SBE 37-SI MicroCAT

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

User Manual, Version 029

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, Washington 98005 USA
Tel: 425/643-9866
Fax:425/643-9954

This page intentionally left blank.

SBE 37-SI MICROCAT OPERATING AND REPAIR MANUAL

TABLE OF CONTENTS

Manual Generation Date.. 1

Limited Liability Statement.. 2

Declaration of Conformity.. 4

SBE 37SI, RS-232, Manual - Version 029.. 5

SBE 37SI, RS-232, Reference Sheet - Version 012............................... 81

Calibration Certificates.. 83

SBE 37SI Specification Sheet.. 89

Appnotes... 91

Dwg 50151B Ext I/O Wiring, External Power, RS-232/RS-485........... 131

Dwg 40890B SBE 37SI/SM 4-Pin Data I/O Wiring, Standard.............. 132

Dwg 32277B Cable Assembly, RMG-4FS to DB-9S w/ Power Leads... 133

Warranty... 134

Service Request Form... 137

SEA-BIRD ELECTRONICS, INC.
13431 NE 20th St.
Bellevue, Washington 98005 USA
Phone: (425) 643 9866
Fax: (425) 643 9954
Email: seabird@seabird.com

Manual Generation Date: 23 June 2011

LIMITED LIABILITY STATEMENT

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

SEA-BIRD ELECTRONICS, INC. disclaims all product liability risks arising from the use or servicing of this system. SEA-BIRD ELECTRONICS, INC. has no way of controlling the use of this equipment or of choosing the personnel to operate it, and therefore cannot take steps to comply with laws pertaining to product liability, including laws which impose a duty to warn the user of any dangers involved in operating this equipment. Therefore, acceptance of this system by the customer shall be conclusively deemed to include a covenant by the customer to defend, indemnify, and hold SEA-BIRD ELECTRONICS, INC. harmless from all product liability claims arising from the use of servicing of this system.

This page intentionally left blank.

Sea-Bird Electronics, Inc.
13431 NE 20th Street, Bellevue, WA 98005 USA

DECLARATION OF CONFORMITY

Manufacturer's Name: **Sea-Bird Electronics**
Manufacturer's Address: 13431 NE 20th Street
Bellevue, WA 98005, USA

The Authorized Representative located within the Community is:
OTT MESSTECHNIK GmbH & Co.KG
P.O.Box: 2140 / 87411 Kempten / Germany
Ludwigstrasse 16 / 87437 Kempten
Internet: http://www.ott.com
Phone: +49 831 5617 – 100
Fax: +49 831 5617 - 209

Device Description: Various Data Acquisition Devices and Sensors

Model Numbers:

3S	3F	3plus	4C	4M	5T	5P	5M	7	8	9plus	11plus
14	16plus V2		16plus-IM V2		17plus V2		18	19plus V2		21	26plus
27	29	32	32C	32SC	33	35	35RT	36	37-IMP	37-IM	37-SMP
37-SM	37-SIP	37-SI	38	39	39-IM	41	41CP	43	43F	44	45
49	50	52-MP	53BPR		54	55	SIM	ICC	IMM	PDIM	AFM
90488	90204	90402	90504		NiMH Battery Charger and Battery Pack						

Applicable EU Directives: Machinery Directive 98 / 37 /EC
EMC Directive 2004 / 108 /EC
Low Voltage Directive (73 / 23 /EEC) as amended by (93 / 68 /EEC)

Applicable Harmonized Standards:

EN 61326-1:2006 Class A Electrical Equipment for Measurement, Control, and Laboratory Use, EMC Requirement – Part 1: General Requirements
(EN 55011:2007 Group 1, Class A)

EN 61010-1:2001, Safety Requirements for Electrical Equipments for Measurement, Control, and Laboratory Use – Part 1: General Requirements

Declaration based upon compliance to the Essential Requirements and Letter of Opinion from CKC Certification Services, LLC., Notified Body 0976

I, the undersigned, hereby declare that the equipment specified above conforms to the above European Union Directives and Standards.

Authorized Signature:

Name: John Backes

Title of Signatory: Vice President

Date: 27 January 2010

Place: Bellevue, WA

SBE 37-SI MicroCAT

Conductivity and Temperature Sensor
with RS-232 Interface

Shown with standard titanium housing;
optional ShallowCAT plastic housing available

Note: NEW ADDRESS
as of January 18, 2010

User's Manual

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, Washington 98005 USA
Telephone: +1 425-643-9866
Fax: +1 425-643-9954
E-mail: seabird@seabird.com
Website: www.seabird.com

Manual version #029, 03/04/11
Firmware version 3.0j and later
SeatermV2 version 1.1b and later
SBE Data Processing version 7.21c and later

Limited Liability Statement

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

SEA-BIRD ELECTRONICS, INC. disclaims all product liability risks arising from the use or servicing of this system. SEA-BIRD ELECTRONICS, INC. has no way of controlling the use of this equipment or of choosing the personnel to operate it, and therefore cannot take steps to comply with laws pertaining to product liability, including laws which impose a duty to warn the user of any dangers involved in operating this equipment. Therefore, acceptance of this system by the customer shall be conclusively deemed to include a covenant by the customer to defend, indemnify, and hold SEA-BIRD ELECTRONICS, INC. harmless from all product liability claims arising from the use or servicing of this system.

Table of Contents

Section 1: Introduction 5
About this Manual 5
Quick Start 5
Unpacking MicroCAT 6

Section 2: Description of MicroCAT 7
System Description 7
Specifications 9
Dimensions and End Cap Connector 10
Sample Timing 11

Section 3: Preparing MicroCAT for Deployment 12
Software Installation 12
Power and Communications Test 12
Test Setup 12
Test 13

Section 4: Deploying and Operating MicroCAT 18
Sampling Modes 18
Polled Sampling 19
Autonomous Sampling 20
Serial Line Sync Sampling 21
Baud Rate, Cable Length, Power, and Data Transmission Rate 22
Timeout Description 24
Command Descriptions 24
Data Formats 38
Setup for Deployment 41
Deployment 41
Recovery 42
Uploading and Processing Data 43

Section 5: Routine Maintenance and Calibration 50
Corrosion Precautions 50
Connector Mating and Maintenance 50
Conductivity Cell Maintenance 51
Pressure Sensor (optional) Maintenance 51
Handling Instructions for Plastic *ShallowCAT* Option 52
Replacing Anti-Foulant Devices (SBE 37-SI, SM, IM) 53
Sensor Calibration 54

Section 6: Troubleshooting 56
Problem 1: Unable to Communicate with MicroCAT 56
Problem 2: No Data Recorded 56
Problem 3: Unreasonable T, C, or P Data 56
Problem 4: Salinity Spikes 57

Glossary 58

Appendix I: Functional Description....60
Sensors....60
Sensor Interface....60
Real-Time Clock....60
Memory....61
Appendix II: Electronics Disassembly/Reassembly....62
Appendix III: Command Summary....64
Appendix IV: AF24173 Anti-Foulant Device....67
Appendix V: Replacement Parts....71
Appendix VI: Manual Revision History....73
Index....75

Section 1: Introduction

This section includes a 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 Sensor (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 contact us with any comments or suggestions (seabird@seabird.com or 425-643-9866). Our business hours are Monday through Friday, 0800 to 1700 Pacific Standard Time (1600 to 0100 Universal Time) in winter and 0800 to 1700 Pacific Daylight Time (1500 to 0000 Universal Time) the rest of the year.

Quick Start

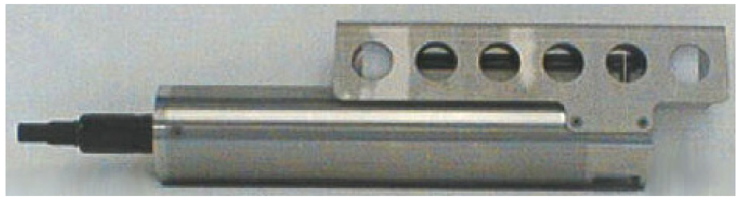
Follow these steps to get a Quick Start using the MicroCAT.
The manual provides step-by-step details for performing each task:

1. Perform pre-check procedures to test power and communications (*Section 3: Preparing MicroCAT for Deployment*):

2. Deploy MicroCAT (*Section 4: Deploying and Operating MicroCAT)*:
   A. Set date and time (**DateTime=**).
   B. Ensure all data has been uploaded, and then send **InitLogging** to make entire memory available for recording if desired.
   C. Establish setup and operating parameters.
   D. Check status (**DS**) and calibration coefficients (**DC**) to verify setup.
   E. Remove protective plugs from anti-foulant device cups, and verify AF24173 Anti-Foulant Devices are installed. Leave protective plugs off for deployment.
   F. Install I/O cable connector and locking sleeve.
   G. Deploy MicroCAT, using optional Sea-Bird mounting hardware or customer-supplied hardware.
   H. If desired, save real-time data to a file, using Seaterm232's Capture function or your own software.
   I. Upload data from memory.

Unpacking MicroCAT

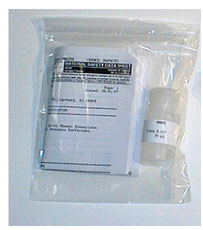
Shown below is a typical MicroCAT shipment.



SBE 37-SI MicroCAT

I/O cable

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, dimensions, end cap connector, and sample timing.

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) sensor with non-volatile memory, 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 (6 – 21,600 seconds), the MicroCAT samples, stores data in its FLASH memory, and transmits the data to the computer. The MicroCAT goes to sleep between samples.

  Continuous sampling: The MicroCAT continuously samples, stores data in its FLASH memory, 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, store data in its FLASH memory, 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 SEACAT and SEACAT *plus* family. 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 strain-gauge pressure sensor is available in the following pressure ranges: 20, 100, 350, 600, 1000, 2000, 3500, and 7000 meters. Compensation of the temperature influence on pressure offset and scale is performed by the MicroCAT's CPU.

Future upgrades and enhancements to the MicroCAT firmware can be easily installed in the field through a computer serial port and the bulkhead connector on the MicroCAT, without the need to return the MicroCAT to Sea-Bird.

Notes:
- Help files provide detailed information on the software.
- A separate software manual on CD-ROM contains detailed information on the setup and use of SBE Data Processing.
- Sea-Bird supplies the current version of our software when you purchase an instrument. As software revisions occur, we post the revised software on our FTP site. See our website (www.seabird.com) for the latest software version number, a description of the software changes, and instructions for downloading the software from the FTP site.

The MicroCAT is supplied with a powerful software package, SEASOFT© V2, which includes:

- **SeatermV2** – terminal program for easy communication and data retrieval. SeatermV2 is a *launcher*, and launches the appropriate terminal program for the selected instrument (**Seaterm232** for RS-232 instruments such as this MicroCAT).

- **SBE Data Processing** - program for calculation and plotting of conductivity, temperature, pressure (optional), and derived variables such as salinity and sound velocity.

Specifications

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

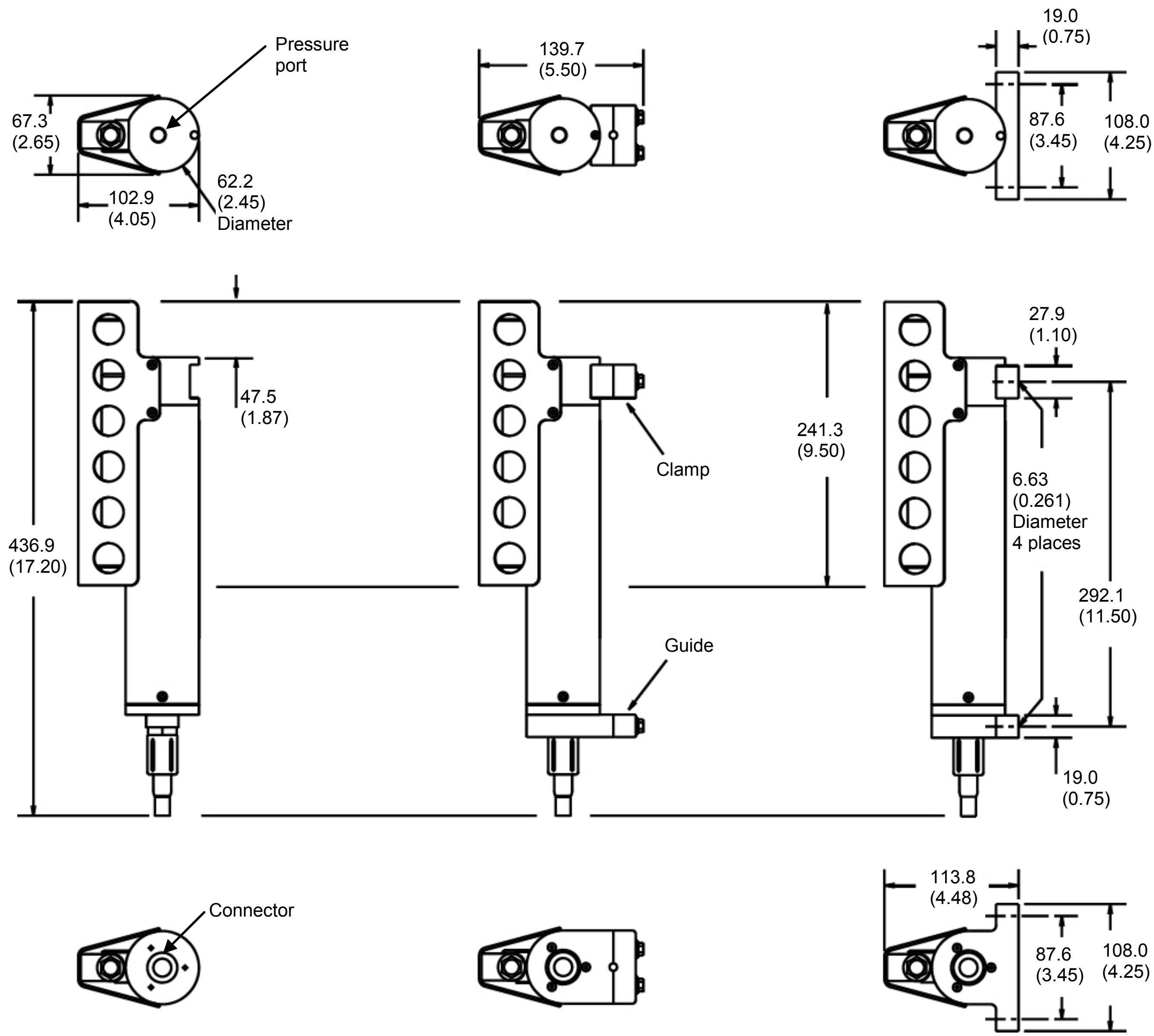
	Temperature (°C)	Conductivity (S/m)	Optional Pressure
Measurement Range	-5 to +35	0 to 7 (0 to 70 mS/cm)	0 to full scale range: 20 / 100 / 350 / 600 / 1000 / 2000 / 3500 / 7000 meters
Initial Accuracy	0.002	0.0003 (0.003 mS/cm)	0.1% of full scale range
Typical Stability	0.0002 per month	0.0003 (0.003 mS/cm) per month	0.05% of full scale range per year
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
Memory	8 Mbyte non-volatile FLASH memory		
Data Storage	Conductivity & temperature: 6 bytes/sample (3 bytes each). Time: 4 bytes/sample. Pressure (optional): 5 bytes/sample <u>**Recorded Parameters**</u> — <u>**Memory Space (# of samples)**</u> C, T, and time — 800,000 C, T, P, and time — 533,000		
Real-Time Clock	32,768 Hz TCXO accurate to ±1 minute/year.		
External Input Power	0.5 Amps at 8.5-24 VDC. See *Power and Cable Length* in *Section 4: Deploying and Operating MicroCAT*. • Quiescent current: 30 microamps • Communication current: 4.3 milliamps • Acquisition current: 15 milliamps • Minimum acquisition time (continuous sampling): 1.0 seconds/sample without pressure; 1.5 seconds/sample with pressure.		
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.

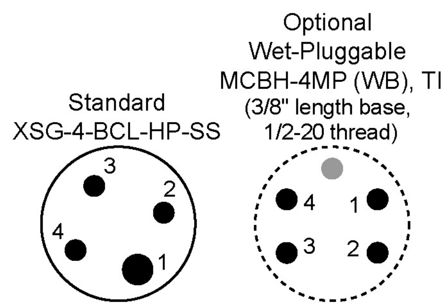
***Resolution**
Typical RMS noise with fixed resistors on temperature and conductivity inputs is 0.000127 °C and 0.000008 S/m.

Dimensions and End Cap Connector

Dimensions in millimeters (inches)



Standard Without Mounting Hardware **Optional Wire Mounting Clamp and Guide** **Optional Flat Surface Mounting Brackets**



Pin	Signal
1	Common
2	RS-232 data receive
3	RS-232 data transmit
4	8.5 - 24 VDC external power

Sample Timing

Notes:
- Time output and stored with the data is the time at the **start** of the sample, after a small amount of time for the MicroCAT to wake up and prepare to sample. For example, if the MicroCAT is programmed to wake up and sample at 12:00:00, the stored and displayed time will indicate 12:00:01 or 12:00:02.
- See *Section 4: Deploying and Operating MicroCAT* for command descriptions.

