SBE 37-SI MicroCAT

Conductivity and Temperature Monitor (Pressure Optional) with RS-232 Interface

User Manual, Version 022

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SBE 37-SI MICROCAT OPERATING AND REPAIR MANUAL

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SBE 37-SI MicroCAT

Conductivity and Temperature Monitor
with RS-232 Interface

Shown with standard titanium housing;
optional ShallowCAT plastic housing available

User's Manual

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Table of Contents

Section 1: Introduction

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

About this Manual

This manual is to be used with the SBE 37-SI MicroCAT Conductivity and Temperature Monitor (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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Except from April to October, when we are on 'summer time'
(1500 to 0000 Universal Time)

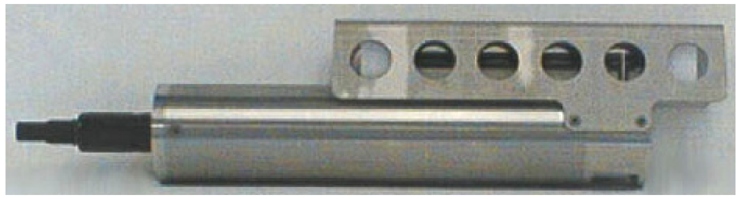
Quick Start

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

1. Perform pre-check procedures (*Section 3: Preparing MicroCAT for Deployment*):
   A. Test power and communications.
   B. Verify power-up mode jumper is correctly set by observing response to **QS**.
2. Deploy MicroCAT (*Section 4: Deploying and Operating MicroCAT)*:
   A. Set date and then time.
   B. Establish setup and operating parameters.
   C. Remove protective plugs from anti-foulant device cups, and verify AF24173 Anti-Foulant Devices are installed. Leave protective plugs off for deployment.
   D. Install I/O cable connector and locking sleeve.
   E. Deploy MicroCAT, using optional Sea-Bird mounting hardware or customer-supplied hardware.
   F. Save real-time data to a file, using Capture on SEATERM's Toolbar or your own software.

Unpacking MicroCAT

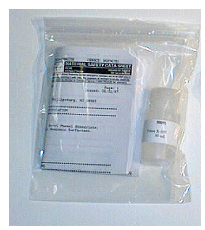
Shown below is a typical MicroCAT shipment.


SBE 37-SI MicroCAT


I/O cable


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


Spare hardware
and o-ring kit


Conductivity cell cleaning
solution (Triton-X)


MicroCAT User Manual


Software, and Electronic Copies of
Software Manuals and User Manual

Section 2: Description of MicroCAT

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

System Description

Standard titanium housing

Optional plastic *ShalowCAT* housing

The SBE 37-SI MicroCAT is a high-accuracy, externally powered, conductivity and temperature (pressure optional) monitor, which includes a standard **RS-232** serial interface. Designed to be incorporated into oceanographic sensing systems, MicroCATs have non-corroding titanium housings rated for operation to 7000 meters (23,000 feet) or pressure sensor full-scale range. An optional plastic *ShallowCAT* housing rated for 250 meters (820 feet) is also available.

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** – There are two types of Autonomous sampling. *Interval sampling*: At pre-programmed intervals, the MicroCAT samples and transmits the data to the computer. The MicroCAT does not go to sleep between samples. *Continuous sampling*: The MicroCAT continuously samples and sends the data to the computer. The MicroCAT does not go to sleep between samples.
- **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** - A pulse on the serial line causes a MicroCAT to wake up, sample, transmit the data, and go to sleep automatically. This mode provides easy integration with Acoustic Doppler Current Profilers (ADCPs) or current meters which can synchronize MicroCAT sampling with their own.

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.

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

The MicroCAT is supplied with a powerful Win 2000/XP software package, SEASOFT-Win32. SEASOFT-Win32 includes SEATERM, a powerful terminal program for easy communication and data retrieval. SEATERM can send commands to the MicroCAT to provide status display, data acquisition setup, data display and capture, and diagnostic tests. Note that SEATERM **does not process the data**.

Specifications

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

	Temperature (°C)	Conductivity (S/m)	Optional Pressure
Measurement Range	-5 to +35	0 to 7 (0 to 70 mS/cm)	0 to full scale range: 20 / 100 / 350 / 600 / 1000 / 2000 / 3500 / 7000 meters
Initial Accuracy	0.002	0.0003 (0.003 mS/cm)	0.1% of full scale range
Typical Stability (per month)	0.0002	0.0003 (0.003 mS/cm)	0.004% of full scale range
Resolution *	0.0001	0.00001 (0.0001 mS/cm)	0.002% of full scale range
Sensor Calibration	+1 to +32	0 to 6; physical calibration over the range 2.6 to 6 S/m, plus zero conductivity (air)	Ambient pressure to full scale range in 5 steps
Counter Time-Base	Quartz TCXO, ±2 ppm per year aging; ±5 ppm vs. temperature (-5 to +30 °C)		
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)		
External Input Power	0.5 Amps at 7-24 VDC. See *Power and Cable Length* in *Section 4: Deploying and Operating MicroCAT*. • Quiescent current: 10 microamps • Communication current: 35 milliamps • Acquisition current: 35 milliamps • Minimum acquisition time: 0.66 seconds/sample (programmable)		
Housing and Depth Rating	*Standard:* Titanium housing, 7000 m (23,000 ft) *Optional:* Plastic *ShallowCAT* housing, 250 m (820 ft)		
Weight (without pressure sensor or clamps)	*Standard titanium housing:* In air: 2.9 kg (6.5 lbs) In water: 1.9 kg (4.3 lbs) *Optional plastic ShallowCAT housing:* In air: 2.2 kg (4.9 lbs) In water: 1.2 kg (2.7 lbs)		

CAUTION:
See *Section 5: Routine Maintenance and Calibration* for handling instructions for the plastic *ShallowCAT* housing.

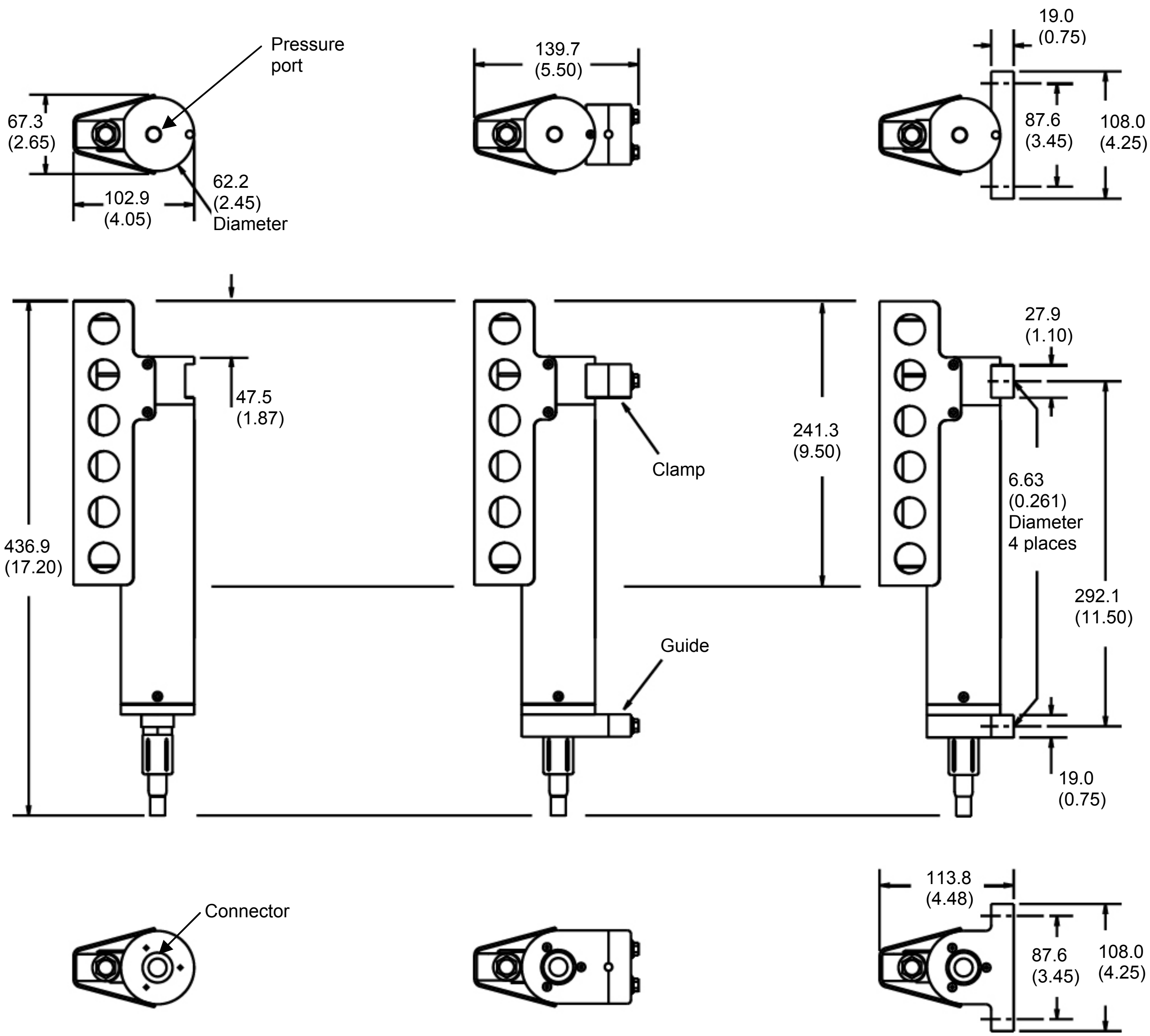
***Resolution**
Typical RMS noise with fixed resistors on the temperature and conductivity inputs:

NCycles	Temperature (°C)	Conductivity (S/m)
1	0.000220	0.000012
2	0.000173	0.000009
4	0.000127	0.000008
8	0.000094	0.000005
16	0.000060	0.000005

See *Command Descriptions* in *Section 4: Deploying and Operating MicroCAT* for a description of **NCycles**.

Dimensions and End Cap Connector

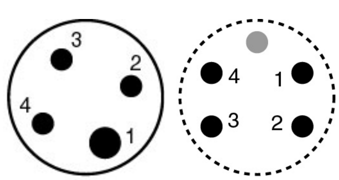
Dimensions in millimeters (inches)



Standard Without Mounting Hardware

Optional Wire Mounting Clamp and Guide

Optional Flat Surface Mounting Brackets



4-Pin Connector

Pin	Signal
1	Common
2	RS-232 data receive
3	RS-232 data transmit
4	7-24 VDC

○ = standard XSG-4-BCL-HP-SS connector

◌ = optional MCBH-4MP (WB), TI (3/8” length base, ½-20 thread) connector

Sample Timing

Notes:
- The MicroCAT transmits data **after** it completes the previous sample and **before** it starts the next sample. Add transmission time to sampling time to determine the minimum time between samples; see *Baud Rate, Cable Length, Power, and Data Transmission Rate* in *Section 4: Deploying and Operating MicroCAT*.
- For the date and time output with the data, time is the time at the **start** of the sample, after a small amount of time for the MicroCAT to wake up, run the pump, and prepare to sample. For example, if the MicroCAT is programmed to wake up and sample at 12:00:00, the displayed time will indicate 12:00:01 or 12:00:02.
- See *Specifications* above for the effect of **NCycles** on RMS noise. See *Command Descriptions* in *Section 4: Deploying and Operating MicroCAT* for a description of **NCycles**.

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 A/D cycles to average per sample (**Ncycles**) – see *Specifications* above for effect of **Ncycles** on RMS noise

Note:
Autonomous Sampling is in effect when:
- Interface PCB J1 jumper is set to Normal or Autopower, **AutoRun=Y**, and **SingleSample=N**, *or*
- Interface PCB J1 jumper is set to Normal, **AutoRun=N**, **SingleSample=N**, and sampling is started with **Go**

The MicroCAT does not go to sleep between samples for Autonomous Sampling.

Autonomous Sampling

If **Interval** < 10 (continuous sampling):
- **Without pressure**
  sampling time (seconds) = (**Ncycles** *0.1336) + 0.52
- **With pressure**
  sampling time (seconds) = (**Ncycles** * 0.1664) + 0.75

If **Ncycles** is large, the time required to sample may be more than **Interval**. The MicroCAT will sample continuously at the rate based on **Ncycles**.

If **Interval** > 10:
- **With or without pressure**
  time between samples (seconds) = **Interval**

However, if **Ncycles** is large, the time required to take a sample may be more than **Interval** (see continuous sampling equations above). The MicroCAT internally sets the sampling rate to **Interval** plus the actual required sampling time.

Example 1: MicroCAT with pressure sensor, **Interval=8** (continuous sampling), **Ncycles=4** (default).
Sampling time = (4 * 0.1664) + 0.75 = 1.4156;
MicroCAT samples continuously at (1.4156-second + transmission time) intervals.

Example 2: MicroCAT with pressure sensor, **Interval=8** (continuous sampling), **Ncycles=64**.
Sampling time= (64 * 0.1664) + 0.75 = 11.3996;
MicroCAT samples continuously at (11.3996-second + transmission time) intervals.

Example 3: MicroCAT with pressure sensor, **Interval=11** (not continuous sampling), **Ncycles=4** (default).
Sampling time = (4 * 0.1664) + 0.75 = 1.4156 < 11;   MicroCAT samples at 11-second intervals.

Example 4: MicroCAT with pressure sensor, **Interval=11** (not continuous sampling), **Ncycles=64**.
Sampling time= (64 * 0.1664) + 0.75 = 11.3996 > 11;   MicroCAT samples at (11.3996 + 11) = 22.3996-second intervals.

> **Note:**
> Polled Sampling is in effect when Interface PCB J1 jumper is set to Normal or Autopower, **AutoRun=N**, and sampling is started with **Go** (if **SingleSample=Y**) or with a polled sampling command.

Polled Sampling

Time from end of take or send sample command to beginning of reply:

- **Without pressure**
  time (seconds) = (**Ncycles** * 0.1350) + 0.53
- **With pressure**
  time (seconds) = (**Ncycles** * 0.1675) + 0.84

> **Note:**
> Serial Line Sync is in effect when Interface PCB J1 jumper is set to Normal (pins 1 and 2), **AutoRun=Y**, and **SingleSample=Y.**

Serial Line Sync

Power-on time:

- **Without pressure**
  time (seconds) = (**Ncycles** * 0.135) + 1.66
- **With pressure**
  time (seconds) = (**Ncycles** * 0.165) + 2.00

The data is sent approximately 60 milliseconds before the MicroCAT enters quiescent state (goes to sleep).

Section 3: Preparing MicroCAT for Deployment

This section describes the pre-check procedure for preparing the MicroCAT for deployment. Installing software, checking the power-up mode jumper, and testing power and communications are discussed.

Software Installation

Recommended minimum system requirements for running SEASOFT-Win32: Windows 2000 or later, 500 MHz processor, 256 MB RAM, and 90 MB free disk space for installation.

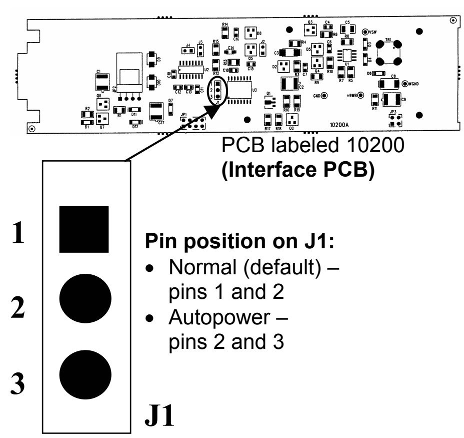
Note:
It is possible to use the MicroCAT without SEATERM by sending direct commands from a dumb terminal or terminal emulator, such as Windows HyperTerminal.

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

1. With the CD in your CD drive, double click on **Seasoft-Win32.exe**.
2. 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. The installation program allows you to install the desired components. Install all the components, or just install SEATERM (terminal program).

Power-Up Jumper Check



Note:
See *Appendix II: Electronics Disassembly/Reassembly* for details on accessing the PCB.

The Interface Printed Circuit Board (PCB) has a jumper that controls how the MicroCAT wakes up.

- Normal (default) - The MicroCAT wakes up when there is a pulse on the serial interface lines. In this configuration, the MicroCAT can be controlled using the documented commands and can be commanded into a quiescent (sleep) state with **QS**.
- Autopower - The MicroCAT wakes up when power is applied. System capability is dependent on the external wiring configuration:
  - Three wires – This configuration is useful in simple systems where a controller applies power, waits for data, and then removes power. Only three of the four wires (Power, Ground, and Transmit) are needed for operation, since it is not necessary to command the MicroCAT to take each sample. Note that the MicroCAT **does not respond to any commands in this configuration**, so initial setup of the system must be performed with all four wires in place (see *Command Descriptions* in *Section 4: Deploying and Operating MicroCAT*).
  - Four wires - With all four wires (Power, Ground, Receive, and Transmit), the MicroCAT *can* receive and respond to most commands. Note that the MicroCAT will not respond to **QS**, which normally places the MicroCAT in quiescent (sleep) state.

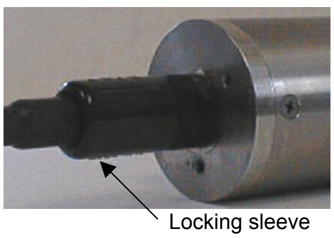
Verify the jumper setting in one of the following ways:

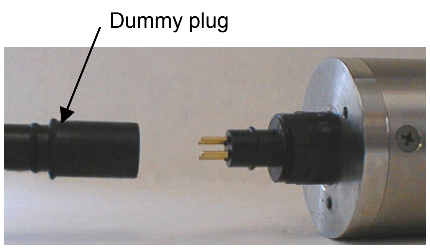
- Remove the PCB from the housing to check the jumper setting, or
- Connect the MicroCAT to the computer and enter communication parameters as described in *Power and Communications Test*, wake up the MicroCAT by clicking Connect on the Toolbar, and then enter **QS** after the `S>` prompt. The response indicates the jumper position:
  - ➢ Autopower – system returns `S>` prompt, indicating that the MicroCAT is not in quiescent state.
  - ➢ Normal – system does not return `S>` prompt, indicating that the MicroCAT is in quiescent state.

Power and Communications Test

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

Test Setup





1. Remove the dummy plug:
   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. Install the Sea-Bird I/O cable connector:
   Standard Connector - Install the Sea-Bird I/O cable connector, aligning the raised bump on the side of the connector with the large pin (pin 1 - ground) on the MicroCAT (XSG connector shown below). **OR**
   MCBH Connector – Install the I/O cable connector, aligning the pins.

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

4. Connect the I/O cable connector's red (+) and black (-) wires to a power supply (7-24 VDC).

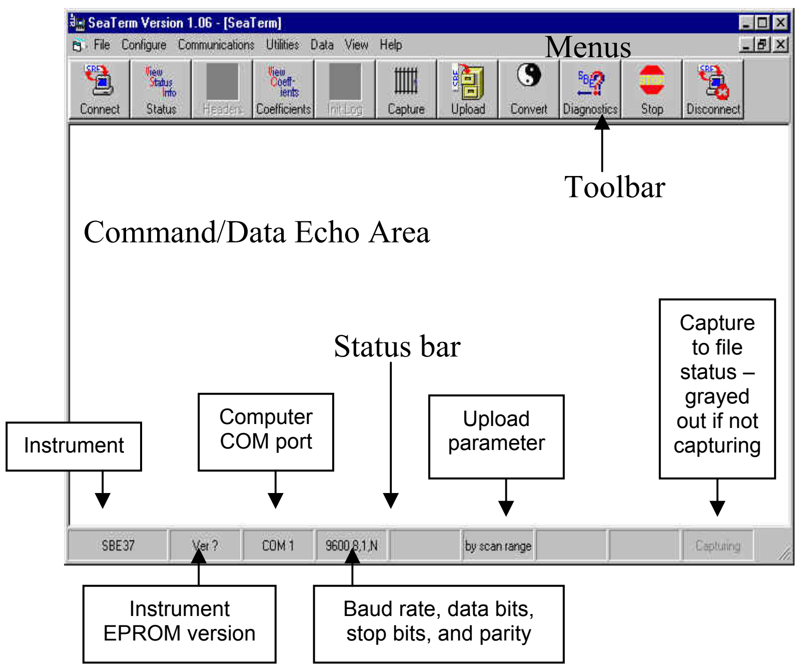
Note:
See SEATERM's Help files.

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:



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

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

Note:
Once the system is configured and connected (Steps 3 through 5 below), to update the Status bar:
- on the Toolbar, click Status; or
- from the Utilities menu, select Instrument Status.

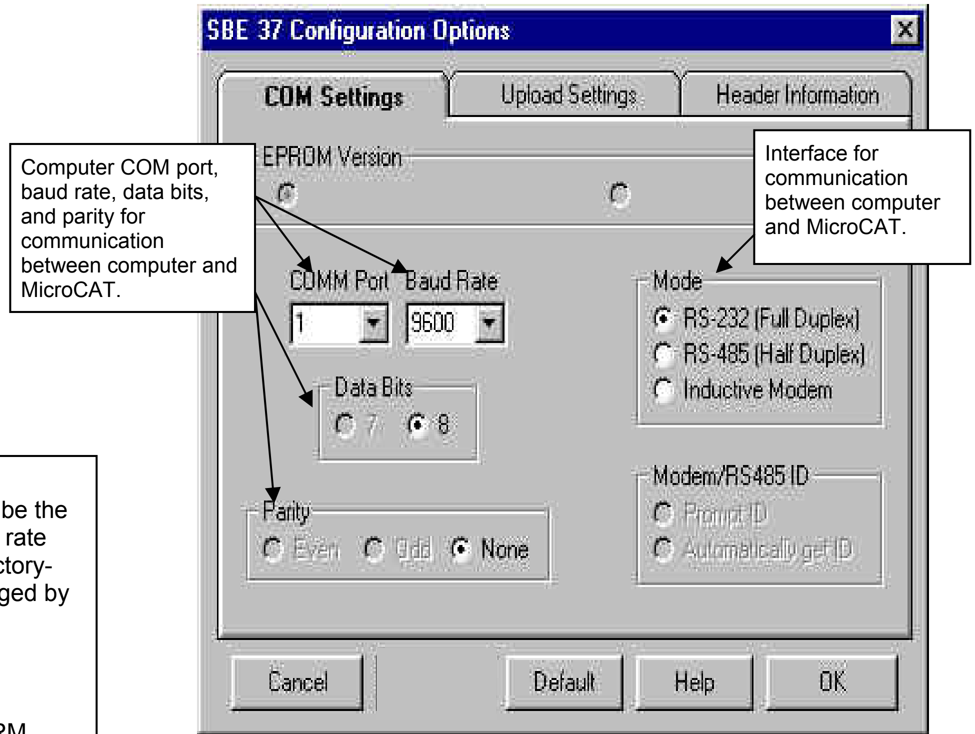
SEATERM sends the status command, which displays in the Command/Data Echo Area, and updates the Status bar.

