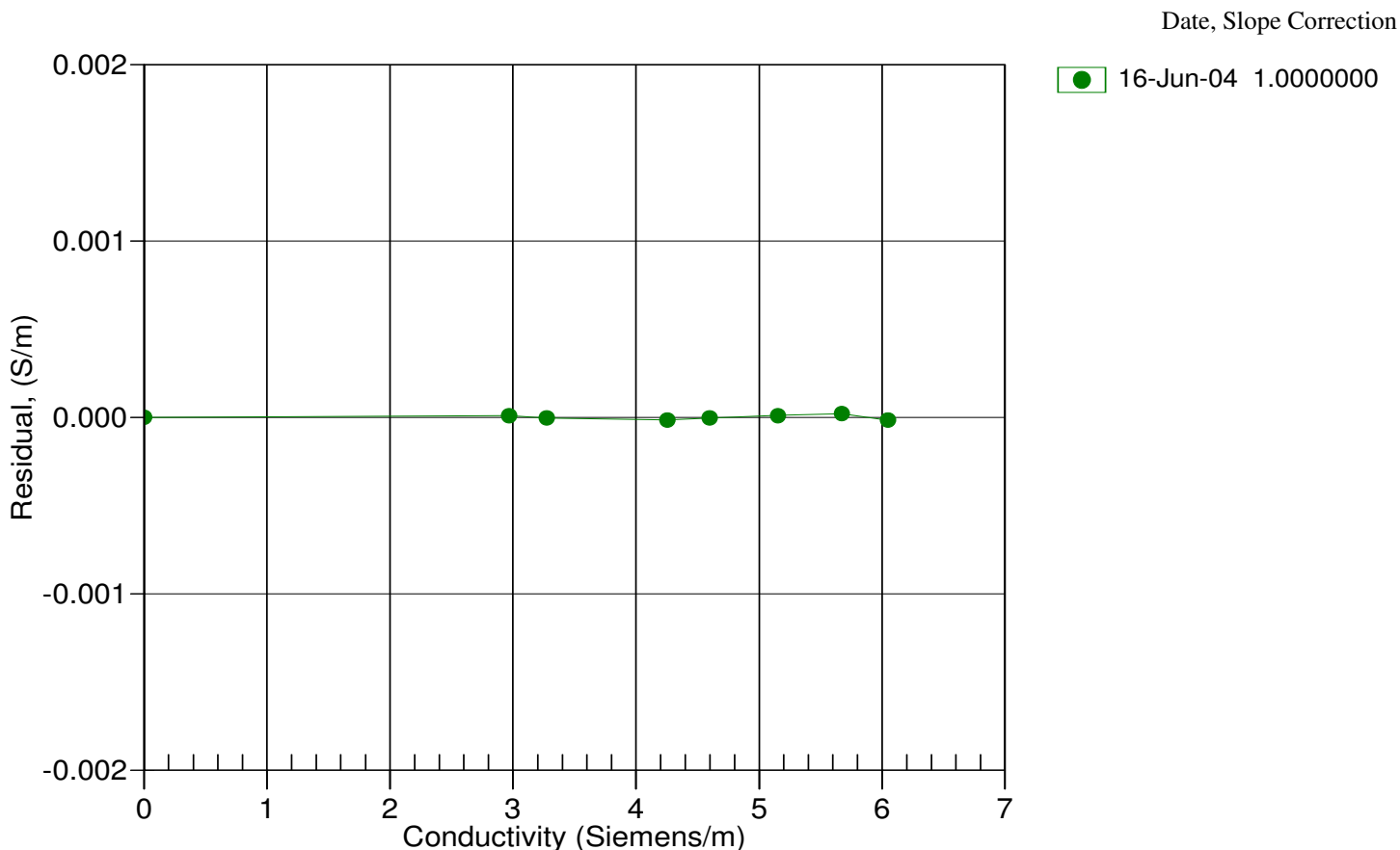
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2720.92	0.00000	0.00000
1.0001	34.7175	2.96833	5347.86	2.96834	0.00001
4.5000	34.6967	3.27455	5548.06	3.27455	-0.00000
15.0000	34.6518	4.25356	6143.87	4.25355	-0.00002
18.5000	34.6421	4.59775	6339.81	4.59774	-0.00000
23.9999	34.6316	5.15417	6644.11	5.15418	0.00001
28.9999	34.6260	5.67464	6916.35	5.67466	0.00002
32.5000	34.6228	6.04605	7104.06	6.04604	-0.00002

$$f = \text{INST FREQ} * \text{sqrt}(1.0 + \text{WBOTC} * t) / 1000.0$$

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

$$t = \text{temperature}[^{\circ}\text{C}]; p = \text{pressure}[\text{decibars}]; \delta = \text{CTcor}; \epsilon = \text{CPcor};$$

$$\text{Residual} = \text{instrument conductivity} - \text{bath conductivity}$$



SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 3596
CALIBRATION DATE: 16-Jun-04

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

rtca0 = 9.999812e-001
rtca1 = 1.690222e-006
rtca2 = -3.328980e-008

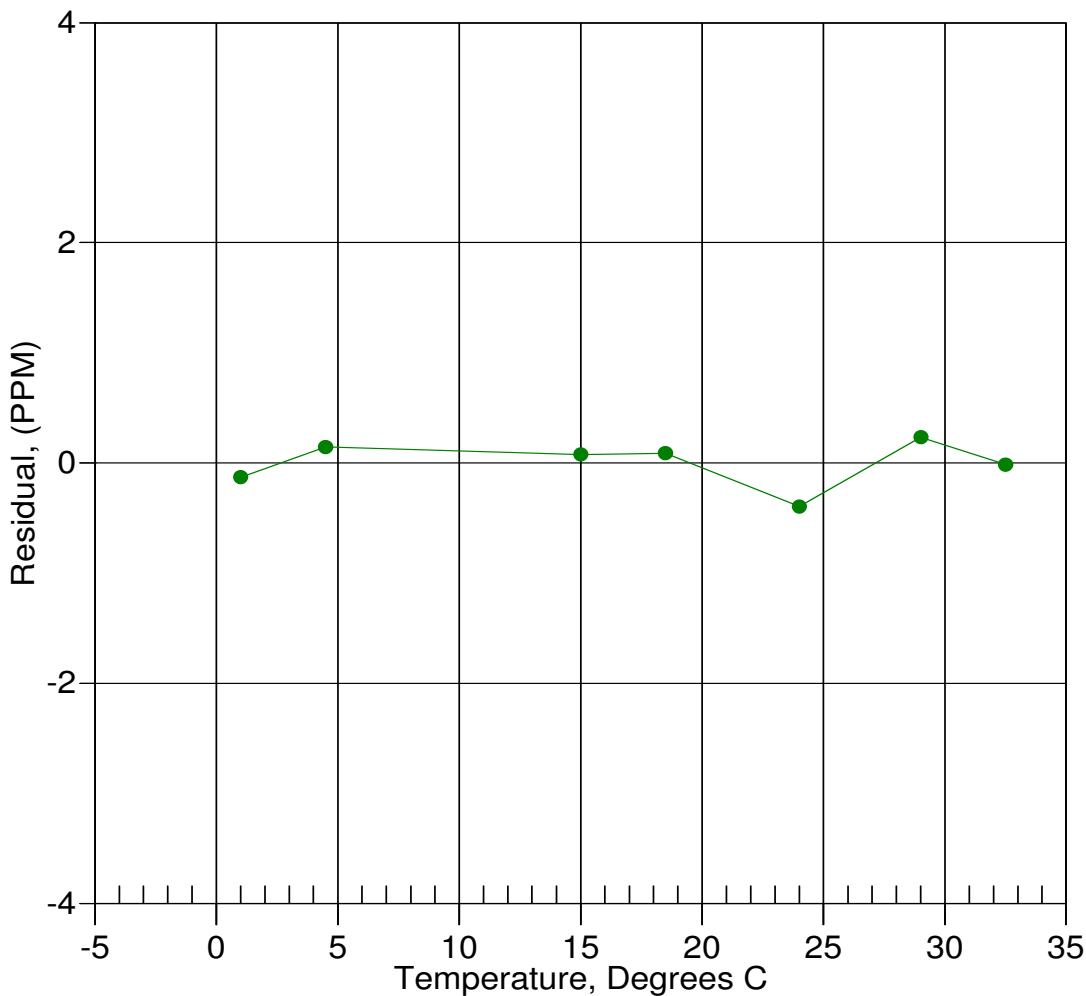
BATH TEMP (ITS-90)	RTC FREQO (Hz)	COMPUTED FREQO (Hz)	RESIDUAL (PPM)
1.0001	0.9999830	0.9999829	-0.1
4.5000	0.9999880	0.9999881	0.1
15.0000	0.9999990	0.9999991	0.1
18.5000	1.0000010	1.0000011	0.1
23.9999	1.0000030	1.0000026	-0.4
28.9999	1.0000020	1.0000022	0.2
32.5000	1.0000010	1.0000010	-0.0

$$\text{RTC frequency} = \text{rtca0} + \text{rtca1} * t + \text{rtca2} * t^2$$

$$\text{Residual} = (\text{Computed RTC frequency} - \text{Measured RTC frequency}) * 1e6$$

Date, Delta F ppm

16-Jun-04 -0.00



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SBE37-SM MicroCAT

*Conductivity & Temperature Recorder
with RS-232 Serial Interface*

Instrument Configuration:

Serial Number	37SM36540-3597
Pressure Sensor	None.
Firmware Version	2.5
Memory	2048Kb
Interface Type	RS-232
Conductivity Range	0-7 S/m
Baud Rate	9600
Maximum Depth	7000m

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



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1808 136th Place NE, Bellevue, Washington 98005 USA

Website: <http://www.seabird.com>

Phone: (425) 643-9866

FAX: (425) 643-9954

Email: seabird@seabird.com

SBE Pressure Test Certificate

Test Date: 4/6/2004 Description SBE-37 Microcat

Job Number: 36540 Customer Name NOAA/OLYMPIC

SBE Sensor Information:

Model Number: 37

Serial Number: 3597

Pressure Sensor Information:

Sensor Type: None

Sensor Serial Number: None

Sensor Rating: 0

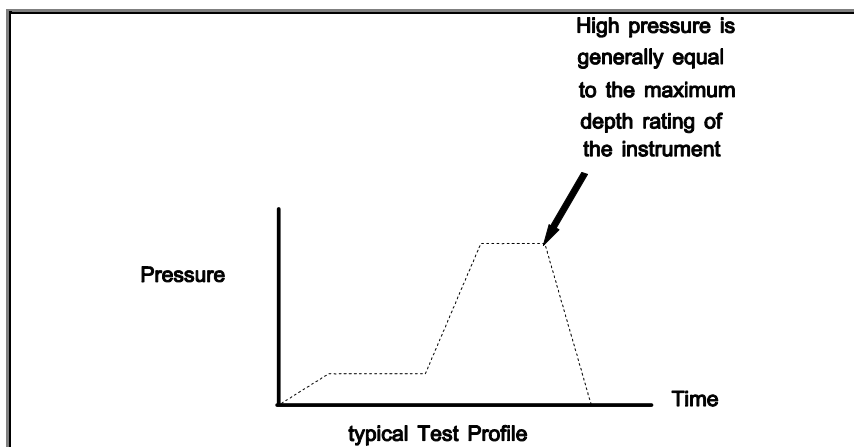
Pressure Test Protocol:

Low Pressure Test: 50 PSI Held For 15 Minutes

High Pressure Test: 10000 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: 3597
CALIBRATION DATE: 10-Jun-04