Sample timing is dependent on several factors, including:
- Sampling mode – autonomous (interval or continuous sampling), polled, or serial line sync
- Inclusion of optional pressure sensor in MicroCAT
- Number of characters of data transmitted - 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.*

Note:
Autonomous Sampling is in effect when:
- **AutoRun=Y** and **SampleMode=2** or **3**, ***or***
- **AutoRun=N** and **SampleMode=2** or **3**, and sampling is started with **Start**

The MicroCAT goes to sleep between samples when sampling at pre-defined intervals (**SampleMode=2**).

Autonomous Sampling

Interval Sampling (**SampleMode=2**), taking a sample every **SampleInterval=** seconds:
- **Without pressure**
  power-on time for each sample= 1.8 seconds
- **With pressure**
  power-on time for each sample = 2.4 seconds

Continuous Sampling (**SampleMode=3**):
- **Without pressure**
  sampling time = 1.0 seconds
- **With pressure**
  sampling time = 1.5 seconds

Note:
Polled Sampling is in effect when:
- Sampling is started with a polled sampling command (**TS**, etc.).

Serial Line Sync is in effect when:
- **AutoRun=N**, **SampleMode=1**, sampling is started with **Start**, and another sample is obtained each time a pulse is received, until **Stop** is sent.
- **AutoRun=Y**, **SampleMode=1**, sampling is started by applying power, and another sample is obtained each time a pulse is received, until **Stop** is sent.

Polled Sampling or Serial Line Sync

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

- **Without pressure**
  power-on time for each sample = 2.0 seconds
- **With pressure**
  power-on time for each sample = 2.6 seconds

Section 3: Preparing MicroCAT for Deployment

This section describes the pre-check procedure for preparing the MicroCAT for deployment, including installing software and testing power and communications.

Software Installation

Sea-Bird recommends the following minimum system requirements for installing the software: Windows 2000 or later, 500 MHz processor, 256 MB RAM, and 90 MB free disk space for installation. Although SEASOFT V2 was designed to work with a PC running Win 2000/XP; extensive testing has not shown any compatibility problems when using the software with a PC running Windows Vista or Windows 7 (32-bit).

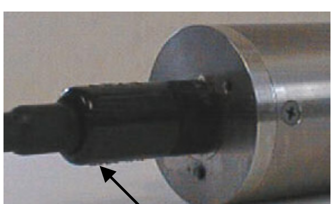
If not already installed, install Sea-Bird software programs on your computer using the supplied software CD:

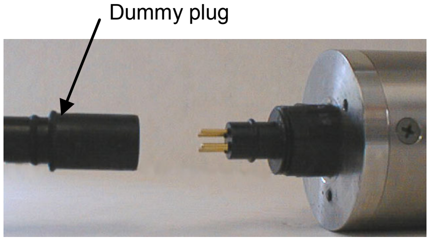
1. Insert the CD in your CD drive.
2. Install software: Double click on **SeasoftV2_*date*.exe** (*date* is the date that version of the software was created). Follow the dialog box directions to install the software. The installation program allows you to install the desired components. Install all the components, or just install SeatermV2 (terminal program *launcher* for the MicroCAT) and SBE Data Processing (data processing).

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

Note:
It is possible to use the MicroCAT without the SeatermV2 terminal program by sending direct commands from a dumb terminal or terminal emulator, such as Windows HyperTerminal.

Power and Communications Test





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

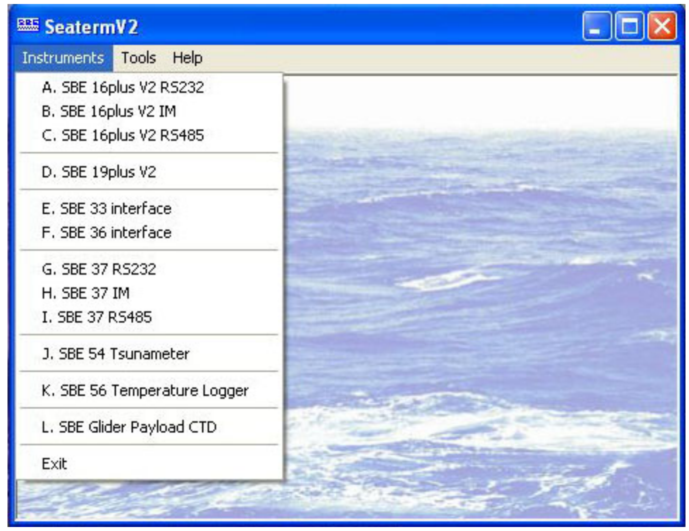
Test Setup

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 (8.5-24 VDC).

Test

Note:
See SeatermV2's Help files.

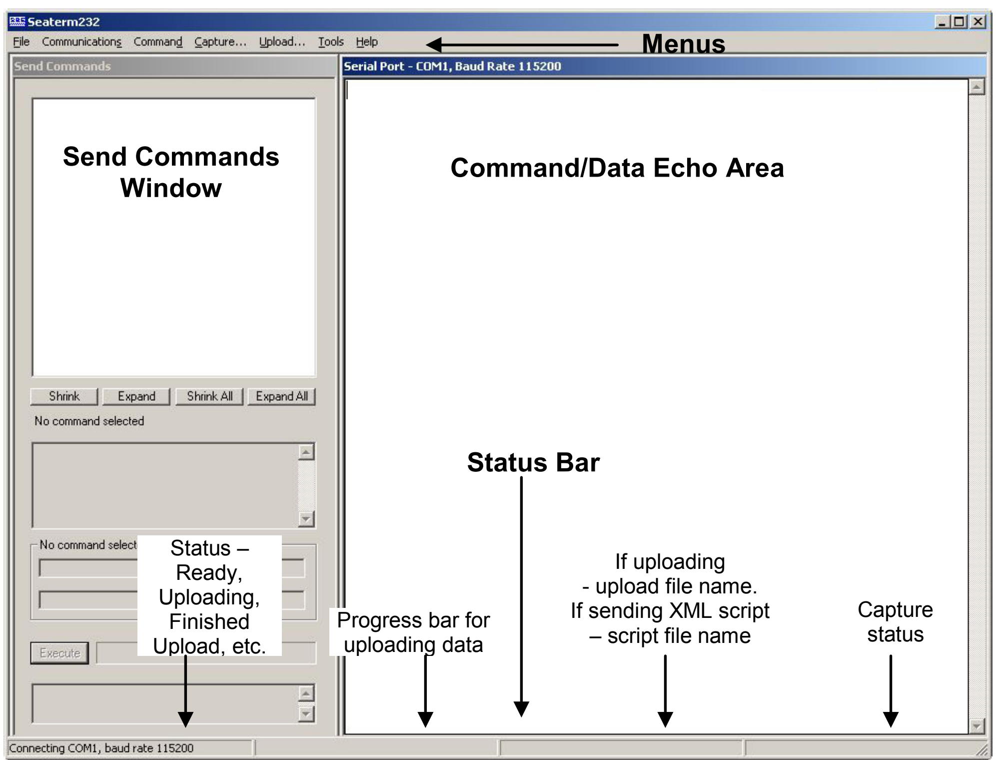
1. Double click on **SeatermV2.exe**. The main screen looks like this:



SeatermV2 is a *launcher*, and launches the appropriate terminal program for the selected instrument.

Note:
See Seaterm232's Help files.

2. In the Instruments menu, select *SBE 37 RS232*.
Seaterm232 opens; the main screen looks like this:



- Menus – For tasks and frequently executed instrument commands.
- Send Commands window – Contains commands applicable to your MicroCAT. The list appears after you connect to the MicroCAT.
- Command/Data Echo Area – Title bar of this window shows Seaterm232's current comm port and baud rate. Commands and the MicroCAT responses are echoed here. Additionally, a command can be manually typed or pasted (ctrl + V) here. Note that the MicroCAT must be *connected* and *awake* for it to respond to a command.
- Status bar – Provides connection, upload, script, and capture status information.

Following is a description of the menus:

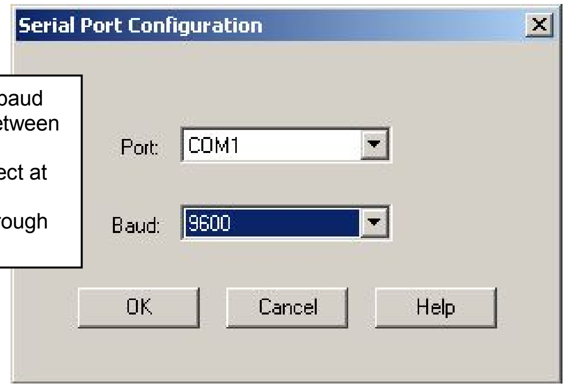
Menu	Description	Equivalent Command*
File	• Load command file – opens selected .XML command file, and fills Send Commands window with commands. • Unload command file – closes command file, and removes commands from Send Commands window. • Exit - Exit program.	-
Communications	• Configure – Establish communication parameters (comm port and baud rate). • Connect – connect to comm port. • Disconnect – disconnect from comm port. • Disconnect and reconnect – may be useful if instrument has stopped responding.	-
Command	• Abort – interrupt and stop MicroCAT's response. • Send 5 second break (for use with Serial Line Sync mode). • Send stop command. • Set local time– Set date and time to time sent by timekeeping software on your computer; accuracy ± 25 msec of time provided by computer. • Set UTC Time (Greenwich Mean Time) – Set date and time to time sent by timekeeping software on your computer; accuracy ± 25 msec of time provided by computer.	• (press Esc key several times for Abort) • **Stop** • **DateTime=** • **DateTime=**
Capture	Capture instrument responses on screen to file, to save real-time data or use for diagnostics. File has .cap extension. Click Capture menu again to turn off capture. Capture status displays in Status bar.	—
Upload	Upload data stored in memory, in a format that Sea-Bird's data processing software can use. Uploaded data has .xml extension, and is then automatically converted to a .hex and a .xmlcon file that can be used in SBE Data Processing's Data Conversion module. Before using Upload: **stop logging** by sending **Stop**.	Several status commands and appropriate data upload command as applicable to user selection of range of data to upload (use Upload menu if you will be processing data with SBE Data Processing)
Tools	• Diagnostics log - Keep a diagnostics log. • Convert .XML data file – Using Upload menu automatically does this conversion; tool is available if there was a problem with the automatic conversion. • Send script – Send XML script to MicroCAT. May be useful if you have a number of MicroCATs to program with same setup.	-

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

Note:
SeatermV2 with version < 1.1 did not convert the uploaded .xml data file to a .hex and .xmlcon file. *Convert .XML data file* in the Tools menu was used to convert the .xml data file to a .cnv file, which could be processed in SBE Data Processing. We recommend that you update your SeatermV2 software to 1.1b or later.

3. If this is the first time Seaterm232 is being used, the configuration dialog box displays:

Computer COM port and baud rate for communication between computer and MicroCAT. Seaterm232 tries to connect at this baud rate, but if unsuccessful will cycle through all available baud rates.



Make the desired selections, and click OK.

Note:
Seaterm232's baud rate must be the same as the MicroCAT baud rate (set with **BaudRate=**). Baud is factory-set to 9600, but can be changed by the user (see *Command Descriptions* in *Section 4: Deploying and Operating MicroCAT*). Other communication parameters – 8 data bits, 1 stop bit, and no parity – cannot be changed.

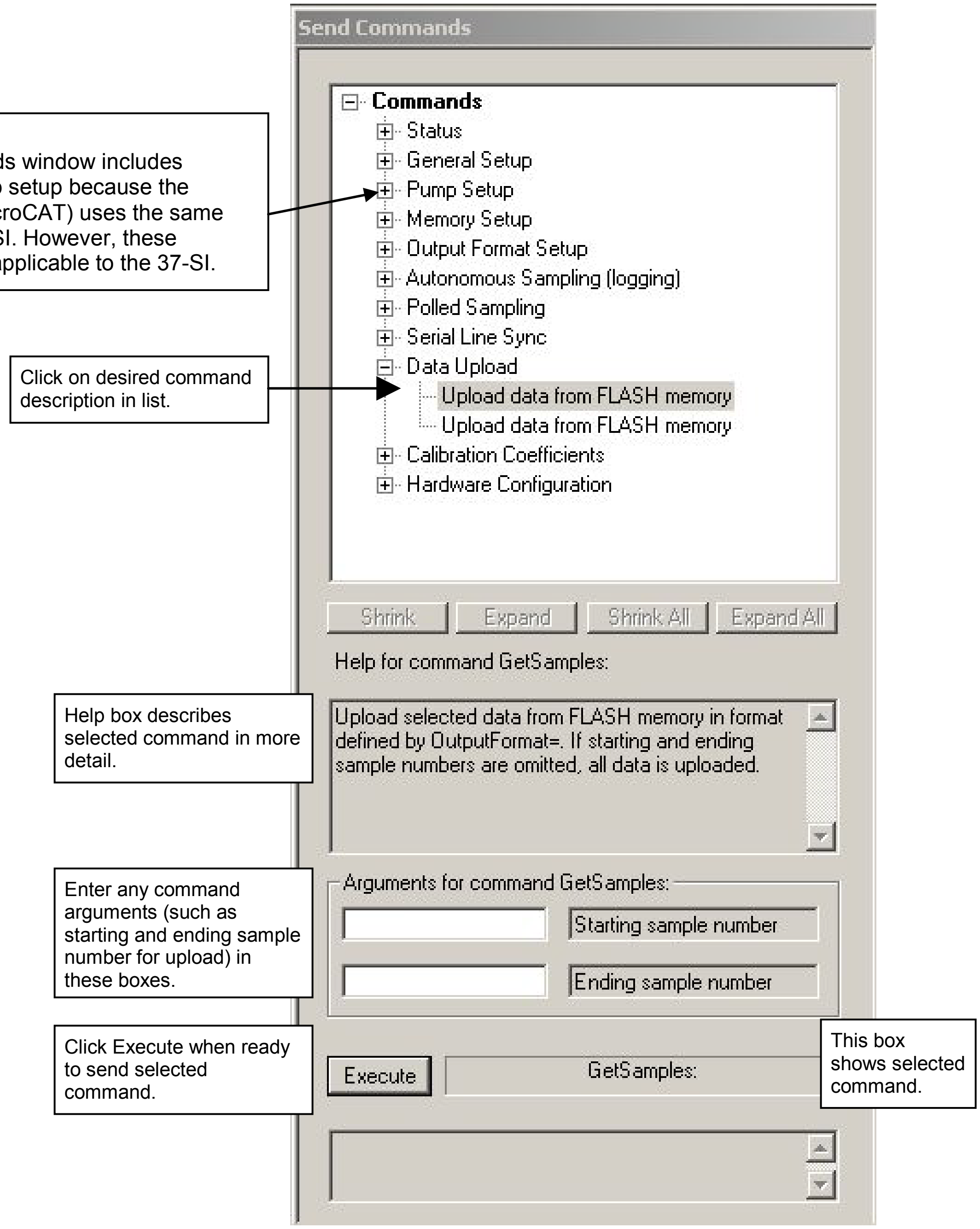
4. Seaterm232 tries to automatically connect to the MicroCAT. As it connects, it sends **GetHD** and displays the response, which provides factory-set data such as instrument type, serial number, and firmware version. Seaterm232 also fills the Send Commands window with the correct list of commands for your MicroCAT.
   If there is no communication:
   A. In the Communications menu, select *Configure*. The Serial Port Configuration dialog box appears. Select the Comm port and baud rate for communication, and click OK. Note that the factory-set baud rate is documented on the Configuration Sheet.
   B. In the Communications menu, select *Connect* (if *Connect* is grayed out, select *Disconnect and reconnect*). Seaterm232 will attempt to connect at the baud specified in Step A, but if unsuccessful will then cycle through all other available baud rates.
   C. If there is still no communication, check cabling between the computer and MicroCAT, and try to connect again.
   D. If there is still no communication, repeat Step A with a different comm port, and try to connect again.

Note:
If **OutputExecutedTag=Y**, the MicroCAT does **not** provide an `S>` prompt after the `<Executed/>` tag at the end of a command response.

After Seaterm232 displays the **GetHD** response, it provides an S> prompt to indicate it is ready for the next command.

Taking a look at the Send Commands window:

Note:
The Send Commands window includes commands for pump setup because the 37-SIP (pumped MicroCAT) uses the same firmware as the 37-SI. However, these commands are not applicable to the 37-SI.



You can use the Send Commands window to send commands, or simply type the commands in the Command/Data Echo area if desired.

Notes:

- You may need to send the **Stop** command (type **Stop** and press the Enter key) to interrupt sampling, depending on how the instrument was set up the last time it was used. You may need to send **Stop** several times to get the MicroCAT to respond.
- The MicroCAT automatically enters quiescent (sleep) state after 2 minutes without receiving a command. This timeout algorithm is designed to draw minimal current if the user does not send **QS** to put the MicroCAT to sleep. If the system does not appear to respond, select *Connect* in the Communications menu to reestablish communications.