Following are the Toolbar buttons applicable to the MicroCAT:

Toolbar Buttons	Description	Equivalent Command*
Connect	Re-establish communications 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 logging status.	**DS**
Coefficients	Display calibration coefficients.	**DC**
Capture	Capture instrument responses on screen to file. **As MicroCAT has no internal memory, you must capture before sampling begins to save data for future review and processing**. File has .cap extension. Press Capture again to turn off capture. Capture status displays in Status bar.	—
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**
Disconnect	Free computer COM port used to communicate with MicroCAT. COM port can then be used by another program. Note that MicroCAT must be connected to COM port for data to be obtained.	—

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

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



Make the selections in the Configuration Options dialog box:

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

Click OK to save the settings.

Note:

- 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. When you open SEATERM and select the desired instrument (SBE 37, 39, etc.) in the Configure menu, the Configuration Options dialog box shows the last saved settings for that instrument.

4. In the Communications menu, select *Options / Cycle baud when connecting*.

5. 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 Sheet in this manual.
- Check cabling between the computer and MicroCAT.

Note:
You may need to press the Enter key several times and send the **Stop** command to interrupt sampling, depending on how the instrument was set up the last time it was used.

Note:
The MicroCAT has a timeout algorithm that applies to some system configurations.
See *Timeout Description* in *Section 4: Deploying and Operating MicroCAT*.

6. Display MicroCAT status information by typing **DS** and pressing the Enter key. The display looks like this:

```
SBE37-SI V 2.3  SERIAL NO. 0011
logging not started
sample interval = 30 seconds
output time with each sample
do not output salinity
do not output sound velocity
do not output density with each sample
do not output depth with each sample
latitude to use for depth calculation = 0.00 deg
do not start sampling when power on
do not power off after taking a single sample
do not power off after two minutes of inactivity
A/D cycles to average = 4
internal pump not installed
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 *do not output salinity, sound velocity, density, or depth with each sample* displayed in response to the status command):

```
23.7658,0.00019, 0.062, 01 Jan 1980, 00:30:43
```

where 23.7658 = temperature in degrees Celsius
0.00019 = conductivity in S/m
0.062 = pressure in decibars
01 Jan 1980 = date (default upon power-up is 01 Jan 1980)
00:30:43 = time (default upon power-up is 00:00:00)

These numbers should be reasonable; i.e., room temperature, zero conductivity, barometric pressure (gauge pressure).

8. Command the MicroCAT to go to sleep (quiescent state) by typing **QS** and pressing the Enter key. The response indicates whether the Interface PCB's J1 jumper is in the Normal or Autopower configuration:
   - Autopower - system returns `S>` prompt.
   - Normal – system does not return `S>` prompt.

   If necessary, remove the PCB and move the jumper to the desired pins. See *Power-Up Jumper Check* for a description of the configurations and the pin settings, and *Appendix II: ElectronicsDisassembly/Reassembly* for directions on accessing the PCB.

The MicroCAT is ready for programming and deployment.

Section 4: Deploying and Operating MicroCAT

This section includes:

- system operation with example sets of operation commands
- baud rate, cable length, power, and data transmission rate limitations
- timeout description
- detailed command descriptions
- data output formats
- instructions for deploying and recovering the MicroCAT.

Sampling Modes

The MicroCAT has three basic sampling modes for obtaining data:

- Polled Sampling
- Autonomous Sampling – Interval or Continuous
- Serial Line Synchronization Sampling

Commands and the J1 jumper setting on the Interface PCB can be used in various combinations to provide a high degree of operating flexibility.

Descriptions and examples of the 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

Note:
After waking the MicroCAT, you may need to press the Enter key several times and send **Stop** to interrupt sampling, depending on how the instrument was set up the last time it was used.

On command, the MicroCAT takes one sample of data and sends the data to the computer.

Example 1*:* Polled Sampling, Interface PCB J1 jumper in Normal position (user input in bold).
Wake up MicroCAT. Set up to wait for command each time it wakes up, send date and time and salinity with data. Send power-off command. Assuming that power is always applied:

(Click Connect on Toolbar to wake up.)
S>**AUTORUN=N**
S>**OUTPUTTIME=Y**
S>**OUTPUTSAL=Y**
S>**DS** (to verify setup)
S>**QS**

When ready to take a sample (repeat as desired): wake up MicroCAT, command it to take a sample and output converted data, and send power-off command.

(Before first sample, click Capture on Toolbar to capture data to a file – program requests file name for data to be stored.)
(Click Connect on Toolbar to wake up.)
S>**TS**
S>**QS**

Example 2*:* Polled Sampling, Interface PCB J1 jumper in Autopower position (user input in bold).
Wake up MicroCAT. Set up to wait for command each time it wakes up, send date and time with salinity with data. Remove power.

(Apply power to wake up.)
S>**AUTORUN=N**
S>**OUTPUTTIME=Y**
S>**OUTPUTSAL=Y**
S>**DS** (to verify setup)
(Remove power.)

When ready to take a sample (repeat as desired): wake up MicroCAT, command it to take a sample and output converted data, and remove power.

(Before first sample, click Capture on Toolbar to capture data to a file – program requests file name for data to be stored.)
(Apply power to wake up.)
S>**TS**
(Remove power.)

Autonomous Sampling

The MicroCAT samples at pre-programmed intervals, defined by **Interval**. Autonomous Sampling includes both Interval and Continuous Sampling:

- 10 ≤ **Interval** ≤ 32767 - **Interval sampling** can range from 10 to 32767 seconds between samples. The MicroCAT samples at the programmed interval and sends data, and does not go to sleep between samples.

- **Interval** < 10 - **Continuous sampling** occurs at the fastest rate possible for the selected parameters (see *Sample Timing* in *Section 2: Description of MicroCAT*). The MicroCAT continuously samples and sends data, and does not go to sleep between samples.

Note:
After waking the MicroCAT, you may need to press the Enter key several times and send **Stop** to interrupt sampling, depending on how the instrument was set up the last time it was used.

Examples: ***Autonomous Sampling*** - both examples illustrate interval sampling; setup for continuous sampling similar.

Example 1*:* Interface PCB J1 jumper in Normal position (user input in bold)
Set up to take a sample every 20 seconds. Send date and time with data. Send power-off command. Assuming power always applied:

(Click Connect on Toolbar to wake up.)
S>**SINGLESAMPLE=N**
S>**INTERVAL=20**
S>**OUTPUTTIME=Y**
S>**AUTORUN=Y**
S>**DS** (to verify setup)
S>**QS**

When ready to begin sampling:

(Click Capture on Toolbar to capture data to a file – program requests file name for data to be stored)
(Click Connect on Toolbar to wake up – MicroCAT takes and transmits sample, and repeats sequence every 20 seconds.)

When ready to stop sampling and go to sleep:

(Press Enter key several times to get S> prompt)
S>**STOP**
S>**QS**

Example 2*:* Interface PCB J1 jumper in Autopower position (user input in bold)
Set up to take a sample every 20 seconds. Send date and time with data. Remove power.

(Apply power to wake up.)
S>**SINGLESAMPLE=N**
S>**INTERVAL=20**
S>**OUTPUTTIME=Y**
S>**AUTORUN=Y**
S>**DS** (to verify setup)
(Remove power.)

When ready to begin sampling:

(Click Capture on Toolbar to capture data to a file – program requests file name for data to be stored.)
(Apply power to wake up – MicroCAT takes and transmits sample, and repeats sequence every 20 seconds.)

When ready to stop sampling:

(Remove power.)

To change setup:

(Apply power to wake up – MicroCAT automatically begins sampling. Press Enter key several times to get S> prompt.)
S>**STOP**
S> (send desired commands)
(Remove power.)

Serial Line Synchronization (Serial Line Sync)

Note:
After waking the MicroCAT, you may need to press the Enter key several times and send **Stop** to interrupt sampling, depending on how the instrument was set up the last time it was used.

In Serial Line Sync Mode, a simple pulse (a single character) on the RS-232 line causes the MicroCAT to wake up, take and output a single sample, and automatically go to sleep (enter quiescent state). This mode provides easy integration with ADCPs or current meters, which can synchronize MicroCAT sampling with their own. This mode is enabled if **AutoRun=Y**, **SingleSample=Y**, and the Interface PCB's J1 jumper is in the Normal position.

Example: ***Serial Line Sync*** (Interface PCB J1 jumper in Normal position) (user input in bold)

Set up to take a sample upon receipt of any character and then automatically go to sleep. Send date and time with data. Send power-off command. Assuming that power is always applied:

(Click Connect on Toolbar to wake up.)
S>**SINGLESAMPLE=Y**
S>**AUTORUN=Y**
S>**OUTPUTTIME=Y**
S>**DS** (to verify setup)
S>**QS**

When ready to take a sample (repeat as desired):

(Before first sample, click Capture on Toolbar to capture data to a file – program requests file name for data to be stored.)
(Click Connect on Toolbar or press Enter key to wake up, sample, and go to sleep.)

When ready to stop sampling or change setup:

(Press Enter key several times to get S> prompt)
S>**STOP**
S> (Enter desired commands)
S>**QS**

Baud Rate, Cable Length, Power, and Data Transmission Rate

Baud Rate, Cable Length, and Data Transmission Rate

Notes:
- Baud rate is set with **Baud=**.
- Real-time output rate is set with **Interval=**.
- Output format is set with **Format=**.

See *Command Descriptions*.

The rate that data can be transmitted from the MicroCAT is dependent on the amount of data to be transmitted per scan and the serial data baud rate:

Time to transmit data = (number of characters * 10 bits/character) / baud rate

where
number of characters is dependent on the included data and output format (see *Data Output Formats*). Add 2 to the number of characters shown in the output format, to account for the carriage return and line feed at the end of each scan. For decimal output (**Format=1** or **2**), include decimal points, commas, and spaces when counting characters.

Note that the MicroCAT transmits data **after** it has completed the previous sample and **before** it starts the next sample (see *Sample Timing* in *Section 2: Description of MicroCAT*).

The length of cable that the MicroCAT can drive to transmit real-time data is also dependent on baud rate. The allowable combinations are:

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

Example – How long does it take to transmit data over 800 m for a MicroCAT with optional pressure sensor, **Format=1**, **OutputDepth=Y**, **OutputSal=Y**, **OutputSV=Y**, **OutputDensity=Y**, and **OutputTime=Y** (output depth, salinity, sound velocity, density, date and time as well as C, T, and P)?

With 800 meters of cable, the MicroCAT requires a baud rate of 1200.
Number of characters (see *Data Output Formats*) = 8(T) + 1(comma) + 8(C) + 2(comma & space) + 8(P) + 2(comma & space) + 8(depth) + 2(comma & space) + 8(salinity) + 2(comma & space) + 8(sound velocity) + 2(comma & space) + 8(density) + 2(comma & space) +11(date) + 2(comma & space) + 8(time)+ 2(carriage return & line feed) = 92
Time required to transmit data = (92 characters * 10 bits/character) / 1200 = 0.77 seconds

What is the minimum time between samples if **Ncycles=4** (default)?
From autonomous sampling equation in *Sample Timing* in *Section 2: Description of MicroCAT*:
Sampling time = (**Ncycles** * 0.1664) + 0.75 = (4 * 0.1664) + 0.75 = 1.42 seconds
So, total time between samples = sampling time + transmission time = 1.42 + 0.77 = 2.19 seconds

Power and Cable Length

There are two issues to consider:

- Limiting the communication IR loss to 1 volt; 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.

Each issue is discussed below.

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

Limiting Communication IR Loss to 1 Volt

The limit to cable length is typically reached when the maximum ***communication*** 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.

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

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

where I =communication current required by MicroCAT (35 milliamps; see *Specifications* in *Section 2: Description of MicroCAT*).

Example 1 – For 20 gauge wire, what is maximum distance to transmit power to MicroCAT when considering communication IR loss?
For 35 milliamp communications current, $R_{limit} = V_{limit} / I$ = 1 volt / 0.035 Amps = 28.5 ohms
For 20 gauge wire, resistance is 0.0107 ohms/foot.
Maximum cable length = 28.5 ohms / 0.0107 ohms/foot = 2670 feet = 814 meters

Example 2 – Same as above, but there are 4 MicroCATs powered from the same power supply.
For 35 milliamp communications current, $R_{limit} = V_{limit} / I$ = 1 volt / (0.035 Amps * 4 MicroCATs) = 7.1 ohms
For 20 gauge wire, resistance is 0.0107 ohms/foot.
Maximum cable length = 7.1 ohms / 0.0107 ohms/foot = 667 feet = 203 meters (to MicroCAT *furthest* from 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 (***from the 0.5 Amp turn-on transient, two-way resistance***), to power the MicroCAT. Provide at least 7 volts, after IR loss.

$V - IR \geq 7$ volts

where I = MicroCAT turn-on transient (0.5 Amps; see *Specifications*).

Example 1 – For 20 gauge wire, what is maximum distance to transmit power to MicroCAT if using 12 volt power source?
V - IR ≥ 7 volts   12 volts - (0.50 Amps) * (0.0107 ohms/foot * 2 * cable length) ≥ 7 volts
5 volts ≥ (0.50 Amps) * (0.0107 ohms/foot * 2 * cable length)   Cable length ≤ 467 ft = 142 meters
Note that 284 meters < 814 meters (maximum distance when considering communication IR loss), so IR drop in power is controlling factor for this example. Using a higher voltage power supply or a different wire gauge would increase allowable cable length.

Example 2 – Same as above, but there are 4 MicroCATs powered from same power supply.
V - IR ≥ 7 volts   12 volts - (0.50 Amps * 4 MicroCATs) * (0.0107 ohms/foot * 2 * cable length) ≥ 7 volts
5 volts ≥ (0.50 Amps * 4 MicroCATs) *(0.0107 ohms/foot * 2 * cable length)
Cable length ≤ 116 ft = 35 meters (to MicroCAT *furthest* from power source)

Timeout Description

The MicroCAT has a timeout algorithm when jumpered in the Normal configuration (Interface PCB J1 pins 1 and 2). If the MicroCAT does not receive a command or sample data for two minutes and **AutoOff=Y**, it powers down its communication circuits. This places the MicroCAT in quiescent (sleep) state, drawing minimal current. **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 twice to get the `S>` prompt.
- If in quiescent (sleep) 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 external voltage is below 6.15 volts, the following displays in response to the status command: `WARNING: LOW BATTERY VOLTAGE!!`

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 (only if set by user) [**MMDDYY=** or **DDMMYY=**, and **HHMMSS=**]
- logging status
- sample interval time [**Interval=**]
- output time with each sample? [**OutputTime=**]
- output salinity with each sample? [**OutputSal=**]
- output sound velocity with each sample? [**OutputSV=**]
- output local density with each sample? [**OutputDensity=**]
- output depth with each sample? [**OutputDepth=**]
- latitude for depth calculation [**Latitude=**]
- start sampling when power turned on? [**AutoRun=**]
- go to sleep after taking a single sample? [**SingleSample=**]
- go to sleep after two minutes of inactivity? [**AutoOff=**]
- A/D cycles to average per sample [**Ncycles=**]
- reference pressure [**RefPress=**]; only displays if no pressure sensor installed
- whether internal pump is installed (never installed in 37-SI) [**PumpInstalled=N**]
- current temperature

> **Note:**
> The 37-SI and 37-SIP use the same firmware. The internal pump is applicable to the 37-SIP only.

Logging status can be:

- logging not started
- logging data
- not logging:received stop command
- unknown status

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

```
S>DS
SBE37-SI V 2.3  SERIAL NO. 0011                          [MMDDYY=, HHMMSS=]
logging not started
sample interval = 30 seconds                             [Interval=]
output time with each sample                             [OutputTime=]
do not output salinity with each sample                  [OutputSal=]
do not output sound velocity with each sample            [OutputSV=]
do not output density with each sample                   [OutputDensity=]
do not output depth with each sample                     [OutputDepth=]
latitude to use for depth calculation = 0.00 deg         [Latitude=]
do not start sampling when power on                      [AutoRun=]
do not power off after taking a single sample            [SingleSample=]
do not power off after two minutes of inactivity         [AutoOff=]
A/D cycles to average = 4                                [Ncycles=]
reference pressure = 0.0 db                              [RefPress=]
internal pump not installed                              [PumpInstalled=N; only valid setting for 37-SI]
temperature = 7.54 deg C
```

Notes:
- **DDMMYY=** and **MMDDYY=** are equivalent. Either can be used to set the date.
- Date is reset to 01 Jan 1980 when power is first applied. If you wish to use the built-in real-time clock, set the date and then time.
- **Always set date and then time.** If a new date is entered but not a new time, the new date will not be saved. If a new time is entered without first entering a new date, the date will reset to the last date it was set for with **MMDDYY=** or **DDMMYY=**.

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

Setup Commands

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

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

HHMMSS=hhmmss Set real-time clock hour, minute, second.

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

```
S>MMDDYY=071004
S>HHMMSS=120000
```

or

```
S>DDMMYY=100704
S>HHMMSS=120000
```

Baud=x **x=** baud rate (1200, 2400, 4800, 9600, 19200, or 38400). Default 9600. Length of cable that MicroCAT can drive is dependent on baud. Allowable combinations:

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

OutputTime=x **x=Y**: output date and time.
x=N: do not.

OutputSal=x **x=Y**: calculate and output salinity (psu).
x=N: do not.

OutputSV=x **x=Y**: calculate and output sound velocity (m/sec), using Chen and Millero formula (UNESCO Technical Papers in Marine Science #44).
x=N: do not.

OutputDepth=x **x=Y**: calculate and output depth (meters), using **Latitude** in calculation
x=N: do not.

OutputDensity=x **x=Y**: calculate and output local density sigma (kg/m^3), based on salinity, temperature, and pressure.
Sigma (s, t, p) = density - 1000 kg/m^3
x=N: do not.

Latitude=x **x=** latitude (degrees) to use in depth calculation. Applicable only if **OutputDepth=Y**.

RefPress=x **x** = reference pressure (gauge) in decibars. MicroCAT without installed pressure sensor uses this reference pressure in conductivity, salinity, sound velocity, depth, and density calculations. Entry ignored if MicroCAT includes pressure sensor.

Setup Commands (*continued*)

Notes:
- See *Data Output Formats* below.
- Output descriptions:
  - t = temperature (°C, ITS-90)
  - c = conductivity (S/m)
  - p = pressure (db); sent only if optional pressure sensor is installed
  - d = depth (m), sent only if **OutputDepth=Y**
  - s = salinity (psu), sent only if **OutputSal=Y**
  - v = sound velocity (m/sec), sent only if **OutputSV=Y**
  - r = density sigma (kg/m^3), sent only if **OutputDensity=Y**
  - dd mmm yyyy = day, month, year; sent only if **OutputTime=Y**
  - mm-dd-yyyy = month, day, year; sent only if **OutputTime=Y**
  - hh:mm:ss = hour, minute, second; sent only if **OutputTime=Y**

Format=x

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

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

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

Notes:
- Binary data does not include date and time, salinity, sound velocity, depth, or density, regardless of the settings for **OutputTime**, **OutputSal**, **OutputSV**, **OutputDepth**, or **OutputDensity**.
- Binary data does not output on the screen. Use Capture on the Toolbar to capture the data to a file before beginning sampling, and then process the data with a utility.

OutputBinary=x

x=Y: output converted data in binary form
ttttccccpppph
where:
tttt = temperature *100000
cccc = conductivity *100000
pppp = pressure *100000 (sent only if optional pressure sensor is installed)
h=1 byte checksum, sum of all bytes including checksum modulo 256 is 0.
Note that tttt, cccc, and pppp are each a 4 byte long integer stored *little endian*.

x=N: do not.

Ncycles=x

x= number of A/D cycles to average (range 1 - 127; default 4). For each measurement, thermistor and (optional) pressure sensor sample **Ncycles** times in rapid succession, and average values are recorded; during this time conductivity measurement is also integrated and average is recorded. Increasing **Ncycles** increases measurement resolution and time (and power) required for measurement. Sea-Bird recommends keeping **Ncycles** at default of 4, providing optimum trade-off between low RMS noise and power requirements. See *Specifications* and *Sample Timing* in *Section 2: Description of MicroCAT*.

Note:
The 37-SI and 37-SIP use the same firmware. The internal pump is applicable to the 37-SIP only.

PumpInstalled=x

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

x=Y: Not applicable to 37-SI.

QS

Quit session and place MicroCAT in quiescent (sleep) state. Sampling stops.
Applicable only if Interface PCB J1 jumper is in Normal position.

Operating Commands

> **Note:**
> If the MicroCAT is sampling data and the voltage is less than 6.15 volts for ten consecutive scans, the MicroCAT halts logging and displays `WARNING: LOW BATTERY VOLTAGE` in response to the status (**DS**) command.

Operating commands configure the MicroCAT's response upon waking up, and direct the MicroCAT to sample data once or at pre-programmed intervals.

Interval=x — **x=** interval (seconds) between samples (maximum 32767 seconds).
x $\geq$ 10 - MicroCAT samples at specified interval.
x < 10 - MicroCAT samples continuously (actual interval between samples is determined by **Ncycles**; see *Sample Timing* in *Section 2: Description of MicroCAT*).

AutoOff=x — **(Functional only if J1 jumper on Interface PCB in Normal position)**
x=Y: Go to sleep (enter quiescent state) if 2 minutes have elapsed without receiving a command or without sampling data.

x= N: Do not automatically go to sleep.

AutoRun=x — **x=Y** or **N** –Interacts with **SingleSample** and J1 jumper; see table below.

SingleSample=x — **x=Y** or **N**: Interacts with **AutoRun** and J1 jumper; see table below.

Go — Start sampling, as defined by **SingleSample** and **Interval**. Only applicable if:
- **AutoRun=N**, or
- **AutoRun=Y** and you previously sent **Stop** to stop sampling.

> **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**.

Stop — Stop sampling. Press Enter key to get `S>` prompt before entering **Stop**.

Interface PCB J1 Jumper	AutoRun	SingleSample	Effect
Normal	**N**	**Y** or **N**	Wake up (when Connect on Toolbar clicked or Enter key pressed while asleep) and wait for command.
	Y	**N**	Wake up (when Connect on Toolbar clicked or Enter key pressed while asleep) and sample at rate specified by **Interval**. MicroCAT does not go to sleep between samples. To stop sampling and get `S>` prompt, type **Stop** and press Enter key.
	Y	**Y**	Wake up (when Connect on Toolbar clicked or Enter key pressed while asleep), take and output a single sample, and automatically go to sleep. To wake up and get `S>` prompt, type **Stop** and press Enter key. Referred to as **Serial Line Sync Mode**.
Autopower	**N**	**Y** or **N**	Wake up (when power applied) and wait for command.
	Y	**N**	Wake up (when power applied) and sample at rate specified by **Interval** until power removed. MicroCAT does not go to sleep between samples.
	Y	**Y**	This is not a valid combination of settings.

Polled Sampling Commands

These commands are used by an external controller to request a sample from the MicroCAT. The MicroCAT stores data for the most recent sample in its RAM. The MicroCAT does not automatically go to sleep after executing these commands. Do not send these commands if MicroCAT is sampling data at pre-programmed intervals (defined by **Interval** and **SingleSample**).

TS	Take sample, hold converted data in RAM, output converted data.
TSR	Take sample, hold raw data in RAM, output raw data.
SLT	Send last sample from RAM, output converted data, then take new sample and hold converted data in RAM.
TH	Take sample, hold converted data in RAM.
SH	Send held converted data from RAM.
SB	Send held converted data from RAM in binary form. Only applicable if **OutputBinary=Y**.

Testing Commands

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, which does not have a pressure sensor (user input in bold).