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

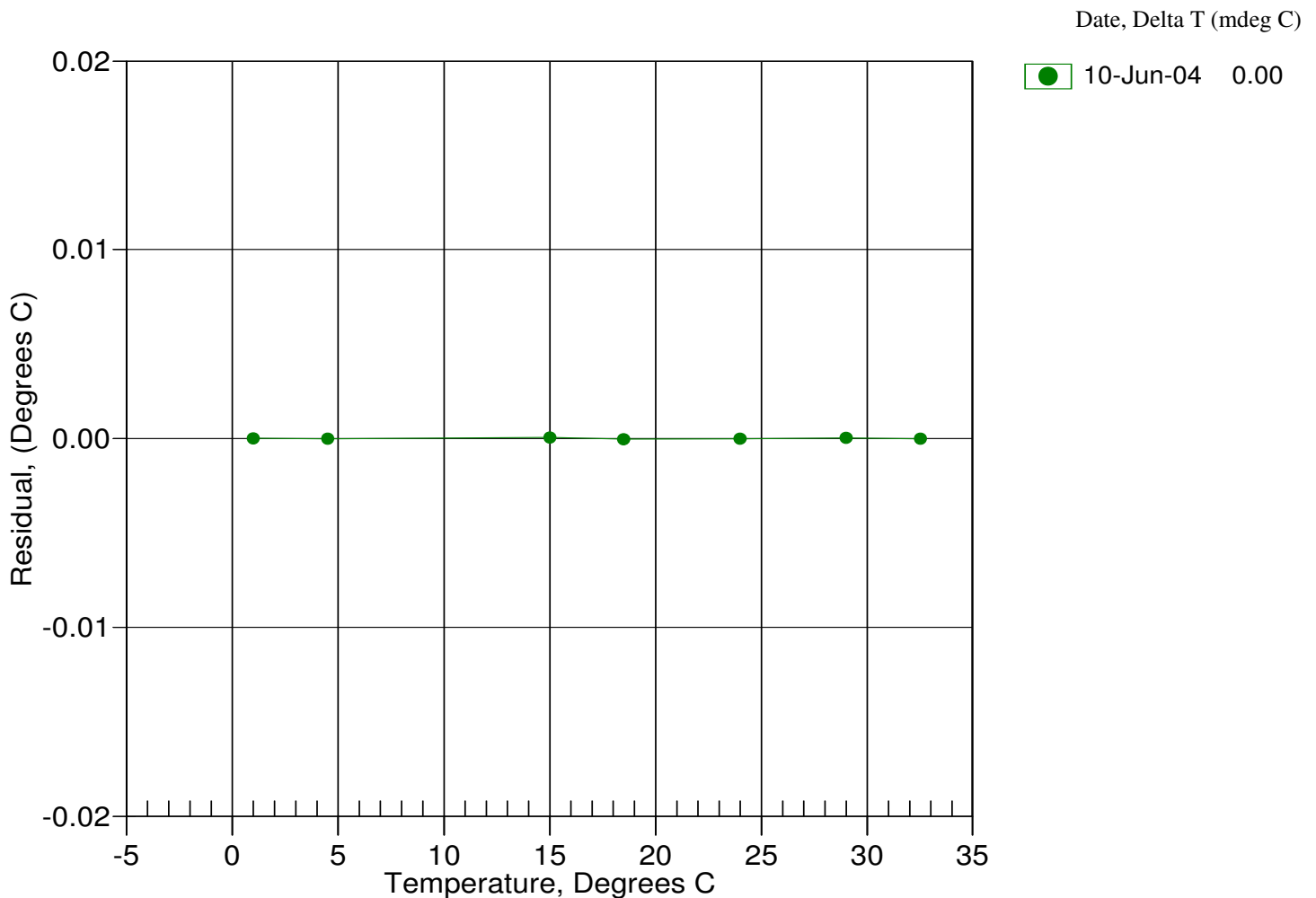
ITS-90 COEFFICIENTS

a0 = -2.176875e-004
a1 = 3.092916e-004
a2 = -4.542004e-006
a3 = 2.073325e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	748011.1	0.9999	0.0000
4.5000	641590.4	4.5000	-0.0000
15.0000	412677.6	15.0001	0.0001
18.5000	358401.7	18.5000	-0.0000
24.0000	288842.8	24.0000	-0.0000
29.0000	238812.8	29.0000	0.0000
32.5000	209724.1	32.5000	-0.0000

Temperature ITS-90 = $1 / \{ a_0 + a_1[\ln(n)] + a_2[\ln^2(n)] + a_3[\ln^3(n)] \} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 3597
CALIBRATION DATE: 10-Jun-04

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

COEFFICIENTS:

g = -1.037575e+000 CPcor = -9.5700e-008
h = 1.444344e-001 CTcor = 3.2500e-006
i = -1.459412e-004 WBOTC = -1.1369e-005
j = 3.345195e-005

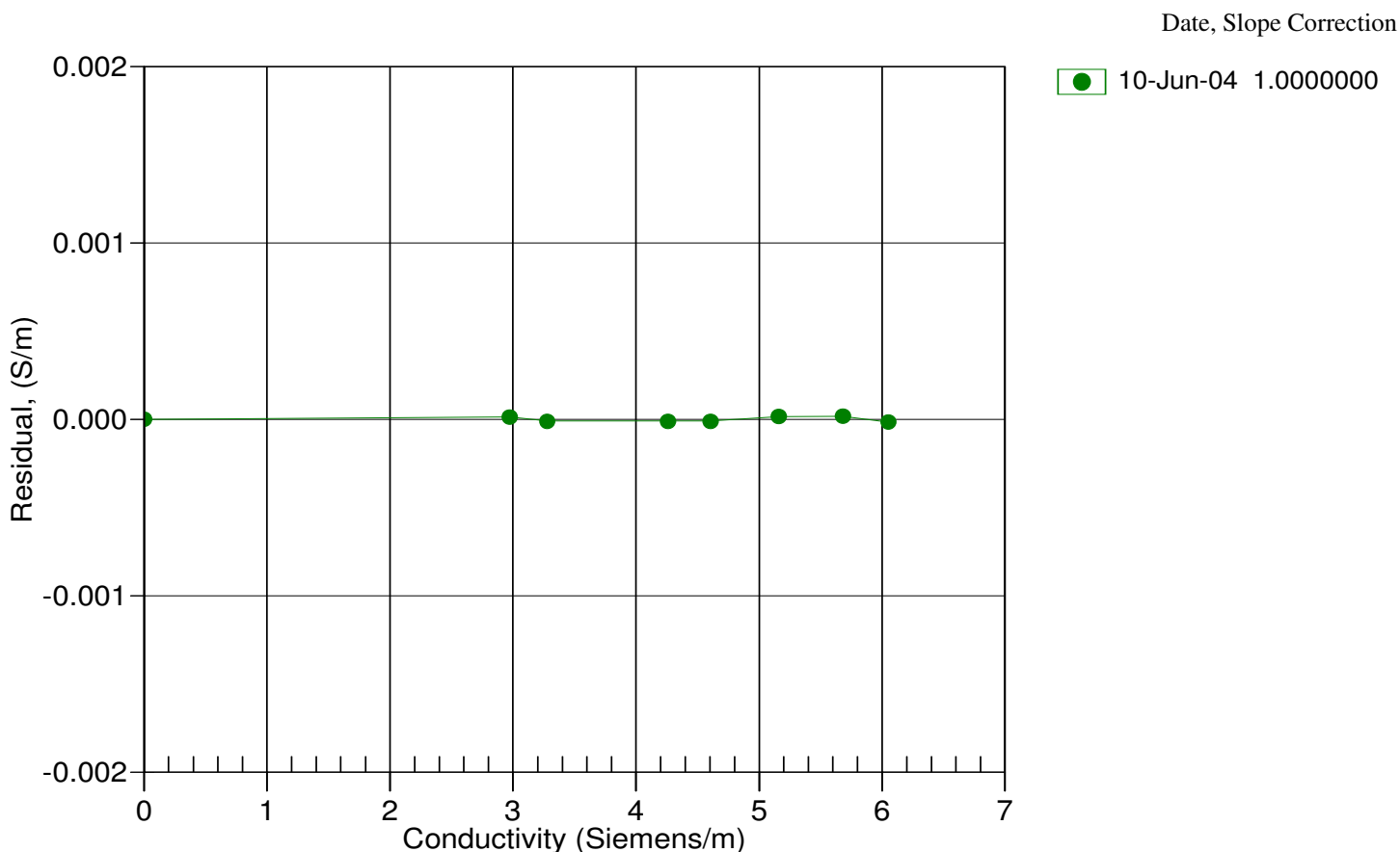
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2681.98	0.00000	0.00000
0.9999	34.7624	2.97179	5265.83	2.97180	0.00001
4.5000	34.7414	3.27835	5462.77	3.27834	-0.00001
15.0000	34.6962	4.25844	6048.84	4.25843	-0.00001
18.5000	34.6865	4.60300	6241.57	4.60299	-0.00001
24.0000	34.6755	5.15999	6540.85	5.16001	0.00002
29.0000	34.6695	5.68097	6808.58	5.68099	0.00002
32.5000	34.6668	6.05286	6993.23	6.05285	-0.00002

$f = \text{INST FREQ} * \text{sqrt}(1.0 + \text{WBOTC} * t) / 1000.0$

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

t = temperature[°C]; p = pressure[decibars]; $\delta = \text{CTcor}$; $\epsilon = \text{CPcor}$;

Residual = instrument conductivity - bath conductivity



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SENSOR SERIAL NUMBER: 3597
CALIBRATION DATE: 10-Jun-04

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

rtca0 = 9.999725e-001
rtca1 = 1.583027e-006
rtca2 = -2.817256e-008

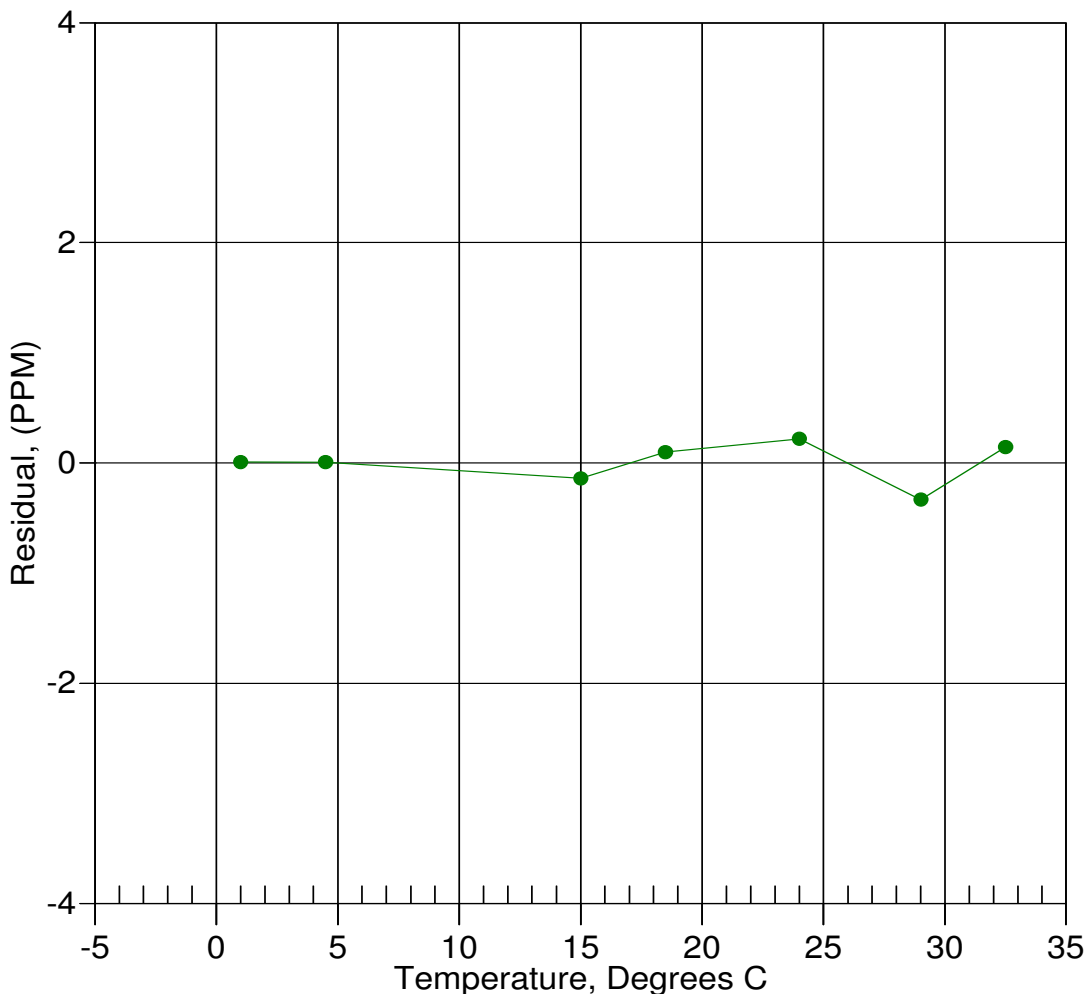
BATH TEMP (ITS-90)	RTC FREQ (Hz)	COMPUTED FREQ (Hz)	RESIDUAL (PPM)
0.9999	0.9999740	0.9999740	0.0
4.5000	0.9999790	0.9999790	0.0
15.0000	0.9999900	0.9999899	-0.1
18.5000	0.9999920	0.9999921	0.1
24.0000	0.9999940	0.9999942	0.2
29.0000	0.9999950	0.9999947	-0.3
32.5000	0.9999940	0.9999941	0.1

$$\text{RTC frequency} = \text{rtca0} + \text{rtca1} * t + \text{rtca2} * t^2$$

$$\text{Residual} = (\text{Computed RTC frequency} - \text{Measured RTC frequency}) * 1e6$$

Date, Delta F ppm

10-Jun-04 -0.00



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SBE37-SM MicroCAT

*Conductivity & Temperature Recorder
with RS-232 Serial Interface*

Instrument Configuration:

Serial Number	37SM36540-3598
Pressure Sensor	None.
Firmware Version	2.5
Memory	2048Kb
Interface Type	RS-232
Conductivity Range	0-7 S/m
Baud Rate	9600
Maximum Depth	7000m

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: 4/6/2004 Description SBE-37 Microcat

Job Number: 36540 Customer Name NOAA/OLYMPIC

SBE Sensor Information:

Model Number: 37

Serial Number: 3598

Pressure Sensor Information:

Sensor Type: None

Sensor Serial Number: None

Sensor Rating: 0

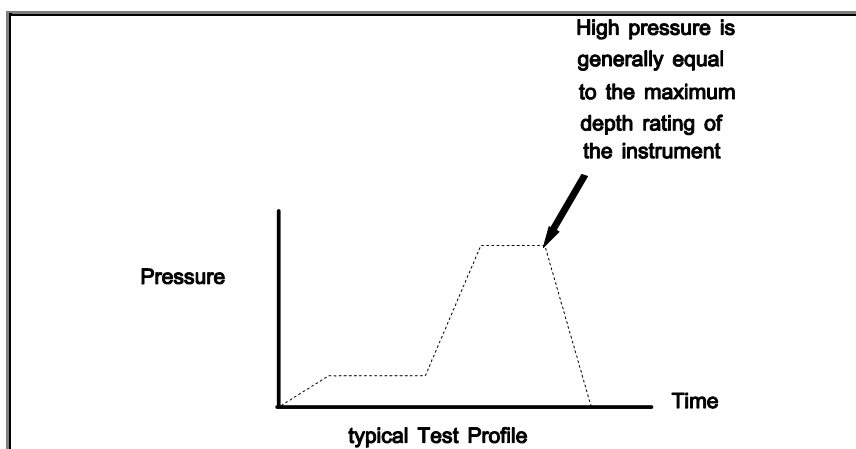
Pressure Test Protocol:

Low Pressure Test: 50 PSI Held For 15 Minutes

High Pressure Test: 10000 PSI Held For 15 Minutes

Passed Test:

Tested By: PCC



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

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

SENSOR SERIAL NUMBER: 3598
CALIBRATION DATE: 10-Jun-04

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

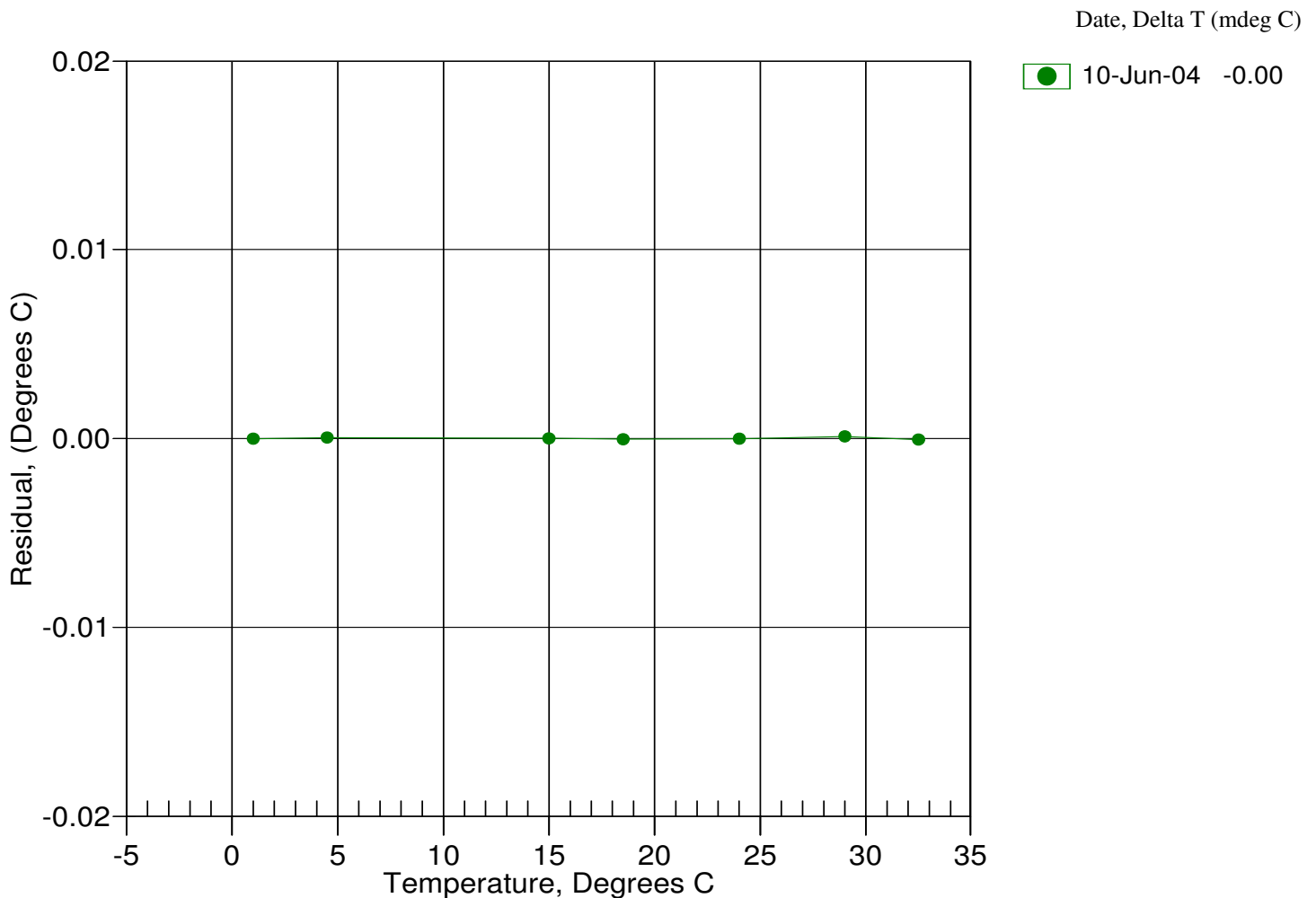
ITS-90 COEFFICIENTS

a0 = -2.373659e-005
a1 = 2.834051e-004
a2 = -2.852970e-006
a3 = 1.706652e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	607779.6	0.9999	-0.0000
4.5000	520768.0	4.5000	0.0000
15.0000	333917.3	15.0000	0.0000
18.5000	289692.9	18.5000	-0.0000
24.0000	233077.5	24.0000	-0.0000
29.0000	192408.2	29.0001	0.0001
32.5000	168787.7	32.4999	-0.0001

Temperature ITS-90 = $1 / \{ a_0 + a_1[\ln(n)] + a_2[\ln^2(n)] + a_3[\ln^3(n)] \} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 3598
CALIBRATION DATE: 10-Jun-04

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

COEFFICIENTS:

g = -1.028647e+000	CPcor = -9.5700e-008
h = 1.515193e-001	CTcor = 3.2500e-006
i = -1.632270e-004	WBOTC = -9.2666e-006
j = 3.691274e-005	

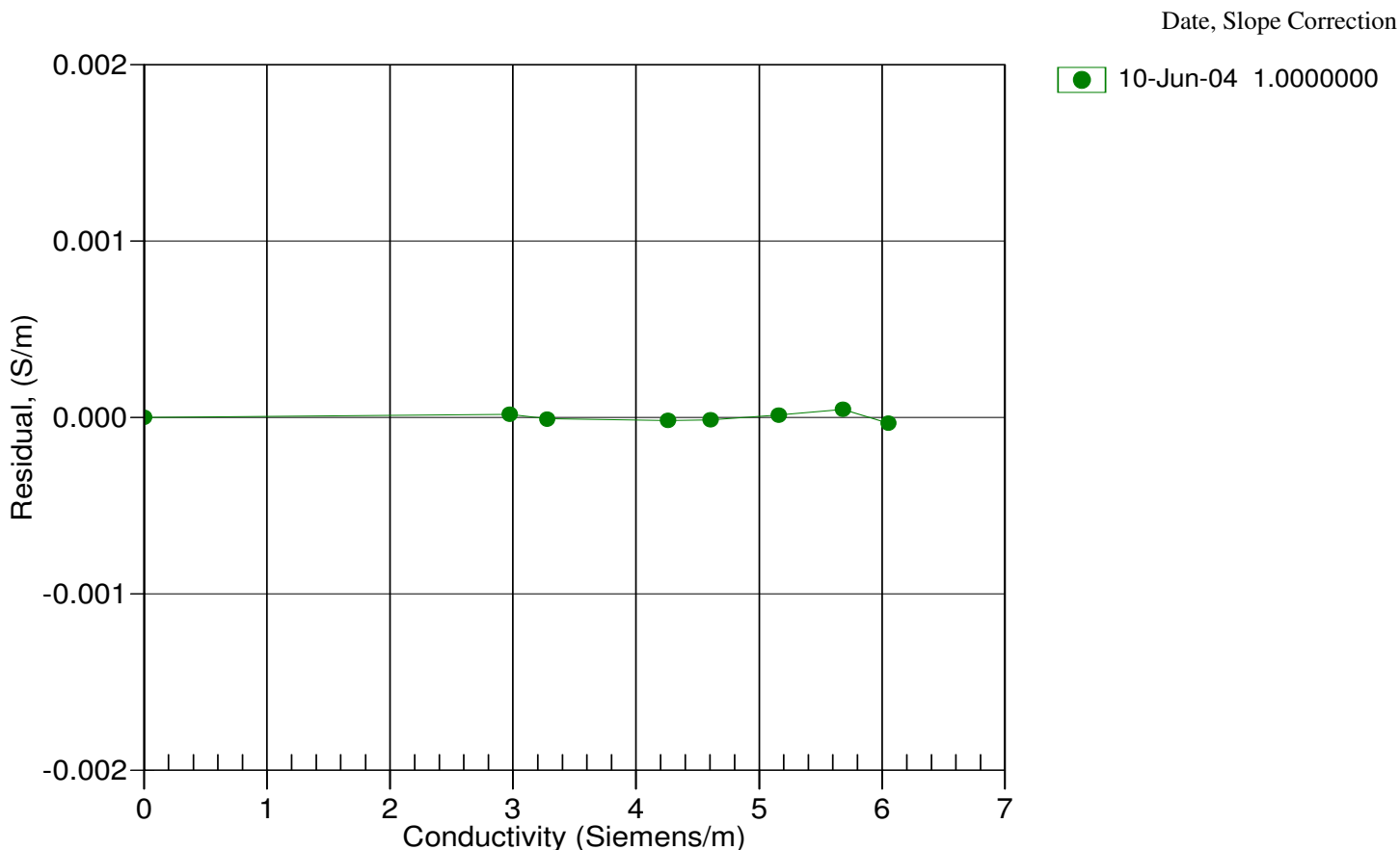
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2607.32	0.00000	0.00000
0.9999	34.7624	2.97179	5136.05	2.97180	0.00002
4.5000	34.7414	3.27835	5328.55	3.27835	-0.00001
15.0000	34.6962	4.25844	5901.34	4.25842	-0.00002
18.5000	34.6865	4.60300	6089.69	4.60299	-0.00001
24.0000	34.6755	5.15999	6382.14	5.16001	0.00001
29.0000	34.6695	5.68097	6643.75	5.68102	0.00004
32.5000	34.6668	6.05286	6824.14	6.05283	-0.00003

$f = \text{INST FREQ} * \text{sqrt}(1.0 + \text{WBOTC} * t) / 1000.0$

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

t = temperature[°C]; p = pressure[decibars]; $\delta = \text{CTcor}$; $\epsilon = \text{CPcor}$;