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

```
SBE37SI-RS232 3.0j SERIAL NO. 6017  20 Oct 2010 00:48:50
vMain =  7.41, vLith =  3.16
samplenumber = 0, free = 559240
status = not logging
sample interval = 15 seconds
data format = converted engineering
output time
sample mode = interval sample
auto run = no
store data = yes
pump installed = no
```

6. 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, **OutputFormat=1**, **OutputTime=Y**, and you are not outputting salinity, sound velocity, density, or depth):

```
  23.7658,  0.00019,    0.062, 20 Oct 2010, 00:51:30
```

where 23.7658 = temperature in degrees Celsius
0.00019 = conductivity in S/m
0.062 = pressure in decibars
20 Oct 2010 = date
00:51:30 = time

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

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

The MicroCAT is ready for programming and deployment.

Section 4: Deploying and Operating MicroCAT

This section includes:

- System operation with example sets of operation commands
- Baud rate, cable length, power, and data transmission rate limitations
- Timeout description
- Command descriptions
- Data output formats
- Deployment
- Recovery – physical handling and uploading data
- Processing data

Note:
Separate software manuals and Help files contain detailed information on installation, setup, and use of Sea-Bird's software.

Sampling Modes

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

The MicroCAT has several basic sampling modes for obtaining data:

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

Data is transmitted real-time. For Autonomous sampling or Serial Line Sync sampling, data can also be saved to the MicroCAT's FLASH memory (for later upload) by setting **StoreData=Y**. Commands can be used in various combinations to provide a high degree of operating flexibility.

Removing external power from the MicroCAT corrupts a small amount of data in the MicroCAT's memory (but the real-time data is unaffected); see *Memory* in *Appendix I: Functional Description* for details. **Therefore, a deployment where power is completely removed between sets of samples (for example, applying power to sample autonomously for a short time and then removing power) will not provide reliable data in memory, unless the data in memory is uploaded before removing power.**

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

On command, the MicroCAT takes one sample of data and sends the data to the computer. Storing of data in the MicroCAT's FLASH memory is dependent on the particular command used.

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

(Select *Connect* in Seaterm232's Communications menu to connect and wake up.)
AUTORUN=N
OUTPUTFORMAT=1
OUTPUTTIME=Y
OUTPUTSAL=Y
GETCD (to verify setup)
QS

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

(Before first sample, click Capture menu to capture data to a file – Seaterm232 requests file name for data to be stored.)
(Select *Connect* in Seaterm232's Communications menu to connect and wake up.)
TS
QS

Autonomous Sampling

Autonomous Sampling includes both Interval and Continuous Sampling:

- **Interval sampling** (**SampleMode=2**) - MicroCAT samples at the programmed interval (**SampleInterval=**) and sends data, and goes to sleep between samples.
- **Continuous sampling** (**SampleMode=3**) - MicroCAT samples at the fastest rate possible for the selected parameters (see *Sample Timing* in *Section 2: Description of MicroCAT*). MicroCAT continuously samples and sends data, and does not go to sleep between samples.

Keep the signal line open circuit or within ± 0.3 V relative to ground to minimize power consumption when not trying to send commands.

Examples: **Autonomous Sampling** - both examples illustrate interval sampling; setup for continuous sampling is similar (but set **SampleMode=3** instead of **2**; MicroCAT ignores any entry for **SampleInterval=** in continuous mode).

Example 1*:* AutoRun=N (user input in bold) **-** Set up to take a sample every 20 seconds, store data in memory, output data in converted decimal format, and send date and time with data. Send power-off.

(Apply power. Select *Connect* in Seaterm232's Communications menu to connect and wake up.)
SAMPLEMODE=2
SAMPLEINTERVAL=20
STOREDATA=Y
OUTPUTFORMAT=1
OUTPUTTIME=Y
AUTORUN=N
GETCD (to verify setup)
QS
(Remove power.)

When ready to begin sampling:

(To save real-time data, click Capture menu to capture data to a file – Seaterm232 requests file name for data to be stored.)
(Apply power, and select *Connect* in Seaterm232's Communications menu to connect and wake up.)
START (MicroCAT takes and transmits sample, stores in memory, and repeats sequence every 20 seconds.)

When ready to stop sampling and go to sleep:

(Press any key)
STOP
(Click Upload menu – Seaterm232 leads you through screens to define data to be uploaded and where to store it.)
QS

Example 2*:* AutoRun=Y (user input in bold) **-** Set up to take a sample every 20 seconds, store data in memory, output data in converted decimal format, and send date and time with data. Remove power.

(Apply power to wake up.)
SAMPLEMODE=2
SAMPLEINTERVAL=20
STOREDATA=Y
OUTPUTFORMAT=1
OUTPUTTIME=Y
AUTORUN=Y
GETCD (to verify setup)
(Remove power.)

When ready to begin sampling:

(To save real-time data, click Capture menu to capture data to a file – Seaterm232 requests file name for data to be stored.)
(Apply power to wake up – MicroCAT takes and transmits sample, stores in memory, 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 sequence. Press any key.)
STOP
(Click Upload menu – Seaterm232 leads you through screens to define data to be uploaded and where to store it.)
(send desired commands)
(Remove power.)

Serial Line Sync Sampling

For Serial Line Sync, a simple pulse (a single character) on the RS-232 serial line causes a MicroCAT to wake up, sample, transmit 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.

Keep the signal line open circuit or within ± 0.3 V relative to ground to minimize power consumption when not trying to send a pulse to take a sample.

Examples: **Serial Line Sync**

Example 1: AutoRun=N (user input in bold)
Set up to take 1 sample when prompted, store data in memory, and send date and time with data. Send power-off command.

(Select *Connect* in Seaterm232's Communications menu to connect and wake up.)
SAMPLEMODE=1
STOREDATA=Y
OUTPUTTIME=Y
AUTORUN=N
GETCD (to verify setup)
QS
(Remove power.)

When ready to begin sampling:

(To save real-time data, click Capture menu to capture data to a file – Seaterm232 requests file name for data to be stored.)
(Apply power, and press any key to wake up)
START (MicroCAT takes and transmits 1 sample, stores in memory, and goes to sleep.)

When ready to take another sample, send a pulse (press any key) to wake up, take and transmit 1 sample, store in memory, and go to sleep. Repeat as desired.

When ready to stop sampling and go to sleep:

(Press any key).
STOP
(Click Upload menu – Seaterm232 leads you through screens to define data to be uploaded and where to store it.)
QS

Example 2: **AutoRun=Y** (user input in bold)
Set up to take 1 sample when prompted, store data in memory, and send date and time with data. Remove power.

(Apply power to wake up.)
SAMPLEMODE=1
STOREDATA=Y
OUTPUTTIME=Y
AUTORUN=Y
GETCD (to verify setup)
Remove power.

When ready to begin sampling:

(To save real-time data, click Capture menu to capture data to a file – Seaterm232 requests file name for data to be stored.)
(Apply power– MicroCAT takes and transmits 1 sample, stores in memory, and goes to sleep.)

When ready to take another sample, send a pulse (press any key) to wake up, take and transmit 1 sample, store in memory, and go to sleep. Repeat as desired.

When ready to stop sampling:

(Remove power.)

To change setup, temporarily disable serial line sync:

(Apply power – MicroCAT automatically begins the sampling sequence. Press any key.)
STOP
(Click Upload menu – Seaterm232 leads you through screens to define data to be uploaded and where to store it.)
(send desired commands)
Remove power.

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

If acquiring real-time data with Seaterm232, click the Capture menu; enter the desired file name in the dialog box, and click Save. Begin sampling. The data displayed in Seaterm232 will be saved to the designated file. Process the data as desired. Note that this file **cannot be processed by SBE Data Processing, as it does not have the required headers and format for Sea-Bird's processing software**. To process data with SBE Data Processing, upload the data from the MicroCAT's memory.

Baud Rate, Cable Length, and Data Transmission Rate

Notes:
- Baud rate is set with **BaudRate=**.
- Output format is set with **OutputFormat=**.

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 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. 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
1600	600
800	1200
400	2400
200	4800
100	9600
50	19200
25	38400
16	57600
8	115200

Example – How long does it take to transmit data over 800 m for a MicroCAT with optional pressure sensor, **OutputFormat=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 Formats*) = 8(T) + 2(comma & space) + 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) = 93
Time required to transmit data = (93 characters * 10 bits/character) / 1200 = 0.78 seconds

What is the minimum time between samples for continuous sampling?
From *Sample Timing* in *Section 2: Description of MicroCAT*, for continuous sampling with pressure:
Sampling time = 1.5 seconds
So, minimum time between samples = sampling time + transmission time = 1.5 + 0.78 = 2.28 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 volt = IR_{limit}

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

where I =communication current required by MicroCAT (4.3 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 4.3 milliamp communications current, $R_{limit} = V_{limit}$ / I = 1 volt / 0.0043 Amps = 232 ohms
For 20 gauge wire, resistance is 0.0107 ohms/foot.
Maximum cable length = 232.6 ohms / 0.0107 ohms/foot = 21734 feet = 6626 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 / (0.0043 Amps * 4 MicroCATs) = 58 ohms
For 20 gauge wire, resistance is 0.0107 ohms/foot.
Maximum cable length = 58 ohms / 0.0107 ohms/foot = 5433 feet = 1656 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 8.5 volts, after IR loss.

V - IR $\geq$ 8.5 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 $\geq$ 8.5 volts   12 volts - (0.50 Amps) * (0.0107 ohms/foot * 2 * cable length) $\geq$ 8.5 volts
3.5 volts $\geq$ (0.50 Amps) * (0.0107 ohms/foot * 2 * cable length)   Cable length $\leq$ 327 ft = 99 meters
Note that 99 meters << 6626 meters (maximum distance when considering communication IR loss), so supplying enough 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 $\geq$ 8.5 volts   12 volts - (0.50 Amps * 4 MicroCATs) * (0.0107 ohms/foot * 2 * cable length) $\geq$ 8.5 volts
3.5 volts $\geq$ (0.50 Amps * 4 MicroCATs) *(0.0107 ohms/foot * 2 * cable length)
Cable length $\leq$ 81 ft = 25 meters (to MicroCAT *furthest* from power source)

Timeout Description

The MicroCAT has a timeout algorithm. If the MicroCAT does not receive a command or sample data for 2 minutes, it powers down its communication circuits. This places the MicroCAT in quiescent (sleep) state, drawing minimal current. **To re-establish control (wake up), select *Connect* in Seaterm232's Communications menu or press the Enter key.**

Command Descriptions

This section describes commands and provides sample outputs. Entries made with the commands are permanently stored in the MicroCAT and remain in effect until you change them. 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. Note that commands are shown with a mix of upper and lower case for ease in reading (for example**, InitLogging**), but do not need to be entered that way.
- The MicroCAT sends an error message if an invalid command is entered.
- If a new command is not received within 2 minutes after the completion of a command, the MicroCAT returns to the quiescent (sleep) state.
- If in quiescent (sleep) state, re-establish communications by selecting *Connect* in Seaterm232's Communications menu or pressing the Enter key.
- If the MicroCAT is transmitting data and you want to stop it, press the Esc key or type ^C. Then press the Enter key. Alternatively, select *Abort* in Seaterm232's Command menu.
- The MicroCAT responds only to **GetCD**, **GetSD**, **GetCC**, **GetEC**, **GetHD**, **DS**, **DC**, **TS**, **TSH**, **SL**, **SLT**, **QS**, and **Stop** while sampling (**Start** has been sent). If you wake the MicroCAT while it is sampling autonomously (for example, to send **DS** to check on progress), it temporarily stops sampling. Autonomous sampling resumes when it goes back to sleep (either by sending **QS** or after the 2-minute timeout).
- For consistency with user systems set up for older firmware (< 3.0), the following commands were re-introduced with firmware 3.0j:
  - **Interval=** (equivalent to **SampleInterval=** in current firmware)
  - **Go** (equivalent to **Start** in current firmware**)**
  - **NCycles=** (no equivalent command in current firmware; this parameter is always set internally to 4. MicroCAT now accepts this command, but does not change any settings or internal calculations.)

Status Commands

> **Note:**
> **GetCD** output does not include calibration coefficients. To display calibration coefficients, use the **GetCC** command.

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

GetCD

Get and display configuration data, which includes parameters related to MicroCAT setup. Most of these parameters can be user-input/modified. List below includes, where applicable, command used to modify parameter:

- Device type, Serial number
- Optional pressure sensor installed?
- Reference pressure to use in calculations if no pressure sensor installed (only appears if pressure sensor not installed) [**ReferencePressure=**]
- Pump installed [**SetPumpInstalled=N**]? Always no for 37-SI
- Minimum conductivity frequency for pump turn-on; not applicable for 37-SI
- Sampling mode [**SampleMode=**]
- Output data format [**OutputFormat=**]
- Output salinity with each sample [**OutputSal=**]?
- Output sound velocity with each sample [**OutputSV=**]?
- Output depth with each sample [**OutputDepth=**]?
- Latitude for depth calculation [**Latitude=**]
- Output local density with each sample [**OutputDensity=**]?
- Output time with each sample [**OutputTime=**]?
- Interval between samples for continuous sampling [**SampleInterval=**]
- Start sampling when power turned on? [**AutoRun=**]
- Store data in memory [**StoreData=**]?

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

```
GETCD
<ConfigurationData DeviceType = 'SBE37SI-RS232' SerialNumber = '037006017'>
   <PressureInstalled>yes</PressureInstalled>          (inclusion of optional pressure sensor set at factory)
   <PumpInstalled>no</PumpInstalled>                   [SetPumpInstalled=N; only valid setting for 37-SI]
   <MinCondFreq>3000.0</MinCondFreq>                   [only applicable for 37-SIP]
   <SampleMode>interval sample</SampleMode>            [SampleMode=]
   <SampleDataFormat>raw Decimal</SampleDataFormat>    [OutputFormat=]
   <OutputSalinity>no</OutputSalinity>                 [OutputSal=]
   <OutputSV>no</OutputSV>                             [OutputSV=]
   <OutputDepth>yes</OutputDepth>                      [OutputDepth=]
   <Latitude>30.0</Latitude>                           [Latitude=]
   <OutputDensity>no</OutputDensity>                   [OutputDensity=]
   <OutputTime>yes</OutputTime>                        [OutputTime=]
   <SampleInterval>15</SampleInterval>                 [SampleInterval=]
   <AutoRun>no</AutoRun>                               [AutoRun=]
   <StoreData>yes</StoreData>                          [StoreData=]
</ConfigurationData>
```

Status Commands (*continued*)

GetSD

Get and display status data, which contains data that changes while deployed.
List below includes, where applicable, command used to modify parameter:

- Device type, Serial number
- Date and time [**DateTime=**] in ISO8601-2000 extended format (yyyy – mm-ddThh:mm:ss)
- Number of recorded events in event counter [reset with **ResetEC**]
- Voltages - external power supply voltage and back-up lithium battery voltage
- Memory – [reset with **InitLogging**]
  - Number of bytes in memory
  - Number of samples in memory
  - Number of additional samples that can be placed in memory
  - Length (number of bytes) of each sample
- Logging status – yes or no, to indicate whether it is currently logging data

Example: (user input in bold, command used to modify parameter in parentheses)

```
getsd
<StatusData DeviceType = 'SBE37SI-RS232' SerialNumber = '03706017'>
   <DateTime>2010-10-20T00:48:32</DateTime>                      [DateTime=]
   <EventSummary numEvents = '0'/>                               [can clear with ResetEC=]
   <Power>
      <vMain> 7.41</vMain>                                       (external power supply voltage)
      <vLith> 3.16</vLith>                                       (back-up lithium battery power supply voltage)
   </Power>
   <MemorySummary>
      <Bytes>0</Bytes>
      <Samples>0</Samples>                                       [can clear with InitLogging]
      <SamplesFree>559240</SamplesFree>                          [can clear with InitLogging]
      <SampleLength>15</SampleLength>
   </MemorySummary>
   <Logging>no</Logging>
</StatusData>
```

Status Commands (*continued*)

Notes:

- Dates shown are when calibrations were performed.
- If the MicroCAT does not include an optional pressure sensor, the user-input reference pressure (**ReferencePressure=**) appears at the end of the conductivity calibration coefficients.

GetCC Get and display calibration coefficients, which are initially factory-set and should agree with Calibration Certificates shipped with MicroCAT.