```
S>DC
SBE37-SI V 2.3 0011
temperature:      08-apr-00
TA0 = -9.420702e-05
TA1 =  2.937924e-04
TA2 = -3.739471e-06
TA3 =  1.909551e-07
conductivity:     09-apr-00
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-00
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
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 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); sent only if optional pressure sensor installed
d = depth (meters), sent only if **OutputDepth=Y**
s = salinity (psu), sent only if **OutputSal=Y**
v = sound velocity (meters/second), sent only if **OutputSV=Y**
r = density sigma (kg/m^3), sent only if **OutputDensity=Y**
dd mmm yyyy = day, month (Jan, Feb, Mar, etc.), year, sent only if **OutputTime=Y**
mm-dd-yyyy = month, day, year, data only if **OutputTime=Y**
hh:mm:ss = hour, minute, second, sent only if **OutputTime=Y**

- There is a comma but no space between temperature and conductivity. All other data is separated with a comma and 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.ccccc, pppp.ppp, dddd.ddd, sss.ssss, vvvv.vvv, rrr.rrrr, 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.ccccc, pppp.ppp, dddd.ddd, sss.ssss, vvvv.vvv, rrr.rrrr, 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, **OutputDepth=N, OutputSal=N**, **OutputSV=N**, **OutputDensity=N, OutputTime=Y**, and **Format=1**:

```
23.7658,0.00019, 0.062, 26 May 2004, 16:30:43
```

(temperature,conductivity, pressure, date, time)

Setup for Deployment

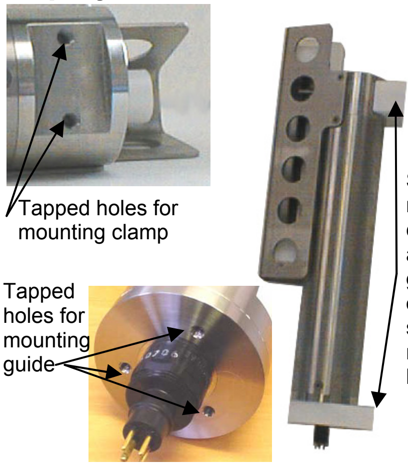
Notes:

- Date is reset to 01 Jan 1980 when power is applied. If you wish to use the built-in real-time clock, set the date and time.
- **Always set date and then time.** If a new date is entered but not a new time, the new date will not be saved. If a new time is entered without first entering a new date, the date will reset to the last date it was set for with **MMDDYY=** or **DDMMYY=**.

Program the MicroCAT for the intended deployment (see *Section 3: Preparing MicroCAT for Deployment* for connection information; see information above on commands and sampling modes):

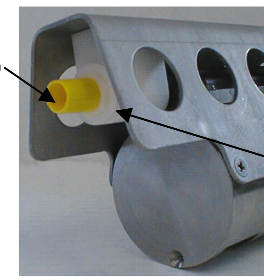
1. Set the date and then time.
2. Establish the setup parameters.
3. Establish the operating command parameters. These parameters configure the MicroCAT's response upon waking up, and direct the MicroCAT to sample data once or at pre-programmed intervals.

Deployment



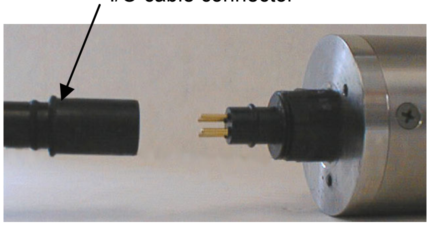
The MicroCAT can be mounted with customer-supplied hardware or can be ordered with pre-installed Sea-Bird mounting brackets.

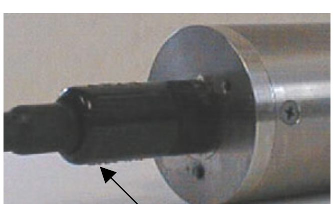
1. Install customer-supplied mounting equipment (if Sea-Bird mounting clamp and guide or brackets are not pre-installed):
   A. Install a mounting bracket that attaches to the tapped holes in the MicroCAT sensor end cap. Use titanium hardware to attach the mounting bracket to the MicroCAT, and place non-metallic material between the titanium housing and any dissimilar metal in the bracket. **Do not drill any holes in the MicroCAT**.
   B. Ensure the mounting scheme does not transfer mooring through-tension to the sensor end cap, which could pull off the end cap.



2. 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*).

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





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

4. Attach the mounting equipment to the mooring cable or support.

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

6. Connect the MicroCAT to the computer and power supply.
   (See *Power and Communications Test* in *Section 3: Preparing MicroCAT for Deployment.*)

7. Click Capture on SEATERM's Toolbar before you begin sampling. The data displayed in SEATERM will be saved to the designated .cap file. Process the data as desired. Note that the .cap file **cannot be processed by Sea-Bird software, as it does not have the required headers and format.**

Recovery

WARNING!
If the MicroCAT stops working while underwater, is unresponsive to commands, or shows other signs of flooding or damage, carefully secure it away from people until you have determined that abnormal internal pressure does not exist or has been relieved. Pressure housings may flood under pressure due to dirty or damaged o-rings, or other failed seals. When a sealed pressure housing floods at great depths and is subsequently raised to the surface, water may be trapped at the pressure at which it entered the housing, presenting a danger if the housing is opened before relieving the internal pressure. Instances of such flooding are rare. However, a housing that floods at 5000 meters depth holds an internal pressure of more than 7000 psia, and has the potential to eject the end cap with lethal force.
A housing that floods at 50 meters holds an internal pressure of more then 85 psia; this force could still cause injury.
If you suspect the MicroCAT is flooded, point it in a safe direction away from people, and loosen the bulkhead connector very slowly, at least 1 turn. This opens an o-ring seal under the connector. Look for signs of internal pressure (hissing or water leak). If internal pressure is detected, let it bleed off slowly past the connector o-ring. Then, you can safely remove the end cap.

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.

Section 5: Routine Maintenance and Calibration

This section reviews corrosion precautions, connector mating and maintenance, conductivity cell storage and cleaning, pressure sensor maintenance, plastic housing handling instructions, 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

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

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:

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.

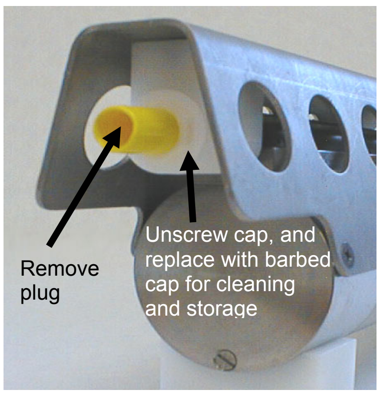
3. Place the locking sleeve over the plug/cable connector. Tighten the locking sleeve finger tight only. **Do not overtighten the locking sleeve and do not use a wrench or pliers.**

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

Conductivity Cell Maintenance

CAUTIONS:

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



The MicroCAT's conductivity cell is shipped dry to prevent freezing in shipping. **Refer to *Application Note 2D: Instructions for Care and Cleaning of Conductivity Cells* for conductivity cell cleaning procedures and cleaning materials.**

- The Active Use (after each cast) section of the application note is not applicable to the MicroCAT, which is intended for use as a moored instrument.

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

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

Pressure Sensor (optional) Maintenance

Pressure sensor port plug

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

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

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

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

Handling Instructions for Plastic *ShallowCAT* Option

The MicroCAT's standard 7000-meter titanium housing offers the best durability with a modest amount of care. The *ShallowCAT* option, substitution of a 250-meter plastic housing, saves money and weight. However, more care and caution in handling is required. To get the same excellent performance and longevity for the plastic-housing version, and if you need to access the electronics and/or remove the screws securing the conductivity cell guard to the housing (not typically done by the customer), observe the following precautions:

- The MicroCAT's end caps are retained by screws through the side of the housing. The screw holes are close to the end of the housing. Particularly in a cold environment, where plastic is more brittle, the potential for developing a crack around the screw hole(s) is greater for the plastic housing than for the titanium housing.
  Observe the following precautions –

  - When removing end caps (to access the electronics), be careful to avoid any impact in this area of the housing.
  - When reinstalling end caps, do not use excess torque on the screws. Sea-Bird recommends tightening the screws to 15 inch-lbs. Alternatively, tighten the screws finger-tight, and then turn each screw an additional 45 degrees.

- A plastic housing is more susceptible to scratches than a titanium housing. Do not use screwdrivers or other metal tools to pry off the end caps.

  - Of primary concern are scratches on O-ring mating and sealing surfaces. Take extra precaution to avoid a scraping contact with these surfaces when re-seating the end cap.
  - Also take care to keep the O-ring lubricated surfaces clean – avoid trapping any sand or fine grit that can scratch the critical sealing surfaces. If the O-ring lubricant does accumulate any material or grit that can cause a leak or make a scratch, it must be carefully cleaned and replaced with fresh, clean lubricant (Parker Super O Lube).
  - Shallow, external scratches are cosmetic only, and will not affect the performance of the MicroCAT. However, deep external scratches can become points of weakness for deep deployments or fracture from impact during very cold weather.

See *Appendix II: Electronics Disassembly / Reassembly* for detailed step-by-step procedures for removing the MicroCAT's end caps.

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

AF24173
Anti-Foulant
Device

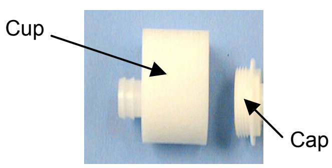
The MicroCAT has an anti-foulant device cup and cap on each end of the cell. New MicroCATs are shipped with an Anti-Foulant Device and a protective plug pre-installed in each cup.

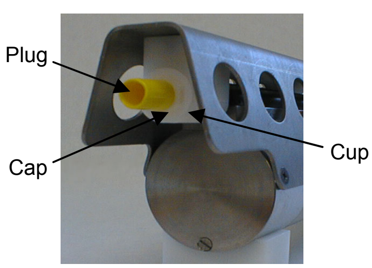
> ***WARNING!***
>
> **AF24173 Anti-Foulant Devices contain bis(tributyltin) oxide. Handle the devices only with rubber or latex gloves. Wear eye protection. Wash with soap and water after handling.**
>
> **Read precautionary information on product label (see Appendix IV) before proceeding.**
>
> **It 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

Note:
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 sensors be calibrated before and after deployment, but particularly when the cell has been exposed to contamination by oil slicks or biological material.

Temperature Sensor Calibration

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

Pressure Sensor (optional) Calibration

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

Pressure sensors show most of their error as a linear offset from zero. A technique is provided below for making small corrections to the pressure sensor calibration using the *offset* (**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.

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

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 (positive or negative) in the MicroCAT's EEPROM, using **POffset=** in SEATERM.

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

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

Section 6: Troubleshooting

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

Problem 1: Unable to Communicate with MicroCAT

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

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

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

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

Problem 2: Unreasonable T, C, or P Data

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

Cause/Solution 1: Data with unreasonable (i.e., out of the expected range) values for temperature, conductivity, or pressure may be caused by incorrect calibration coefficients in the MicroCAT. Send **DC** to verify the calibration coefficients in the MicroCAT match the instrument Calibration Certificates.

Problem 3: Salinity Spikes

Salinity is a function of conductivity, temperature, and pressure, and must be calculated from C, T, and P measurements made on the same parcel of water. Salinity is calculated and output by the 37-SI if **OutputSal=Y**.

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

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

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

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

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

Glossary

Fouling – Biological growth in the conductivity cell during deployment.

MicroCAT – High-accuracy conductivity, temperature, and optional pressure Recorder/Monitor. 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, -SI, and -SIP are available with RS-232 (standard) or RS-485 (optional) interface.

PCB – Printed Circuit Board.

Scan – One data sample containing temperature, conductivity, optional pressure, and optional date and time, as well as derived variables (depth, salinity, sound velocity, and density).

SEASOFT-Win32 – Sea-Bird's complete Win 2000/XP software package, which includes software for communication, real-time data acquisition, and data analysis and display. SEASOFT-Win32 includes ***SEATERM***.

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

Super O-Lube – Silicone lubricant used to lubricate O-rings and O-ring mating surfaces. Super O-Lube can be ordered from Sea-Bird, but should also be available locally from distributors. Super O-Lube is manufactured by Parker Hannifin; see http://www.parker.com/ead/cm2.asp?cmid=3956 for details.

TCXO – Temperature Compensated Crystal Oscillator.

Triton X100 – Reagent grade non-ionic surfactant (detergent), used for cleaning the conductivity cell. Triton can be ordered from Sea-Bird, but should also be available locally from chemical supply or laboratory products companies. Triton is manufactured by Mallinckrodt Baker (see http://www.mallbaker.com/changecountry.asp?back=/Default.asp for local distributors).

Appendix I: Functional Description

Sensors

The MicroCAT embodies the same sensor elements (3-electrode, 2-terminal, borosilicate glass cell, and pressure-protected thermistor) previously 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, 600, 1000, 2000, 3500, and 7000 meters.

Sensor Interface

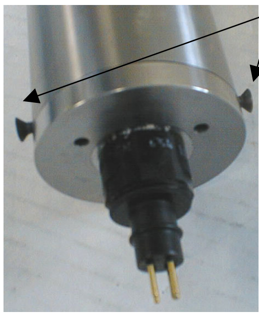
Temperature is acquired by applying an AC excitation to a hermetically sealed VISHAY reference resistor and an ultra-stable aged thermistor with a drift rate of less than 0.002°C per year. A 24-bit A/D converter digitizes the outputs of the reference resistor and thermistor (and optional pressure sensor).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

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

Appendix II: Electronics Disassembly/Reassembly

Disassembly

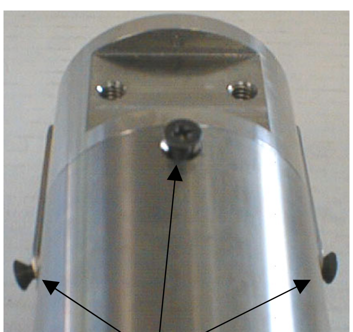
> **CAUTION:**
> See *Section 5: Routine Maintenance and Calibration* for handling instructions for the plastic *ShallowCAT* housing.



Screws securing connector end cap (screws shown partially removed)

1. Remove the I/O connector end cap and disconnect the electronics from the end cap:
   A. Wipe the outside of the I/O connector 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 connector end cap by pulling on it firmly and steadily. It may be necessary to rock or twist 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 4-pin Molex connector. Holding the wire cluster near the connector, pull gently to detach the female end of the connector from the pins.
   E. Remove any water from the O-ring mating surfaces inside the housing with a lint-free cloth or tissue.
   F. Put the end cap aside, being careful to protect the O-rings from damage or contamination.

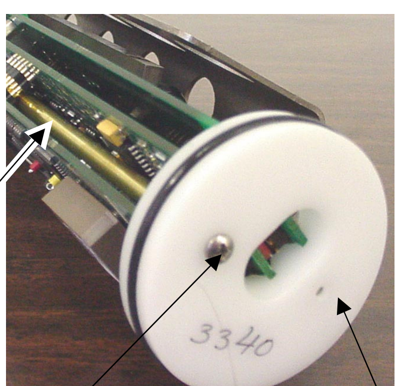
Molex connector



Screws securing sensor end cap (shown partially removed)

2. Remove the housing from the electronics:
   A. Wipe the outside of the sensor 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 connecting the guard to the housing and sensor end cap. Do not remove any other screws from the guard.
   C. Remove the flat Phillips-head titanium machine screw connecting the housing to the sensor end cap.
   D. Remove the housing by pulling it out firmly and steadily. It may be necessary to twist or rock the housing back and forth to loosen it.

3. The electronics are on a sandwich of three rectangular PCBs. These PCBs are assembled to a bulkhead. To remove the PCB assembly:
   A. Remove the Phillips-head screw on the bulkhead that fits inside the small diameter brass sleeve. The Phillips-head screw is a 198 mm (7.8 inch) threaded rod with Phillips-head.
   B. Pull out the PCB assembly by carefully grasping the bulkhead and pulling. The assembly will pull away from the 10-position edge connector used to connect to the cells.

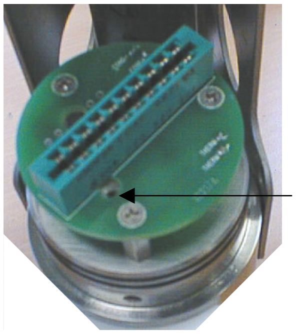


Brass sleeve

Screw securing electronics

Bulkhead

Reassembly



Align brass sleeve with hole

1. Reinstall the electronics:
   A. Align the brass sleeve with the hole for the Phillips-head screw, and push the PCB assembly into the 10-position edge connector.
   B. Drop the Phillips-head screw into the hole and tighten gently.

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

2. Reinstall the housing on the sensor end cap:
   A. Remove any water from the sensor end cap's 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. Carefully fit the housing onto the sensor end cap until the O-rings have fully seated.
   C. Reinstall the three flat Phillips-head screws that connect the housing to the sensor end cap and the guard.

3. Reinstall the I/O connector end cap on the housing:
   A. Remove any water from the I/O connector end cap's 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. Carefully fit the end cap into the housing until the O-rings have fully seated.
   C. Reinstall the two flat Phillips-head screws that connect the end cap to the housing.

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.

Appendix III: Command Summary

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

CATEGORY	COMMAND	DESCRIPTION
Status	**DS**	Display status.
Setup	**MMDDYY=mmddyy**	Set real-time clock month, day, year. Follow with **HHMMSS=** or it will not set date.
	DDMMYY=ddmmyy	Set real-time clock day, month, year. Follow with **HHMMSS=** or it will not set date.
	HHMMSS=hhmmss	Set real-time clock hour, minute, second.
	Baud=x	**x=** baud rate (1200, 2400, 4800, 9600, 19200, or 38400). Default 9600.
	OutputTime=x	**x=Y**: output date and time. **x=N**: do not.
	OutputSal=x	**x=Y**: calculate and output salinity (psu). **x=N**: do not.
	OutputSV=x	**x=Y**: calculate and output sound velocity (m/sec). **x=N**: do not.
	OutputDepth=x	**x=Y**: calculate and output depth (meters). **x=N**: do not.
	OutputDensity=x	**x=Y**: calculate and output local density sigma (kg/m^3). **x=N**: do not.
	Latitude=x	**x** = latitude (degrees) to use in depth calculation.
	RefPress=x	**x** = reference pressure (gauge) in decibars. (used for conductivity, salinity, and sound velocity computation when MicroCAT does not have pressure sensor).
	Format=x	**x=0**: output raw hex data, for diagnostic use at Sea-Bird. **x=1**: output converted data, date dd mmm yyyy. **x=2**: output converted data, date mm-dd-yyyy.
	OutputBinary=x	**x=Y**: output data in binary form. **x=N**: do not.
	Ncycles=x	**x** = number of A/D cycles to average (range 1 - 127; default 4).
	PumpInstalled=x	**x=N**: Internal pump is **not** installed **(only valid setting for 37-SI)**.
	QS	Quit session and place MicroCAT in quiescent (sleep) state. Sampling stops. Applicable only if Interface PCB J1 jumper in Normal position.

CATEGORY	COMMAND	DESCRIPTION
Operating Interface PCB's J1 jumper interacts with these commands: • Normal – pins 1 and 2 • Autopower – pins 2 and 3	**Interval=x**	**x=** interval (seconds) between samples (10 - 32767). If **x** < 10 seconds, sample continuously.
	AutoOff=x	**(Functional only if J1 jumper in Normal position)** **x=Y**: Go to sleep (enter quiescent state) if 2 minutes have elapsed without receiving a command or without sampling data. **x=N**: Do not automatically go to sleep.
	J1 jumper - Normal **AutoRun=N** **SingleSample=** **Y** or **N**	Wake up when Connect on Toolbar clicked or Enter key pressed while asleep, wait for a command.
	J1 jumper - Normal **AutoRun=Y** **SingleSample=N**	Wake up when Connect on Toolbar clicked or Enter key pressed while asleep, sample at rate specified by **Interval**. To stop sampling and get S> prompt, type **Stop** and press Enter key.
	J1 jumper - Normal **AutoRun=Y** **SingleSample=Y**	Wake up when Connect on Toolbar clicked or Enter key pressed while asleep, take and output a single sample and automatically go to sleep. To wake up and get S> prompt, type **Stop** and press Enter key.
	J1 jumper - Autopower **AutoRun=N** **SingleSample=** **Y** or **N**	Wake up when power applied, wait for a command.
	J1 jumper - Autopower **AutoRun=Y** **SingleSample=N**	Wake up when power applied, sample at rate specified by **Interval** until power removed.
	Go	Start sampling, as defined by **SingleSample** and **Interval**.
	Stop	Stop sampling.
Polled Sampling Do not send these commands if MicroCAT is sampling data at pre-programmed intervals.	**TS**	Take sample, hold converted data in RAM, output converted data.
	TSR	Take sample, hold raw data in RAM, output raw data.
	SLT	Send converted data from last sample in RAM, then take new sample and hold converted data in RAM.
	TH	Take sample, hold converted data in RAM.
	SH	Send held converted data from RAM.
	SB	Send held converted data from RAM in binary form. Only applicable if **OutputBinary=Y**.
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.

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 MicroCATs.	**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 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.

Appendix IV: AF24173 Anti-Foulant Device

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

AF24173 ANTI-FOULANT DEVICE

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

ACTIVE INGREDIENT:

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

DANGER

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

Net Contents: Two anti-foulant devices

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

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

AF24173 Anti-Foulant Device

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

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

DANGER
See Precautionary Statements for additional information.