Residual = instrument conductivity - bath conductivity



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

SENSOR SERIAL NUMBER: 3598
CALIBRATION DATE: 10-Jun-04

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

rtca0 = 9.999805e-001
rtca1 = 1.587001e-006
rtca2 = -2.869549e-008

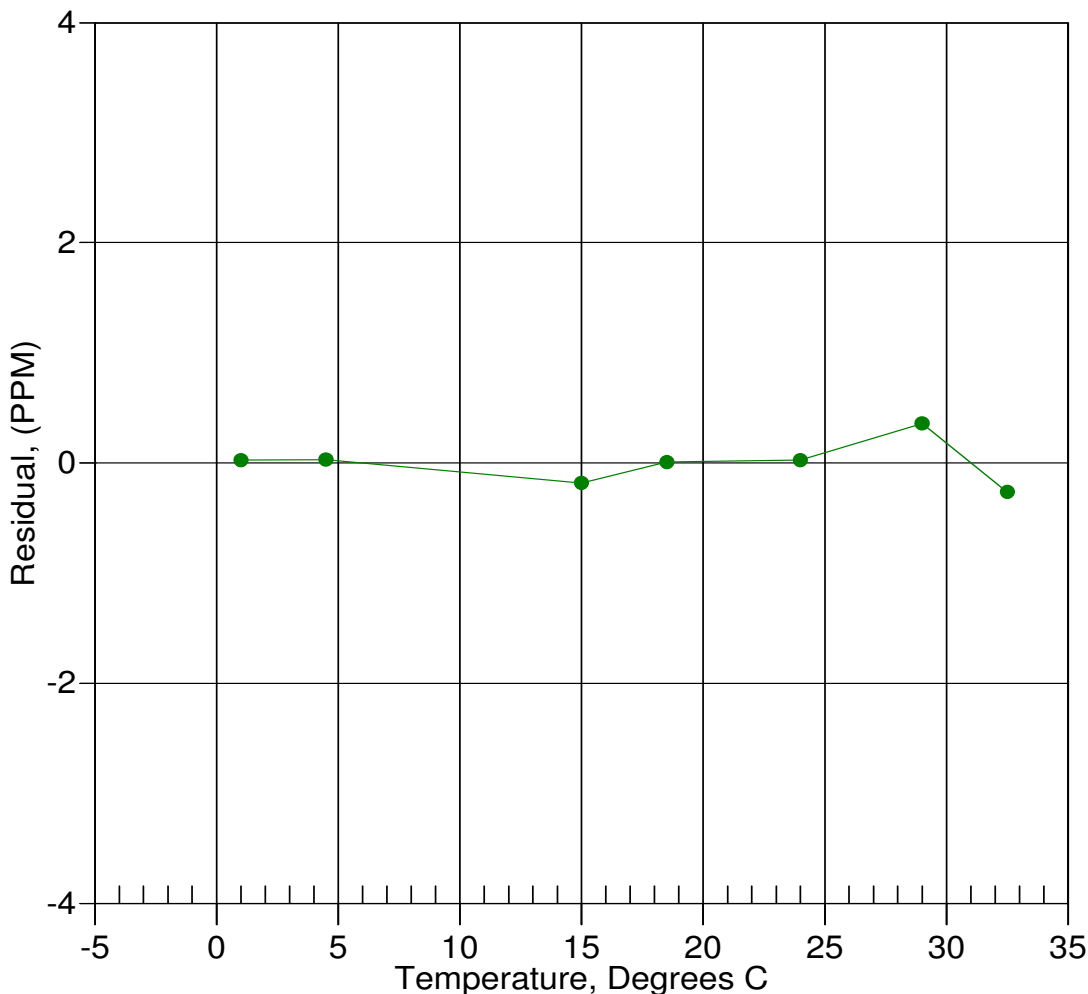
BATH TEMP (ITS-90)	RTC FREQO (Hz)	COMPUTED FREQO (Hz)	RESIDUAL (PPM)
0.9999	0.9999820	0.9999820	0.0
4.5000	0.9999870	0.9999870	0.0
15.0000	0.9999980	0.9999978	-0.2
18.5000	1.0000000	1.0000000	0.0
24.0000	1.0000020	1.0000020	0.0
29.0000	1.0000020	1.0000024	0.4
32.5000	1.0000020	1.0000017	-0.3

$$\text{RTC frequency} = \text{rtca0} + \text{rtca1} * t + \text{rtca2} * t^2$$

$$\text{Residual} = (\text{Computed RTC frequency} - \text{Measured RTC frequency}) * 1e6$$

Date, Delta F ppm

10-Jun-04 0.00



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SBE37-SM MicroCAT

*Conductivity & Temperature Recorder
with RS-232 Serial Interface*

Instrument Configuration:

Serial Number	37SM36540-3599
Pressure Sensor	None.
Firmware Version	2.5
Memory	2048Kb
Interface Type	RS-232
Conductivity Range	0-7 S/m
Baud Rate	9600
Maximum Depth	7000m

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: 4/6/2004 Description SBE-37 Microcat

Job Number: 36540 Customer Name NOAA/OLYMPIC

SBE Sensor Information:

Model Number: 37

Serial Number: 3599

Pressure Sensor Information:

Sensor Type: None

Sensor Serial Number: None

Sensor Rating: 0

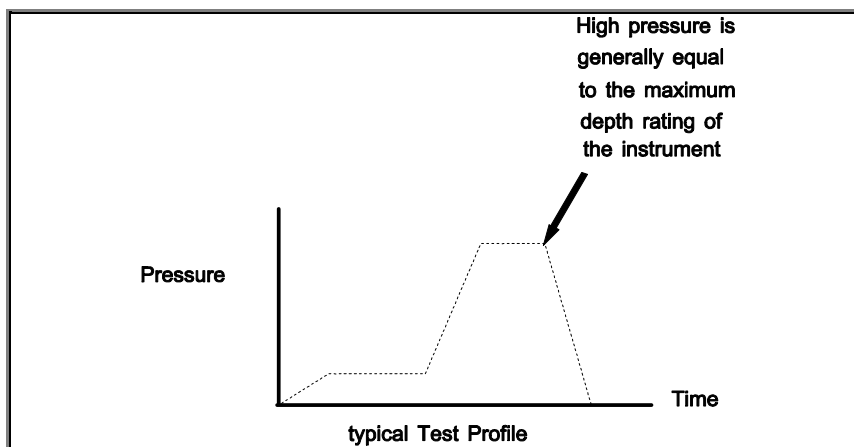
Pressure Test Protocol:

Low Pressure Test: 50 PSI Held For 15 Minutes

High Pressure Test: 10000 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: 3599
CALIBRATION DATE: 10-Jun-04

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

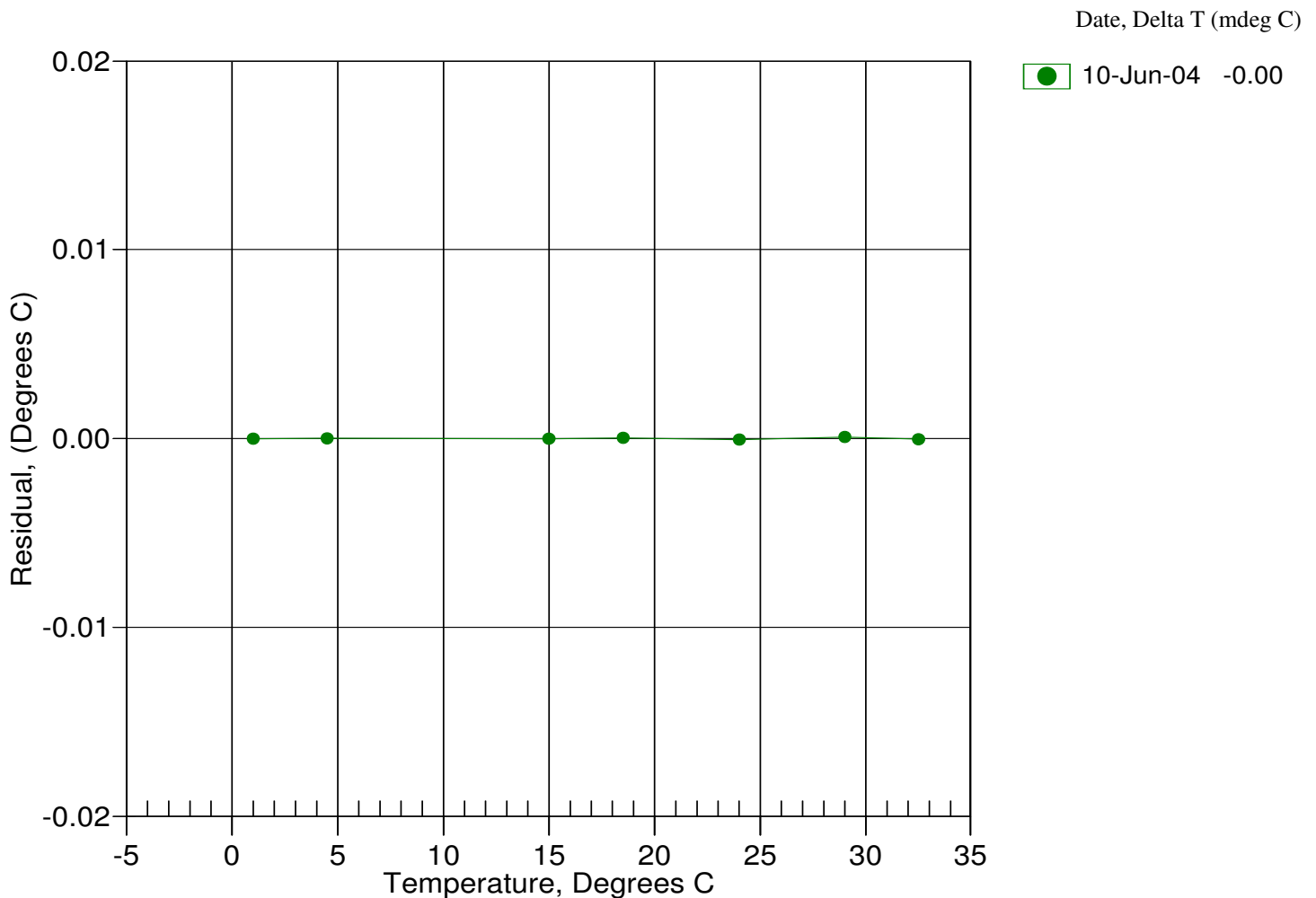
ITS-90 COEFFICIENTS

a0 = -2.331607e-004
a1 = 3.157429e-004
a2 = -5.047280e-006
a3 = 2.213422e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	713930.8	0.9999	-0.0000
4.5000	612389.1	4.5000	0.0000
15.0000	393949.2	15.0000	-0.0000
18.5000	342148.3	18.5000	0.0000
24.0000	275761.9	23.9999	-0.0001
29.0000	228009.8	29.0001	0.0001
32.5000	200245.7	32.5000	-0.0000

Temperature ITS-90 = $1 / \{ a_0 + a_1[\ln(n)] + a_2[\ln^2(n)] + a_3[\ln^3(n)] \} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 3599
CALIBRATION DATE: 10-Jun-04

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

COEFFICIENTS:

g = -1.004796e+000 CPcor = -9.5700e-008
h = 1.342870e-001 CTcor = 3.2500e-006
i = -1.477162e-004 WBOTC = -1.5337e-005
j = 3.139689e-005

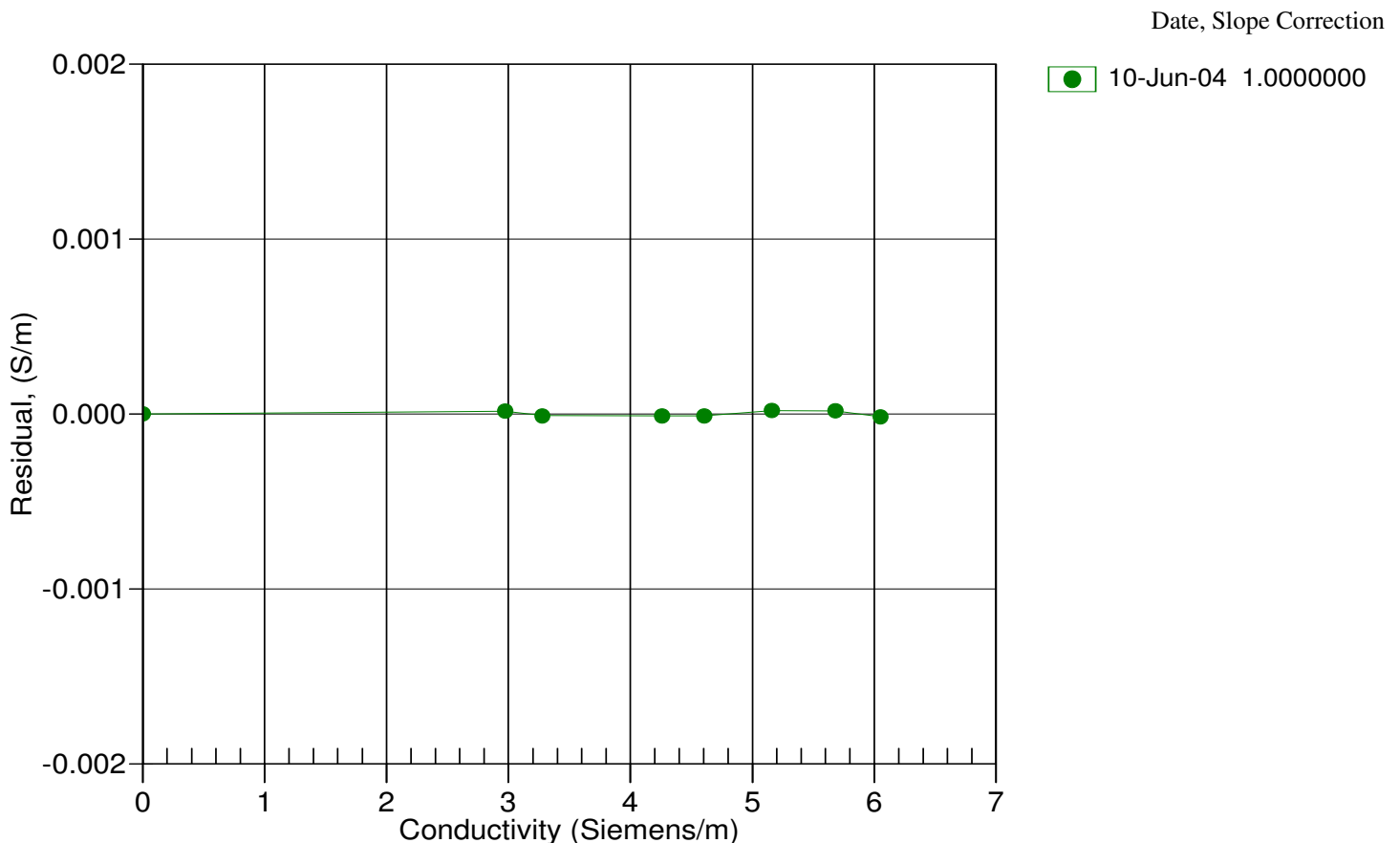
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2737.59	0.00000	0.00000
0.9999	34.7624	2.97179	5439.26	2.97180	0.00001
4.5000	34.7414	3.27835	5644.33	3.27834	-0.00001
15.0000	34.6962	4.25844	6254.26	4.25842	-0.00001
18.5000	34.6865	4.60300	6454.74	4.60299	-0.00001
24.0000	34.6755	5.15999	6765.98	5.16001	0.00002
29.0000	34.6695	5.68097	7044.32	5.68099	0.00002
32.5000	34.6668	6.05286	7236.25	6.05285	-0.00002