Example: MicroCAT with a pressure sensor (user input in bold, command used to modify parameter in parentheses)

```
getcc
<CalibrationCoefficients DeviceType = 'SBE37SI-RS232' SerialNumber = '03706017'>
   <Calibration format = 'TEMP1' id = 'Temperature'>
      <SerialNum>03706017</SerialNum>
      <CalDate>04-Aug-10</CalDate>                              [TCalDate=]
      <A0>6.947802e-05</A0>                                     [TA0=]
      <A1>2.615233e-04</A1>                                     [TA1=]
      <A2>-1.265233e-06</A2>                                    [TA2=]
      <A3>1.310479e-07</A3>                                     [TA3=]
   </Calibration>
   <Calibration format = 'WBCOND0' id = 'Conductivity'>
      <SerialNum>03706017</SerialNum>
      <CalDate>04-Aug-10</CalDate>                              [CCalDate=]
      <G>-1.009121e+00</G>                                      [CG=]
      <H>1.410162e-01</H>                                       [CH=]
      <I>-2.093167e-04</I>                                      [CI=]
      <J>3.637053e-05</J>                                       [CJ=]
      <PCOR>-9.570000e-08</PCOR>                                [CTCor=]
      <TCOR>3.250000e-06</TCOR>                                 [CPCor=]
      <WBOTC>1.954800e-05</WBOTC>                               [CWBOTC=]
   </Calibration>
   <Calibration format = 'STRAIN0' id = 'Pressure'>
      <SerialNum>2478619</SerialNum>
      <CalDate>28-Jul-10</CalDate>                              [PCalDate=]
      <PA0>1.729067e+00</PA0>                                   [PA0=]
      <PA1>1.415754e-01</PA1>                                   [PA1=]
      <PA2>1.246912e-08</PA2>                                   [PA2=]
      <PTCA0>2.243971e+00</PTCA0>                               [PTCA0=]
      <PTCA1>1.055267e+00</PTCA1>                               [PTCA1=]
      <PTCA2>-2.276308e-02</PTCA2>                              [PTCA2=]
      <PTCB0>1.003849e+02</PTCB0>                               [PTCB0=]
      <PTCB1>1.014510e-02</PTCB1>                               [PTCB1=]
      <PTCB2>-2.057110e-04</PTCB2>                              [PTCB2=]
      <PTEMPA0>5.669780e+01</PTEMPA0>                           [PTempA0=]
      <PTEMPA1>-5.474043e-02</PTEMPA1>                          [PTempA1=]
      <PTEMPA2>1.267908e-05</PTEMPA2>                           [PTempA2=]
      <POFFSET>0.000000e+00</POFFSET>                           [POffset= (decibars)]
      <PRANGE>0.000000e+00</PRANGE>                             [PRange= (psi)]
   </Calibration>
</CalibrationCoefficients>
```

Status Commands (*continued*)

GetEC

Get and display event counter data, which can help to identify root cause of a malfunction. Event counter records number of occurrences of common timeouts, power-on resets, etc. Can be cleared with **ResetEC**. Possible events that may be logged include:

- WDT reset – unexpected reset
- PON reset - power cycled on (each time power is applied)
- ErrorADC12TimeOut – response delayed from A/D converter that measures external power and back-up lithium battery power
- ErrorUART0TimeOut – timeout for transmitter to finish transmitting previous character via RS-232
- ErrorAD7714TimeOut – response delayed from temperature and pressure A/D converter
- ErrorInvWakeUpFlag – unexpected wakeup
- ErrorFLASHTimeOut – problem with writing data to FLASH memory
- Alarm long - time to take next sample is too far in future
- Alarm short - woke up MicroCAT to send a command while logging, and missed taking a sample
- LoggingRestartNoAlarm – no sample taken for 8 hours while logging, restart logging

Example: (user input in bold, command used to modify parameter in parentheses)

```
getec
<EventCounters DeviceType = 'SBE37SI-RS232' SerialNumber = '03706017'>
   <EventSummary numEvents = '0'/>                        [can clear with ResetEC]
</EventCounters>
```

ResetEC

Delete all events in event counter (number of events displays in **GetSD** response, and event details display in **GetEC** response).

Status Commands (*continued*)

GetHD

Get and display hardware data, which is fixed data describing MicroCAT:

- Device type, Serial number
- Manufacturer
- Firmware version
- Firmware date
- PCB assembly number
- Manufacture date
- Sensor types and serial numbers

Example: (user input in bold, command used to modify parameter in parentheses)

```
gethd
<HardwareData DeviceType = 'SBE37SI-RS232' SerialNumber = '03706017'>
   <Manufacturer>Sea-Bird Electronics, Inc.</Manufacturer>
   <FirmwareVersion>3.0j</FirmwareVersion>
   <FirmwareDate>14 June 2010 08:30</FirmwareDate>
   <PCBAssembly>41609A</PCBAssembly>                        [SetPCBAssembly1=]
   <PCBAssembly>41610A</PCBAssembly>                        [SetPCBAssembly2=]
   <PCBAssembly>41611B</PCBAssembly>                        [SetPCBAssembly3=]
   <MfgDate>28 Feb 2010</MfgDate>                           [SetMfgDate=]
   <FirmwareLoader>SBE 37 FirmwareLoader V 1.0</FirmwareLoader>
   <InternalSensors>
      <Sensor id = 'Temperature'>
         <type>temperature-1</type>
         <SerialNumber>03706017</SerialNumber>
      </Sensor>
      <Sensor id = 'Conductivity'>
         <type>conductivity-1</type>
         <SerialNumber>03706017</SerialNumber>
      </Sensor>
      <Sensor id = 'Pressure'>                              [SetPressureInstalled=]
         <type>strain-0</type>
         <SerialNumber>2478619</SerialNumber>
      </Sensor>
   </InternalSensors>
</HardwareData>
```

Status Commands (*continued*)

> **Note:**
> The **DS** response contains similar information as the combined responses from **GetSD** and **GetCD**, but in a different format.

DS

Display operating status and setup parameters.

List below includes, where applicable, command used to modify parameter.

- Firmware version, serial number, date and time [**DateTime=**]
- External power voltage and back-up internal lithium battery voltage
- Number of samples and available sample space in memory
- Logging status (logging not started, logging data, not logging, or unknown)
- Interval between samples for autonomous sampling [**SampleInterval=**]
- Output data format [**OutputFormat=**]
- Output salinity with each sample [**OutputSal=**]? Only displays if set to yes
- Output sound velocity with each sample [**OutputSV=**]? Only displays if set to yes
- Output local density with each sample [**OutputDensity=**]?
  Only displays if set to yes
- Output depth with each sample [**OutputDepth=**]? Latitude for depth calculation [**Latitude=**]. Only displays if **OutputDepth=** set to yes
- Output time with each sample [**OutputTime=**]?
  Only displays if set to yes
- Sampling mode [**SampleMode=**]
- Start sampling when power turned on [**AutoRun=**]?
- Store data in memory [**StoreData=**]?
- Pump installed [**SetPumpInstalled=N**]? Always no for 37-SI
- Reference pressure to use in calculations if no pressure sensor installed (only appears if pressure sensor not installed) [**ReferencePressure=**]

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

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

DS	
`SBE37SI-RS232 3.0j  SERIAL NO. 6017  20 Oct 2010 00:48:50`	[**DateTime=**]
`vMain =  7.41, vLith =  3.16`	
`samplenumber = 0, free = 559240`	[can clear with **InitLogging**]
`status = not logging`	
`sample interval = 15 seconds`	[**SampleInterval=**]
`data format = converted engineering`	[**OutputFormat=**]
`output salinity`	[**OutputSal=**]
`output sound velocity`	[**OutputSV=**]
`output density`	[**OutputDensity=**]
`output depth, latitude = 30.0`	[**OutputDepth=**, **Latitude=**]
`output time`	[**OutputTime=**]
`sample mode = interval sample`	[**SampleMode=**]
`auto run = no`	[**AutoRun=**]
`store data = yes`	[**StoreData=**]
`pump installed = no`	[**SetPumpInstalled=N**; only valid setting for 37-SI]

Status Commands (*continued*)

Notes:
- The **DC** and **GetCC** responses contain the same information, but in different formats.
- Dates shown are when calibrations were performed.

DC Display calibration coefficients, which are initially factory-set and should agree with Calibration Certificates shipped with MicroCAT.

Example: MicroCAT with a pressure sensor (user input in bold, command used to modify parameter in parentheses).

```
DC
SBE37SI-RS232 V 3.0j 6017
temperature: 04-aug-10                                   [TCalDate=]
TA0 = 6.947802e-05                                       [TA0=]
TA1 = 2.615233e-04                                       [TA1=]
TA2 = -1.265233e-06                                      [TA2=]
TA3 = 1.310479e-07                                       [TA3=]
conductivity: 04-aug-10                                  [CCalDate=]
G = -1.036689e+00                                        [CG=]
H = 1.444342e-01                                         [CH=]
I = -3.112137e-04                                        [CI=]
J = 3.005941e-05                                         [CJ=]
CPCOR = -9.570001e-08                                    [CPCor=]
CTCOR = 3.250000e-06                                     [CTCor=]
WBOTC = 1.968100e-05                                     [CWBOTC=]
pressure S/N 2478619, range = 2901 psia, 03-aug-10       [PRange= (psi), PCalDate=]
    PA0 = 0.000000e+00                                   [PA0=]
    PA1 = 0.000000e+00                                   [PA1=]
    PA2 = 0.000000e+00                                   [PA2=]
    PTCA0 = 0.000000e+00                                 [PTCA0=]
    PTCA1 = 0.000000e+00                                 [PTCA1=]
    PTCA2 = 0.000000e+00                                 [PTCA2=]
    PTCB0 = 0.000000e+00                                 [PTCB0=]
    PTCB1 = 0.000000e+00                                 [PTCB1=]
    PTCB2 = 0.000000e+00                                 [PTCB2=]
    PTEMPA0 = 0.000000e+00                               [PTempA0=]
    PTEMPA1 = 0.000000e+00                               [PTempA1=]
    PTEMPA2 = 0.000000e+00                               [PTempA2=]
    POFFSET = 0.000000e+00                               [POffset= (decibars)]
```

General Setup Commands

DateTime=
mmddyyyyhhmmss Set real-time clock month, day, year, hour, minute, second.

Example: Set current date and time to 10 September 2010 12:00:00 (user input in bold).
datetime=09102010120000

Notes:
- The MicroCAT baud rate (set with **BaudRate=**) must be the same as Seaterm232's baud rate (set in the Communications menu).
- **BaudRate=** must be sent twice. After the first entry, the MicroCAT changes to the new baud, and then waits for the command to be sent again at the new baud (In the Communications menu, select *Configure*. In the dialog box, select the new baud rate and click OK. Then retype the command.). This prevents you from accidentally changing to a baud that is not supported by your computer. If it does not receive the command again at the new baud, it reverts to the previous baud rate.

BaudRate=x **x=** baud rate (600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, or 115200). Default 9600. Check capability of your computer and terminal program before increasing baud rate. **Command must be sent twice to change rate.**

Length of cable that MicroCAT can drive is dependent on baud. See *Baud Rate, Cable Length, Power, and Data Transmission Rate*.

OutputExecutedTag=x **x=Y**: Display XML Executing and Executed tags. Executed tag displays at end of each command response; Executing tag displays one or more times if MicroCAT response to command requires additional time.

x=N: Do not.

Example: Set MicroCAT to output Executed and Executing tags (user input in bold).
outputexecutedtag=y
<Executed/>**getcd**
. . . (**GetCD** response)
<Executed/>
(Note: <Executed/> tag at end of command response takes place of S> prompt.)

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

Note:
The MicroCAT automatically enters quiescent state after 2 minutes without receiving a command. This timeout algorithm is designed to conserve power if the user does not send **QS** to put the MicroCAT to sleep.

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

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

Note:
Do not send InitLogging or SampleNumber=0 until all data has been uploaded. These commands do not delete the data; they just reset the data pointer. **If you accidentally send one of these commands before uploading**, recover the data as follows:
1. Set **SampleNumber=x**, where **x** is your estimate of number of samples in memory.
2. Upload data. If **x** is more than actual number of samples in memory, data for non-existent samples will be bad, random data. Review uploaded data file carefully and delete any bad data.
3. If desired, increase **x** and upload data again, to see if there is additional valid data in memory.

Memory Setup Commands

StoreData=x

x=Y (default): Store data to FLASH memory when sampling.

x=N: Do not.

InitLogging

Initialize logging – after all previous data has been uploaded, initialize logging before starting to sample again to make entire memory available for recording. **InitLogging** sets sample number (**SampleNumber=**) to 0 (sampling will start with sample 1). If not set to 0, data will be stored after last recorded sample. **Do not send InitLogging until all existing data has been uploaded.**

SampleNumber=

x = sample number for last sample in memory. **SampleNumber=0** is equivalent to **InitLogging**. **Do not send SampleNumber=0 until all existing data has been uploaded.**

Output Format Setup Commands

Notes:
- See *Data Formats* after the command descriptions for complete details.
- Binary data does not output on the screen. Use Seaterm232's Capture menu to capture the data to a file before beginning sampling, and then process the data with a utility.
- The MicroCAT always stores the sample time in memory, regardless of the setting for **OutputTime=**.
- The MicroCAT does not *store* salinity, sound velocity, density, and/or depth in memory if the respective parameters are enabled for output. It calculates and outputs the values real-time or as data is uploaded; therefore, outputting these parameters has no effect on the number of samples that can be stored in memory.
- Salinity, sound velocity, density, and depth can also be calculated in SBE Data Processing, from data uploaded from the MicroCAT's memory.

OutputFormat=x

x=0: output raw decimal data.

x=1 (default): output converted decimal data.

x=2: output converted decimal data in XML.

x=3: output converted binary data.

x=4: output converted decimal data, alternate format.

x=5: output converted decimal data, BSH format.

OutputTime=x

x=Y: output date and time. Only applies if **OutputFormat=0**, **1**, **2**, **4**, or **5**.

x=N: do not.

OutputSal=x

x=Y: calculate and output salinity (psu). Only applies if **OutputFormat=1**, **2**, **4**, or **5**.
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). Only applies if **OutputFormat=1**, **2**, **4**, or **5**.

x=N: do not.

OutputDensity=x

x=Y: calculate and output local density (kg/m^3), based on salinity, temperature, and pressure. Only applies if **OutputFormat=1**, **2**, **4**, or **5**.
Note: Local density = Sigma (s,t,p) - 1000

x=N: do not.

OutputDepth=x

x=Y: calculate and output depth (meters), using **Latitude** in calculation. Only applies if **OutputFormat=1**, **2**, **4**, or **5**.

x=N: do not.

Latitude=x

x= latitude (degrees) to use in depth calculation. Only applicable if **OutputDepth=Y**.

Operating Commands

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

Note:
Sampling is started by one of the following methods:
- (if **AutoRun=N**) Send **Start**.
- (if **AutoRun=Y**) Apply power.

SampleMode=x

x=1: When commanded to sample, take a single sample.

x=2: When commanded to sample, sample at intervals defined by **SampleInterval=**.

x=3: When commanded to sample, sample continuously.

SampleInterval=x or **Interval=x**

x= interval (6 - 21600 seconds) between samples when **SampleMode=2**.

Note:
If **AutoRun=Y** and **SampleMode=2** or **3**, a simple 3-wire system (Power, Ground, Transmit) may be used for deployment, 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 must be performed with all 4 wires in place.

AutoRun=x

x=Y: When power is applied, wake up and automatically begin to sample as defined by **SampleMode=**.

x=N: When power is applied, wake up but do **not** automatically begin to sample, unless **Start** has been sent and **Stop** has not been sent.

Start or **Go**

Start sampling, as defined by **SampleMode=**. 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 continuously or with a small **SampleInterval**.

Stop

Stop sampling. Press any key before entering **Stop**. **Stop** must be sent before uploading data from memory.

The table below summarizes the interaction of the operating commands:

SampleMode=	AutoRun=	Effect
1	N	Wake up when power is applied and *Connect* (Communications menu) is selected or any key is pressed while asleep, and wait for command. When **Start** is sent, take 1 sample and go to sleep. Take another sample each time a pulse is received (press any key) or power is cycled.
2	N	Wake up when power is applied and *Connect* (Communications menu) is selected or any key is pressed while asleep, and wait for command. When **Start** is sent, sample at intervals defined by **SampleInterval=**. MicroCAT goes to sleep between samples. To stop sampling: press any key, type **Stop**, and press Enter key. Note: If power is removed before **Stop** is sent, sampling restarts when power is reapplied.
3	N	Wake up when power is applied and *Connect* (Communications menu) is selected or any key is pressed while asleep, and wait for command. When **Start** is sent, sample continuously, at fastest possible rate. To stop sampling: press any key, type **Stop**, and press Enter key. Note: If power is removed before **Stop** is sent, sampling restarts when power is reapplied.
1	Y	Wake up when power is applied, take 1 sample, and go to sleep. Take another sample each time a pulse is received (press any key) or power is cycled. To wake up: press any key, type **Stop**, and press Enter key.
2	Y	Wake up when power is applied and sample at rate specified by **SampleInterval=** until power is removed. MicroCAT goes to sleep between samples. To stop sampling: press any key, type **Stop**, and press Enter key. Note: If power is removed before **Stop** is sent, sampling restarts when power is reapplied.
3	Y	Wake up when power is applied and sample continuously, at fastest possible rate, until power is removed. MicroCAT does not go to sleep between samples. To stop sampling: press any key, type **Stop**, and press Enter key. Note: If power is removed before **Stop** is sent, sampling restarts when power is reapplied.