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

Net Contents: Two anti-foulant devices

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

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

PRECAUTIONARY STATEMENTS

HAZARD TO HUMANS AND DOMESTIC ANIMALS

DANGER

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

PERSONAL PROTECTIVE EQUIPMENT

USER SAFETY RECOMMENDATIONS

Users should:

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

ENVIRONMENTAL HAZARDS

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

PHYSICAL OR CHEMICAL HAZARDS

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

DIRECTIONS FOR USE

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

STORAGE AND DISPOSAL

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

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

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

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

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

Appendix V: Replacement Parts

Part Number	Part	Application Description	Quantity in MicroCAT
801542	AF24173 Anti-Foulant Device	Bis(tributyltin) oxide device inserted into anti-foulant device cup	1 (set of 2)
231459	Anti-foulant device cup	Holds AF24173 Anti-Foulant Device	2
231505	Anti-foulant device cap	Secures AF24173 Anti-Foulant Device in cup	2
30984	Plug	Seals end of anti-foulant cap when not deployed, keeping dust and aerosols out of conductivity cell during storage	2
30411	Triton X-100	Octyl Phenol Ethoxylate – Reagent grade non-ionic cleaning solution for conductivity cell (supplied in 100% strength; dilute as directed)	-
50087.1	Conductivity cell filling & storage device with hose barb caps	For cleaning and storing conductivity cell	-
30507	Parker 2-206N674-70 O-ring	O-ring between end of conductivity cell and anti-foulant device cup	2
60034	37-SI / -SIP spare hardware/ O-ring kit	Assorted hardware and O-rings, including: • 30859 Machine screw, 8-32 x 3/8" FH, PH, titanium (secures housing to I/O connector end cap, housing to sensor end cap, and guard to sensor end cap) • 30857 Parker 2-033E515-80 O-ring (I/O connector end cap and sensor end cap O-ring) • 30544 Machine screw, 8-32 x 1/2" FH, PH, titanium (secures guard to sensor end cap through holes that also secure housing to end cap) • 30860 Machine screw, 6-32 x ½ FH TI (secures cable clamp half to flat area of sensor end cap) • 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 1 FH, TI (secures cable guide base to I/O connector end cap)	-

Continued on next page

Continued from previous page

Part Number	Part	Application Description	Quantity in MicroCAT
801385	4-pin RMG-4FS (standard connector) to 9-pin DB-9S I/O cable with power leads, 2.4 m (8 ft)	From MicroCAT to computer	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)	From MicroCAT to computer	1
171888	25-pin DB-25S to 9-pin DB-9P cable adapter	For use with computer with DB-25 connector	1
17046.1	4-pin RMG-4FS (standard connector) dummy plug with locking sleeve	For when I/O cable not used	1
171398.1	4-pin MCDC-4F (wet-pluggable connector) dummy plug with locking sleeve	For when I/O cable not used	1
17043	Locking sleeve for RMG cable	Locks I/O cable or dummy plug in place	1
171192	Locking sleeve for MCIL cable	Locks I/O cable or dummy plug in place	1

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

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

Sampling Modes

- **Autonomous sampling** – There are two types of Autonomous sampling.
  Interval sampling: At pre-programmed intervals, the MicroCAT samples and transmits data.
  Continuous sampling: The MicroCAT continuously samples and transmits data.
- **Polled sampling –** On command, the MicroCAT takes 1 sample and transmits data. Polled sampling is useful for integrating MicroCAT with satellite, radio, or wire telemetry equipment.
- **Serial Line Sync** - A pulse on the serial line causes a MicroCAT to wake up, sample, transmit data, and enter quiescent (sleep) state automatically. This mode provides easy integration with Acoustic Doppler Current Profilers (ADCPs) or current meters which can synchronize MicroCAT sampling with their own, 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:
   - Comm 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. Wiring to MicroCAT:
   A. Install I/O cable connector. For standard connector, align raised bump on side of connector with large pin on MicroCAT.
   B. Install locking sleeve.
   C. Connect I/O cable connector to computer serial port.
   D. Connect I/O cable connector's red and black wires to power supply (7-24 VDC).
2. Verify Power-Up Jumper J1 on Interface PCB (labeled 10200) inside MicroCAT's housing is correctly set (see manual for procedure for removing PCB from housing to access) by observing response to **QS**:
   - Normal (default) – pins 1 and 2: system does not return S> after **QS** is sent, indicating MicroCAT is asleep.
   - Autopower – pins 2 and 3: system returns S> after **QS** is sent, indicating MicroCAT is not asleep.
3. Set time and date.
4. Establish setup and operating parameters.

Interface PCB J1 Jumper	AUTORUN	SINGLESAMPLE	Effect
Normal	**N**	**Y** or **N**	Wake up (when Connect on Toolbar clicked or Enter key pressed) and wait for command.
	Y	**N**	Wake up (when Connect on Toolbar clicked or Enter key pressed) and sample at rate specified by **INTERVAL**. To stop sampling and get S> prompt, type **STOP** and press Enter key.
	Y	**Y**	Wake up (when Connect on Toolbar clicked or Enter key pressed), take and output a single sample, and automatically go to sleep. To wake up and get S> prompt, type **STOP** and press Enter key. Referred to as **Serial Line Sync Mode**.
Autopower	**N**	**Y** or **N**	Wake up (when power applied) and wait for command.
	Y	**N**	Wake up (when power applied) and sample at rate specified by **INTERVAL** until power removed.
	Y	**Y**	This is not a valid combination of settings.

5. Deploy MicroCAT, using optional Sea-Bird mounting hardware or customer-supplied mounting hardware.

Command Instructions and List

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

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=mmddyy**	Set real-time clock month, day, year. Must follow with **HHMMSS=.**
	DDMMYY=ddmmyy	Set real-time clock day, month, year. Must follow with **HHMMSS=.**
	HHMMSS=hhmmss	Set real-time clock hour, minute, second.
	BAUD=x	**x**= baud rate (1200, 2400, 4800, 9600, 19200, 38400). Default 9600.
	OUTPUTTIME=x	**x=Y**: output date and time with data. **x=N**: do not.
	OUTPUTSAL=x	**x=Y**: output salinity (psu) with data **x=N**: do not.
	OUTPUTSV=x	**x=Y**: output sound velocity (m/sec) with data. **x=N**: do not.
	OUTPUTDEPTH=x	**x=Y**: output depth (meters) with data. **x=N**: do not.
	OUTPUTDENSITY=x	**x=Y**: output local density sigma (kg/m^3) with data. **x=N**: do not.
	LATITUDE=x	**x**= latitude (degrees) to use in depth calculation.
	REFPRESS=x	**x** = reference pressure (decibars) (used when MicroCAT has no pressure sensor).
	FORMAT=x	**x=1**: output converted data, date dd mmm yyyy **x=2**: output converted data, date mm-dd-yyyy
	OUTPUTBINARY=x	**x=Y**: output data in binary form. **x=N**: do not.
	NCYCLES=x	**x** = number of A/D cycles to average (range 1 - 127; default 4).
	PUMPINSTALLED=x	**x=N**: internal pump not installed **(only valid setting for 37-SI)**.
	QS	Quit session and place MicroCAT in quiescent (sleep) state. Sampling stops. Applicable only if Interface PCB J1 jumper in Normal position.
Operating Interface PCB's J1 jumper interacts with these commands: • Normal – pins 1 and 2 • Autopower – pins 2 and 3	**INTERVAL=x**	**x** = interval between samples (10 - 32767 seconds). If **x** < 10, sample continuously.
	AUTOOFF=x	**(Functional only if J1 jumper in Normal position)** **x=Y**: Go to sleep if 2 minutes have elapsed without receiving command or sampling data. **x=N**: Do not automatically go to sleep.
	J1 jumper - Normal **AUTORUN=N** **SINGLESAMPLE=Y** or **N**	Wake up (when Connect on Toolbar clicked or Enter key pressed) and wait for command.
	J1 jumper - Normal **AUTORUN=Y** **SINGLESAMPLE=N**	Wake up (when Connect on Toolbar clicked or Enter key pressed) and sample at rate specified by **INTERVAL**. To stop sampling and get `S>` prompt, type **STOP** and press Enter key.
	J1 jumper - Normal **AUTORUN=Y** **SINGLESAMPLE=Y**	Wake up (when Connect on Toolbar clicked or Enter key pressed), take and output single sample, and go to sleep. To wake up and get `S>` prompt, type **STOP** and press Enter key. Referred to as **Serial Line Sync Mode**.
	J1 jumper - Autopower **AUTORUN=N** **SINGLESAMPLE=Y** or **N**	Wake up (when power applied) and wait for command.
	J1 jumper - Autopower **AUTORUN=Y** **SINGLESAMPLE=N**	Wake up (when power applied) and sample at rate defined by **INTERVAL** until power removed.
	GO	Start sampling, as defined by **SINGLESAMPLE** and **INTERVAL**.
	STOP	Stop sampling.
Sampling Do not send if MicroCAT is sampling data at pre-programmed intervals.	**TS**	Take sample, hold converted data in RAM, output converted data
	TSR	Take sample, hold raw data in RAM, output raw data.
	SLT	Send converted data from last sample in RAM, then take new sample and hold converted data in RAM.
	TH	Take sample, hold converted data in RAM.
	SH	Send held converted data from RAM.
	SB	Send held converted data from RAM in binary (applicable only if **OUTPUTBINARY=Y**).
Coefficients	**DC**	Display calibration coefficients.

CALIBRATION SHEETS

SBE37-SI MicroCAT

Conductivity & Temperature Recorder
with RS-232 Serial Interface

Instrument Configuration:

Serial Number	37SI48427-5143
Pressure Sensor	None
Firmware Version	2.3
Interface Type	RS-232
Conductivity Range	0-7 S/m
Baud Rate	9600, 8 data bits, no parity
Maximum Depth	**250 meters**

CAUTION - The maximum deployment depth is limited by the pressure housing to 250m.

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: **10/12/2007** Description **SBE-37 Microcat**

Job Number: **48427** Customer Name **TAMU/GERG**

SBE Sensor Information:

Model Number: **37**
Serial Number: **5143**

Pressure Sensor Information:

Sensor Type: **None**
Sensor Serial Number: **None**
Sensor Rating: **0**

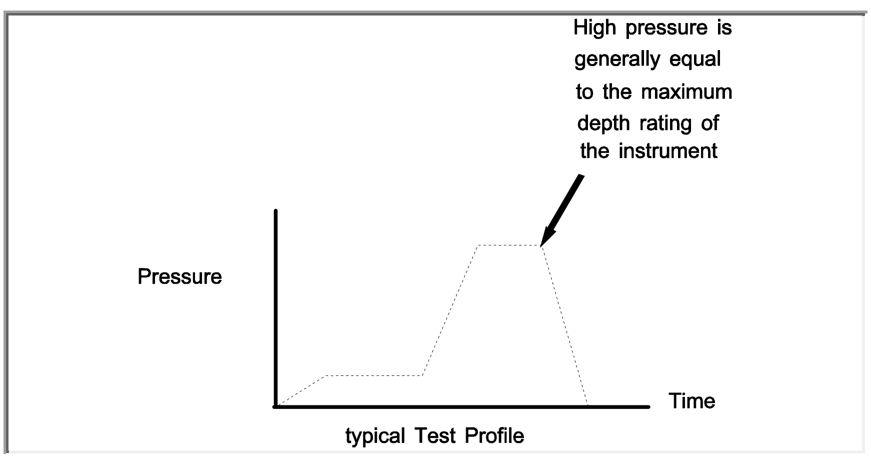
Pressure Test Protocol:

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

High Pressure Test: **350** 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: 5143
CALIBRATION DATE: 24-Sep-07

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

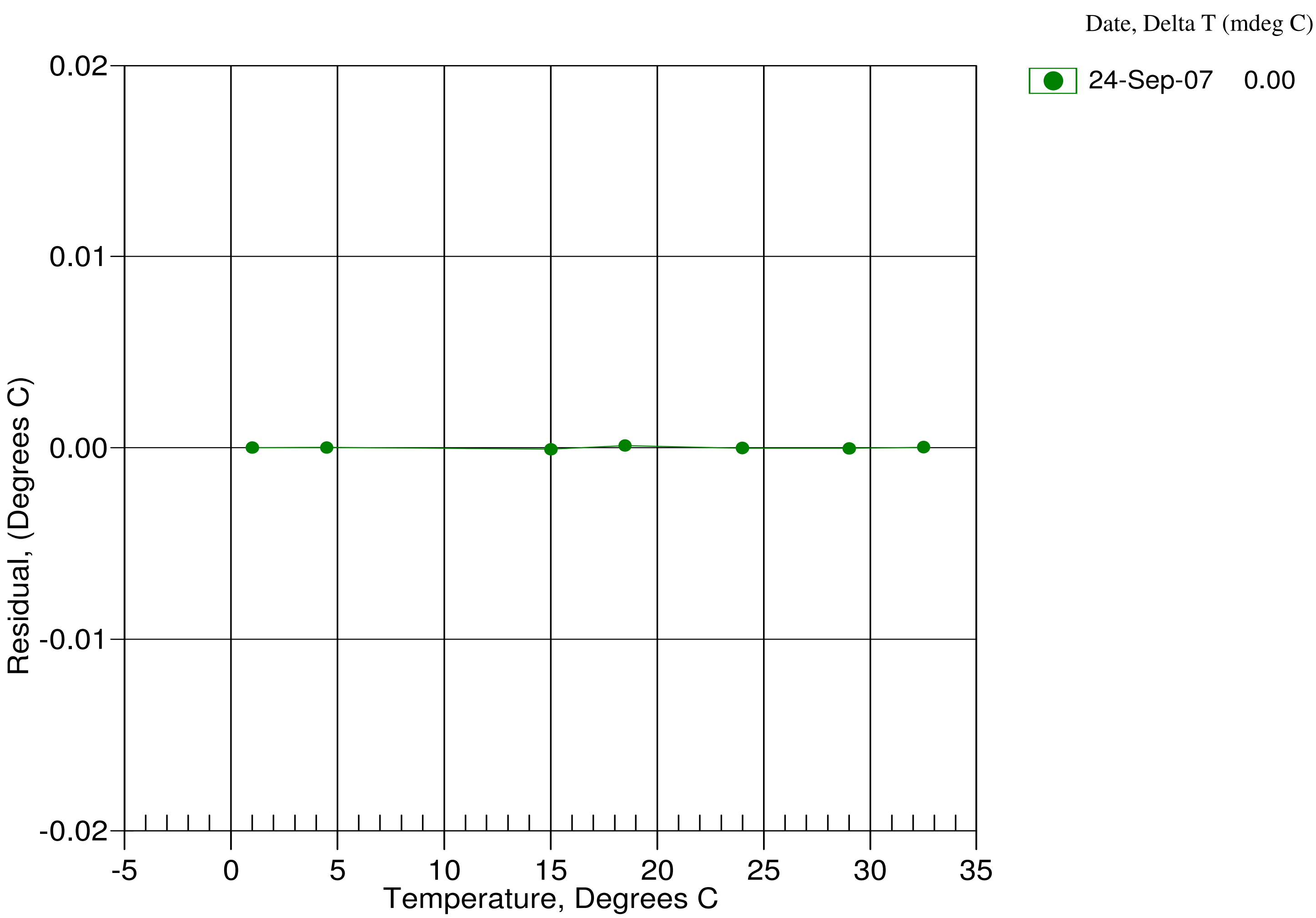
ITS-90 COEFFICIENTS

a0 = -2.443898e-006
a1 = 2.728129e-004
a2 = -2.049083e-006
a3 = 1.487464e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	669871.2	1.0000	-0.0000
4.5000	573951.1	4.5000	0.0000
15.0000	367979.8	14.9999	-0.0001
18.5000	319229.9	18.5001	0.0001
24.0000	256827.7	24.0000	-0.0000
29.0000	212001.9	29.0000	-0.0000
32.4999	185965.8	32.4999	0.0000

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

Residual = instrument temperature - bath temperature



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: 5143
CALIBRATION DATE: 24-Sep-07

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

COEFFICIENTS:

```
g = -1.015777e+000
h =  1.569481e-001
i = -1.588861e-004
j =  4.061959e-005

CPcor = -9.5700e-008
CTcor =  3.2500e-006
WBOTC =  2.6305e-005
```

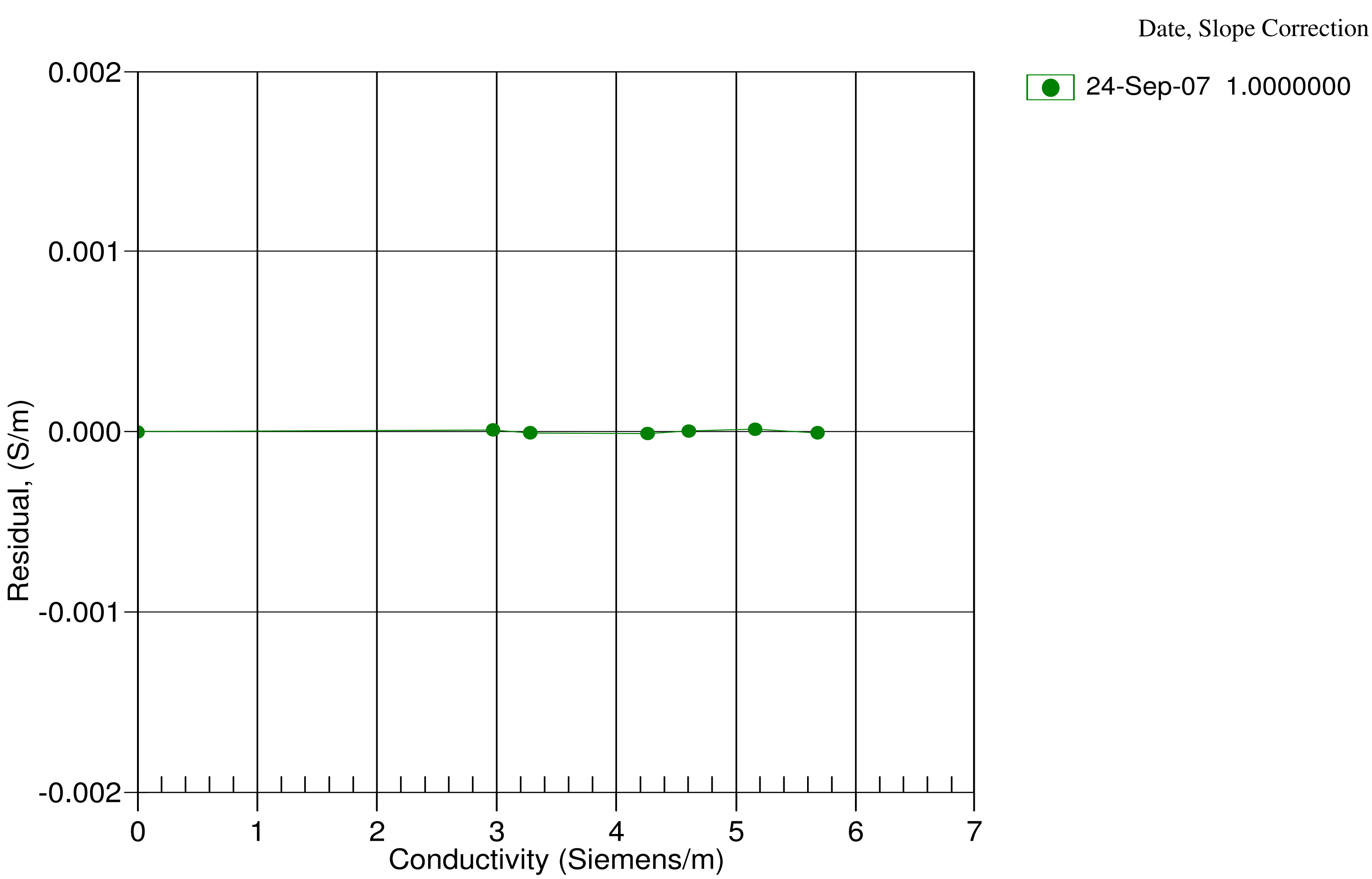
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2544.43	0.00000	0.00000
1.0000	34.7579	2.97145	5036.56	2.97146	0.00001
4.5000	34.7384	3.27810	5225.61	3.27809	-0.00001
15.0000	34.6965	4.25847	5787.82	4.25846	-0.00001
18.5000	34.6880	4.60318	5972.60	4.60319	0.00000
24.0000	34.6790	5.16046	6259.45	5.16047	0.00001
29.0000	34.6747	5.68173	6515.94	5.68172	-0.00001

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

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

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

Residual = instrument conductivity - bath conductivity



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SENSOR SERIAL NUMBER: 5143
CALIBRATION DATE: 24-Sep-07

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

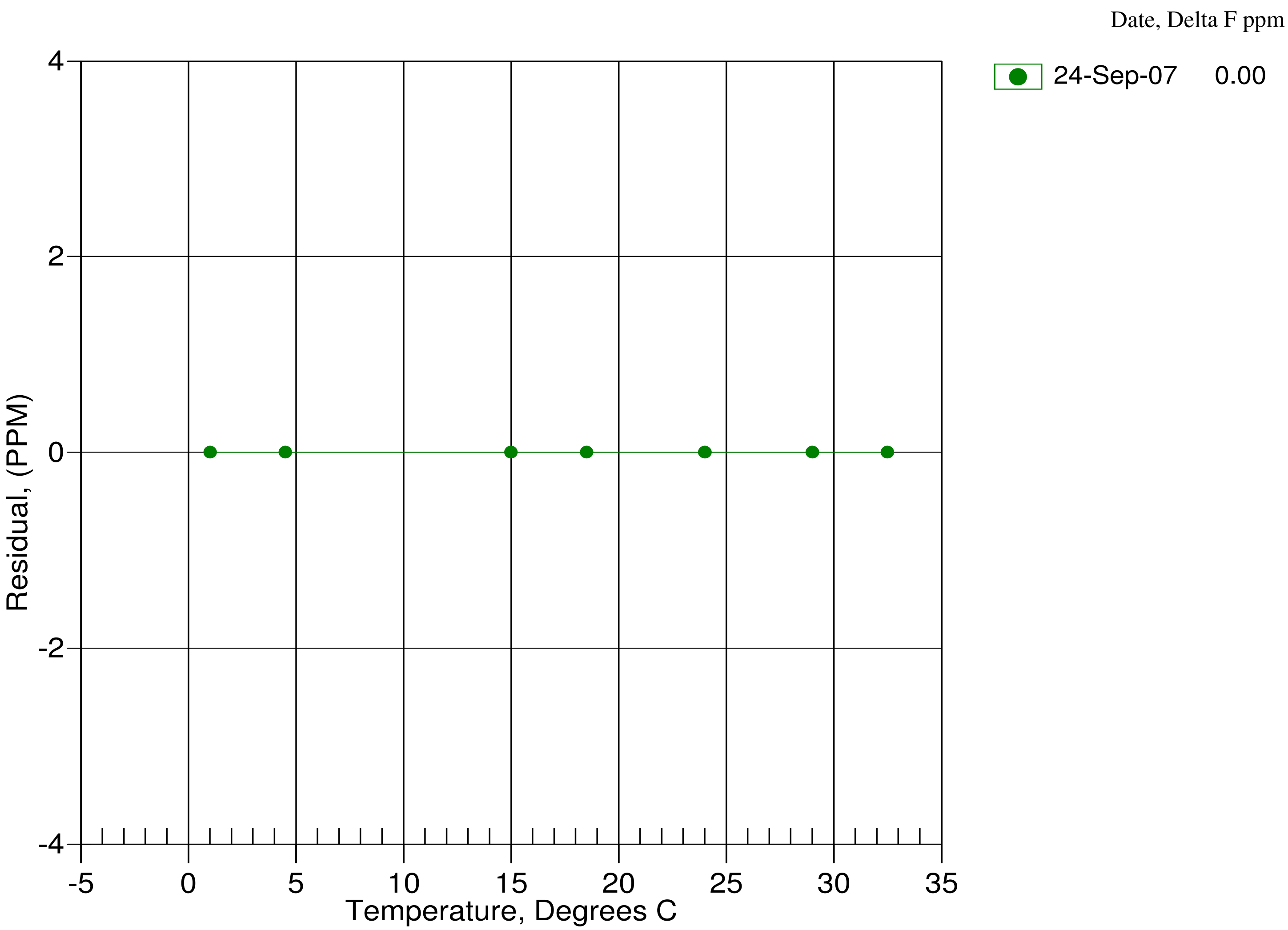
COEFFICIENTS:

```
rtca0 =  1.000000e+000
rtca1 =  0.000000e+000
rtca2 = -0.000000e+000
```

BATH TEMP (ITS-90)	RTC FREQ (Hz)	COMPUTED FREQ (Hz)	RESIDUAL (PPM)
1.0000	1.0000000	1.0000000	0.0
4.5000	1.0000000	1.0000000	0.0
15.0000	1.0000000	1.0000000	0.0
18.5000	1.0000000	1.0000000	0.0
24.0000	1.0000000	1.0000000	0.0
29.0000	1.0000000	1.0000000	0.0
32.4999	1.0000000	1.0000000	0.0

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

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



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MicroCAT C-T Monitor (Serial Interface)

SBE 37-SI

The SBE 37-SI MicroCAT is a high-accuracy conductivity and temperature (pressure optional) **S**erial **I**nterface sensor without batteries or memory. It is useful as a stand-alone monitoring device, and is easily integrated with current meters, ROVs, AUVs, towed sonars, and other instrumentation platforms. Constructed of titanium and other non-corroding materials to ensure long life with minimum maintenance, the MicroCAT's depth capability is 7000 meters; it is also available with an optional 250-meter plastic *ShallowCAT* housing.