$$f = \text{INST FREQ} * \text{sqrt}(1.0 + \text{WBOTC} * t) / 1000.0$$

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

$$t = \text{temperature}[^{\circ}\text{C}]; p = \text{pressure}[\text{decibars}]; \delta = \text{CTcor}; \epsilon = \text{CPcor};$$

$$\text{Residual} = \text{instrument conductivity} - \text{bath conductivity}$$



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

SENSOR SERIAL NUMBER: 3599
CALIBRATION DATE: 10-Jun-04

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

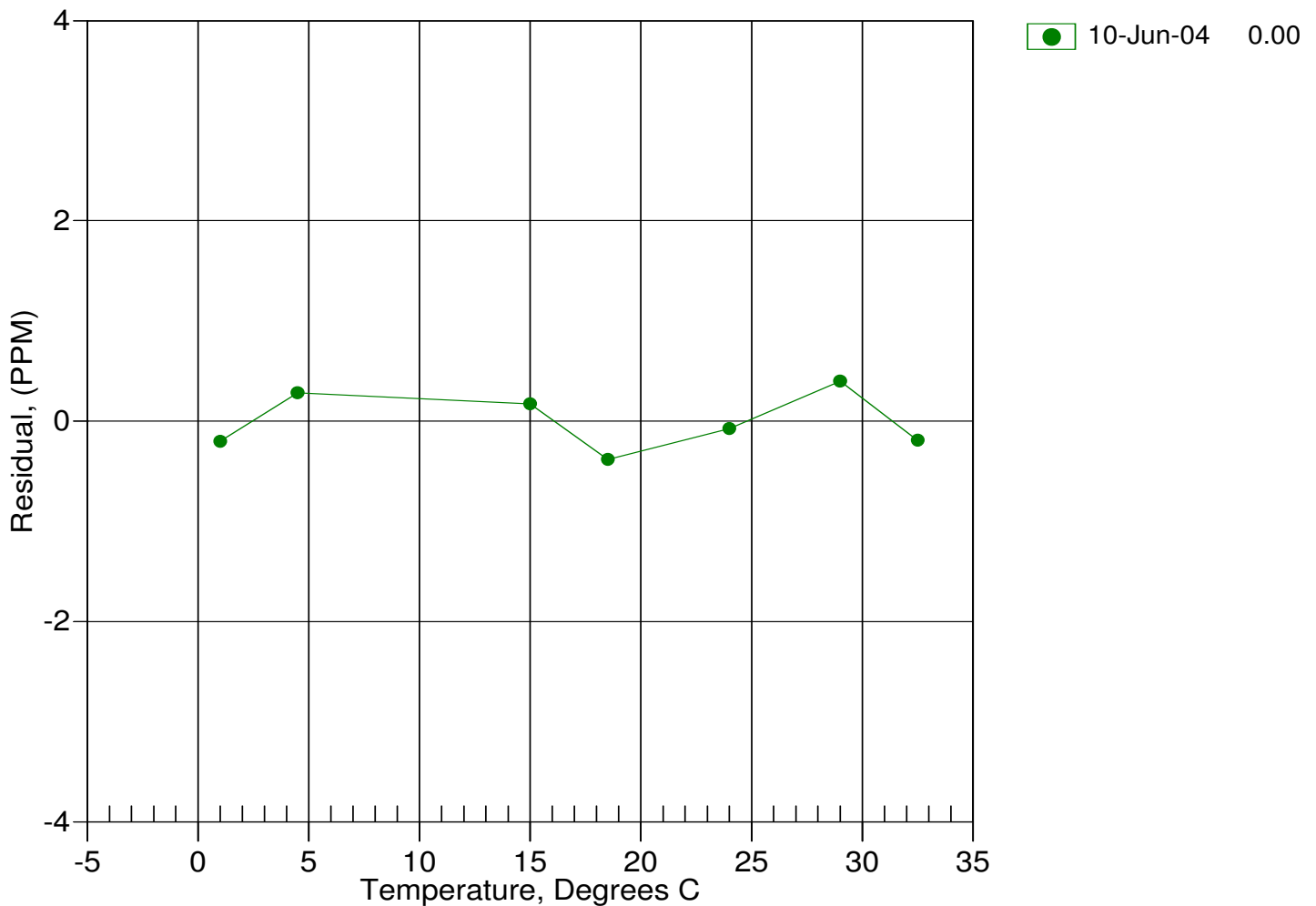
rtca0 = 9.999761e-001
rtca1 = 1.736438e-006
rtca2 = -3.098022e-008

BATH TEMP (ITS-90)	RTC FREQO (Hz)	COMPUTED FREQO (Hz)	RESIDUAL (PPM)
0.9999	0.9999780	0.9999778	-0.2
4.5000	0.9999830	0.9999833	0.3
15.0000	0.9999950	0.9999952	0.2
18.5000	0.9999980	0.9999976	-0.4
24.0000	1.0000000	0.9999999	-0.1
29.0000	1.0000000	1.0000004	0.4
32.5000	1.0000000	0.9999998	-0.2

$$\text{RTC frequency} = \text{rtca0} + \text{rtca1} * t + \text{rtca2} * t^2$$

$$\text{Residual} = (\text{Computed RTC frequency} - \text{Measured RTC frequency}) * 1e6$$

Date, Delta F ppm



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MicroCAT C-T Recorder (Serial interface & Memory)

SBE 37-SM


The SBE 37-SM MicroCAT is a high-accuracy conductivity and temperature (pressure optional) recorder with internal battery and memory. Designed for moorings or other long duration, fixed-site deployments, the MicroCAT includes a standard serial interface and non-volatile FLASH memory. Construction is of titanium and other non-corroding materials to ensure long life with minimum maintenance, and depth capability is 7000 meters (23,000 feet).

Calibration coefficients are stored in EEPROM, and uploaded data is presented in ASCII engineering units. The data always includes Conductivity, Temperature, and Pressure (if optional pressure sensor is installed). If desired, time can be added to each scan, and the MicroCAT can calculate and output salinity and sound velocity (Chen-Millero). 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. Electrical isolation of the conductivity electronics eliminates any possibility of ground-loop noise.

The MicroCAT'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.

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.



SENSOR INTERFACE ELECTRONICS

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.

COMMUNICATIONS AND INTERFACING

The MicroCAT communicates directly with a computer via standard RS-232 interface. Data can be uploaded at up to 38.4K baud. Real-time data can be transmitted at distances of up to 1600 meters (5200 feet) at 600 baud, simultaneously with recording. An optional RS-485 interface allows multiple MicroCATs to share a common 2-wire cable, minimizing cable complexity for C-T chains.

User-selectable operating modes include:

- **Autonomous Sampling** – At pre-programmed intervals of 5 seconds to 9.1 hours, the MicroCAT wakes up, samples, stores the data in its FLASH memory, and goes to sleep.
- **Polled Sampling** – On command from a computer or satellite, radio, or wire telemetry equipment, the MicroCAT takes a sample and transmits the data.
- **Serial Line Sync** – In response to a pulse on the serial line, the MicroCAT wakes up, samples, stores the data in its FLASH memory, transmits real-time data, and goes to sleep.

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.



Sea-Bird Electronics, Inc.

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MicroCAT C-T Recorder (Serial interface and Memory)

SBE 37-SM

DATA STORAGE AND BATTERY ENDURANCE

Converted temperature and conductivity are stored 5 bytes per sample, time 4 bytes per sample, and optional pressure 2 bytes per 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 without hazardous material restrictions. The pack provides sufficient internal battery capacity for more than 300,000 samples. *

SPECIFICATIONS

Measurement Range

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

*Expressed in 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

Quiescent Current* 10 microamps

Sampling and Communication Current *

Without external power option

Communication 38 milliamps
 Sampling 20 milliamps for autonomous or serial line sync sampling;
 39 milliamps for polled sampling

With external power option

Communication 35 milliamps
 Sampling 35 milliamps

Acquisition Time 1 - 3 seconds/sample
 (for 1 measurement/sample),
 dependent on sampling mode
 and inclusion of pressure sensor

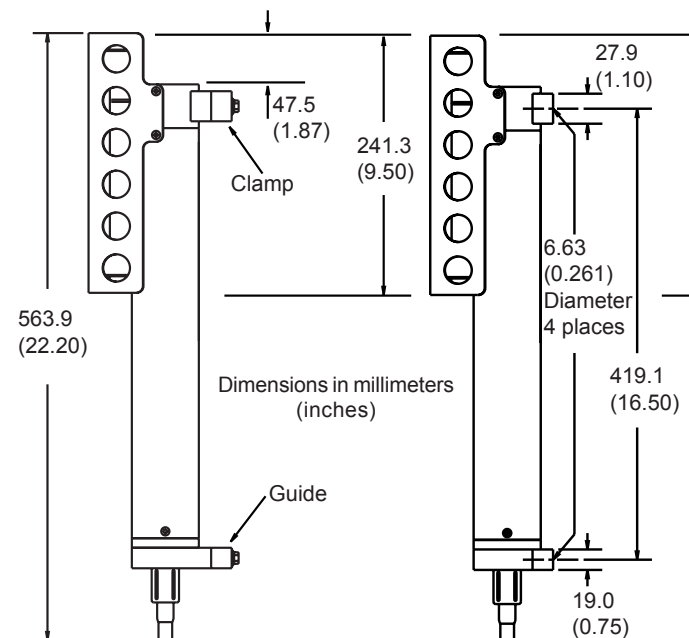
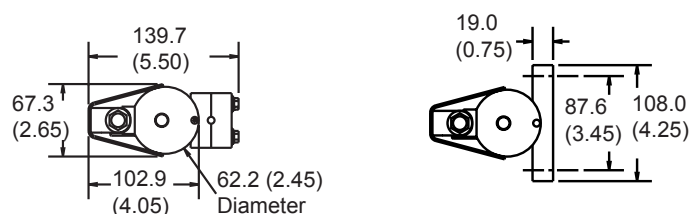
Optional External Input Power 0.5 Amps at 9-24 VDC

Housing Titanium

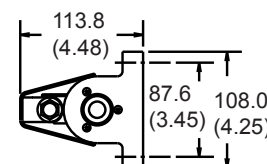
Depth Capability 7000 m (23,000 feet)

Weight

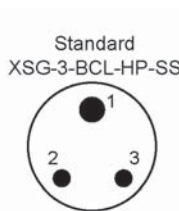
in air: 3.8 kg (8.3 lbs)
 in water: 2.3 kg (5.1 lbs)



Standard Wire Mounting
Clamp and Guide

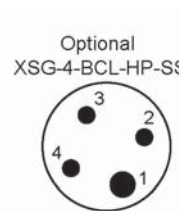
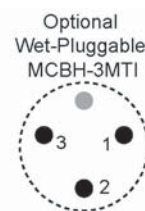


Alternate Flat Surface
Mounting Brackets



3-pin Connector

Pin	Signal
1	Common
2	RS-232 data receive
3	RS-232 data transmit



Optional 4-pin Connector

Pin	Signal
1	Common
2	RS-232 data receive
3	RS-232 data transmit
4	9-24 VDC (optional external power)

* Power consumption / battery endurance values are for standard RS-232 interface; for optional RS-485 interface, see RS-485 manual

06/04

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APPLICATION NOTE NO. 2D

Revised December 2002

INSTRUCTIONS FOR CARE AND CLEANING OF CONDUCTIVITY CELLS

Since any conductivity sensor's output reading is proportional to its 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.

If the cell is allowed to dry out between usage, salt crystals may form on (and in) the platinized electrode surfaces. When the instrument is next used, there will be a delay before these crystals are dissolved - in the meantime, sensor accuracy may be affected. Therefore, we recommend that the cell be kept filled with distilled or de-ionized water between uses. A length of 7/16" ID Tygon tubing is provided for this purpose, to be connected in such a way that any air entrapped will be in the Tygon tube rather than in the cell.

An additional important benefit of keeping the cell ends closed with Tygon is to keep air-borne contaminants (which are abundant on most research vessels) from entering the cell.