Polled Sampling Commands

> **Note:**
> The MicroCAT has a buffer that stores the most recent data samples. Unlike data in the FLASH memory, data in the buffer is erased upon removal of power.

These commands are used to request 1 or more samples from the MicroCAT. The MicroCAT stores data for the most recent sample in its buffer. Unless noted otherwise, the MicroCAT does not store the data in FLASH memory.

TS — Take sample, store data in buffer, output data.

TSH — Take sample, store data in buffer (do not output data).

TSS — Take new sample, store data in buffer and in **FLASH memory**, and output data.
Note: MicroCAT ignores this command if sampling data (**Start** has been sent).

TSn:x — Take **x** samples and output data. To interrupt this sampling, press Esc key.
Note: MicroCAT ignores this command if sampling data (**Start** has been sent).

SL — Output last sample stored in buffer.

SLT — Output last sample stored in buffer. Then take new sample and store data in buffer (do not output data from new sample).

Data Upload Commands

> **Notes:**
> - **Use Seaterm232's Upload menu to upload data that will be processed by SBE Data Processing**. Manually entering a data upload command does not produce data with the required header information for processing by our software. These commands are included here for reference for users who are writing their own software.
> - **If not using the Upload menu** - To save data to a file, click Capture before entering a data upload command.
> - See *Data Formats*.

Stop sampling (send **Stop** command) before uploading data.

GetSamples:b,e — Upload data from scan **b** to scan **e**, in format defined by **OutputFormat=**.
First sample is number 1.
As data is uploaded, screen first displays
`start time =`
`start sample number =`
These are start time and starting sample number for last set of logged data; can be useful in determining what data to review.

DDb,e — Upload data from scan **b** to scan **e**, in alternate converted decimal form (**OutputFormat=4**) (regardless of setting for **OutputFormat=**).
First sample is number 1.
As data is uploaded, screen first displays
`start time =`
`start sample number =`.
These are start time and starting sample number for last set of logged data; can be useful in determining what data to review.

Example: Upload samples 1 to 200 to a file (user input in bold).
(Click Capture menu and enter desired filename in dialog box)
GETSAMPLES:1,200
or
DD1,200

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

Calibration Coefficients Commands

Calibration coefficients are initially factory-set and should agree with Calibration Certificates shipped with the MicroCAT.

Temperature

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

Conductivity

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

Pressure

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
PTempA0=F	**F**=Pressure temperature a0
PTempA1=F	**F**=Pressure temperature a1
PTempA2=F	**F**=Pressure temperature a2
POffset=F	**F**=Pressure offset (decibars)

Hardware Configuration Commands

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

The following commands are used to set pump and pressure sensor configuration, manufacturing date, and PCB assembly numbers **at the factory**. Do not modify in the field.

SetPumpInstalled=N (pump is never installed for 37-SI)

SetPressureInstalled= (pressure sensor is optional, and is factory installed)

SetMfgDate=
SetPCBAssembly1=
SetPCBAssembly2=
SetPCBAssembly3=

Data Formats

Each scan ends with a carriage return <CR> and line feed <LF>.

Notes:
- Time is the time at the **start** of the sample.
- 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

- **OutputFormat=0**: raw decimal data, for diagnostic use at Sea-Bird
  tttttt, cccc.ccc, pppppp, vvvv, dd mmm yyyy, hh:mm:ss

  where
  tttttt = temperature A/D counts.
  cccc.ccc = conductivity frequency (Hz).
  pppppp = pressure sensor pressure A/D counts; sent only if optional pressure sensor installed.
  vvvv = pressure sensor pressure temperature compensation A/D counts; sent only if optional pressure sensor installed.
  dd mmm yyyy = day, month, year; sent only if **OutputTime=Y**.
  hh:mm:ss = hour, minute, second; sent only if **OutputTime=Y**.
  Note that depth, density, salinity, and sound velocity are not sent, regardless of the setting for those parameters. All data is separated with a comma and a space.

Example: Sample data output when pressure sensor is installed, **OutputFormat=0**, **OutputDepth=Y, OutputSal=Y**, **OutputSV=Y**, **OutputDensity=Y**, and **OutputTime=Y**:

```
524276,  2886.656, 785053, 2706, 20 Oct 2010, 09:01:34
```

(temperature, conductivity, pressure sensor pressure, pressure sensor temperature compensation, date, time)

- **OutputFormat=1** (default): converted decimal data
  tttt.tttt,ccc.ccccc,ppppp.ppp,dddd.ddd,ssss.ssss,vvvv.vvv,rrr.rrrr, dd mmm yyyy, hh:mm:ss

  where
  tttt.tttt = temperature (°C, ITS-90).
  ccc.ccccc = conductivity (S/m).
  ppppp.ppp = pressure (decibars); sent only if optional pressure sensor installed.
  dddd.ddd = depth (meters); sent only if **OutputDepth=Y**.
  ssss.ssss= salinity (psu); sent only if **OutputSal=Y**.
  vvvv.vvv = sound velocity (meters/second); sent only if **OutputSV=Y**.
  rrr.rrrr = local density (kg/m^3); sent only if **OutputDensity=Y**.
  dd mmm yyyy = day, month, year; sent only if **OutputTime=Y**.
  hh:mm:ss = hour, minute, second; sent only if **OutputTime=Y**.

  Leading zeros are suppressed, except for one zero to the left of the decimal point. All data is separated with a comma, date and time are also preceded by a space.

Example: Sample data output when pressure sensor is installed, **OutputFormat=1**, **OutputDepth=Y, OutputSal=Y**, **OutputSV=Y**, **OutputDensity=Y, OutputTime=Y**:

```
   8.5796,  0.15269,  531.316, 527.021,   1.1348,1451.478,  3.2486, 20 Oct 2010, 09:01:44
```

(temperature, conductivity, pressure, depth, salinity, sound velocity, local density, date, time)

Note:
For ease in reading, the data structure is shown with each XML tag on a separate line. However, there are no carriage returns or line feeds between tags (see example below).

- **OutputFormat=2**: converted decimal data in XML
  <?xml version="1.0"?>
  <datapacket>
  <hdr>
  <mfg>Sea-Bird</mfg>
  <model>37si</model>
  <sn>nnnnnnnn</sn>
  </hdr>
  <data>
  <t1>ttt.tttt</t1>
  <c1>cc.ccccc</c1>
  <p1>pppp.ppp </p1>
  <dm>dddd.ddd</dm>
  <sal>sss.ssss</sal>
  <sv>vvvv.vvv</sv>
  <sr>rrr.rrrr</sr>
  <dt>yyyy-mm-ddThh:mm:ss</dt>
  </data>
  </datapacket>

  where
  nnnnnnnn = MicroCAT serial number.
  ttt.tttt = temperature (°C, ITS-90).
  cc.ccccc = conductivity (S/m).
  pppp.ppp = pressure (decibars); sent only if optional pressure sensor installed.
  dddd.ddd = depth (meters); sent only if **OutputDepth=Y**.
  sss.ssss= salinity (psu); sent only if **OutputSal=Y**.
  vvvv.vvv = sound velocity (meters/second); sent only if **OutputSV=Y**.
  rrr.rrrr = local density (kg/m^3); sent only if **OutputDensity=Y**.
  yyyy-mm-ddThh:mm:ss = year, month, day, hour, minute, second; sent only if **OutputTime=Y**.

  Leading zeros are suppressed, except for one zero to the left of the decimal point.

Example: Sample data output when pressure sensor is installed, **OutputFormat=2**, **OutputDepth=Y, OutputSal=Y**, **OutputSV=Y**, **OutputDensity=Y**, and **OutputTime=Y**:

```
<?xml version="1.0"?><datapacket><hdr><mfg>Sea-Bird</mfg><model>37SI</model>
<sn>03709999</sn></hdr><data><t1>  8.5796</t1><c1> 0.15269</c1><p1> 531.316</p1>
<dm> 527.021</dm><sal>   1.1348</sal><sv>1451.478</sv><sr>  3.2486</sr>
<dt>2010-10-20T09:01:44</dt></data></datapacket> CRLF
```

(temperature, conductivity, pressure, depth, salinity, sound velocity, local density, date and time)

- **OutputFormat=3**: converted data in binary.
  ttttccccpppph
  where:
  tttt = temperature *100000.
  cccc = conductivity *100000.
  pppp = pressure *100000 (sent only if optional pressure sensor installed).
  h=1 byte checksum, sum of all bytes including checksum modulo 256 is 0.
  tttt, cccc, and pppp are each a 4 byte long integer stored *little endian*.

Note:
This format is identical to the format from an SBE 37-SI with ***firmware < 3.0*** and **Format=1**.
It is provided for compatibility with systems programmed for those older instruments.

- **OutputFormat=4**: converted decimal data, ***alternate***
ttt.tttt,cc.ccccc, pppp.ppp, dddd.ddd, sss.ssss, vvvv.vvv, rrr.rrrr, dd mmm yyyy, hh:mm:ss

where
ttt.tttt = temperature (°C, ITS-90).
cc.ccccc = conductivity (S/m).
pppp.ppp = pressure (decibars); sent only if optional pressure sensor installed.
dddd.ddd = depth (meters); sent only if **OutputDepth=Y**.
sss.ssss= salinity (psu); sent only if **OutputSal=Y**.
vvvv.vvv = sound velocity (meters/second); sent only if **OutputSV=Y**.
rrr.rrrr = local density (kg/m^3); sent only if **OutputDensity=Y**.
dd mmm yyyy = day, month, year; sent only if **OutputTime=Y**.
hh:mm:ss = hour, minute, second; sent only if **OutputTime=Y**.

Leading zeros are suppressed, except for one zero to the left of the decimal point. There is a comma but no space between temperature and conductivity. All other data is separated with a comma and a space.

Example: Sample data output when pressure sensor is installed, **OutputFormat=4**, **OutputDepth=Y, OutputSal=Y**, **OutputSV=Y**, **OutputDensity=Y, OutputTime=Y**:

```
  8.5796, 0.15269,  531.316,  527.021,   1.1348, 1451.478,   3.2486, 20 Oct 2010,
09:01:44
```

(temperature, conductivity, pressure, depth, salinity, sound velocity, local density, date, time)

Note:
This format is identical to the format from an SBE 37-SI with ***firmware < 3.0*** and **Format=2**.
It is provided for compatibility with systems programmed for those older instruments.

- **OutputFormat=5**: converted decimal data, ***BSH***
ttt.tttt,cc.ccccc, pppp.ppp, dddd.ddd, sss.ssss, vvvv.vvv, rrr.rrrr, mm-dd-yyyy, hh:mm:ss

where
ttt.tttt = temperature (°C, ITS-90).
cc.ccccc = conductivity (S/m).
pppp.ppp = pressure (decibars); sent only if optional pressure sensor installed.
dddd.ddd = depth (meters); sent only if **OutputDepth=Y**.
sss.ssss= salinity (psu); sent only if **OutputSal=Y**.
vvvv.vvv = sound velocity (meters/second); sent only if **OutputSV=Y**.
rrr.rrrr = local density (kg/m^3); sent only if **OutputDensity=Y**.
mm-dd-yyyy = month, day, year; sent only if **OutputTime=Y**.
hh:mm:ss = hour, minute, second; sent only if **OutputTime=Y**.

Leading zeros are suppressed, except for one zero to the left of the decimal point. There is a comma but no space between temperature and conductivity. All other data is separated with a comma and a space.

Example: Sample data output when pressure sensor is installed, **OutputFormat=5**, **OutputDepth=Y, OutputSal=Y**, **OutputSV=Y**, **OutputDensity=Y, OutputTime=Y**:

```
  8.5796, 0.15269,  531.316,  527.021,   1.1348, 1451.478,   3.2486, 10-20-2010, 09:01:44
```

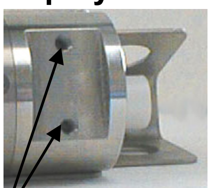
(temperature, conductivity, pressure, depth, salinity, sound velocity, local density, date, time)

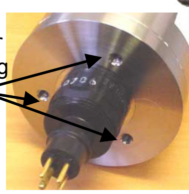
Setup for Deployment

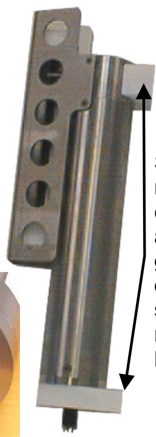
Program the MicroCAT for the intended deployment (see *Section 3: Preparing MicroCAT for Deployment* for connection information; see information above on commands and sampling modes):

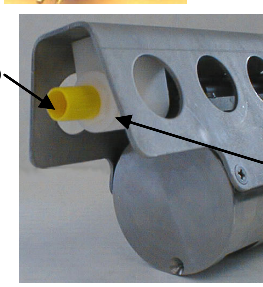
1. Set the date and time (**DateTime=**), and establish setup parameters.
2. Ensure all data has been uploaded, and then send **InitLogging** to make the entire memory available for recording.
3. Establish operating command parameters. These parameters configure the MicroCAT's response upon waking up, and direct the MicroCAT to sample data once, at pre-programmed intervals, or continuously.

Deployment

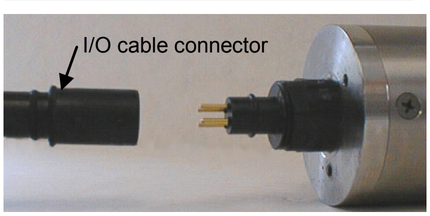


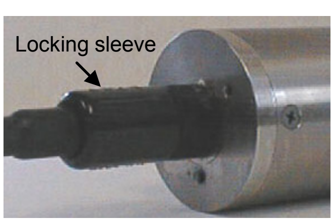






CAUTION:
Do not use WD-40 or other petroleum-based lubricants, as they will damage the connectors.





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*).
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 (see *Power and Communications Test* in *Section 3: Preparing MicroCAT for Deployment*). If you have not already done so, send **Start** to start sampling.
7. If using Seaterm232 to view real-time data, click the Capture menu before you begin sampling. Enter the desired capture file name in the dialog box, and click Save. Data displayed in Seaterm232 will be saved to the designated .cap file. 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 than 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.

Uploading and Processing Data

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

1. Double click on **SeatermV2.exe**. The main screen appears.

2. In the Instruments menu, select *SBE 37 RS232*. **Seaterm232** opens.

3. Seaterm232 tries to automatically connect to the MicroCAT. As it connects, it sends **GetHD** and displays the response. Seaterm232 also fills the Send Commands window with the correct list of commands for your MicroCAT. **If there is no communication**:

   A. In the Communications menu, select *Configure*. The Serial Port Configuration dialog box appears. Select the Comm port and baud rate for communication, and click OK. Note that the factory-set baud rate is documented on the Configuration Sheet.

   B. In the Communications menu, select *Connect* (if *Connect* is grayed out, select *Disconnect and reconnect*). Seaterm232 will attempt to connect at the baud specified in Step A, but if unsuccessful will then cycle through all other available baud rates.

   C. If there is still no communication, check cabling between the computer and MicroCAT.

   D. If there is still no communication, repeat Step A with a different comm port, and try to connect again.

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

4. If sampling autonomously, command the MicroCAT to stop logging by pressing any key, typing **Stop**, and pressing the Enter key.

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

```
SBE37SI-RS232 3.0j SERIAL NO. 6017  20 Oct 2010 00:48:50
vMain =  7.41, vLith =  3.16
samplenumber = 32, free = 559208
status = not logging
sample interval = 15 seconds
data format = converted engineering
output time
sample mode = interval sample
auto run = no
store data = yes
pump installed = no
```

   Verify that the status is **`not logging.`**

6. Click Upload menu to upload stored data. Seaterm232 responds as follows:

   A. Seaterm232 sends **GetSD** and displays the response. **GetSD** provides information on the instrument status, and number of samples in memory.