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

Calibration coefficients are stored in EEPROM, and the MicroCAT provides data in ASCII engineering units. The output format always includes Conductivity, Temperature, and Pressure (if optional sensor installed); users can choose to add any combination of time, sound velocity (Chen-Millero), salinity, depth, and density. 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. Its aged and pressure-protected thermistor has a long history of exceptional accuracy and stability.

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

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 a standard serial interface. Real-time data can be transmitted at distances of up to 800 meters (2600 feet) at 1200 baud (power considerations may limit the distance). An optional RS-485 interface allows multiple MicroCATs to share a common 4-wire cable (power, common, data +, data -), minimizing cable complexity for C-T chains.

User-selectable operating modes include:

- **Autonomous Sampling** — At pre-programmed intervals, the MicroCAT samples. There are two types of autonomous sampling:
  — *Continuous sampling* at the fastest rate possible (0.66 second minimum), or
  — *Interval sampling* at intervals of 10 seconds to 9.1 hours.
- **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, transmits the data, and goes to sleep.

SOFTWARE

The MicroCAT is supplied with SEATERM©, a powerful Win 95/98/NT/2000/XP terminal program for easy communication and data retrieval. SEATERM can send commands to the MicroCAT to provide status display, data acquisition setup, data display and capture, and diagnostic tests.

MicroCAT C-T Monitor (Serial Interface) SBE 37-SI

SPECIFICATIONS

Measurement Range

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

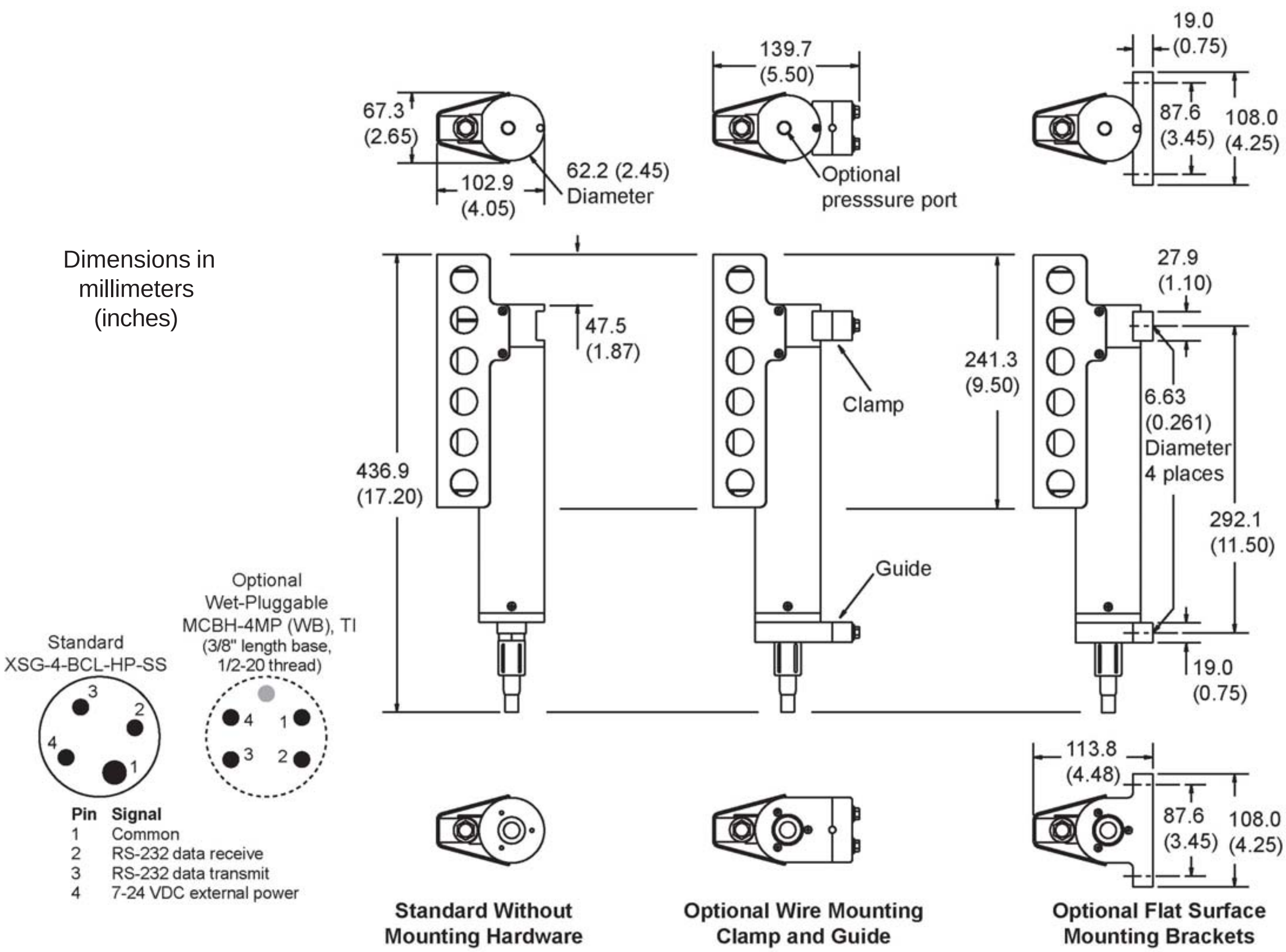
Conductivity:	0.00001 S/m (0.0001 mS/cm)
Temperature:	0.0001 °C
Optional Pressure:	0.002% of full scale range

Time Resolution	1 second
Clock Stability	13 seconds/month
Input Power	0.5 Amps at 7-24 VDC
Quiescent Current*	10 microamps
Communication Current*	35 milliamps
Acquisition Current*	35 milliamps
Acquisition Time	0.66 seconds/sample minimum (programmable)

Housing, Depth Rating, & Weight (without pressure or clamps)

Standard	Titanium, 7000 m (23,000 ft) Weight in air: 2.9 kg (6.5 lbs) Weight in water: 1.9 kg (4.3 lbs)
Optional ShallowCAT	Plastic, 250 m (820 ft) Weight in air: 2.2 kg (4.9 lbs) Weight in water: 1.2 kg (2.7 lbs)

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



11/06

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APPLICATION NOTES

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

Instructions for Care and Cleaning of Conductivity Cells

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

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

General Discussion

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

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

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

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

Rinsing, Cleaning, and Storage Procedures

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

CAUTIONS:

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

Active Use (after each cast)

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

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

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

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

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

Long-Term Storage (after field use)

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

Cleaning Materials

Water

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

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

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

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

Triton X-100

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

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

Bleach

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

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

Tygon Tubing

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

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

Acid

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

CAUTIONS:

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

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

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

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

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

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

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

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

COMPRESSIBILITY COMPENSATION OF SEA-BIRD CONDUCTIVITY SENSORS

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

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

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

or

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

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

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

where

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

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

DISCUSSION OF PRESSURE CORRECTION

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

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

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

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

MATHEMATICAL DERIVATION OF PRESSURE CORRECTION

For a cube under hydrostatic load:

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

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

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

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

Since conductivity is 1/R:

$C_p = C_0 (1 + s)$ and $C_0 = C_p / (1 + s) = C_p / (1 + [Cpcor] [p])$
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:

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

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

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APPLICATION NOTE NO. 14 **January 1989**

1978 PRACTICAL SALINITY SCALE

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

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

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

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

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

CONCLUSIONS

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

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

T in °C (IPTS '68), P in decibars.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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APPLICATION NOTE 27Druck **Revised July 2005**

Minimizing Strain Gauge Pressure Sensor Errors

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

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

* **Note:** SBE 16 and SBE 19 SEACATs were originally supplied with other types of pressure sensors. However, a few of these instruments have been retrofitted with Druck sensors.

The Druck sensors are designed to respond to pressure in nominal ranges 0 - 20 meters, 0 - 100 meters, 0 - 350 meters, 0 – 600 meters, 0 – 1000 meters, 0 – 2000 meters, 0 – 3500 meters, and 0 – 7000 meters (with pressures expressed in meters of deployment depth capability). The sensors offer an initial accuracy of 0.1% of full scale range.

DEFINITION OF PRESSURE TERMS

The term *psia* means *pounds per square inch, absolute* (*absolute* means that the indicated pressure is referenced to a vacuum).

For oceanographic purposes, pressure is most often expressed in *decibars* (1 dbar = 1.4503774 psi). A dbar is 0.1 bar; a bar is approximately equal to a standard atmosphere (1 atmosphere = 1.01325 bar). For historical reasons, pressure at the water surface (rather than absolute or total pressure) is treated as the reference pressure (0 dbar); this is the value required by the UNESCO formulas for computation of salinity, density, and other derived variables.

Some oceanographers express pressure in Newtons/meter^2 or *Pascals* (the accepted SI unit). A Pascal is a very small unit (1 psi = 6894.757 Pascals), so the mega-Pascal (MPa = 10^6 Pascals) is frequently substituted (1 MPa = 100 dbar).

Since the pressure sensors used in Sea-Bird instruments are *absolute* types, their raw data inherently indicate atmospheric pressure (about 14.7 psi) when in air at sea level. Sea-Bird outputs pressure in one of the following ways:

- CTDs that output **raw data** (**SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, and 49**) and are supported by SEASOFT's SEASAVE (real-time data acquisition) and SBE Data Processing (data processing) software – In SEASOFT, user selects pressure output in psi (*not* psia) or dbar. SEASOFT subtracts 14.7 psi from the raw absolute reading and outputs the remainder as psi or converts the remainder to dbar.
- **SBE 26*plus*** – Real-time wave and tide data is output in psia. Wave and tide data stored in memory is processed using SEASOFT for Waves' Convert Hex module, and output in psia. Tide data can be converted to psi by subtracting a barometric pressure file using SEASOFT for Waves' Merge Barometric Pressure module.
- **SBE 50** – User selects pressure output in psia (including atmospheric pressure) or dbar. Calculation of dbar is as described above.
- All other instruments that can output **converted data in engineering units** (**SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 39-IM, 49, and 52-MP**) – Instrument subtracts 14.7 psi from the raw absolute reading and converts the remainder to dbar.

Note: SBE 16*plus*, 16*plus*-IM, 19*plus*, 49, and 52-MP can output raw **or** converted data.

RELATIONSHIP BETWEEN PRESSURE AND DEPTH

Despite the common nomenclature (CTD = **C**onductivity - **T**emperature - **D**epth), all CTDs measure *pressure*, which is not quite the same thing as depth. The relationship between pressure and depth is a complex one involving water density and compressibility as well as the strength of the local gravity field, but it is convenient to think of a decibar as essentially equivalent to a meter, an approximation which is correct within 3% for almost all combinations of salinity, temperature, depth, and gravitational constant.

SEASOFT (most instruments)

SEASOFT offers two methods for estimating depth from pressure.

- For oceanic applications, salinity is presumed to be 35 PSU, temperature to be 0^o C, and the compressibility of the water (with its accompanying density variation) is taken into account. This is the method recommended in UNESCO Technical Paper No. 44 and is a logical approach in that by far the greatest part of the deep-ocean water column approximates these values of salinity and temperature. Since pressure is also proportional to gravity and the major variability in gravity depends on latitude, the user's latitude entry is used to estimate the magnitude of the local gravity field.
  - SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, and 49 - User is prompted to enter latitude if Depth [salt water] is selected as a display variable in SEASAVE or as an output variable in the Data Conversion or Derive module of SBE Data Processing.
  - SBE 37-SM, 37-SMP, 37-IM, and 37-IMP - User is prompted to enter latitude if Depth [salt water] is selected as an output variable in the Derive module of SBE Data Processing.
  - SBE 37-SI, 37-SIP, and 50 - Latitude is entered in the instrument's EEPROM using the **LATITUDE=** command in SEASOFT's SEATERM (terminal program) software.
  - SBE 39 and 39-IM – User is prompted to enter latitude if conversion of pressure to depth is requested when converting an uploaded .asc file to a .cnv file in SEATERM.
- For fresh water applications, compressibility is not significant in the shallow depths encountered and is ignored, as is the latitude-dependent gravity variation. Fresh water density is presumed to be 1 gm/cm, and depth (in meters) is calculated as 1.019716 * pressure (in dbars). No latitude entry is required for the following:
  - SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, and 49 - If Depth [fresh water] is selected as a display variable in SEASAVE or as an output variable in the Data Conversion or Derive module of SBE Data Processing.
  - SBE 37-SM, 37-SMP, 37-IM, and 37-IMP - If Depth [fresh water] is selected as an output variable in the Derive module of SBE Data Processing.

SEASOFT for Waves (SBE 26plus SEAGAUGE Wave and Tide Recorder)

SEASOFT for Waves' Merge Barometric Pressure module subtracts a user-input barometric pressure file from the tide data file, and outputs the remainder as pressure in psi or as depth in meters. When converting to depth, the compressibility of the water is taken into account by prompting for user-input values for average density and gravity. See the SBE 26*plus* manual's appendix for the formulas for conversion of pressure to depth.

CHOOSING THE RIGHT SENSOR

Initial accuracy and resolution are expressed as a percentage of the full scale range for the pressure sensor. The initial accuracy is 0.1% of the full scale range. Resolution is 0.002% of full scale range, except for the SBE 25 (0.015% resolution). For best accuracy and resolution, select a pressure sensor full scale range to correspond to no more than the greatest depths to be encountered. The effect of this choice on CTD accuracy and resolution is shown below:

Range (meters)	Maximum Initial Error (meters)	SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 39-IM, 49, 50, and 52-MP - Resolution (meters)	SBE 25 - Resolution (meters)
0 – 20	0.02	0.0004	0.003
0 – 100	0.10	0.002	0.015
0 – 350	0.35	0.007	0.052
0 – 600	0.60	0.012	0.090
0 – 1000	1.0	0.02	0.15
0 - 2000	2.0	0.04	0.30
0 - 3500	3.5	0.07	0.52
0 - 7000	7.0	0.14	1.05

Note: See the SBE 26*plus* manual or data sheet for its resolution specification; 26*plus* resolution is a function of integration time as well as pressure sensor range.

The meaning of *accuracy*, as it applies to these sensors, is that the indicated pressure will conform to true pressure to within ± *maximum error* (expressed as equivalent depth) throughout the sensor's operating range. Note that a 7000-meter sensor reading + 7 meters at the water surface is operating within its specifications; the same sensor would be expected to indicate 7000 meters ± 7 meters when at full depth.

Resolution is the magnitude of indicated increments of depth. For example, a 7000-meter sensor on an SBE 25 (resolution 1.05 meters) subjected to slowly increasing pressure will produce readings approximately following the sequence *0, 1.00, 2.00, 3.00* (meters). Resolution is limited by the design configuration of the CTD's A/D converter. For the SBE 25, this restricts the possible number of discrete pressure values for a given sample to somewhat less than 8192 (13 bits); an approximation of the ratio 1 : 7000 is the source of the SBE 25's 0.015% resolution specification.

Note: SEASOFT (and other CTD software) presents temperature, salinity, and other variables as a function of depth or pressure, so the CTD's pressure resolution limits the number of plotted data points in the profile. For example, an SBE 25 with a 7000-meter sensor might acquire several values of temperature and salinity during the time required to descend from 1- to 2-meters depth. However, all the temperature and salinity values will be graphed in clusters appearing at either 1 or 2 meters on the depth axis.

High-range sensors used in shallow water generally provide better accuracy than their *absolute* specifications indicate. With careful use, they may exhibit *accuracy* approaching their *resolution* limits. For example, a 3500-meter sensor has a nominal accuracy (irrespective of actual operating depth) of ± 3.5 meters. Most of the error, however, derives from variation over time and temperature of the sensor's *offset*, while little error occurs as a result of changing *sensitivity*.

MINIMIZING ERRORS

Offset Errors

Note: Follow the procedures below for all instruments except the SBE 26*plus* (see the 26*plus* manual for details).

The primary *offset* error due to drift over time can be eliminated by comparing CTD readings in air before beginning the profile to readings from a barometer. Follow this procedure:

1. Allow the instrument to equilibrate in a reasonably constant temperature environment for at least 5 hours. Pressure sensors exhibit a transient change in their output in response to changes in their environmental temperature; allowing the instrument to equilibrate before starting will provide the most accurate calibration correction.

2. Place the instrument in the orientation it will have when deployed.

3. Set the pressure offset to 0.0:
   - In the .con file, using SEASAVE or SBE Data Processing (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, or 49).
   - In the CTD's EEPROM, using the appropriate command in SEATERM (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 39-IM, 49, 50, or 52-MP).

4. Collect pressure data from the instrument using SEASAVE or SEATERM (see instrument manual for details). If the instrument is not outputting data in decibars, convert the output to decibars.

5. Compare the instrument output to the reading from a good barometer placed at the same elevation as the pressure sensor. Calculate *offset* (decibars) = barometer reading (converted to decibars) – instrument reading (decibars).

6. Enter calculated offset (positive or negative) in decibars:
   - In the .con file, using SEASAVE or SBE Data Processing (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, or 49).
   - In the CTD's EEPROM, using the appropriate command in SEATERM (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 39-IM, 49, 50, or 52-MP).

Note: For instruments that store calibration coefficients in EEPROM and also use a .con file (SBE 16*plus*, 16*plus*-IM, 19*plus*, and 49), set the pressure offset (Steps 3 and 6 above) in both the EEPROM and in the .con file.

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

Another source of *offset* error results from temperature-induced drifts. Because Druck sensors are carefully temperature compensated, errors from this source are small. Offset errors can be estimated for the conditions of your profile, and eliminated when post-processing the data in SBE Data Processing by the following procedure:

1. **Immediately** before beginning the profile, take a pre-cast *in air* pressure reading.

2. **Immediately** after ending the profile, take a post-cast *in air* pressure reading with the instrument at the same elevation and orientation. This reading reflects the change in the instrument temperature as a result of being submerged in the water during the profile.

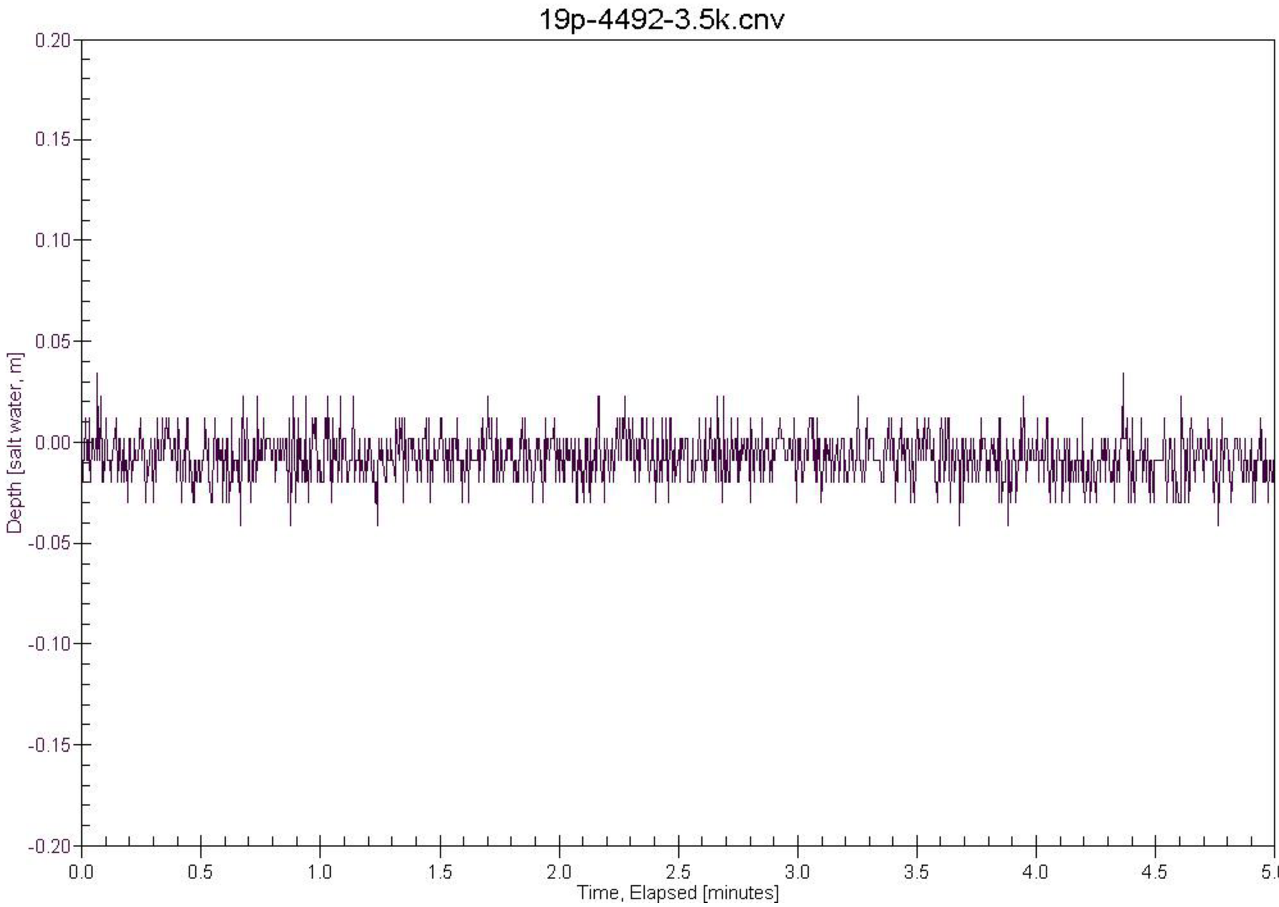
3. Calculate the average of the pre- and post-cast readings. Enter the negative of the average value (in decibars) as the *offset* in the .con file.