If it is not practical to keep the cell filled with distilled (or de-ionized) water between use (for example, in Arctic environments where freezing is a hazard), flush the cell with clean fresh water (preferably distilled or de-ionized) and close the cell with Tygon. Also, remember to keep the Tygon in a clean place (so that it does not pick up contaminants) while the instrument is in use.

Experience indicates that in normal intermittent use (such as in CTD profiling operations), drift rates of 0.0003 S/m (0.003 mmho/cm) or less per month can be expected **without any cleaning** if the procedures described above are followed.

PRECAUTIONS!!!!!!

The conductivity cell is primarily made of glass, and therefore is subject to breakage if mishandled. It is especially important to use the right size Tygon tubing, since if you use tubing with a too small ID, it will be difficult to remove the tubing, and the cell end may break if excessive force is used. **The correct size tubing for all instruments produced since 1980 is 7/16" ID, 9/16" OD, 1/16" wall.** Instruments shipped prior to 1980 had smaller retaining ridges at the ends of the cell, and 3/8" ID Tygon is required for these older instruments. It is better to use Tygon (brand) than other plastic tubing, since it tends to remain flexible over a wide temperature range and with age.

Do not insert any sort of cleaning probe (e.g., Q-tip) into the interior of the cell. If the platinized (black) electrode surface is touched, it may be damaged and require the electrodes to be replatinized.

If a cell is filled with water, do not subject it to low temperatures that will freeze the water and break the cell. **Remove the water before shipment during the winter, or to polar regions at any season.** No adverse effects have been observed as a result of temporary *dry* storage, particularly if the cell is rinsed with fresh water before storage.

CELL CLEANING

Routine Cleaning (inside of cell not visibly dirty)

Fill the cell with a 1% solution of Triton X-100* and let soak for 30 minutes. This is most easily done by using a length of 7/16" ID Tygon tubing to form a closed loop including the cell. After the soak, drain and flush with warm (not hot) fresh water for 1 minute. Refill the cell with distilled (or de-ionized) water until the next usage.

Cleaning Severely Fouled Cells (visible deposits or marine growths on the inside of the cell)

Clamp the instrument so that the cell is vertical, and attach a length of 7/16" Tygon tubing to the lower end of the cell. Use masking or other tape to secure the open end of the Tygon about even with the top end of the cell. Pour Muriatic Acid (37% HCl) into the open end of the Tygon until the cell is filled to near the top and let soak for 1 to 2 minutes only. **Avoid breathing the acid fumes!!** Drain the acid from the cell and flush for 5 minutes with warm (not hot) fresh water. Also rinse the exterior of the instrument to remove any spilled acid from the surface. Then fill the cell with 1% Triton* solution, let stand for 5 minutes, and flush with warm fresh water for 1 minute. Refill with distilled or de-ionized water until the next usage.

If this process does not remove the visible deposits, mechanically clean the cell with a small (0.275" diameter). soft-bristled nylon bottle brush and 1% Triton solution. **NOTE: Be extremely careful when cleaning, because the platinum electrodes are thin and could be damaged if you use a brush that is too large or too stiff. The electrodes must be replatinized after brush cleaning. Our service department will clean and replatinize your cell for a nominal fee.**

*Triton X-100 (a trade name of J. T. Baker, Inc) is a concentrated liquid non-ionic detergent available at most chemical or scientific supply stores. Other liquid detergents can probably also be used, but scientific grades are preferable 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.



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APPLICATION NOTE NO. 10

Revised May 2004

**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, 9plus, 16, 19, 21, 25, and 26/26plus

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

or

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

SBE 16plus, 19plus, 37, 45, and 49

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

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
- **CPcor is the correction term for pressure effects on conductivity**
- 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)
- t is the water temperature (°C)
- p is the water pressure (decibars)

Sea-Bird CTD data acquisition, display, and post-processing software *SEASOFT* automatically implements 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:

$$1 + s$$

$$\text{where } s = (\text{CPcor}) (p)$$

$$\text{Typical value for CPcor is } -9.57 \times 10^{-8} \text{ for pressure in decibars } \text{ or } -6.60 \times 10^{-8} \text{ for pressure in psi}$$

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 $1/R$:

$$C_p = C_0 (1 + s) \quad \text{and} \quad C_0 = C_p / (1 + s) = C_p / (1 + [\text{Cpcor}] [p])$$

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:

$$\Delta V / V = 3 \Delta L / L = -3p (1 - 2 \nu) / E \quad \text{or} \quad \Delta V / V = -p / K$$

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.

$$R_T = \frac{R}{R_{PT}}, R_P = 1 + \frac{P \times (A_1 + A_2P + A_3P^2)}{1 + B_1T + B_2T^2 + B_3R + B_4RT}$$

$$r_T = c_0 + c_1T + c_2T^2 + c_3T^3 + c_4T^4$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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



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APPLICATION NOTE 27Druck

NOVEMBER 2003

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 37 MicroCAT (37-IM, -IMP, -SM, -SMP, and -SI) with optional pressure sensor (built after September 2000)
- SBE 39 Temperature Recorder with optional pressure sensor (built after September 2000)
- SBE 49 FastCAT CTD Sensor
- SBE 50 Digital Oceanographic Pressure 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 - 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/meter² or *Pascals* (the accepted SI unit). A Pascal is a very small unit (1 psi = 6894.757 Pascals), so the mega-Pascal (MPa = 10⁶ 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:

- For 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.
- For the **SBE 50** – User selects pressure output in psia (including atmospheric pressure) or dbar. Calculation of dbar is as described above.
- For all other instruments that can output **converted data in engineering units** (SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, and 49) – 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*, and 49 can output raw or converted data.

RELATIONSHIP BETWEEN PRESSURE AND DEPTH

Despite the common nomenclature (CTD = Conductivity - Temperature - Depth), 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 offers two methods for estimating depth from pressure.

- For oceanic applications, salinity is presumed to be 35 PSU, temperature to be 0° 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-SI and 50 - Latitude is entered in the instrument's EEPROM using the **LATITUDE=** command in SEASOFT's SEATERM (terminal program) software.
 - SBE 39 - 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 $1.019716 * \text{pressure (in dbars)}$.

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 <i>plus</i> , 16 <i>plus</i> -IM, 19 <i>plus</i> , 37, 39, 49, & 50 - 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 – 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

The meaning of *accuracy*, as it applies to these sensors, is that the indicated pressure will conform to true pressure to within \pm *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 \pm 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 \pm 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

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, 49, or 50).
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 height as the pressure sensor. Calculate *offset* (decibars) = barometer reading (converted to decibars) – instrument reading (decibars).
6. Enter calculated offset 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, 49, or 50).

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

Pressure measured by a barometer is 14.65 psia. Pressure displayed from instrument is -2.5 dbars.

Convert barometer reading to dbars using the relationship: $(\text{psia} - 14.7) * 0.6894759 = \text{dbars}$

Barometer reading = $(14.65 - 14.7) * 0.6894759 = -0.034$ dbars

Offset = $-0.034 - (-2.5) = +2.466$ 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:

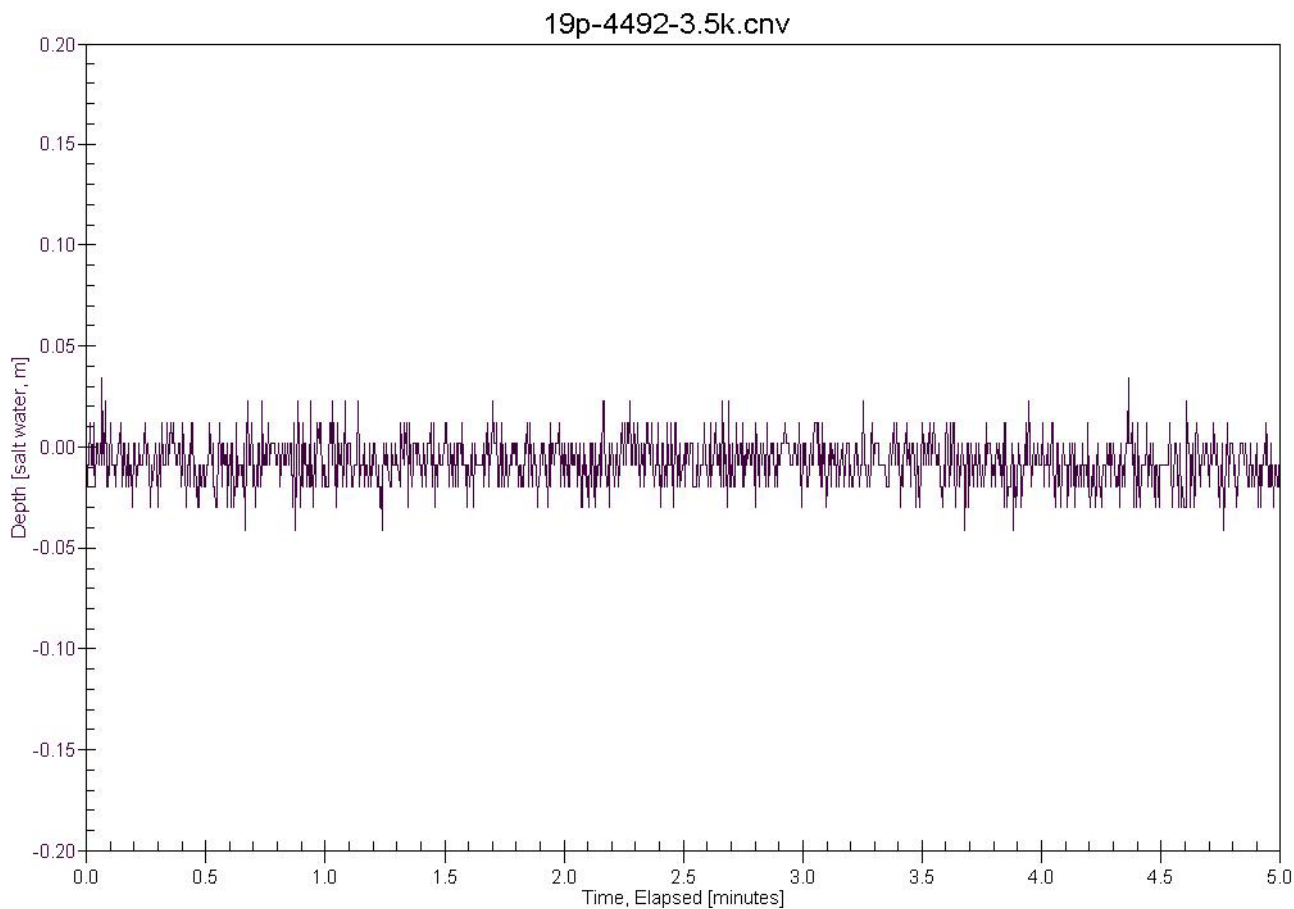
1. **Immediately** before beginning the profile, take a pre-cast *in air* pressure reading.
2. **Immediately** after ending the profile, take a post-cast *in air* pressure reading with the instrument at the same elevation and orientation. This reading reflects the change in the instrument temperature 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:

$$T_{68} = 1.00024 * T_{90}$$

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. 57

Revised May 2003

I/O Connector Care and Installation

This Application Note describes the proper care and installation of standard I/O connectors for Sea-Bird CTD instruments. Once properly installed, the connections require minimal care. Unless access to the bulkhead is required, the connections can be left in place indefinitely.

The Application Note is divided into three sections:

- Connector Cleaning and Installation
- Locking Sleeve Installation
- Cold Weather Tips

Connector Cleaning and Installation

1. Carefully clean the bulkhead connector and the inside of the mating inline (cable end) connector with a Kimwipe. Remove all grease, hair, dirt, and other contamination.



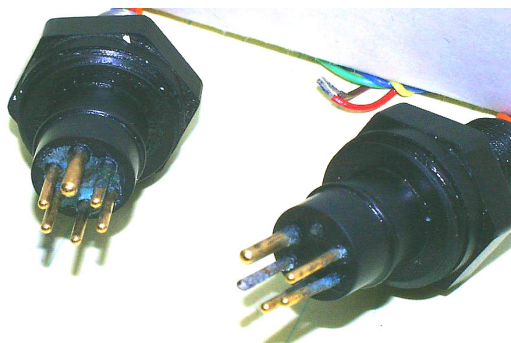
Clean bulkhead connector



Clean inside of connector

2. Inspect the connectors:
 - A. Inspect the pins on the bulkhead connector for signs of corrosion. The pins should be bright and shiny, with no discoloration. If the pins are discolored or corroded, clean with alcohol and a Q-tip.
 - B. Inspect the bulkhead connector for chips, cracks, or other flaws that may compromise the seal.
 - C. Inspect the inline connector for cuts, nicks, breaks, or other problems that may compromise the seal.

Replace severely corroded or otherwise damaged connectors - contact SBE for instructions or a Return Authorization Number (RMA number).