   B. In the Save As dialog box, enter the desired upload file name and click Save. The upload file has a .XML extension.

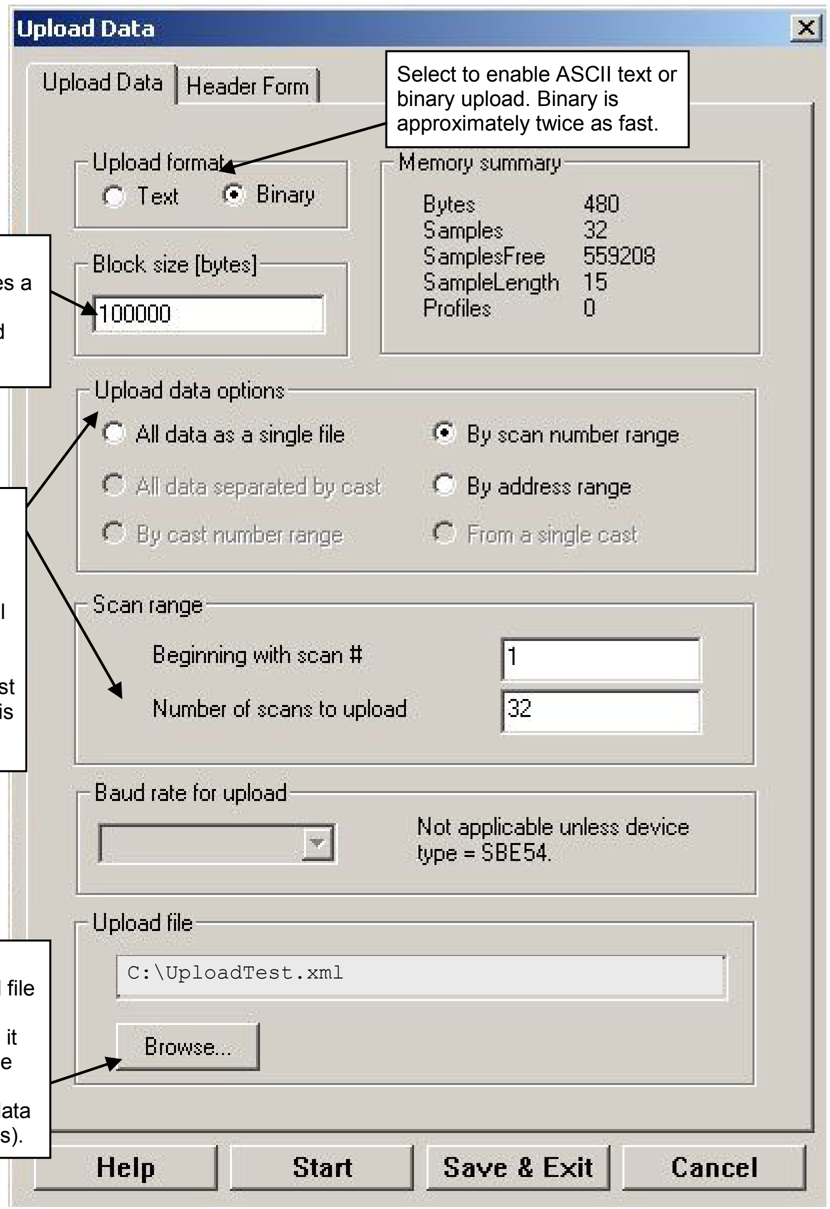
   C. An Upload Data dialog box appears:

Note:
If binary upload is selected, Seaterm232 uploads the data in binary and then converts it to ASCII text, resulting in a data file that is identical to one uploaded in ASCII text.

Select number of bytes uploaded in each block. Seaterm232 uploads data in blocks, and calculates a checksum at end of each block. If block fails checksum verification, Seaterm232 tries to upload block of data again, cutting block size in half.

Defines data upload type and range:
- All data as a single file – All data is uploaded into 1 file.
- By scan number range – Enter beginning scan (sample) number and total number of scans. All data within range is uploaded into 1 file.
- By address range – Enter beginning byte number and total number of bytes. Note that first byte in memory is byte 0. All data within range is uploaded into 1 file.

To change upload file name selected in Step B above, click Browse to navigate to desired upload file path and name. Upload file has a .xml extension. After Seaterm232 uploads data into .xml data file, it creates .hex data file and .xmlcon configuration file that are compatible with SBE Data Processing. These files are placed in same directory as .xml data file, and have same name (but different extensions).

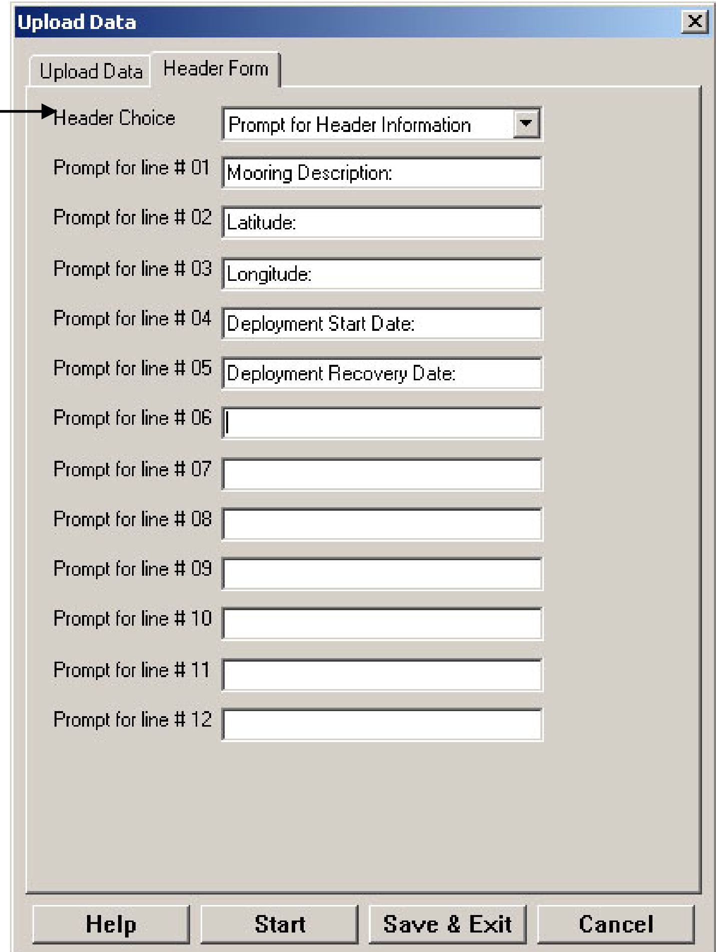


Make the desired selections.

7. Click the Header Form tab to customize the header:

Defines header information included with uploaded data:

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



The entries are free form, 0 to 12 lines long. This dialog box establishes:

- the header prompts that appear for the user to fill in when uploading data, if *Prompt for header information* was selected
- the header included with the uploaded data, if *Include default header form in upload file* was selected

Enter the desired header/header prompts.

8. Click Start; the Status bar at the bottom of the window displays the upload progress:
   A. Seaterm232 sends several status commands providing information regarding the number of samples in memory, calibration coefficients, etc., and writes the responses to the upload .xml file.
   B. **If you selected *Prompt for header information* in the Upload Data dialog box** – a dialog box with the header form appears. Enter the desired header information, and click OK. Seaterm232 writes the header information to the upload .xml file.
   C. Seaterm232 sends the data upload command, based on your selection of upload range in the Upload Data dialog box, and writes the data to the upload .xml file.
   D. From the information in the .xml file, Seaterm232 creates a .hex data file and .xmlcon configuration file that are compatible with SBE Data Processing for processing and plotting the data. These files are placed in the same directory as the .xml data file and have the same name (but different extensions).

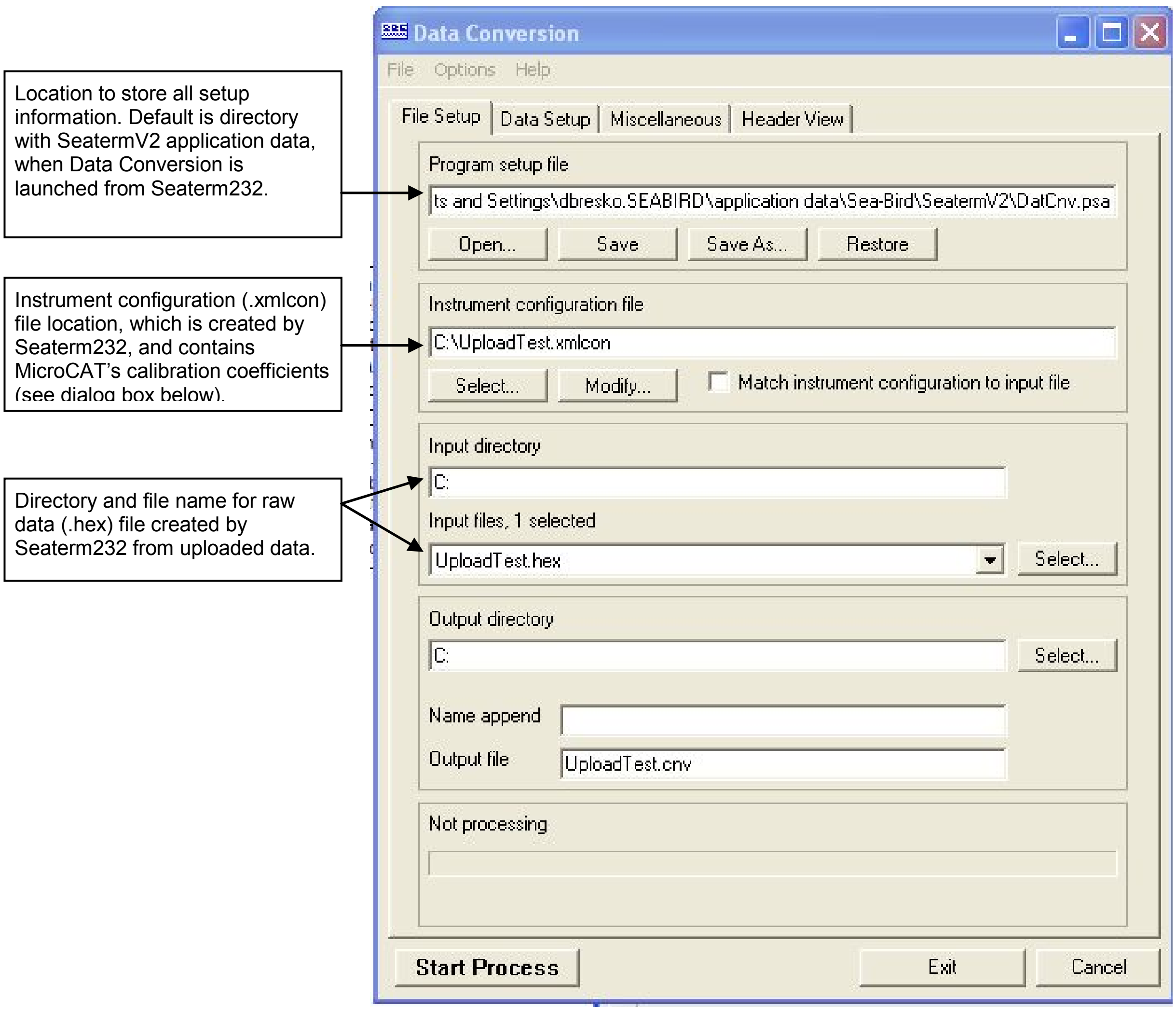
Note:
SeatermV2 with version < 1.1 did not convert the uploaded .xml data file to a .hex and .xmlcon file. *Convert .XML data file* in the Tools menu was used to convert the .xml data file to a .cnv file, which could be processed in SBE Data Processing. We recommend that you update your SeatermV2 software to 1.1b or later.

Notes:
- Ensure all data has been uploaded from the MicroCAT by reviewing the data in SBE Data Processing.
- If you do not run Data Conversion now, you can run it later by opening SBE Data Processing.
- See the SBE Data Processing manual and/or Help for details.

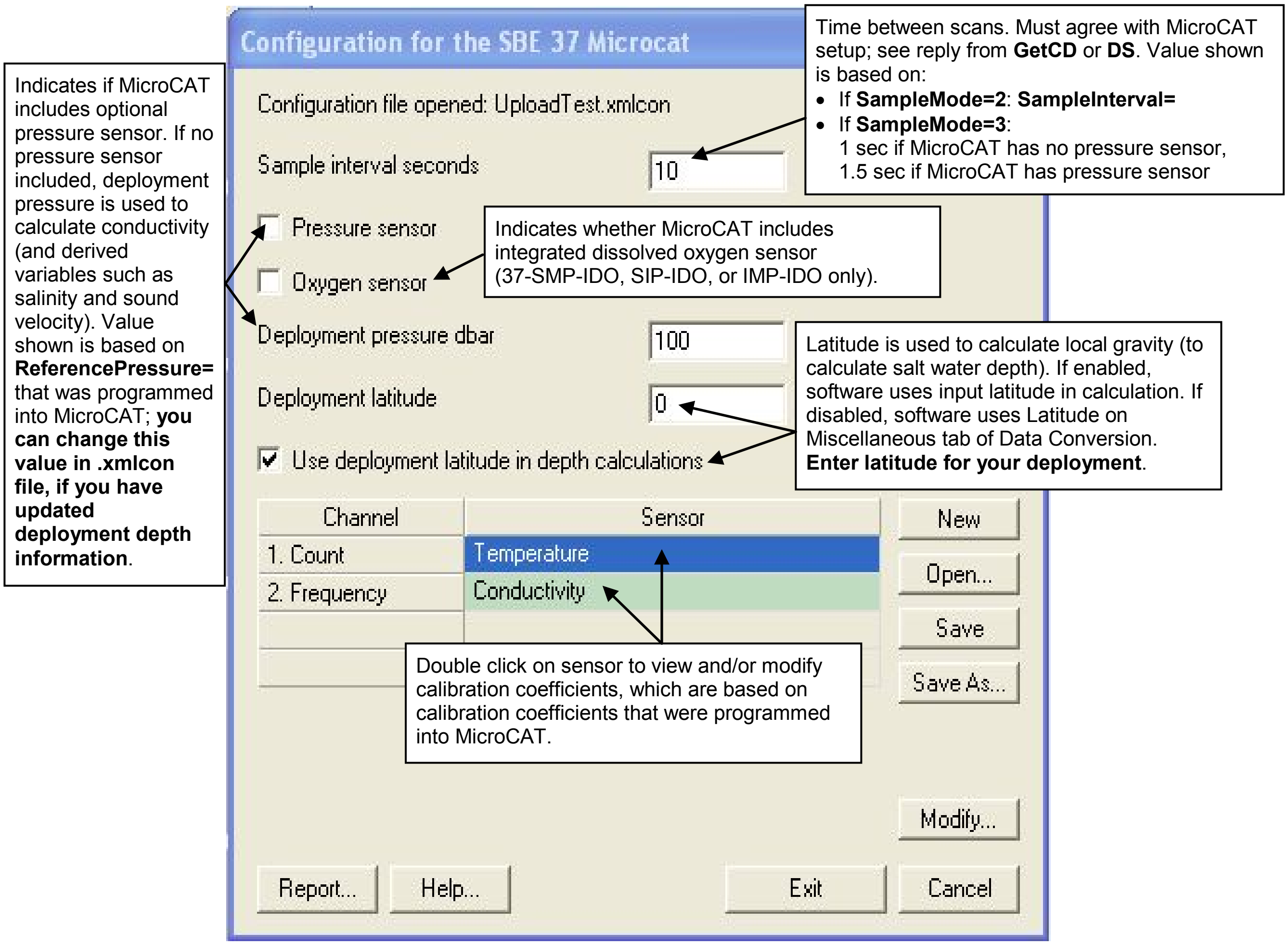
.

9. After the data has been uploaded, Seaterm232 prompts you to run SBE Data Processing's Data Conversion module if desired. Data Conversion converts the .hex (raw data) file to a .cnv file, which can then be processed by other modules in SBE Data Processing.

A. If you click Yes, Seaterm232 opens SBE Data Processing's Data Conversion module, and fills in the appropriate instrument configuration (.xmlcon) file and data (.hex) file on the File Setup tab.