Hysteresis Errors

Hysteresis is the term used to describe the failure of pressure sensors to repeat previous readings after exposure to other (typically higher) pressures. The Druck sensor employs a micro-machined silicon diaphragm into which the strain elements are implanted using semiconductor fabrication techniques. Unlike metal diaphragms, silicon's crystal structure is perfectly elastic, so the sensor is essentially free of pressure hysteresis.

Power Turn-On Transient

Druck pressure sensors exhibit virtually no power turn-on transient. The plot below, for a 3500-meter pressure sensor in an SBE 19*plus* SEACAT Profiler, is representative of the power turn-on transient for all pressure sensor ranges.



Thermal Transient

Pressure sensors exhibit a transient change in their output in response to changes in their environmental temperature, so the thermal transient resulting from submersion in water must be considered when deploying the instrument.

During calibration, the sensors are allowed to *warm-up* before calibration points are recorded. Similarly, for best depth accuracy the user should allow the CTD to *warm-up* for several minutes before beginning a profile; this can be part of the *soak* time in the surface water. *Soaking* also allows the CTD housing to approach thermal equilibrium (minimizing the housing's effect on measured temperature and conductivity) and permits a Beckman- or YSI-type dissolved oxygen sensor (if present) to polarize.

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APPLICATION NOTE NO. 42 **Revised May 2007**

ITS-90 TEMPERATURE SCALE

Beginning in January 1995, Sea-Bird's temperature metrology laboratory (based upon water triple-point and gallium melt cell, SPRT, and ASL F18 Temperature Bridge) converted to ITS-90 (T90). These T90 standards are employed in calibrating *all* Sea-Bird temperature sensors, and as the reference temperature used in conductivity calibrations.

The international oceanographic research community continues to use IPTS-68 (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), our software and our instrument firmware (for instruments that can calculate and output salinity and other seawater properties directly) converts 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 our software and in those instruments that directly output salinity and other seawater parameters.

Note: In our SEASOFT-Win32 suite of software programs, edit the CTD configuration (.con) file to enter calibration coefficients using the Configure Inputs menu in SEASAVE V7 (real-time data acquisition software) or the Configure menu in SBE Data Processing (data processing software).

SBE 9*plus* (using SBE 3*plus* temperature sensor), 16, 19, 21, and 25 (using SBE 3F temperature sensor)

Beginning in January 1995, Sea-Bird temperature calibration certificates began listing a set of coefficients labeled *g*, *h*, *i*, *j*, and *F0*, corresponding to ITS-90 (T90) temperatures. For user convenience and for historical comparison with older calibrations, the certificates also continue to list *a*, *b*, *c*, *d*, and *F0* coefficients corresponding to IPTS-68 (T68) temperatures. The T90 coefficients result directly from T90 standards; the T68 coefficients are computed using the Saunders linear approximation.

SEASOFT supports entry of either the T90 or the T68 coefficients for these instruments. 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 performs the calculations accordingly, depending on which coefficients were used and which display variable type is selected.

- If *g, h, i, j, F0* coefficients (T90) are entered in the .con file and you select temperature display/output variable type as T68, SEASOFT computes T90 temperature directly and multiplies it by 1.00024 to display or output T68.
- If *a, b, c, d,* and *F0* coefficients (T68) are entered in the .con file and you select temperature display/output variable type as T90, SEASOFT computes T68 directly and divides by 1.00024 to display or output T90.

SBE 16*plus* and 16*plus*-IM, 19*plus*, 26*plus*, 35, 35RT, 37 (all), 38, 39 and 39-IM, 45, 49, 51, 52-MP, 53, *and all higher numbered instruments*

For these instruments, all first manufactured after the switch of our metrology lab to ITS-90, Sea-Bird provides only one set of calibration coefficients, based on the T90 standards. These instruments all have user-programmable internal calibration coefficients, and can output data in engineering units (°C, S/m, dbar, etc. as applicable to the instrument). When outputting temperature in engineering units, these instruments always output T90 temperatures.

- Instruments that can internally compute and then output salinity and other seawater parameters (for example, SBE 37-SI) - Use of T68 for salinity and other seawater calculations is automatic; the instrument internally performs the conversion between T90 and T68 according to the Saunders equation.
- Instruments supported in SEASOFT (for example, SBE 19*plus*) - Use of T68 for salinity and other seawater calculations is automatic; the software performs the conversion between T90 and T68 according to the Saunders equation. 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.

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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

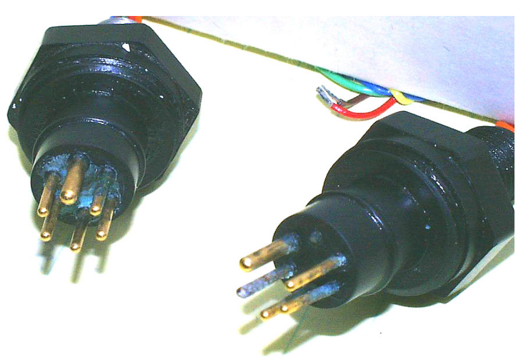
1. Carefully clean the bulkhead connector and the inside of the mating inline (cable end) connector with a Kimwipe. Remove all grease, hair, dirt, and other contamination.

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).

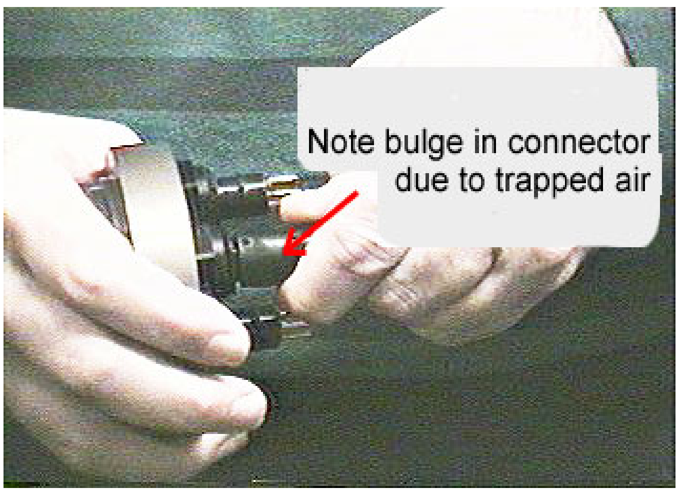


Corroded pins on bulkhead connectors -
Connector on right has a missing pin

3. 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.

4. 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.

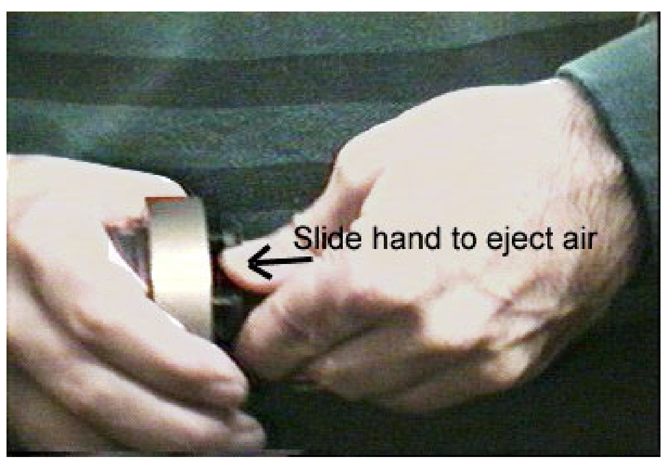


5. Mate the inline connector to the bulkhead, being careful to align the pins with the sockets. Do not twist the inline connector on the bulkhead connector. Twisting can lead to bent pins, which will soon break.

6. 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.

7. 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.



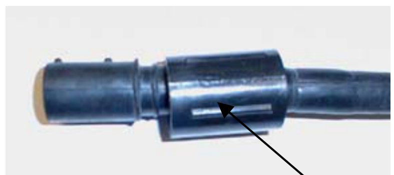
Locking Sleeve Installation

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 **November 2006**

Using USB Ports to Communicate with Sea-Bird Instruments

Most Sea-Bird instruments use the RS-232 protocol for transmitting setup commands to the instrument and receiving data from the instrument. However, many newer PCs and laptop computers have USB port(s) instead of RS-232 serial port(s).

USB serial adapters are available commercially. These adapters plug into the USB port, and allow one or more serial devices to be connected through the adapter. Sea-Bird tested USB serial adapters from three manufacturers on desktop computers at Sea-Bird, and verified compatibility with our instruments. These manufacturers and the tested adapters are:

- **IOGEAR** (www.iogear.com) –
  USB 1.1 to Serial Converter Cable (model # GUC232A).
  Note: This adapter can also be purchased from Sea-Bird, as Sea-Bird part # 20163.

- **Keyspan** (www.keyspan.com) -
  USB 4-Port Serial Adapter (part # USA-49WLC, replacing part # USA-49W)

- **Edgeport** (www.ionetworks.com) -
  Standard Serial Converter Edgeport/2 (part # 301-1000-02)

Other USB adapters from these manufacturers, and adapters from other manufacturers, **may** also be compatible with Sea-Bird instruments.

We have one report from a customer that he could not communicate with his instrument using a notebook computer and the Keyspan adapter listed above. He was able to successfully communicate with the instrument using an XH8290 DSE Serial USB Adapter (www.dse.co.nz).

We recommend testing any adapters, *including those listed above*, with the instrument and the computer you will use it with before deployment, to verify that there is no problem.

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APPLICATION NOTE NO. 69 July 2002

Conversion of Pressure to Depth

Sea-Bird's SEASOFT software can calculate and output depth, if the instrument data includes pressure. Additionally, some Sea-Bird instruments (such as the SBE 37-SI or SBE 50) can be set up by the user to internally calculate depth, and to output depth along with the measured parameters.

Sea-Bird uses the following algorithms for calculating depth:

Fresh Water Applications

Because most fresh water applications are shallow, and high precision in depth not too critical, Sea-Bird software uses a very simple approximation to calculate depth:

depth (meters) = pressure (decibars) * 1.019716

Seawater Applications

Sea-Bird uses the formula in UNESCO Technical Papers in Marine Science No. 44. This is an empirical formula that takes compressibility (that is, density) into account. An ocean water column at 0 °C (t = 0) and 35 PSU (s = 35) is assumed.

The gravity variation with latitude and pressure is computed as:

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

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

Then, depth is calculated from pressure:

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

where
p = pressure (decibars)
g = gravity (m/sec^2)

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APPLICATION NOTE NO. 71 — Revised July 2005

Desiccant Use and Regeneration (drying)

This application note applies to all Sea-Bird instruments intended for underwater use. The application note covers:

- When to replace desiccant
- Storage and handling of desiccant
- Regeneration (drying) of desiccant
- Material Safety Data Sheet (MSDS) for desiccant

When to Replace Desiccant Bags

Before delivery of the instrument, a desiccant package is placed in the housing, and the electronics chamber is filled with dry Argon. These measures help prevent condensation. To ensure proper functioning:

1. Install a new desiccant bag each time you open the housing and expose the electronics.
2. If possible, dry gas backfill each time you open the housing and expose the electronics. If you cannot, wait at least 24 hours before redeploying, to allow the desiccant to remove any moisture from the chamber.

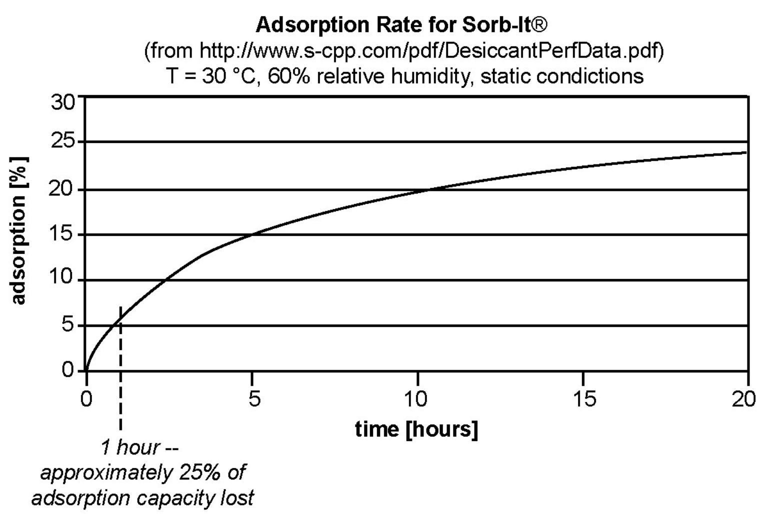
What do we mean by *expose the electronics*?

- For most battery-powered Sea-Bird instruments (such as SBE 16, 16*plus*, 16*plus*-IM, 17*plus*, 19, 19*plus*, 25, 26, 26*plus*, 37-SM, 37-SMP, 37-IM, 37-IMP, 44, 53; Auto Fire Module [AFM]), there is a bulkhead between the battery and electronics compartments. Battery replacement does not affect desiccation of the electronics, as the batteries are removed without removing the electronics and no significant gas exchange is possible through the bulkhead. Therefore, opening the battery compartment to replace the batteries does not expose the electronics; you do not need to install a new desiccant bag in the electronics compartment each time you open the battery compartment. For these instruments, install a new desiccant bag if you open the electronics compartment to access the printed circuit boards.
- For the SBE 39, 39-IM, and 48, the electronics must be removed or exposed to access the battery. Therefore, install a new desiccant bag each time you open the housing to replace a battery.

Storage and Handling

Testing by Süd-Chemie (desiccant's manufacturer) at 60% relative humidity and 30 °C shows that approximately 25% of the desiccant's adsorbing capacity is used up after only 1 hour of exposure to a constantly replenished supply of moisture in the air. In other words, if you take a bag out of a container and leave it out on a workbench for 1 hour, one-fourth of its capacity is gone before you ever install it in the instrument. Therefore:

- Keep desiccant bags in a tightly sealed, impermeable container until you are ready to use them. Open the container, remove a bag, and quickly close the container again.
- Once you remove the bag(s) from the sealed container, rapidly install the bag(s) in the instrument housing and close the housing. **Do not use the desiccant bag(s) if exposed to air for more than a total of 30 minutes.**



Regeneration (drying) of Desiccant

Replacement desiccant bags are available from Sea-Bird:

- PN 60039 is a metal can containing 25 1-gram desiccant bags and 1 humidity indicator card. The 1-gram bags are used in our smaller diameter housings, such as the SBE 3 (*plus*, F, and S), 4 (M and C), 5T, 37 (-SI, -SIP, -SM, -SMP, -IM, and –IMP), 38, 39, 39-IM, 43, 44, 45, 48, 49, and 50.
- PN 31180 is a 1/3-ounce desiccant bag, used in our SBE 16*plus*, 16*plus*-IM, 19*plus*, 21, and 52-MP.
- PN 30051 is a 1-ounce desiccant bag. The 1-ounce bags are used in our larger diameter housings, such as the SBE 9*plus*, 16, 17*plus*, 19, 25, 26, 26*plus*, 32, 53 BPR, AFM, and PDIM.

However, if you run out of bags, you can regenerate your existing bags using the following procedure provided by the manufacturer (Süd-Chemie Performance Packaging, a Division of United Catalysts, Inc.):

MIL-D-3464 Desiccant Regeneration Procedure

Regeneration of the United Desiccants' Tyvek Desi Pak® or Sorb-It® bags or United Desiccants' X-Crepe Desi Pak® or Sorb-It® bags can be accomplished by the following method:

1. Arrange the bags on a wire tray in a single layer to allow for adequate air flow around the bags during the drying process. The oven's inside temperature should be room or ambient temperature (25 – 29.4 °C [77 – 85 °F]). **A convection, circulating, forced-air type oven is recommended for this regeneration process. Seal failures may occur if any other type of heating unit or appliance is used.**

2. When placed in forced air, circulating air, or convection oven, allow a minimum of 3.8 to 5.1 cm (1.5 to 2.0 inches) of air space between the top of the bags and the next metal tray above the bags. If placed in a radiating exposed infrared-element type oven, shield the bags from direct exposure to the heating element, giving the closest bags a minimum of 40.6 cm (16 inches) clearance from the heat shield. Excessive surface film temperature due to infrared radiation will cause the Tyvek material to melt and/or the seals to fail. Seal failure may also occur if the temperature is allowed to increase rapidly. This is due to the fact that the water vapor is not given sufficient time to diffuse through the Tyvek material, thus creating internal pressure within the bag, resulting in a seal rupture. Temperature should not increase faster than 0.14 to 0.28 °C (0.25 to 0.50 °F) per minute.

3. Set the temperature of the oven to 118.3 °C (245 °F), and allow the bags of desiccant to reach equilibrium temperature. **WARNING**: Tyvek has a melt temperature of 121.1 – 126.7 °C (250 – 260 °F) (Non MIL-D-3464E activation or reactivation of both silica gel and Bentonite clay can be achieved at temperatures of 104.4 °C [220 °F]).

4. Desiccant bags should be allowed to remain in the oven at the assigned temperature for 24 hours. At the end of the time period, the bags should be immediately removed and placed in a desiccator jar or dry (0% relative humidity) airtight container for cooling. If this procedure is not followed precisely, any water vapor driven off during reactivation may be re-adsorbed during cooling and/or handling.

5. After the bags of desiccant have been allowed to cool in an airtight desiccator, they may be removed and placed in either an appropriate type polyliner tightly sealed to prevent moisture adsorption, or a container that prevents moisture from coming into contact with the regenerated desiccant.

NOTE: Use only a metal or glass container with a tight fitting metal or glass lid to store the regenerated desiccant. Keep the container lid **closed tightly** to preserve adsorption properties of the desiccant.

SÜD-CHEMIE
Creating Performance Technology

ISO 9002 CERTIFIED

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MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

SECTION I -- PRODUCT IDENTIFICATION

Trade Name and Synonyms:	Silica Gel, Synthetic Amorphous Silica, Silicon, Dioxide
Chemical Family:	Synthetic Amorphous Silica
Formula:	SiO_2.x H_2O

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

COMPONENT	CAS No	%	ACGIH/TLV (PPM)	OSHA-(PEL)
Amorphous Silica	63231-67-4	>99	PEL - 20 (RESPIRABLE), TLV – 5	LIMIT – NONE, HAZARD - IRRITANT

Synthetic amorphous silica is not to be confused with crystalline silica such as quartz, cristobalite or tridymite or with diatomaceous earth or other naturally occurring forms of amorphous silica that frequently contain crystalline forms.

This product is in granular form and packed in bags for use as a desiccant. Therefore, no exposure to the product is anticipated under normal use of this product. Avoid inhaling desiccant dust.

SECTION III -- PHYSICAL DATA

Appearance and Odor:	White granules; odorless.
Melting Point:	>1600 Deg C; >2900 Deg F
Solubility in Water:	Insoluble.
Bulk Density:	>40 lbs./cu. ft.
Percent Volatile by Weight @ 1750 Deg F:	<10%.

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SECTION IV -- FIRE EXPLOSION DATA

Fire and Explosion Hazard - Negligible fire and explosion hazard when exposed to heat or flame by reaction with incompatible substances.

Flash Point - Nonflammable.

Firefighting Media - Dry chemical, water spray, or foam. For larger fires, use water spray fog or foam.

Firefighting - Nonflammable solids, liquids, or gases: Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in enclosed area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of the tank due to fire.

SECTION V -- HEALTH HAZARD DATA

Health hazards may arise from inhalation, ingestion, and/or contact with the skin and/or eyes. Ingestion may result in damage to throat and esophagus and/or gastrointestinal disorders. Inhalation may cause burning to the upper respiratory tract and/or temporary or permanent lung damage. Prolonged or repeated contact with the skin, in absence of proper hygiene, may cause dryness, irritation, and/or dermatitis. Contact with eye tissue may result in irritation, burns, or conjunctivitis.

First Aid (Inhalation) - Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep affected person warm and at rest. Get medical attention immediately.

First Aid (Ingestion) - If large amounts have been ingested, give emetics to cause vomiting. Stomach siphon may be applied as well. Milk and fatty acids should be avoided. Get medical attention immediately.

First Aid (Eyes) - Wash eyes immediately and carefully for 30 minutes with running water, lifting upper and lower eyelids occasionally. Get prompt medical attention.

First Aid (Skin) - Wash with soap and water.

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MATERIAL SAFETY DATA SHEET – August 13, 2002
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NOTE TO PHYSICIAN: This product is a desiccant and generates heat as it adsorbs water. The used product can contain material of hazardous nature. Identify that material and treat accordingly.

SECTION VI -- REACTIVITY DATA

Reactivity - Silica gel is stable under normal temperatures and pressures in sealed containers. Moisture can cause a rise in temperature which may result in a burn.

SECTION VII --SPILL OR LEAK PROCEDURES

Notify safety personnel of spills or leaks. Clean-up personnel need protection against inhalation of dusts or fumes. Eye protection is required. Vacuuming and/or wet methods of cleanup are preferred. Place in appropriate containers for disposal, keeping airborne particulates at a minimum.

SECTION VIII -- SPECIAL PROTECTION INFORMATION

Respiratory Protection - Provide a NIOSH/MSHA jointly approved respirator in the absence of proper environmental control. Contact your safety equipment supplier for proper mask type.

Ventilation - Provide general and/or local exhaust ventilation to keep exposures below the TLV. Ventilation used must be designed to prevent spots of dust accumulation or recycling of dusts.

Protective Clothing - Wear protective clothing, including long sleeves and gloves, to prevent repeated or prolonged skin contact.

Eye Protection - Chemical splash goggles designed in compliance with OSHA regulations are recommended. Consult your safety equipment supplier.

SECTION IX -- SPECIAL PRECAUTIONS

Avoid breathing dust and prolonged contact with skin. Silica gel dust causes eye irritation and breathing dust may be harmful.

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MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

* No Information Available

HMIS (Hazardous Materials Identification System) for this product is as follows:

Health Hazard	0
Flammability	0
Reactivity	0
Personal Protection	HMIS assigns choice of personal protective equipment to the customer, as the raw material supplier is unfamiliar with the condition of use.

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APPLICATION NOTE NO. 73 **Revised July 2005**

Using Instruments with Pressure Sensors at Elevations Above Sea Level

This application note covers use of a Sea-Bird instrument that includes a pressure sensor at elevations above sea level, such as in a mountain lake or stream.

Background

Sea-Bird pressure sensors are absolute sensors, so their raw output includes the effect of atmospheric pressure. As shown on the Calibration Sheet that accompanies the instrument, our calibration (and resulting calibration coefficients) is in terms of psia. However, when outputting pressure in engineering units, most of our instruments output pressure relative to the ocean surface (i.e., at the surface the output pressure is 0 decibars). Sea-Bird uses the following equation in our instruments and/or software to convert psia to decibars:

Pressure (db) = [pressure (psia) – 14.7] * 0.689476
where 14.7 psia is the assumed atmospheric pressure (based on atmospheric pressure at sea level).

This conversion is based on the assumption that the instrument is being used in the ocean; the surface of the ocean water is by definition at sea level. However, if the instrument is used in a mountain lake or stream, the assumption of sea level atmospheric pressure (14.7 psia) in the instrument and/or software can lead to incorrect results. Procedures are provided below for measuring the pressure *offset* from the assumed sea level atmospheric pressure, and entering the offset in the instrument and/or software to make the appropriate correction.