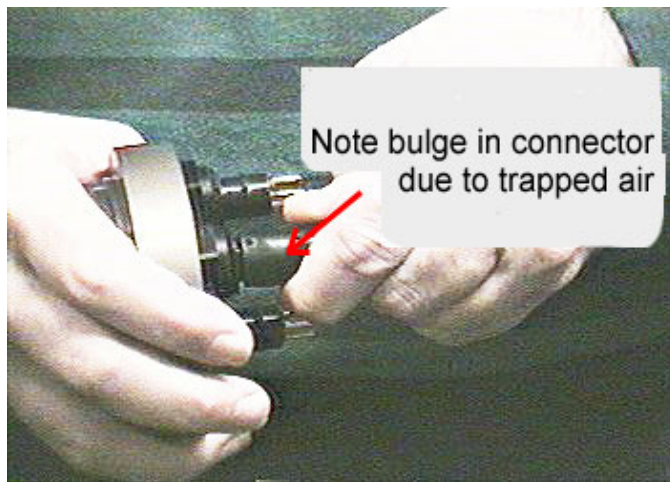
Corroded pins on bulkhead connectors -
Connector on right has a missing pin

- Using a tube of 100% silicone grease (Dow DC-4 or equivalent), squeeze approximately half the size of a pea onto the end of your finger.

CAUTION:

Do not use WD-40 or other petroleum-based lubricants, as they will damage the connectors.

- Apply a light, even coating of grease to the molded ridge around the base of the bulkhead connector. The ridge looks like an o-ring molded into the bulkhead connector base and fits into the groove of the mating inline connector.

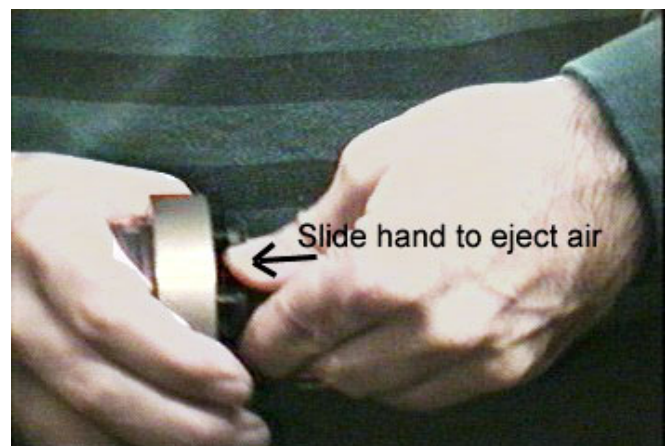


- Mate the inline connector to the bulkhead, being careful to align the pins with the sockets. Do not twist the inline connector on the bulkhead connector. Twisting can lead to bent pins, which will soon break.
- Push the connector all the way onto the bulkhead. There may be an audible pop, which is good. With some newer cables, or in cold weather, there may not be an initial audible pop.

- After the cable is mated, run your fingers along the inline connector toward the bulkhead, *milking* any trapped air out of the connector. You should hear the air being ejected.

CAUTION:

Failure to eject the trapped air will result in the connector leaking.

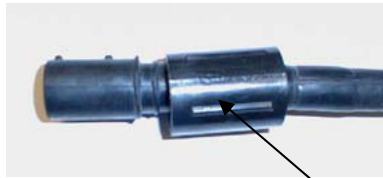


Locking Sleeve Installation

After the connectors are mated, install the locking sleeve. The locking sleeve secures the inline connector to the bulkhead connector and prevents the cable from being inadvertently removed.

Important points regarding locking sleeves:

- Tighten the locking sleeve by hand. **Do not** use a wrench or pliers to tighten the locking sleeve. Overtightening will gall the threads, which can bind the locking sleeve to the bulkhead connector. Attempting to remove a tightly bound locking sleeve may instead result in the bulkhead connector actually unthreading from the end cap. A loose bulkhead connector will lead to a flooded instrument. **Pay particular attention when removing a locking sleeve to ensure the bulkhead connector is not loosened.**
- It is a common misconception that the locking sleeve provides watertight integrity. **It does not, and continued re-tightening of the locking sleeve will not fix a leaking connector.**
- As part of routine maintenance at the end of every cruise, remove the locking sleeve, slide it up the cable, and rinse the connection (still mated) with fresh water. This will prevent premature cable failure.



Locking Sleeve

Cold Weather Tips

In cold weather, the connector may be hard to install and remove.

Removing a *frozen* inline connector:

1. Wrap the connector with a washrag or other cloth.
2. Pour hot water on the cloth and let the connector sit for a minute or two. The connector should thaw and become flexible enough to be removed.

Installing an inline connector:

When possible, mate connectors in warm environments before the cruise and leave them connected. If not, warm the connector sufficiently so it is flexible. A flexible connector will install properly.

By following these procedures, you will have many years of reliable service from your cables!



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APPLICATION NOTE NO. 68

Revised **June 2004**

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 with our instruments, and verified compatibility. 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 recommend testing of any other adapters with the instrument 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:

$$g \text{ (m/sec}^2\text{)} = 9.780318 * [1.0 + (5.2788 \times 10^{-3} + 2.36 \times 10^{-5} * x) * x] + 1.092 \times 10^{-6} * p$$

where

$$x = [\sin (\text{latitude} / 57.29578)]^2$$

p = pressure (decibars)

Then, depth is calculated from pressure:

$$\text{depth (meters)} = [(((-1.82 \times 10^{-15} * p + 2.279 \times 10^{-10}) * p - 2.2512 \times 10^{-5}) * p + 9.72659) * p] / g$$

where

p = pressure (decibars)

g = gravity (m/sec²)



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APPLICATION NOTE NO. 71

September 2003

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.

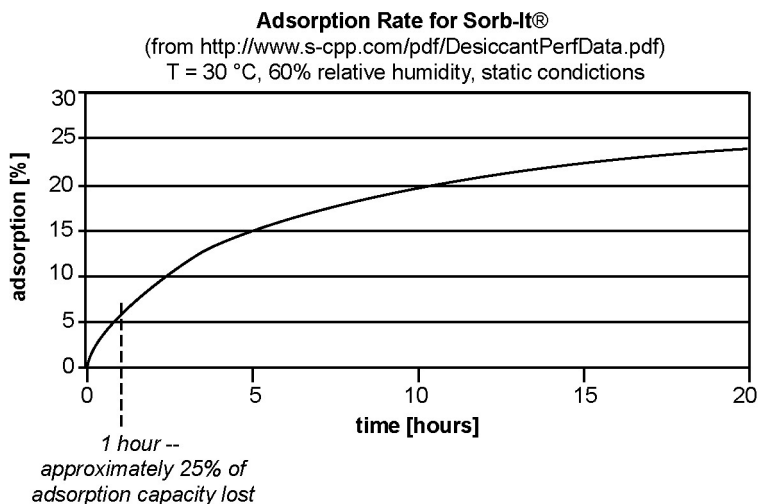
What do we mean by *expose the electronics*?

- For most battery-powered Sea-Bird instruments (such as SBE 16, 16*plus*, 16*plus*-IM, 17*plus*, 19, 19*plus*, 25, 37-SM, 37-SMP, 37-IM, 37-IMP, 44; PN 90208 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 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, -SM, -SMP, -IM, and -IMP), 38, 39, 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*, and 21.
- 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, 32, 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.



Sud-Chemie Performance
Packaging
101 Christine Dr.
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 864-9296

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 ₂ O

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%.



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.



ISO 9002 CERTIFIED

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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.

SÜD-CHEMIE
Creating Performance Technology



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**Sud-Chemie Performance
Packaging**

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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.

The information contained herein is based upon data considered true and accurate. However, United Desiccants makes no warranties expressed or implied, as to the accuracy or adequacy of the information contained herein or the results to be obtained from the use thereof. This information is offered solely for the user's consideration, investigation and verification. Since the use and conditions of use of this information and the material described herein are not within the control of United Desiccants, United Desiccants assumes no responsibility for injury to the user or third persons. The material described herein is sold only pursuant to United Desiccants' Terms and Conditions of Sale, including those limiting warranties and remedies contained therein. It is the responsibility of the user to determine whether any use of the data and information is in accordance with applicable federal, state or local laws and regulations.



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APPLICATION NOTE NO. 73

June 2004

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:

$$\text{Pressure (db)} = [\text{pressure (psia)} - 14.7] * 0.689476$$

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 *9plus* and 25
- SBE *16plus* (RS-232 version), *19plus*, and 49
- SBE *16plus* (RS-485 version) and *16plus-IM*
- SBE 37 (all models)
- SBE 50
- SBE 39
- SBE *26plus*

SBE 9plus 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 $offset = (0 - \text{instrument reading})$.
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 16plus (RS-232 version), 19plus, 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 $offset = (0 - \text{instrument reading})$.
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 16plus (RS-485 version) and 16plus-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 $offset = (0 - \text{instrument reading})$.
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 $offset = (0 - \text{instrument reading})$.
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	#iPOFFSET=	#iFORMAT=1 or #iFORMAT=2	#iTP (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 $offset = (0 - \text{instrument reading})$.
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 39

The SBE 39 directly outputs data that is already converted to engineering units, 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 $(0.1 * \text{sensor range}) < (\text{decrease in atmospheric pressure from sea level to elevation})$, 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 first page: $\text{pressure (db)} = [\text{pressure (psia)} - 14.7] * 0.689476$;
Rearranging: $\text{pressure (psia)} = [\text{Pressure (db)} / 0.689476] + 14.7$
Measuring relative to atmospheric: $\text{pressure (psi; relative to atmospheric pressure)} = \text{Pressure (db)} / 0.689476$

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.

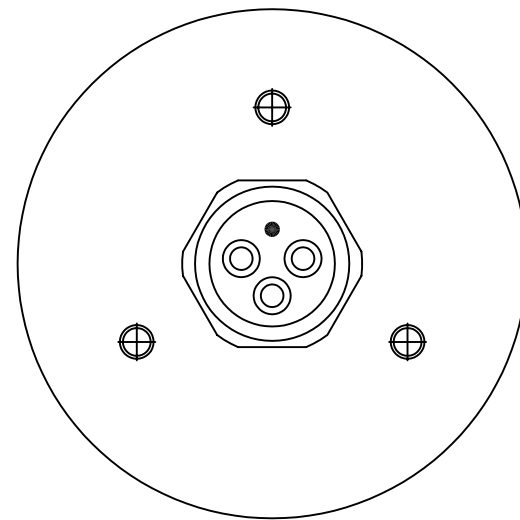
SBE 26plus

Unlike our other instruments that include a pressure sensor, the SBE 26plus outputs absolute pressure (i.e., at the surface the output pressure is atmospheric pressure at the deployment elevation). Therefore, no corrections are required when using the SBE 26plus above sea level. SBE 26plus software (SEASOFT for Waves) includes a module that can subtract measured barometric pressures from tide data, and convert the resulting pressures to water depths.

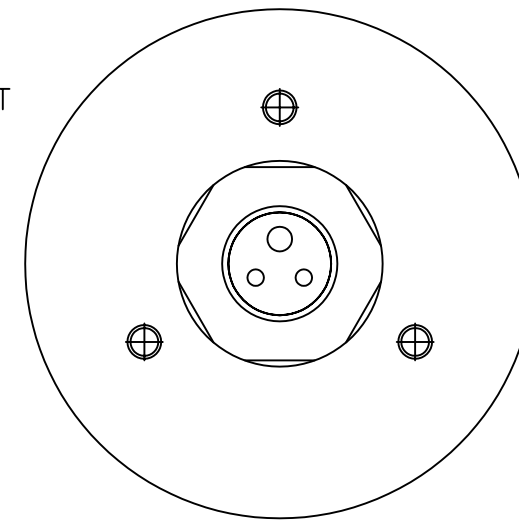
DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
04.22.03	A	ADD SUBCONN, ADD REFERENCE TO POTTED AND MODULAR MICROCATS	CB	CB	