The Configuration dialog box (which appears if you click *Modify* on the File Setup tab) looks like this:

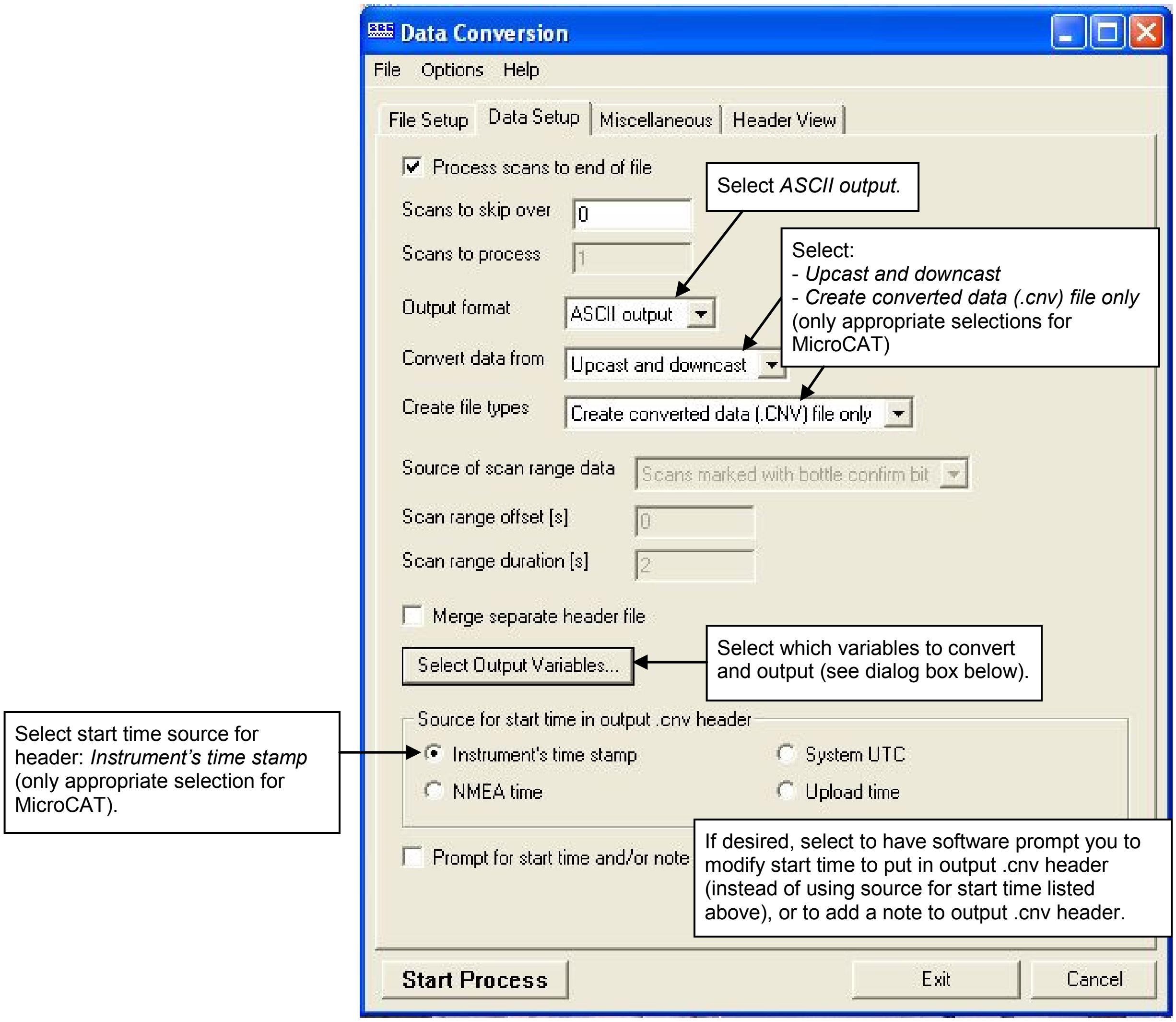


The settings in the .xmlcon file created by Seaterm232 are based on the setup of the MicroCAT.

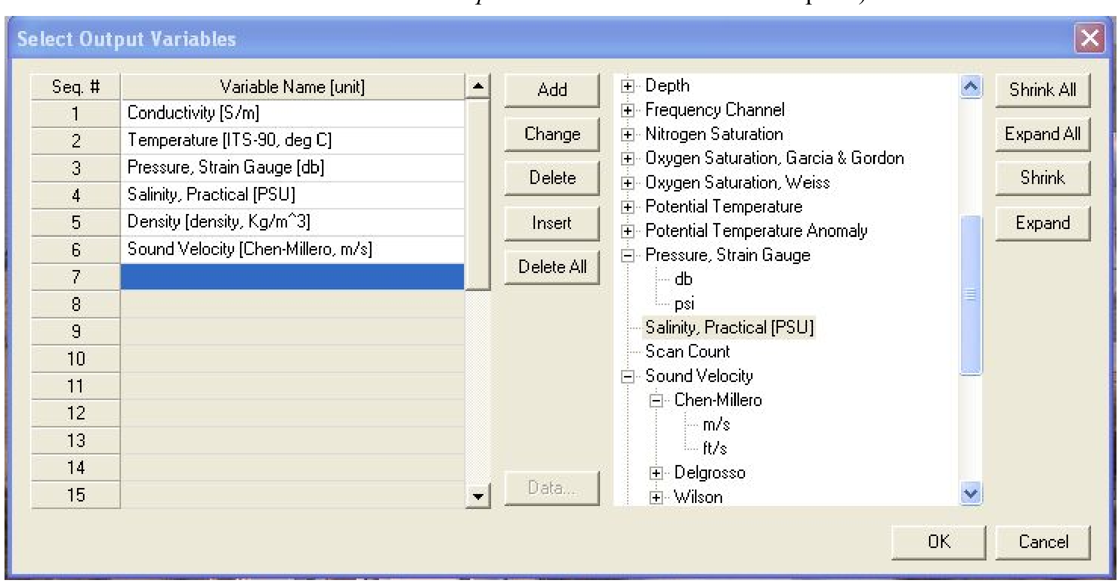
- Review the deployment latitude, and modify as needed.
- If your MicroCAT does not have a pressure sensor, review the deployment pressure, and modify as needed.

Click Save if you made any changes, and then click Exit.

B. Click on the Data Setup tab.



The Select Output Variables dialog box (which appears when you click *Select Output Variables* on the Data Setup tab) looks like this:



Select Temperature, Conductivity, and Pressure (optional), as well as desired derived variables such as salinity, sound velocity, etc. Click OK.

C. At the bottom of the Data Conversion dialog box, click Start Process to convert the .hex file to a .cnv file.

10. Once the data is converted to a .cnv file, use the other SBE Data Processing modules as desired:
    - Derive module - Calculate additional derived variables.
    - Sea Plot module - Plot data.

Notes:
To prepare for re-deployment:
1. After all data has been uploaded, send **InitLogging**. If this is not sent, new data will be stored after the last recorded sample, preventing use of the entire memory capacity.
2. Do *one* of the following:
    - Send **QS** to put the MicroCAT in quiescent (sleep) state until ready to redeploy.
    - Use **Start** to begin sampling immediately.

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

Note:
See *Application Note 57: Connector Care and Cable Installation*.

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

Clean and inspect the connectors, cable, and dummy plug before every deployment and as part of your yearly equipment maintenance. Inspect connectors that are unmated for signs of corrosion product around the pins, and for cuts, nicks or other flaws that may compromise the seal.

When remating:

1. Lightly lubricate the inside of the dummy plug/cable connector with silicone grease (DC-4 or equivalent).

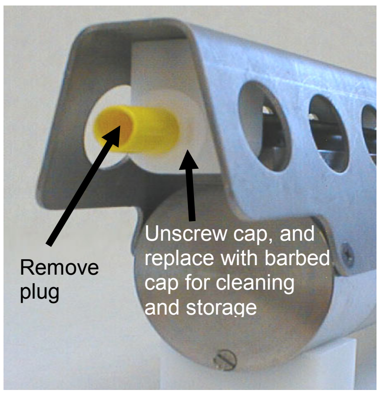
2. **Standard Connector** - Install the plug/cable connector, aligning the raised bump on the side of the plug/cable connector with the large pin (pin 1 - ground) on the MicroCAT. Remove any trapped air by *burping* or gently squeezing the plug/connector near the top and moving your fingers toward the 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.

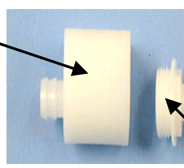
It is a violation of US Federal Law to use this product in a manner inconsistent with its labeling.

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.

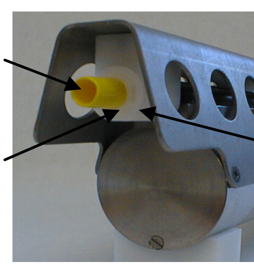
Cup



Cap

Plug

Cap



Cup

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

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

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

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

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

1. Place the MicroCAT in the orientation it will have when deployed.

2. In Seaterm232:
   A. Set the pressure offset to 0.0 (**POffset=0**).
   B. Set the output format to converted decimal (**OutputFormat=1**), so the pressure output will be in decibars.
   C. Send **TSn:100** to take 100 samples and transmit data.

3. Compare the MicroCAT output to the reading from a good barometer at the same elevation as the MicroCAT's pressure sensor port.
   Calculate *offset* = barometer reading – MicroCAT reading

4. Enter the calculated offset (positive or negative) in the MicroCAT's EEPROM, using **POffset=** in Seaterm232.

> *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

If **OutputExecutedTag=N**, the S> prompt indicates that communications between the MicroCAT and computer have been established. Before proceeding with troubleshooting, attempt to establish communications again by selecting *Connect* in the Communications menu in Seaterm232 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 communication settings may not have been entered correctly in Seaterm232. Verify the settings in the Serial Port Configuration dialog box (Communications menu -> *Configure*). 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: No Data Recorded

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

Cause/Solution 2: **StoreData=** may be set to *no*. If it is set to no, data will be output real-time but will not be stored to memory. With **StoreData=Y**, **GetCD** or **DS** will show *store data* set to *yes*.

Problem 3: 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 **GetCC** to verify the calibration coefficients in the MicroCAT match the instrument Calibration Certificates. Note that calibration coefficients do not affect the raw data stored in MicroCAT memory.

- If you have not yet overwritten the memory with new data, you can correct the coefficients and then upload the data again.
- If you have overwritten the memory with new data, you can manually correct the coefficients in the .xmlcon configuration file, and then reprocess the data in SBE Data Processing's Data Conversion module.

Problem 4: Salinity Spikes

Salinity is a function of conductivity, temperature, and pressure, and must be calculated from C, T, and P measurements made on the same parcel of water. Salinity is calculated and output by the 37-SI if **OutputSal=Y**. Alternatively, salinity can be calculated in SBE Data Processing's Data Conversion module from the data uploaded from memory (.hex file) or in SBE Data Processing's Derive module from the converted (.cnv) file.

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

In **moored,** free-flushing instruments such as the 37-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 (SBE 37) – High-accuracy conductivity, temperature, and optional pressure Recorder/Sensor. A number of models are available:

- 37-IM (**I**nductive **M**odem, internal battery and memory)
- 37-IMP (**I**nductive **M**odem, internal battery and memory, integral **P**ump)
- 37-IMP-IDO (**I**nductive **M**odem, internal battery and memory, integral **P**ump, **I**ntegral **D**issolved **O**xygen)
- 37-SM (**S**erial interface, internal battery and **M**emory)
- 37-SMP (**S**erial interface, internal battery and **M**emory, integral **P**ump)
- 37-SMP-IDO (**S**erial interface, internal battery and **M**emory, integral **P**ump, **I**ntegral **D**issolved **O**xygen)
- 37-SI (**S**erial **I**nterface, memory, no internal battery) *
- 37-SIP (**S**erial **I**nterface, integral **P**ump, memory, no internal battery) *
- 37-SIP-IDO (**S**erial **I**nterface, integral **P**ump, **I**ntegral **D**issolved **O**xygen, memory, no internal battery)

The SM, SMP, SMP-IDO, SI, SIP, and SIP-IDO are available with RS-232 (standard) or RS-485 (optional) interface.
* Note: Version 3.0 and later of the 37-SI and 37-SIP include memory; earlier versions did not include memory.

PCB – Printed Circuit Board.

Note:
All Sea-Bird software listed was designed to work with a computer running Windows 2000/XP. Extensive testing has not shown any compatibility problems when using the software with a computer running Windows Vista or Windows 7 (32-bit).

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

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

SEASOFT V2 – Sea-Bird's complete Win 2000/XP software package, which includes software for communication, real-time data acquisition, and data analysis and display. SEASOFT V2 includes ***SeatermV2*** and ***SBE Data Processing***.

SeatermV2 – Win 2000/XP terminal program *launcher*, which launches the appropriate terminal program for the selected instrument (Seaterm232 for this MicroCAT).

Seaterm232 – Win 2000/XP terminal program used with Sea-Bird instruments that communicate via an RS-232 interface, and that were developed or redesigned in 2006 and later. The common feature of these instruments is the ability to output data in XML. The current list of instruments supported by Seaterm232 includes: SBE 16*plus* V2 (RS-232 interface, version 2 or later firmware); SBE 19*plus* V2 (version 2 or later firmware); SBE 37-SM / SMP / SI / SIP (all RS-232 interface, all version 3 or later firmware), SBE 37-SMP-IDO / SIP-IDO (all RS-232 interface), SBE 54, and Glider Payload CTD.

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 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 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 our modular SBE 3 and SBE 4 sensors and in the SEACAT and SEACAT *plus* family.

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

The MicroCAT's optional strain-gauge pressure sensor is available in the following pressure ranges: 20, 100, 350, 600, 1000, 2000, 3500, and 7000 meters. Compensation of the temperature influence on pressure offset and scale is performed by the MicroCAT's CPU.

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.

Real-Time Clock

To minimize power and improve clock accuracy, a temperature-compensated crystal oscillator (TCXO) is used as the real-time-clock frequency source. The TCXO is accurate to ± 1 minute per year (0 ºC to 40 ºC).

Memory

The MicroCAT has a 8-Mbyte non-volatile FLASH memory for data storage. FLASH memory is non-volatile, and data in the memory is not lost as a result of removed of external power. Because FLASH is written to a *page* (256 bytes) at a time, data is first accumulated in a 256-byte RAM buffer. When the buffer is full, its contents are transferred to FLASH memory. The buffer is volatile, and thus depends on external power. Therefore, any data that is in the buffer when external power is removed will be corrupted.

Conductivity and temperature are stored in 6 bytes/sample, time in 4 bytes/sample, and optional pressure in 5 bytes/sample. Thus, the 256-byte buffer can hold 25 samples of T, C, and time, or 17 samples, of T, C, P, and time. This is the maximum amount of data that will be corrupted each time external power is removed.

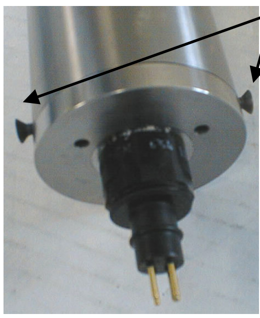
Example 1: You stop logging, do not upload data from memory, and remove external power when there are 256,000 bytes in FLASH memory and 100 bytes in the buffer. When you apply power and resume logging, the MicroCAT fills the remaining 156 bytes in the buffer with new data, writes the entire buffer to the FLASH memory, and continues logging and writing data to the buffer. The 100 bytes that were in the buffer when power was removed is corrupted; the data before it (from the first deployment) and the data after it (from the second deployment) are unaffected.

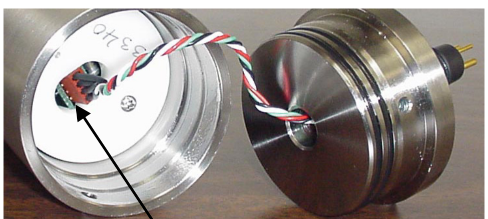
Example 2: You stop logging, upload data from memory, and remove external power when there are 256,000 bytes in FLASH memory and 100 bytes in the buffer. The MicroCAT correctly uploads the data in the FLASH memory as well as the data in the buffer.

Appendix II: Electronics Disassembly/Reassembly

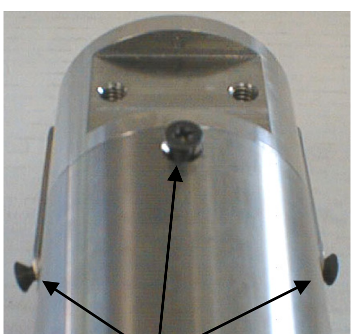
Disassembly

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



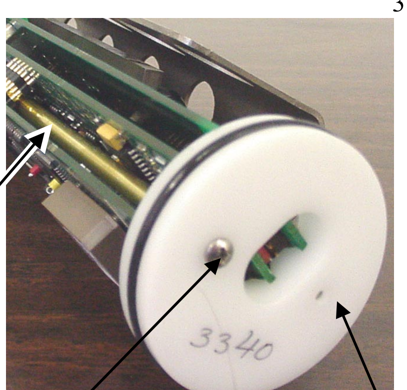


1. Remove the I/O connector end cap and disconnect the electronics from the end cap:
   A. Wipe the outside of the I/O connector end cap and housing dry, being careful to remove any water at the seam between them.
   B. Remove the two flat Phillips-head titanium machine screws. Do not remove any other screws from the housing.
   Note: For plastic-housing MicroCATs shipped or retrofitted after July 2008, these are hex screws instead of Phillips-head screws. Sea-Bird ships the MicroCAT with a 9/64-inch Allen wrench for these screws.
   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.

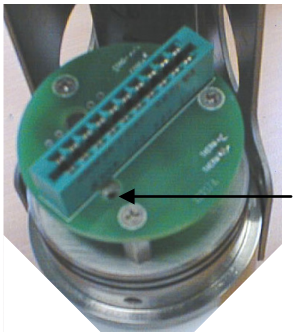


2. Remove the housing from the electronics:
   A. Wipe the outside of the sensor end cap and housing dry, being careful to remove any water at the seam between them.
   B. Remove the two flat Phillips-head titanium machine screws connecting the guard to the housing and sensor end cap. Do not remove any other screws from the guard.
   C. Remove the flat Phillips-head titanium machine screw connecting the housing to the sensor end cap.
   Note: For plastic-housing MicroCATs shipped or retrofitted after July 2008, this is a hex screw instead of a Phillips-head screw. Sea-Bird ships the MicroCAT with a 9/64-inch Allen wrench for this screw.
   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.