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

Inclusion of calibration coefficients in the instrument itself or in a file used by our software to interpret raw data varies, depending on the instrument. Commands used to program the instrument vary as well. Therefore, there are variations in the correction procedure, depending on the instrument. These instruments are addressed below:

- SBE **9*plus*** CTD and SBE **25** SEALOGGER CTD
- SBE **16*plus* (RS-232 version)** SEACAT C-T (pressure optional) Recorder, SBE **19*plus*** SEACAT Profiler CTD, and SBE **49** FastCAT CTD Sensor
- SBE **16*plus* (RS-485 version)** SEACAT C-T (pressure optional) Recorder and SBE **16*plus*-IM** SEACAT C-T (pressure optional) Recorder
- SBE **37** MicroCAT (all models – IM, IMP, SI, SIP, SM, SMP)
- SBE **50** Digital Oceanographic Pressure Sensor
- SBE **52-MP** Moored Profiler CTD and DO Sensor
- SBE **39-IM** Temperature (pressure optional) Recorder
- SBE **39** Temperature (pressure optional) Recorder
- SBE **26*plus*** SEAGAUGE Wave and Tide Recorder and SBE **53** BPR Bottom Pressure Recorder

SBE 9*plus* and 25

Sea-Bird software (SEASAVE or SBE Data Processing) uses calibration coefficients programmed in a configuration (.con) file to convert raw data from these instruments to engineering units.

Follow this procedure to correct the pressure:
1. With the instrument in the air, place it in the orientation it will have when deployed.
2. In SEASAVE, in the .con file, set the pressure offset to 0.0.
3. Acquire data in SEASAVE, and display the pressure sensor output in decibars.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the .con file.

Offset Correction Example:
Pressure displayed at elevation is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
Enter offset in .con file.

SBE 16*plus* (RS-232 version), 19*plus*, and 49

Sea-Bird software (SEASAVE or SBE Data Processing) uses calibration coefficients programmed in a configuration (.con) file to convert raw data from these instruments to engineering units. These instruments are also able to directly output data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the instrument.

Follow this procedure to correct the pressure:
1. With the instrument in the air, place it in the orientation it will have when deployed.
2. In SEASAVE, in the .con file, set the pressure offset to 0.0.
3. Acquire data in SEASAVE, and display the pressure sensor output in decibars.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the .con file.
6. Also enter the calculated offset in the instrument (use the **POFFSET=** command in SEATERM).

Offset Correction Example:
Pressure displayed at elevation is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
Enter offset in .con file and in instrument.

SBE 16*plus* (RS-485 version) and 16*plus*-IM

Sea-Bird software (SEASAVE or SBE Data Processing) uses calibration coefficients programmed in a configuration (.con) file to convert raw data from these instruments to engineering units. These instruments are also able to directly output data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the instrument.

Follow this procedure to correct the pressure:
1. With the instrument in the air, place it in the orientation it will have when deployed.
2. In SEATERM, set the pressure offset to 0.0 (**#iiPOFFSET=0**) and set the output format to converted data in decimal form (**#iiOUTPUTFORMAT=3**).
3. Acquire data using the **#iiTP** command.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the instrument (use **#iiPOFFSET=** in SEATERM).
6. Also enter the calculated offset in the .con file, using SBE Data Processing.

Offset Correction Example:
Pressure displayed at elevation is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
Enter offset in .con file and in instrument.

SBE 37 (all models)

The SBE 37 is able to directly output data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the instrument. The SBE 37 does not use a .con file.

Follow this procedure to correct the pressure:
1. With the SBE 37 in the air, place it in the orientation it will have when deployed.
2. In SEATERM, set the pressure offset to 0.0 and pressure sensor output to decibars. *
3. Acquire data. *
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the SBE 37 in SEATERM. *

   Offset Correction Example:
   Pressure displayed at elevation is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
   Enter offset in the SBE 37.

* NOTE: Commands for setting pressure offset, setting output format, and acquiring data vary:

Instrument	Pressure Offset Command	Output Format Command	Command to Acquire Data
SBE 37-IM and 37-IMP, and RS-485 version of SBE 37-SM, 37-SMP, 37-SI, and 37-SIP	**#iiPOFFSET=**	**#iiFORMAT=1** or **#iiFORMAT=2**	**#iiTP** (measures and outputs pressure 30 times)
RS-232 version of SBE 37-SM, 37-SMP, 37-SI, and 37-SIP	**POFFSET=**	**FORMAT=1** or **FORMAT=2**	**TP** (measures and outputs pressure 100 times)

SBE 50

The SBE 50 is able to directly output data that is already converted to engineering units (psia, decibars, or depth in feet or meters), using calibration coefficients that are programmed into the instrument. The SBE 50 does not use a .con file.

Follow this procedure to correct the pressure:
1. With the SBE 50 in the air, place it in the orientation it will have when deployed.
2. In SEATERM, set the pressure offset to 0.0 (**POFFSET=0**) and set the output format to the desired format (**OUTPUTFORMAT=**).
3. Acquire data using the **TS** command a number of times.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the SBE 50 (use **POFFSET=** in SEATERM). The offset must be entered in units consistent with **OUTPUTFORMAT=**. For example, if the output format is decibars (**OUTPUTFORMAT=2**), enter the offset in decibars.

   Offset Correction Example:
   Pressure displayed at elevation with **OUTPUTFORMAT=2** (db) is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
   Enter offset in the SBE 50.

SBE 52-MP

The SBE 52-MP is able to directly output data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the instrument. The SBE 52-MP does not use a .con file.

Follow this procedure to correct the pressure:
1. With the SBE 52-MP in the air, place it in the orientation it will have when deployed.
2. In SEATERM, set the pressure offset to 0.0 (**POFFSET=0**).
3. Acquire data using the **TP** command.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the SBE 52-MP (use **POFFSET=** in SEATERM).

   Offset Correction Example:
   Pressure displayed at elevation is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
   Enter offset in the SBE 52-MP.

SBE 39-IM

The SBE 39-IM directly outputs data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the SBE 39-IM. The SBE 39-IM does not use a .con file.

Follow this procedure to correct the pressure:
1. With the SBE 39-IM in the air, place it in the orientation it will have when deployed.
2. In SEATERM, set the pressure offset to 0.0 (**#iiPOFFSET=0**).
3. Acquire data using the **#iiTP** command.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the SBE 39-IM (use **#iiPOFFSET=** in SEATERM)

   Offset Correction Example:
   Pressure displayed at elevation is -1.655 db. *Offset* = 0 – (-1.655) = + 1.655 db
   Enter offset in the SBE 39-IM.

SBE 39

The SBE 39 directly outputs data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the SBE 39. The SBE 39 does not use a .con file. The SBE 39 is a special case, because its programmed calibration coefficients do not currently include a pressure offset term. The lack of a pressure offset term creates two difficulties when deploying at elevations above sea level:

- After the data is recorded and uploaded, you must perform post-processing to adjust for the pressure offset. Sea-Bird software cannot currently perform this adjustment for the SBE 39.
- Without adjusting the instrument range, internal calculation limitations prevent the SBE 39 from providing accurate data at high elevations. Specifically, if (0.1 * sensor range) < (decrease in atmospheric pressure from sea level to elevation), an error condition in the SBE 39's internal calculations occurs. The table below tabulates the atmospheric pressure and approximate elevation at which this calculation limitation occurs for different pressure sensor ranges.

Range (m or db) *	**Range (psi) = Range (db) / 0.689476**	**0.1 * Range (psi)**	**Atmospheric Pressure (psi) at elevation at which error occurs = [14.7 – 0.1 * Range (psi)]**	**Approximate Corresponding Elevation (m)**
20	29	2.9	11.8	1570
100	145	14.5	0.2	7885
350	507	50.7	-	-
1000	1450	145	-	-
2000	2900	290	-	-
3500	5076	507	-	-
7000	10152	1015	-	-

* Notes:

- Although decibars and meters are not strictly equal, this approximation is close enough for this Application Note. See Application Note 69 for conversion of pressure (db) to depth (m) for fresh or salt water applications.
- Equations used in conversions -
  As shown on page 1: pressure (db) = [pressure (psia) – 14.7] * 0.689476;
  Rearranging: pressure (psia) = [Pressure (db) / 0.689476] + 14.7
  Measuring relative to atmospheric: pressure (psi; relative to atmospheric pressure) = Pressure (db) / 0.689476

From the table, it is apparent that the only practical limitation occurs with a 20 meter pressure sensor. To use the SBE 39 in this situation, change the sensor range internally to 100 meters by entering **PRANGE=100** in the SBE 39 (using SEATERM). This changes the electronics' operating range, allowing you to record pressure data at high elevations, but slightly decreases resolution. After the data is recorded and uploaded, perform post-processing to adjust for the pressure offset. Note that Sea-Bird software cannot currently perform this adjustment for the SBE 39.

CAUTION: Changing **PRANGE** in the SBE 39 does not increase the actual maximum water depth at which the instrument can be used (20 meters) without damaging the sensor.

> *Example 1*: You want to deploy the SBE 39 with a 20 m pressure sensor in a mountain lake at 1400 meters (4590 feet). This is lower than 1570 meters shown in the table, so you do not need to adjust the sensor range. After the data is recorded and uploaded, perform post-processing to adjust for the pressure offset.
>
> *Example 2*: You want to deploy the SBE 39 with a 20 m pressure sensor in a mountain lake at 2000 meters (6560 feet). This is higher than 1570 meters shown in the table, so you need to adjust the sensor range. In SEATERM, set **PRANGE=100** to allow use of the SBE 39 at this elevation. After the data is recorded and uploaded, perform post-processing to adjust for the pressure offset.

SBE 26*plus* and 53

Unlike our other instruments that include a pressure sensor, the SBE 26*plus* and 53 output absolute pressure (i.e., at the surface the output pressure is atmospheric pressure at the deployment elevation). Therefore, no corrections are required when using these instruments above sea level. SBE 26*plus* / 53 software (SEASOFT for Waves) includes a module that can subtract measured barometric pressures from tide data, and convert the resulting pressures to water depths.

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APPLICATION NOTE NO. 83 **April 2006**

Deployment of Moored Instruments

This Application Note applies to Sea-Bird instruments intended to provide time series data on a mooring or fixed site:

- SBE 16*plus* and 16*plus*-IM SEACAT Conductivity and Temperature Recorder
- SBE 19*plus* SEACAT Profiler CTD (in moored mode)
- SBE 26*plus* SEAGAUGE Wave and Tide Recorder
- SBE 37 (-IM, -IMP, -SM, -SMP, -SI, -SIP) MicroCAT Conductivity and Temperature Recorder
- SBE 39 and 39-IM Temperature Recorder
- SBE 53 BPR Bottom Pressure Recorder

We have developed a check list to assist users in deploying moored instruments. **This checklist is intended as a guideline to assist you in developing a checklist specific to your operation and instrument setup.** The actual procedures and procedure order may vary, depending on such factors as:

- Instrument communication interface - RS-232, RS-485, or inductive modem
- Deployment interface for RS-232 or RS-485 - with an I/O cable for real-time data or with a dummy plug for self-contained operation
- Sampling initiation - using delayed start commands to set a date and time for sampling to automatically begin or starting sampling just before deploying the instrument
- Sensors included in your instrument –
  - Pressure is optional in the SBE 16*plus*, 16*plus*-IM, 37 (all), 39, and 39-IM.
  - Conductivity is optional in the SBE 26*plus* and 53, and is not provided in the SBE 39 and 39-IM.
  - Optional auxiliary sensors can be integrated with the SBE 16*plus*, 16*plus*-IM, and 19*plus*.

Deployment Summary

Instrument serial number	
Mooring number	
Date of deployment	
Depth of instrument	
Intended date of recovery	
Capture file printout(s) attached, or file name and location (showing status command, calibration coefficients command if applicable, any other applicable commands)	
Actual date of recovery	
Condition of instrument at recovery	
Notes	

Preparation for Deployment

Task	Completed?
If applicable, upload existing data in memory. Perform preliminary processing / analysis of data to ensure you have uploaded all data, that data was not corrupted in upload process, and that (if uploading converted data) instrument EEPROM was programmed with correct calibration coefficients. If there is a problem with data, you can try to upload again now. Once you record over data in next deployment, opportunity to correct any upload problem is gone.	
Initialize memory to make entire memory available for recording. If memory is not initialized, data will be stored after last recorded sample.	
Calculate battery endurance to ensure sufficient power for intended sampling scheme. See instrument manual for example calculations.	
Calculate memory endurance to ensure sufficient memory for intended sampling scheme. See instrument manual for example calculations.	
Install fresh batteries. Even if you think there is adequate battery capacity left for another deployment, cost of fresh batteries is small price to pay to ensure successful deployment.	
Establish setup / operating parameters. 1. Click Capture button in SEATERM and enter file name to record instrument setup, so you have complete record of communication with instrument. 2. Set current date and time. 3. Establish setup / operating parameters. 4. If desired, set date and time for sampling to automatically begin. 5. Send *Status* command (**DS** or **#iiDS**) to verify and provide record of setup. ** 6. Send *Calibration Coefficients* command (**DC**, **#iiDC**, **DCAL**, or **#iiDCAL**) to verify and provide record of calibration coefficients. **	
Get conductivity sensor ready for deployment: Remove protective plugs that were placed in Anti-Foulant Device caps **or** remove Tygon tubing that was looped end-to-end around conductivity cell to prevent dust / dirt from entering cell. *Note*: Deploying instrument with protective plugs or looped Tygon tubing in place will prevent instrument from measuring conductivity during deployment, and may destroy cell.	
Install fresh AF24173 Anti-Foulant Devices for conductivity sensor. Rate of anti-foul use varies greatly, depending on location and time of year. If you think there is adequate capability remaining, and previous deployment(s) in this location and at this time of year back up that assumption, you may not choose to replace Anti-Foulant Devices for every deployment. However, as for batteries, cost of fresh Anti-Foulant Devices is small price to pay to ensure successful deployment.	
For instrument with external pump (16*plus*, 16*plus*-IM, 19*plus*), verify that system plumbing is correctly installed. See instrument manual for configuration.	
Start sampling (if you did not set up instrument with a delayed start command), or verify that sampling has begun (if you set up instrument with a delayed start command). 1. Click Capture button in SEATERM and enter file name to record instrument setup, so you have a complete record of communication with instrument. 2. If you did not set up instrument with a delayed start command, send command to start sampling. 3. Send *Status* command (**DS** or **#iiDS**) to verify and provide record that instrument is sampling. ** 4. Send *Send Last* command (**SL** or **#iiSL**) to look at most recent sample and verify that output looks reasonable (i.e., ambient temperature, zero conductivity, atmospheric pressure). ** 5. If instrument has pressure sensor, record atmospheric pressure with barometer. You can use this information during data processing to check and correct for pressure sensor drift, by comparing to instrument's pressure reading in air (from Step 4). Note: For instrument with pump (external **or** integral), avoid running pump *dry* for extended period of time.	
If cable connectors or dummy plugs were unmated, reinstall cables or dummy plugs as described in *Application Note 57: I/O Connector Care and Installation*. Failure to correctly install cables may result in connector leaking, causing data errors as well as damage to bulkhead connector.	
Install mounting hardware on instrument. Verify that hardware is secure.	

** **Note:** Actual instrument command is dependent on communication interface and instrument.

Recovery

Immediately upon recovery

Task	Completed?
Rinse instrument with fresh water.	
Remove locking sleeve on dummy plug or cable, slide it up cable (if applicable), and rinse connection (still mated) with fresh water.	
For instrument with pump (external or integral), stop sampling. Connect to instrument in SEATERM and send command to stop sampling (**STOP** or **#iiSTOP**). Stop sampling as soon as possible upon recovery to avoid running pump *dry* for an extended period of time. **	
If instrument has pressure sensor, record atmospheric pressure with barometer. You can use this information during data processing to check and correct for pressure sensor drift, by comparing to instrument's pressure reading in air.	
Gently rinse conductivity cell with clean de-ionized water, drain, and gently blow through cell to remove larger water droplets. • If cell is not rinsed between uses, salt crystals may form on platinized electrode surfaces. When instrument is used next, sensor accuracy may be temporarily affected until these crystals dissolve. • Note that **vigorous flushing is not recommended** if you will be sending instrument to Sea-Bird for post-deployment calibration to establish drift during deployment.	
For instrument with external pump (16*plus*, 16*plus*-IM, 19*plus*): Remove Tygon tubing from pump head's hose barbs, and rinse inside of pump head, pouring fresh water through a hose barb. If pump head is not rinsed between uses, salt crystals may form on impeller. Over time, this may *freeze* impeller in place, preventing pump from working.	
Install protective plugs in Anti-Foulant Device caps or loop Tygon tubing end-to-end around conductivity cell for *long term* storage. This will prevent dust / dirt from entering conductivity cell. *Note*: For short term (less than 1 day) storage, see *Application Note 2D: Instructions for Care and Cleaning of Conductivity Cells*.	
Upload data in memory. 1. Connect to instrument in SEATERM. 2. If you have not already done so, send command to stop sampling (**STOP** or **#iiSTOP**). ** 3. Upload data in memory, using Upload button in SEATERM. 4. Perform preliminary processing / data analysis to ensure you have uploaded all data, data was not corrupted in upload process, and (if uploading converted data) instrument EEPROM was programmed with correct calibration coefficients. If there is a problem with data, you can try to upload again now. Once you record over data in next deployment, opportunity to correct any upload problem is gone.	

** **Note:** Actual instrument command is dependent on communication interface and instrument.

Later

Task	Completed?
Clean conductivity cell, as needed: • Do not clean cell if you will be sending instrument to Sea-Bird for post-deployment calibration to establish drift during deployment. • Clean cell if you will not be performing a post-deployment calibration to establish drift. See cleaning instructions in instrument manual and *Application Note 2D: Instructions for Care and Cleaning of Conductivity Cells*.	
For instrument with external pump (16*plus*, 16*plus*-IM, 19*plus*): Clean pump as described in *Application Note 75: Maintenance of SBE 5T and 5M Pumps*.	
(Annually) Inspect and (if applicable) rinse pressure port. See instructions in instrument manual.	
Send instrument to Sea-Bird for calibrations / regular inspection and maintenance. We typically recommend that instrument be recalibrated once a year, but possibly less often if used only occasionally. We recommend that you return instrument to Sea-Bird for recalibration. In between laboratory calibrations, take field salinity samples to document conductivity cell drift. ***Notes:*** 1. We cannot place instrument in our calibration bath if heavily covered with biological material or painted with anti-foul paint. Remove as much material as possible before shipping to Sea-Bird; if we need to clean instrument before calibrating it, we will charge you for cleaning. To remove barnacles, plug ends of conductivity cell to prevent cleaning solution from getting into cell, then soak instrument in white vinegar *for a few minutes*. To remove anti-foul paint, use Heavy Duty Scotch-Brite pad or similar material. 2. If using lithium batteries, do not ship batteries installed in instrument. See http://www.seabird.com/customer_support/LithiumBatteriesRev2005.htm for shipping details.	

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Web: www.seabird.com

APPLICATION NOTE NO. 84 **July 2006**

Using Instruments with Druck Pressure Sensors in Muddy or Biologically Productive Environments

This Application Note applies to Sea-Bird instruments with **Druck** pressure sensors, for moored applications or other long deployments that meet **either** of the following conditions:

- used in a **high-sediment (muddy)** environment, in a **pressure sensor end up** orientation
- used in a **biologically productive** environment, in **any** orientation

Standard pressure sensor port plug

At Sea-Bird, a pressure port plug with a small (0.042-inch diameter) vent hole in the center is inserted in the pressure sensor port. The vent hole allows hydrostatic pressure to be transmitted to the pressure sensor inside the instrument.

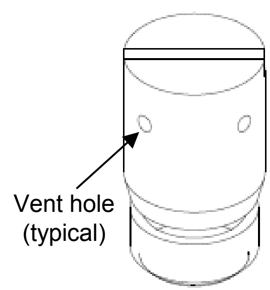
- If the instrument is deployed in a **high-sediment (muddy)** environment **with the pressure sensor end up**, the pressure port may partially fill with sediment (through the vent hole) over time, causing a delay in the pressure response.
- If the instrument is deployed in a **biologically productive** environment, the vent hole may be covered with biological growth over time, causing a delay in the pressure response, or in extreme cases completely blocking the pressure signal.

***Note**:* Photo is for an SBE 37-SM. Pressure port details are similar for all instruments included in this application note.

Sea-Bird has developed a high-head pressure port plug for deployment in muddy and/or biologically productive environments. The high-head plug extends beyond the surface of the instrument end cap, and has *four* horizontal vent holes connecting *internally* to a vertical vent hole.

- The horizontal orientation of the external holes prevents the deposit of sediment inside the pressure port.
- Each of the four vent holes is larger (0.062-inch vs. 0.042-inch diameter) than the single vent hole in the standard pressure port plug, significantly reducing the possibility that biological growth will cover all of the hole(s).

To purchase the high-head pressure port plug, Part Number 233186, contact Sea-Bird.



High-Head
Pressure Port Plug,
Part Number 233186

High-Head Pressure Port Plug Installation

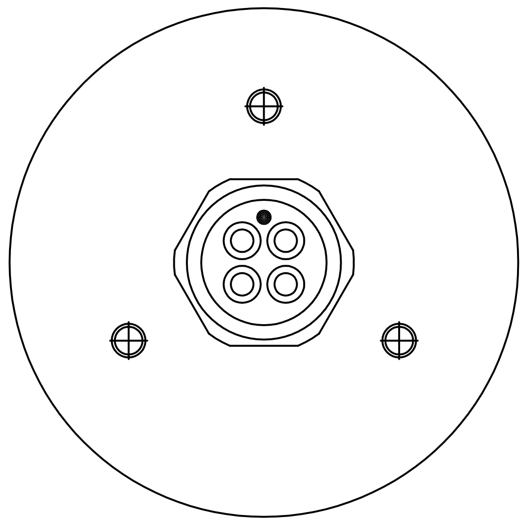
1. Unscrew the standard pressure port plug from the pressure port.
2. Rinse the pressure port with warm, de-ionized water to remove any particles, debris, etc. **Do not put a brush or any object in the pressure port;** doing so may damage or break the pressure sensor.
3. Install the *high-head* pressure port plug in the pressure port.

Note: Until several years ago, Sea-Bird filled the pressure port with silicon oil at the factory. For **Druck** pressure sensors, we determined that this was unnecessary, and no longer do so. It is not necessary to refill the oil in the field. However, for **Paine** or **Paroscientific Digiquartz** pressure sensors, the pressure port **does** need to be refilled with silicon oil. Please contact Sea-Bird with the serial number of your instrument if you are unsure of the type of pressure sensor installed in your instrument.