WET-MATABLE (SUBCONN)
CONNECTOR OPTIONS

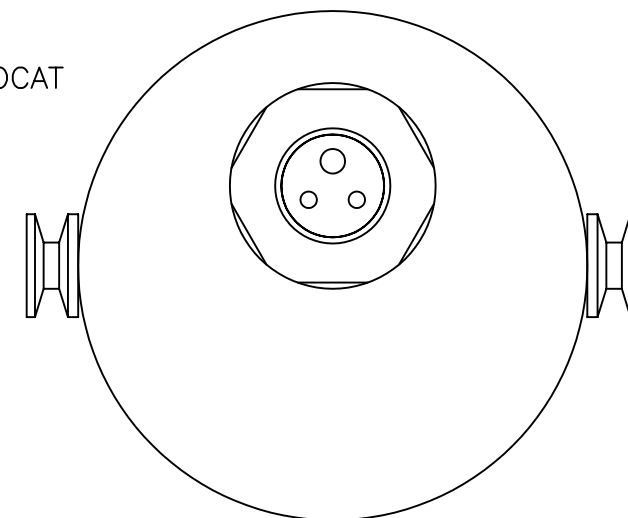
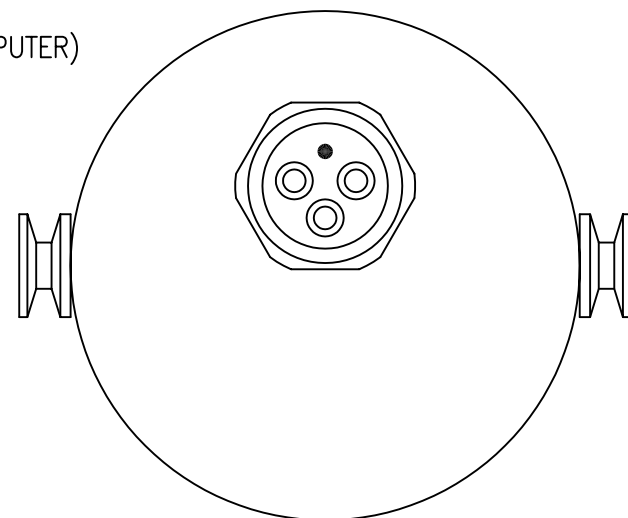
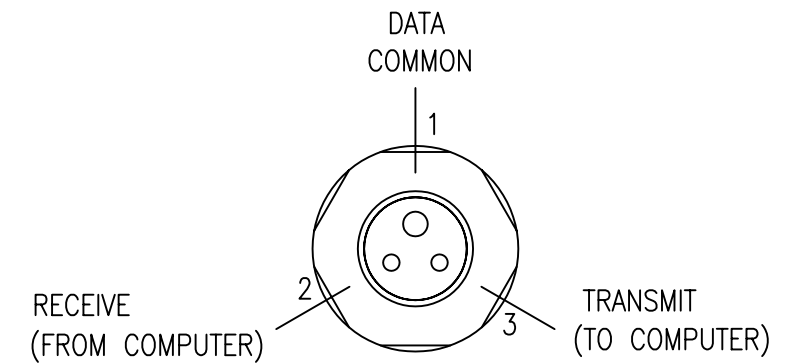
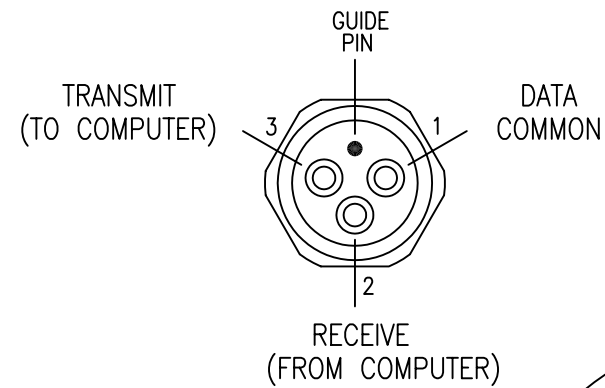
STANDARD (IMPULSE)
CONNECTOR OPTIONS



SBE 37SM ENDCAP FOR MODULAR MICROCAT

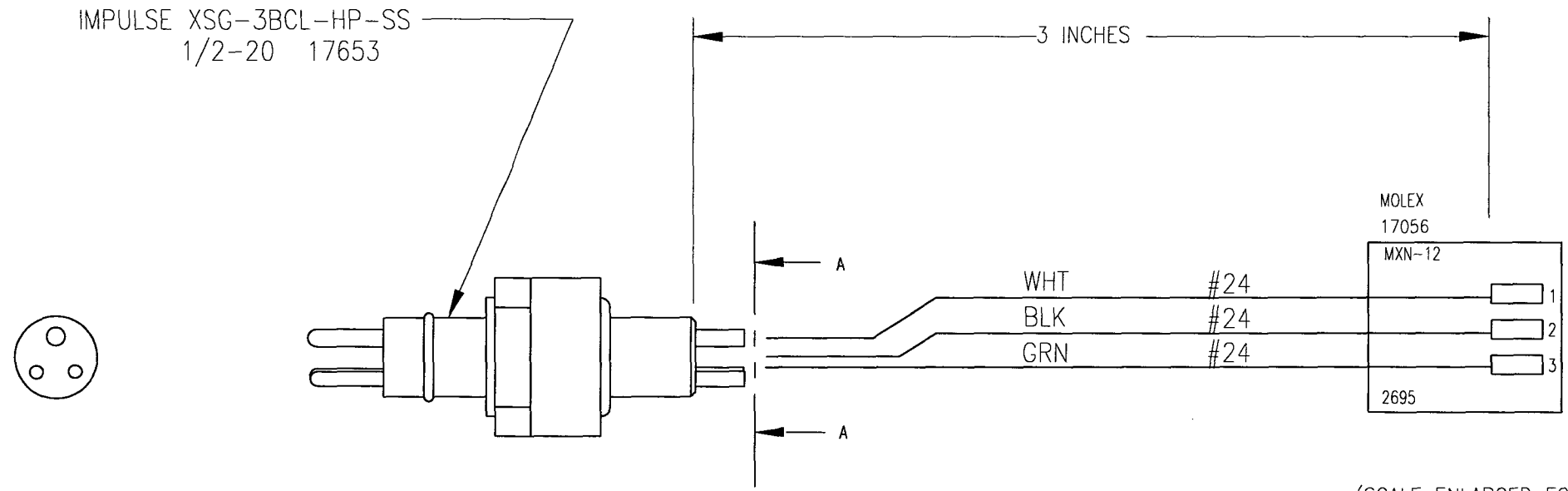


SBE 37SM ENDCAP FOR POTTED MICROCAT

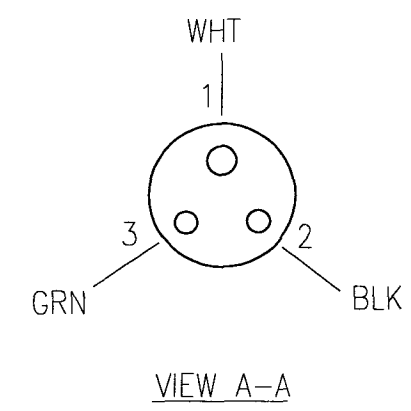


TOLERANCES	SEA-BIRD ELECTRONICS, INC				
FRACTIONAL	P/N	N/A	SCALE	DRAWN BY	DG
			NTS	APPROVED BY	
DECIMAL	TITLE SBE37-SM, EXTERNAL I/O WIRING INTERNAL POWER, RS-232				
ANGULAR	DATE	1/14/97	DWG NO.	50147	REV A

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
9/11/01	A	CORRECTED CONNECTOR		LRG	

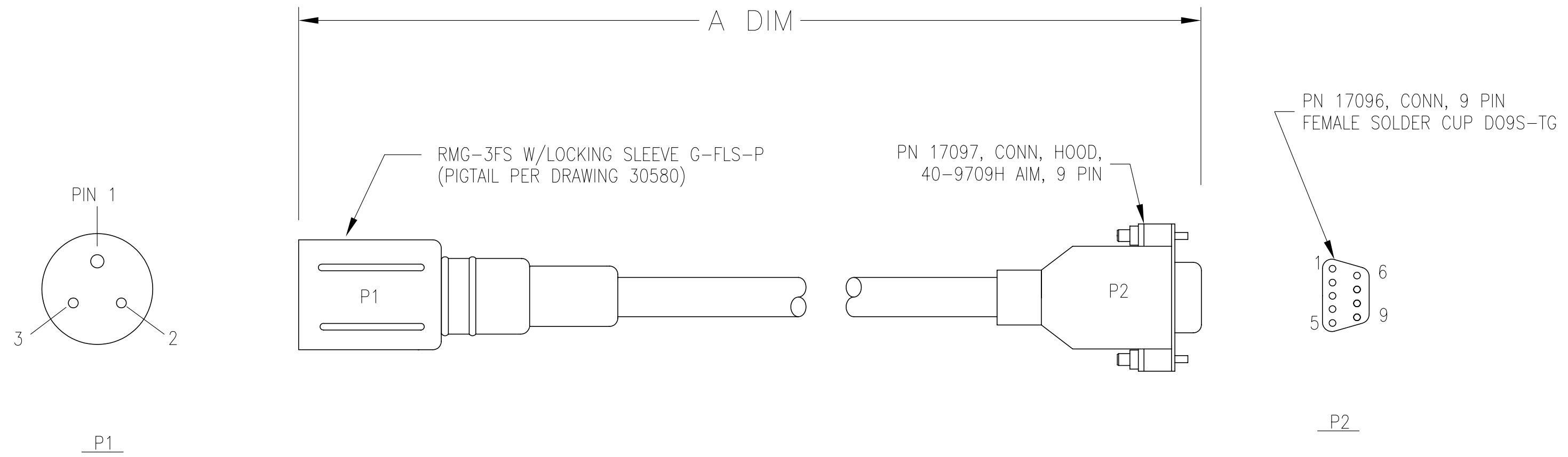


(SCALE ENLARGED FOR CLARITY)



SEA-BIRD ELECTRONICS, INC					
P/N	N/A	SCALE	DRAWN BY	CEG	
		1:1	APPROVED BY		
SBE 37 3 PIN DATA I/O MOLEX WIRING					
DATE	DWG NO.	SHEET	REV		
5/1/97	40889	1 of 1	A		

DATE	REV	REVISION RECORD	AUTH.	DR.	CK.
3.24.04	A	ADDED SHIELDED TABLES		KLP	



△ SHIELDED
CONSOLIDATED 1702 PIGTAIL, DWG 30584

NON-SHIELDED
18/3-S0 PIGTAIL, DWG 30580

P1 RMG-3FS	P2 DB-9S	COLOR
PIN 1	PIN 5	SHIELD
PIN 2	PIN 3	BLACK
PIN 3	PIN 2	WHITE

P1 RMG-3FS	P2 DB-9S	COLOR
PIN 1	PIN 5	WHITE
PIN 2	PIN 3	BLACK
PIN 3	PIN 2	GREEN

SBE PART NO.	A DIM	PIGTAIL PN
801493	50 m	17390
801498	50 ft	17205

SBE PART NO.	A DIM	PIGTAIL PN
801412	8 FT	17030
801526	20 m	17156

TOLERANCES	SEA-BIRD ELECTRONICS, INC			
FRACTIONAL	P/N SEE TABLE	SCALE 1:1	DRAWN BY KLP	
DECIMAL	APPROVED BY			
ANGULAR	DATE 3.28.03	DRAWING NUMBER 32778	REV A	
	TITLE DATA I/O CABLE ASSY DB-9S TO RMG-3FS			

WARRANTY POLICY

2003

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 13 and 23 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.
4. Batteries, zinc anodes, or other consumable/expendable items are not covered under this warranty.
5. This warranty is void if in our opinion the instrument has been damaged by accident, mishandled, altered, or repaired by the customer where such treatment has affected its performance or reliability. In the event of such 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.
6. 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

RMA Number: _____

CONTACT INFORMATION

Your name: _____

Institution/Organization/Company: _____

Shipping/Delivery address for packages: _____

Telephone: _____ Fax: _____

e-mail: _____

SERVICE INFORMATION

Date Shipped: _____

Sea-Bird Model Number (for example, SBE 37-SM): _____

Quantity: _____

Serial Numbers: _____

(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 the repairs in the appropriate section of the form.)
SEASOFT Version you have been using with this instrument(s): _____

[] Perform Routine 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.)

___ Full System Diagnostic and Check Out

___ Other (specify): _____

[] System Upgrade or Conversion:

Specify (include instrument serial number if multiple instruments are part of shipment): _____

[] Diagnose and Repair Operational Faults:

Please send a disk containing the raw data (.hex or .dat files) which 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): _____

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):

_____**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):

_____**Instructions for Returning Goods to Sea-Bird**

You can ship any of the following ways:

- 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
- Foreign Shipments** - Ship via prepaid airfreight to:
Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005, USA
Telephone: (425) 643-9866 Fax: (425) 643-9954
Notify: MTI Worldwide Logistics for Customs Clearance
Seattle, WA, USA
Telephone: (206) 431-4366 Fax: (206) 431-4374
(Please note Airport of Destination: **SEA** for Seattle, WA)
- Ship via EXPRESS COURIER directly to Sea-Bird Electronics** (UPS, FedEx, or DHL; **do not ship via TNT SKYPACK**). Courier services will clear Customs and deliver the package to Sea-Bird. It is not necessary to notify our customs broker.
Include a **commercial invoice** showing the description of the instruments, and **value for Customs purposes only**. On the invoice, include the statement that **"Goods are of USA Origin"**.
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 crates based on the dimensions of the crate we receive. The charge will be determined as follows:

- Multiply the crate length x width x height in centimeters (overall volume in cm³, not internal volume).
- Determine the price based on your calculated overall volume and the following chart:

Overall Volume (cm ³)	Example Instrument	Price (USD)
less than 52,000	37-SM MicroCAT	\$45
52,000 to less than 65,000	SEACAT, no cage	\$70
65,000 to 240,000	CTD in cage	\$125
more than 240,000	--	consult factory

These prices are valid only for crate replacement required in conjunction with the return of a customer's instrument after servicing, and only when the instrument was shipped to Sea-Bird in a crate originally supplied by Sea-Bird.