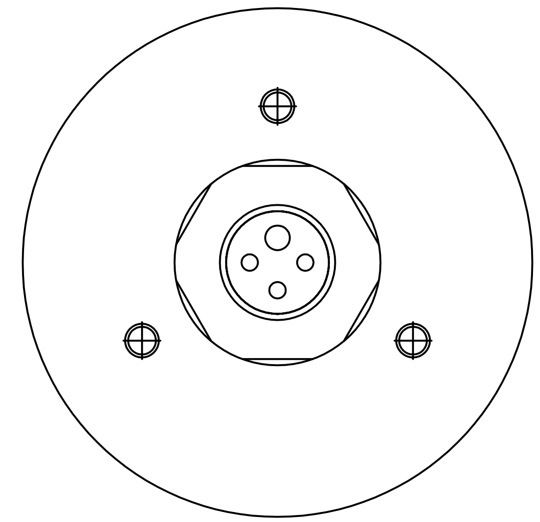
DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
09.06.02	A	Add Subconn, SBE49 Add reference to both endcap types	CB	MJ	CB
04.21.03	B	ADD RS-485, CLARIFY PINOUT	CB	CB	

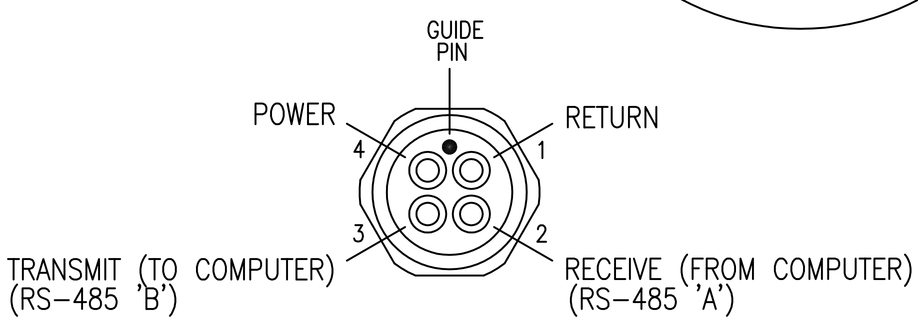
WET-MATABLE (SUBCONN) CONNECTOR OPTIONS

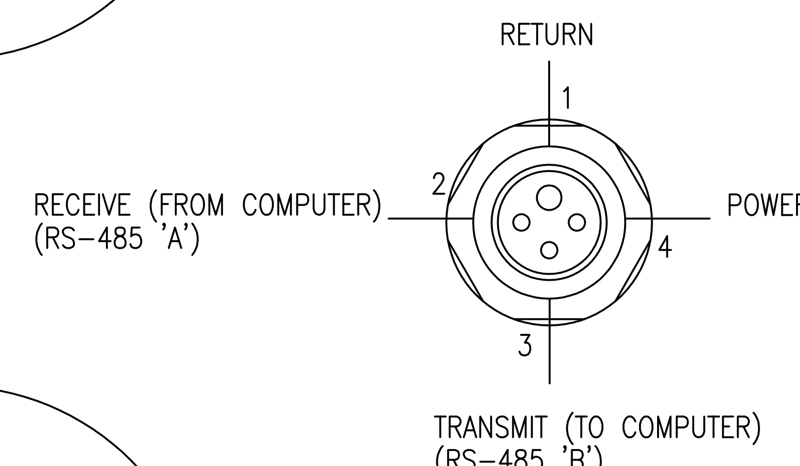
STANDARD (IMPULSE) CONNECTOR OPTIONS

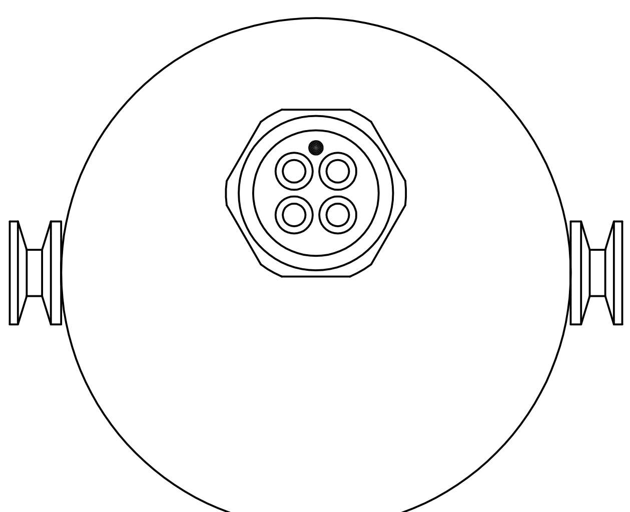


Standard SBE37/49 Endcap Design, for CTDs with Modular Housings

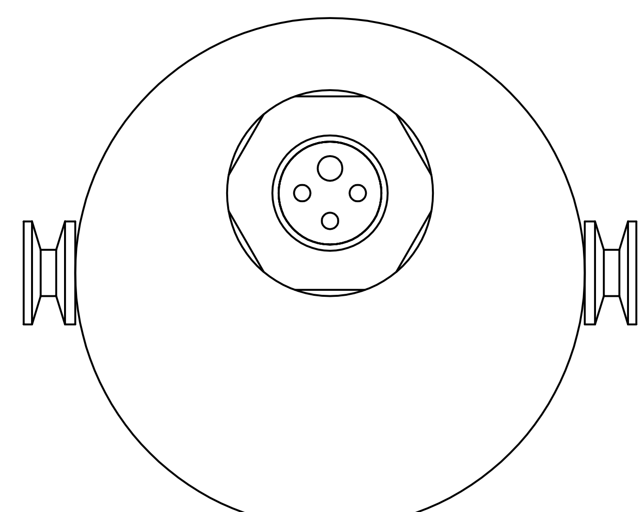






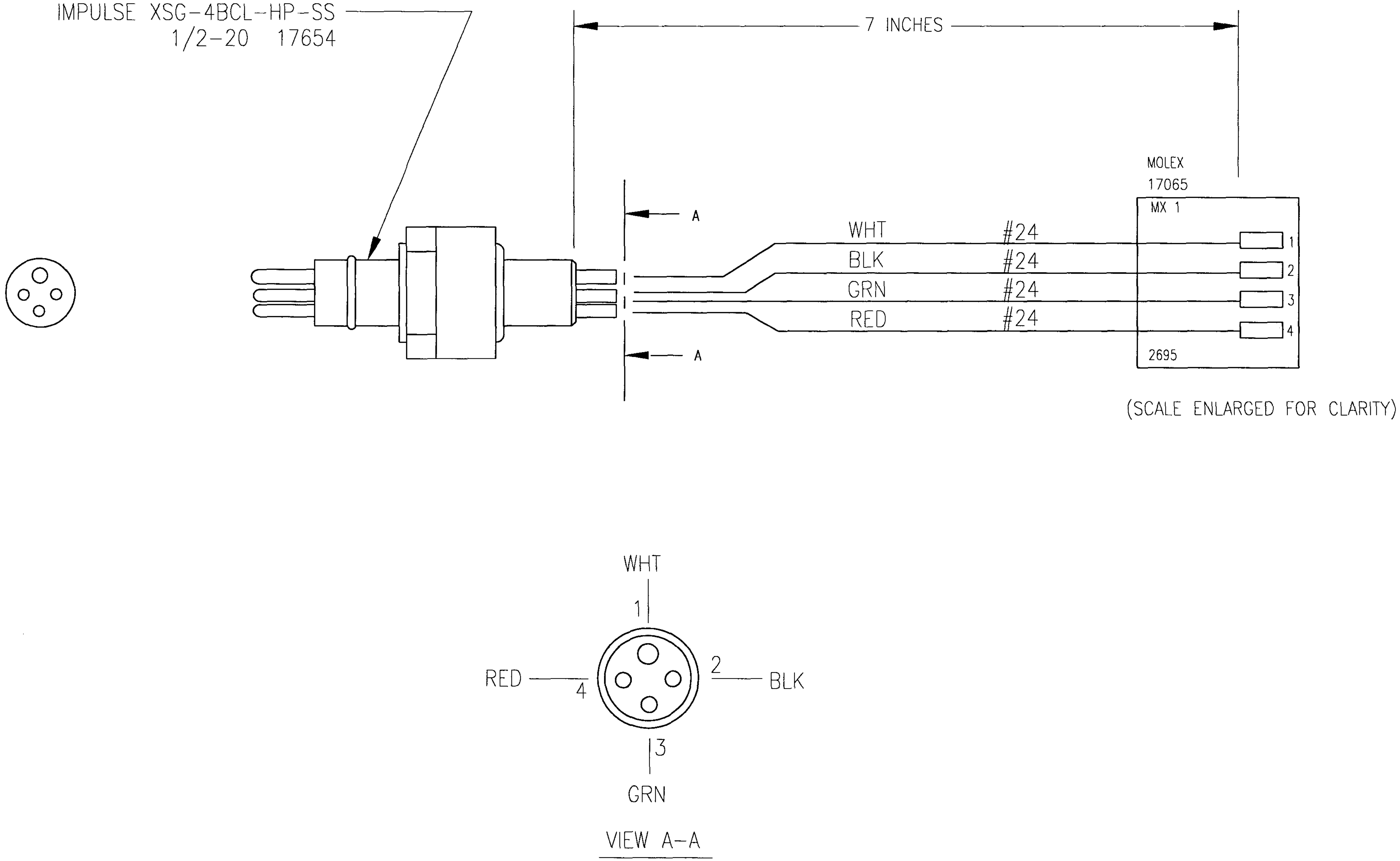


SBE37 Only Endcap Design, for Microcats with Potted Housings



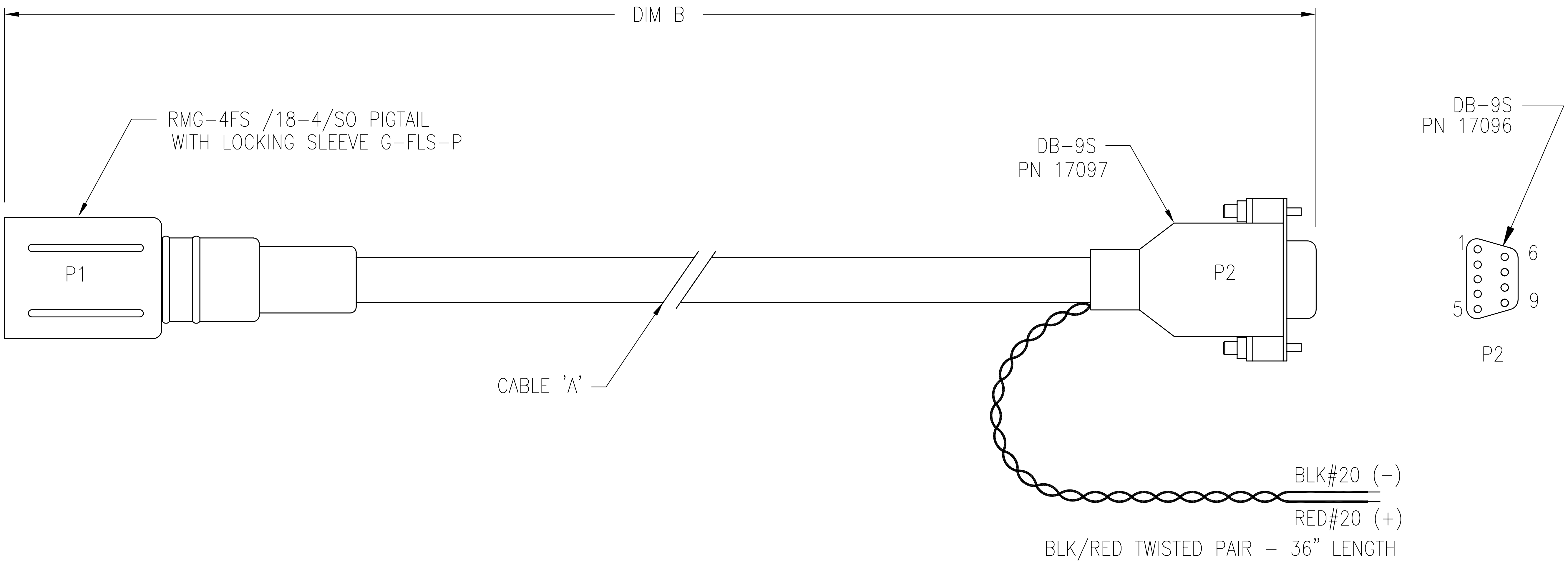
TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N N/A	SCALE NTS	DRAWN BY DG / APPROVED BY
DECIMAL	TITLE SBE37-SM/SI, SBE49, RS-232/RS-485 EXTERNAL POWER, EXTERNAL I/O WIRING		
ANGULAR	DATE 1/14/97	DWG NO. 50151	REV B

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
2/99	A	CHANGED WIRE LENGTH		CEG	
9/11/01	B	CORRECTED WIRE TYPE, AND P/N		LRG	



SEA-BIRD ELECTRONICS, INC		
P/N N/A	SCALE 1:1	DRAWN BY CEG / APPROVED BY
SBE 37SI 4 PIN DATA I/O STANDARD WIRING		
DATE 5/1/97	DWG NO. 40890	SHEET 1 of 1 / REV B

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
6.19.02	A	CHANGED PIN ASSIGNMENTS	CB	KLP	–
4.3.07	B	UPDTAE LENGTHS	CB	CB	–



		DIM B	
SBE PN	CABLE 'A' PN	FEET	METER
801133	17267	17 FT	5 METER
801302	171572	200 FT	60.9 METER
801355	17114	65.6 FT	20 METER
801385	17031	8 FT	2.4 MEER
801461	17106	35 FT	10.6 METER
801560	17117	98.5 FT	30 METER
801735	172349	131 FT	40 METER

B

P1 RMG-4FS	P2 DB-9S	BLK/RED PAIR
PIN 1 WHITE	PIN 5	BLK
PIN 2 BLACK	PIN 3	
PIN 3 GRN	PIN 2	
PIN 4 RED		RED

TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N SEE TABLE	SCALE NTS	DRAWN BY RMB / APPROVED BY
DECIMAL	TITLE CABLE: RMG-4FS TO DB-9S ASSEMBLY W/ POWER LEADS		
ANGULAR	DATE 3.26.99	DRAWING NUMBER 32277	REV B

WARRANTY POLICY 2006

5-YEAR LIMITED WARRANTY (NEW PRODUCTS)

For a period of five years after the date of original shipment from our factory, products manufactured by Sea-Bird are warranted to function properly and be free of defects in materials and workmanship. Should a Sea-Bird instrument fail during the warranty period, return it freight pre-paid to our factory. We will repair it (or at our option, replace it) at no charge, and pay the cost of shipping it back to you. Certain products and components have modified coverage under this warranty as described below.

LIMITED WARRANTY ON SERVICE & REPAIRS

Service work, repairs, replacement parts and modifications are warranted to be free of defects in materials or workmanship for the remainder of the original 5-year warranty or one year from the date of shipment from our factory after repair or service, which ever is longer. Certain products and components have modified coverage under this warranty as described below.

MODIFICATIONS / EXCEPTIONS / EXCLUSIONS

1. The SBE 43 DO sensor is warranted to function properly for 5 years. Under normal use however, the electrolyte in an SBE 43 DO sensor will require replenishment after about 3 years. Purchase of an SBE 43 includes one free electrolyte replenishment (as necessitated by chemical depletion of electrolyte) anytime during the warranty period. To obtain the replenishment, return the sensor freight pre-paid to our factory. We will refurbish it for free (electrolyte refill, membrane replacement, and recalibration) and pay the cost of shipping it back to you. Membrane damage or depletion of electrolyte caused by membrane damage is not covered by this warranty.

2. Because pH and other dissolved oxygen (DO) electrodes have a limited life caused by the depletion of their chemical constituents during normal storage and use, our warranty applies differently to such electrodes. Electrodes in SBE 13Y and 23Y DO sensors, SBE 18 pH sensors, and SBE 27 pH/ORP sensors are covered under warranty for the first 90 days only. Other components of the sensor are covered for 5 years.

3. Equipment manufactured by other companies (e.g., fluorometers, transmissometers, PAR, optical backscatter sensors, altimeters, etc.) are warranted only to the limit of the warranties provided by their original manufacturers (typically 1 year).

4. Batteries, zinc anodes or other consumable/expendable items are not covered under this warranty.

5. Electrical cables and dummy plugs are warranted to function properly and be free of defects in materials and workmanship for 1 year.

6. This warranty is void if in our opinion the instrument has been damaged by accident, mishandled, altered, improperly serviced, or repaired by the customer where such treatment has affected its performance or reliability. In the event of such misuse/abuse by the customer, costs for repairs plus two-way freight costs will be borne by the customer. Instruments found defective should be returned to the factory carefully packed, as the customer will be responsible for freight damage.

7. Incidental or consequential damages or costs incurred as a result of product malfunction are not the responsibility of SEA-BIRD ELECTRONICS, INC

<u>Warranty Administration Policy</u>

Sea-Bird Electronics, Inc. and its authorized representatives or resellers provide warranty support only to the original purchaser. Warranty claims, requests for information or other support, and orders for post-warranty repair and service, by end-users that did not purchase directly from Sea-Bird or an authorized representative or reseller, must be made through the original purchaser. The intent and explanation of our warranty policy follows:

1. Warranty repairs are only performed by Sea-Bird.

2. Repairs or attempts to repair Sea-Bird products performed by customers (owners) shall be called *owner repairs*.

3. Our products are designed to be maintained by competent owners. Owner repairs of Sea-Bird products will NOT void the warranty coverage (as stated above) simply as a consequence of their being performed.

4. Owners may make repairs of any part or assembly, or replace defective parts or assemblies with Sea-Bird manufactured spares or authorized substitutes without voiding warranty coverage of the entire product, or parts thereof. Defective parts or assemblies removed by the owner may be returned to Sea-Bird for repair or replacement within the terms of the warranty, without the necessity to return the entire instrument. If the owner makes a successful repair, the repaired part will continue to be covered under the original warranty, as if it had never failed. Sea-Bird is not responsible for any costs incurred as a result of owner repairs or equipment downtime.

5. We reserve the right to refuse warranty coverage *on a claim by claim basis* based on our judgment and discretion. We will not honor a warranty claim if in our opinion the instrument, assembly, or part has been damaged by accident, mishandled, altered, or repaired by the customer *where such treatment has affected its performance or reliability*.

6. For example, if the CTD pressure housing is opened, a PC board is replaced, the housing is resealed, and then it floods on deployment, we do not automatically assume that the owner is to blame. We will consider a claim for warranty repair of a flooded unit, subject to our inspection and analysis. If there is no evidence of a fault in materials (e.g., improper or damaged o-ring, or seal surfaces) or workmanship (e.g., pinched o-ring due to improper seating of end cap), we would cover the flood damage under warranty.

7. In a different example, a defective PC board is replaced with a spare and the defective PC board is sent to Sea-Bird. We will repair or replace the defective PC board under warranty. The repaired part as well as the instrument it came from will continue to be covered under the original warranty.

8. As another example, suppose an owner attempts a repair of a PC board, but solders a component in backwards, causing the board to fail and damage other PC boards in the system. In this case, the evidence of the backwards component will be cause for our refusal to repair the damage under warranty. However, this incident will NOT void future coverage under warranty.

9. If an owner's technician attempts a repair, we assume his/her qualifications have been deemed acceptable to the owner. The equipment owner is free to use his/her judgment about who is assigned to repair equipment, and is also responsible for the outcome. The decision about what repairs are attempted and by whom is entirely up to the owner.

Service Request Form

To return your instrument for calibration or other service, please take a few moments to provide us with the information we need, so we can serve you better.

PLEASE:

1. **Get a Returned Material Authorization (RMA) number from Sea-Bird (*phone 425-643-9866, fax 425-643-9954, or email seabird@seabird.com*). Reference the RMA number on this form, on the outside shipping label for the equipment, and in all correspondence related to this service request.**
2. **Fill out 1 form for each type (model) of instrument.**
3. **Include this form when shipping the instrument to Sea-Bird for servicing.**
4. **Fax us a copy of this form on the day you ship.** ***FAX: (425) 643-9954***

RETURNED MATERIAL AUTHORIZATION (RMA) NUMBER: ______________________________

DATE EQUIPMENT REQUIRED BY: ______________________________

DO YOU REQUIRE A WRITTEN QUOTE? ______________________________

CONTACT INFORMATION
Your name: ______________________________
Institution/Organization/Company: ______________________________
Shipping/Delivery address for packages: ______________________________
____
____
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 repairs in the appropriate section of the form.)
SEASOFT Version you have been using with this instrument(s): ______________________________

[ ] **Calibration Services:**
____Calibration (includes basic diagnostic):
___Temperature ___Conductivity ___Pressure ___DO ___pH
(Please allow a minimum of 3 weeks after we receive the instrument(s) to complete calibration.)
____Other (specify): ______________________________
____

[ ] **Internal Inspection and O-Ring Replacement (includes hydrostatic pressure test):**
Additional charges may apply.
____
____

[ ] **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) that shows the problems you describe. Also send the .con files you used to acquire or display the data.
Problem Description (continue on additional pages if needed; include instrument serial number if multiple instruments are part of shipment): ______________________________
____
____
____

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

1. **Domestic Shipments (USA)** - **Ship prepaid** (via UPS, FedEx, DHL, etc.) directly to:
   Sea-Bird Electronics, Inc.
   1808 136th Place NE
   Bellevue, WA 98005, USA
   Telephone: (425) 643-9866 Fax: (425) 643-9954
2. **International Shipments** –
   Option A. Ship via **PREPAID AIRFREIGHT to SEA-TAC International Airport (IATA Code "SEA")**:
   Sea-Bird Electronics, Inc.
   1808 136th Place NE
   Bellevue, WA 98005, USA
   Telephone: (425) 643-9866 Fax: (425) 643-9954 E-mail: seabird@seabird.com

   Notify: MTI Worldwide Logistics for Customs Clearance
   Seattle, WA, USA
   Telephone: (206) 431-4366 Fax: (206) 431-4374 E-mail: bill.keebler@mti-worldwide.com

   E-mail flight details and airway bill number to seabird@seabird.com and bill.keebler@mti-worldwide.com when your shipment is en-route. Include your RMA number in the e-mail.

   Option B. Ship via **EXPRESS COURIER directly to Sea-Bird Electronics**:
   If you choose this option, **we recommend shipping via UPS, FedEx, or DHL**. Their service is door-to-door, including customs clearance. It is not necessary to notify our customs agent, MTI Worldwide, if you ship using a courier service.

   E-mail the airway bill / tracking number to seabird@seabird.com when your shipment is en-route. Include your RMA number in the e-mail.

   For All International Shipments:
   Include a **commercial invoice** showing the description of the instruments, and **Value for Customs purposes only**.
   Include the following statement:
   "U.S. Goods Returned for Repair/Calibration. Country of Origin: USA. Customs Code: 9801001012."
   Failure to include this statement in your invoice will result in US Customs assessing duties on the shipment, which we will in turn pass on to the customer/shipper.

Note: Due to changes in regulations, if Sea-Bird receives an instrument from outside the U.S. in a crate containing non-approved (i.e., non-heat-treated) wood, we will return the instrument in a new crate that meets the requirements of ISPM 15 (see http://www.seabird.com/customer_support/retgoods.htm for details). We will charge for the replacement crate based on the dimensions of the crate we receive, determined as follows:

1. Multiply the crate length x width x height in centimeters (overall volume in cm^3, not internal volume).
2. Determine the price based on your calculated overall volume and the following chart:

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

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