Reassembly



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	**GetCD**	Get and display configuration data.
	GetSD	Get and display status data.
	GetCC	Get and display calibration coefficients.
	GetEC	Get and display event counter data.
	ResetEC	Reset event counter.
	GetHD	Get and display hardware data.
	DS	Get and display status and configuration data.
	DC	Get and display calibration coefficients.
General Setup	**DateTime= mmddyyyyhhmmss**	Set real-time clock month, day, year, hour, minute, second.
	BaudRate=x	**x=** baud rate (600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, or 115200). Default 9600.
	OutputExecutedTag=x	**x=Y**: Display XML Executing and Executed tags. **x=N**: Do not.
	ReferencePressure=x	**x** = reference pressure (gauge) in decibars (used for conductivity, salinity, and sound velocity computation when MicroCAT does not have pressure sensor).
	QS	Quit session and place MicroCAT in quiescent (sleep) state.
Memory Setup	**StoreData=x**	**x=Y**: Store data to FLASH memory when sampling. **x=N**: Do not.
	InitLogging	Initialize logging to make entire memory available for recording.
	SampleNumber=x	**x=** sample number for last sample in memory. **SampleNumber=0** equivalent to **InitLogging**.
Output Format Setup	**OutputFormat=x**	**x=0**: output raw decimal data. **x=1**: output converted decimal data. **x=2**: output converted decimal data in XML. **x=3**: output converted binary data. **x=4**: output converted decimal data, alternate format. **x=5**: output converted decimal data, BSH format.
	OutputTime=x	**x=Y**: output date and time. Only applies if **OutputFormat=0**, **1**, **2**, **4**, or **5**. **x=N**: do not.
	OutputSal=x	**x=Y**: calculate and output salinity (psu). Only applies if **OutputFormat=1**, **2**, **4**, or **5**. **x=N**: do not.
	OutputSV=x	**x=Y**: calculate and output sound velocity (m/sec). Only applies if **OutputFormat=1**, **2**, **4**, or **5**. **x=N**: do not.
	OutputDensity=x	**x=Y**: calculate and output local density (kg/m^3). Only applies if **OutputFormat=1**, **2**, **4**, or **5**. **x=N**: do not.
	OutputDepth=x	**x=Y**: calculate and output depth (meters). Only applies if **OutputFormat=1**, **2**, **4**, or **5**. **x=N**: do not.
	Latitude=x	**x** = latitude (degrees) to use in depth calculation.

CATEGORY	COMMAND	DESCRIPTION
Operating	**SampleMode=x**	**x=1**: When commanded to sample, take 1 sample. **x=2**: When commanded to sample, sample at intervals defined by **SampleInterval=**. **x=3**: When commanded to sample, sample continuously.
	SampleInterval=x or **Interval=x**	**x=** interval (seconds) between samples (6 - 21600) if **SampleMode=2**.
	AutoRun=x	**x=Y**: When power applied, automatically sample as defined by **SampleMode=**. **x=N**: When power applied, do not begin to automatically sample.
	Start or **Go**	Start sampling, as defined by **SampleMode=**.
	Stop	Stop sampling. Must send **Stop** before uploading data.
Polled Sampling	**TS**	Take sample, store in buffer, output data.
	TSH	Take sample, store in buffer (do not output).
	TSS	Take sample, store in buffer and in FLASH memory, output data.
	TSn:x	Take **x** samples and output data.
	SL	Output last sample stored in buffer.
	SLT	Output last sample stored in buffer, then take new sample and store in buffer (do not output data from new sample).
Data Upload (send **Stop** before sending upload command)	**GetSamples:b,e**	Upload scan **b** to scan **e**, in format defined by **OutputFormat=**.
	DDb,e	Upload scan **b** to scan **e**, in alternate converted decimal form (**OutputFormat=4**) (regardless of setting for **OutputFormat=**).
Calibration 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. View all coefficients with **GetCC** or **DC**.	**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.
	PTempA0=F	**F**=Pressure temperature a0.
	PTempA1=F	**F**=Pressure temperature a1.
	PTempA2=F	**F**=Pressure temperature a2.
	POffset=F	**F**=Pressure offset (decibars).
Hardware Configuration	*Factory Settings – do not modify in the field* **SetPumpInstalled=N** (only valid setting for 37-SI) **SetPressureInstalled=** **SetMfgDate=** **SetPcbAssembly1=, SetPcbAssembly2=, SetPcbAssembly3=**	

Note:
Use Seaterm232's Upload menu to upload data that will be processed by SBE Data Processing. Manually entering a data upload command does not produce data with the required header information for processing by SBE Data Processing.

Note:
For consistency with user systems set up for older firmware (< 3.0), the following commands were re-introduced with firmware 3.0j:

- **Interval=** (equivalent to **SampleInterval=** in current firmware)
- **Go** (equivalent to **Start** in current firmware)
- **NCycles=** (no equivalent command in current firmware; this parameter is always set internally to 4. MicroCAT now accepts this command, but does not change any settings or internal calculations.)

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.
13431 NE 20th Street
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.
13431 NE 20th Street
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 HANDLING: Nonrefillable container. Do not reuse this container for any other purpose. Offer for recycling, if available.

Sea-Bird Electronics/label revised 01-28-10

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)
233539	Anti-foulant device cup	Holds AF24173 Anti-Foulant Device	2
233540	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	Spare hardware/O-ring kit for 37-SI / -SIP with titanium housing	Assorted hardware and O-rings, including: • 30859 Machine screw, 8-32 x 3/8” FH, 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, titanium (secures guard to sensor end cap through holes that also secure housing to end cap) • 30860 Screw, 6-32 x ½ FH, titanium (secures cable clamp half to flat area of sensor end cap) • 30900 Bolt, 1/4-20 x 2” hex head, titanium (secures mounting clamp) • 30633 Washer, 1/4” split ring lock, titanium (for 30900) • 30634 Washer 1/4” flat, titanium (for 30900) • 31019 O-ring Parker 2-008 N674-70 (for 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
60051	Spare hardware/ O-ring kit for 37-SI / -SIP with plastic housing	Assorted hardware and O-rings, including: • 30859 Machine screw, 8-32 x 3/8" FH, titanium (secures housing to I/O connector end cap, housing to sensor end cap, and guard to sensor end cap) • 30857 Parker 2-033E515-70 O-ring (I/O connector end cap and sensor end cap O-ring) • 30544 Machine screw, 8-32 x 1/2" FH, titanium (secures guard to sensor end cap through holes that also secure housing to end cap) • 30860 Screw, 6-32 x ½ FH, titanium (secures cable clamp half to flat area of sensor end cap) • 30900 Bolt, 1/4-20 x 2" hex head, titanium (secures mounting clamp) • 30633 Washer, 1/4" split ring lock, titanium (for 30900) • 30634 Washer 1/4" flat, titanium (for 30900) • 31019 O-ring Parker 2-008 N674-70 (for 30900 – retains mounting clamp hardware) • 31040 Screw, 8-32 x 1 FH, titanium (secures cable guide base to I/O connector end cap) • 31755 Cap screw, 8-32 x 1/4" SH, titanium (secures connector end cap to housing) • 31516 Hex key, 9/64 inch long arm (for installing 31755)	-
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

Appendix VI: Manual Revision History

Manual Version	Date	Description
008	10/99	• Rewrite.
009	11/99	• Design change from potted to modular (take apart).
010	12/99	• Firmware 2.1: add **Latitude=**, **OutputDensity=**, and **OutputDepth=**.
011	09/00	• Changes related to firmware version 2.2. • Change to Druck pressure sensor. • Incorporate SEATERM. • Correct pressure port size. • Add information and drawing of brackets. • Remove 'optically-isolated' from description. • Remove reference to SEASOFT for post-processing.
012	01/01	• Minor update to specifications for consistency with new data sheet. • Add more description of effect of **NCycles=** on sampling rate.
013	02/02	• Add 2000 m pressure sensor. • Add connector diagram for wet-pluggable connector. • Correct sample timing calculation. • Add explanation that output density is sigma (s,t,p).
014	12/02	• Add caution that setting time without date resets date to last date set with **ddmmyy=** or **mmddyy=**. • Add information on baud rate, sampling time, and cable length. • Correct pressure sensor calibration fitting. • Anti-foul information: use EPA-approved descriptions and labels.
015	01/03	• Add AF label information in appendix.
016	11/03	• Design change: update photos showing molex connection. • Add information that reference pressure line appears in **DS** reply only if no pressure sensor. • Update replacement parts list to include contents of spares kit. • Update Seaterm screens.
017	03/04	• Add information that if jumper set in autopower position, 37-SI won't go to sleep between samples, but it will still sample at the set interval. • Update power and cable length section.
018	06/04	• Firmware 2.3: new board layout, new power specifications. • Update power consumption / cable length calculations.
019	05/05	• Add 600 m Druck pressure sensor. • Update cleaning recommendations to correspond to revised application note 2D. • Update AF24173 Anti-Foulant Device appendix to current label. • Add troubleshooting section.
020	05/06	• Add information that 37-SI does not 'go to sleep' between samples when interval > 10 sec, regardless of jumper setting. • Update wet-pluggable connector information. • Add more information to Recovery Warning.
021	11/06	• Add option for 250 m plastic housing. • Add more explanation of **NCycles=**. • Update pressure port maintenance – SBE no longer putting silicon oil in port.
022	06/07	• Add handling precautions for plastic housing.
023	04/08	• Update for Version 3 firmware changes: 37-SI now has memory, many commands changed, power specifications changed. • Change stability specification for pressure to per year instead of per month. • Update connector maintenance information for consistency with application note 57. • Add information that **POffset** is in decibars.

Continued on next page

Continued from previous page

024	08/08	• Firmware revision 3.0d: new output format to match format available from firmware<3.0. **DDb,e** uploads data in this new output format. • Manufacturing change: for plastic housing, 2 phillips-head screws at connector end cap end and 1 at sensor end cap end are replaced with hex screws. 9/64" allen wrench shipped with instrument. • Remove **SetPCBSerialNum** commands**.**
025	01/09	• Update for SeatermV2 terminal program. • Firmware updates: - Add **OutputFormat=5** (same as old **Format=2**), says "converted engineering BSH" in status. - If no pressure sensor, reference pressure appears in **GetCD** (only if pressureinstalled=no). Does not appear in **DC**, appears in **DS** instead (only if pressureinstalled=no) • Add information that when external power removed, any data in 256 byte Ram buffer does not get put in FLASH RAM. • Add information about compatibility with Vista. • Correction: Add PTempA0, PTempA1, PTempA2 to calibration coefficient commands.
026	01/10	• Change Seasoft-Win32 to Seasoft V2, update file name to SeasoftV2_*date*.exe. • SBE Data Processing 7.20a: Add information about .xmlcon file. • Add CE mark. • Update SBE address. • Update anti-foul label in Appendix with new Container Handling requirement and new address.
027	07/10	• Firmware 3.0j added following 3 commands for compatibility with firmware < 3.0: **Go** (same as **Start**), **Interval=** (same as **SampleInterval=**), **NCycles=** (accepts command but does nothing). • Add 60051 spares kit for plastic housing.
028	10/10	• Update for changes to SeatermV2 version 1.1 (upload now converts .xml file to .hex and .xmlcon files, which are used in Data Conversion to convert to .cnv file for further processing). • Troubleshooting, Problem 2 (no data recorded): add that **StoreData=N** will prevent data from being stored to memory. • Remove references to Druck pressure sensors (pressure sensors can be supplied by other manufacturers).
029	03/11	• SeatermV2 1.1b changes: - Update upload procedure, Seaterm232 now automatically starts SBE Data Processing after upload - Update SeatermV2 Instruments list screen capture • Add information about compatibility with Windows 7

Index

A

Anti-Foulant Device · 67
- removal before shipping to Sea-Bird · 54
- replacing · 53

Autonomous sampling · 20, 35

B

Baud rate · 22, 32

C

Cable length · 22, 23
Calibration · 54
calibration coefficients · 37
Cleaning · 51
Clock · 9, 60
Command summary · 64
Commands
- autonomous sampling · 35
- baud rate · 32
- calibration coefficients · 37
- data format · 34
- data upload · 36, 43
- date and time · 32
- descriptions · 24
- general setup · 32
- hardware configuration · 37
- memory setup · 33
- operating · 35
- polled sampling · 36
- pressure sensor · 37
- pump setup · 37
- serial line sync · 35
- status · 25
- upload · 43

Communication defaults · 15
Conductivity cell · 60
Conductivity cell cleaning · 51
Connector · 10, 50
Continuous sampling · 20, 35
Corrosion precautions · 50

D

Data Conversion · 46
Data format · 34, 38
Data processing · 8, 12, 43, 46
Data transmission rate · 22
Data upload · 36, 43
Date and time · 32
Deployment
- installation · 41
- preparing for · 12
- setup · 41

Derive · 46
Description · 7
Dimensions · 10

E

Electronics disassembly/reassembly · 62
End cap · 10, 50
External power and memory · 18, 61

F

Flooded MicroCAT · 42
Format
- data · 38

Functional description · 60

G

Glossary · 58
Guard
- removal · 53

H

hardware configuration · 37

I

Initializing memory · 33
Interval sampling · 20, 35

M

Maintenance · 50
Manual revision history · 73
Memory · 9
Memory and power · 18, 61
Memory setup · 33
Modes · *See* Sampling modes
Mounting · 41

O

Output format · 34, 38

P

Parker Super O-Lube · 59
Parts
- replacement · 71

Plastic housing
- handling · 52

Polled sampling · 19, 36
Power · 9, 23
Power and memory · 18, 61
Pressure sensor · 60
- maintenance · 51

Pressure sensor setup · 37
Processing data · 43
Pump setup · 37

Q

Quick start · 5

R

Recovery · 42
  uploading data · 43
Replacement parts · 71
Revision history · 73

S

Sample timing · 11
Sampling modes · 18
  autonomous · 20
  polled · 19
  serial line sync · 21
SBE Data Processing · 8, 12, 46
Sea Plot · 46
SEASOFT · 8, 12
Seaterm232 · 8, 12, 13, 43
SeatermV2 · 8, 12, 13, 43
Sensors · 9
Serial line sync · 21, 35
Setup commands · 32
ShallowCAT
  handling · 52
Software · 8, 12
Specifications · 9
Status commands · 25
Storage · 51
Super O-Lube · 59
System description · 7

T

Terminal program · 8, 12, 13, 43
Testing · 12
Thermistor · 60
Timeout description · 24
Triton · 59
Troubleshooting · 56

U

Unpacking MicroCAT · 6
Upload · 36
Uploading data · 43

V

Versions · 73

W

Wiring · 12

SBE 37-SI (RS-232) MicroCAT Reference Sheet
(see SBE 37-SI MicroCAT User's Manual for complete details)

Sampling Modes

Sampling modes include:

- **Autonomous sampling** – There are two types of Autonomous sampling.
  Interval sampling: At pre-programmed intervals, the MicroCAT samples and transmits data, and stores data in FLASH memory.
  Continuous sampling: The MicroCAT continuously samples and transmits data, and stores data in FLASH memory.

- **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, store data in FLASH memory, 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 SeatermV2.exe. SeatermV2 opens; in the Instruments menu, select *SBE 37 RS232*. Seterm232 opens.

2. In Seaterm232's Communications menu, select Configure. Select the Comm port and baud rate (factory set to 9600), and click OK.

3. Seaterm232 should automatically connect to the MicroCAT. As it connects, it sends **GetHD** and displays the response, and then fills the Send Commands window with the list of commands for your MicroCAT.

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 (8.5 - 24 VDC).

2. Set date and time (**DateTime=**).

3. Establish setup and operating parameters. Parameters that control operation include:
   - **SampleMode=**
     SampleMode=1: When commanded to sample, take a single sample.
     SampleMode=2: When commanded to sample, sample at intervals defined by **SampleInterval=**.
     SampleMode=3: When commanded to sample, sample continuously.
   - **AutoRun=**
     AutoRun=Y: When power applied, automatically sample as defined by **SampleMode=**.
     AutoRun=N: When power applied, do not begin to automatically sample.

4. Ensure all data has been uploaded from memory, and then send **InitLogging** to make entire memory available for recording. If **InitLogging** is not sent, data will be stored after last recorded sample.

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 in Communications menu or pressing Enter key.
- If a new command is not received within 2 minutes after completion of a command, MicroCAT returns to quiescent (sleep) state.
- MicroCAT sends an error message 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	**GetCD**	Get and display configuration data.
	GetSD	Get and display status data.
	GetCC	Get and display calibration coefficients.
	GetEC	Get and display event counter data.
	ResetEC	Reset event counter.
	GetHD	Get and display hardware data.
	DS	Get and display status.
	DC	Get and display calibration coefficients.
General Setup	**DateTime= mmddyyyyhhmmss**	Set real-time clock month, day, year, hour, minute, second.
	BaudRate=x	**x=** baud rate (600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, or 115200). Default 9600.
	OutputExecutedTag=x	**x=Y**: output XML Executed and Executing tags. **x=N**: do not.
	ReferencePressure=x	**x** = reference pressure (decibars) (used when MicroCAT has no pressure sensor).
	QS	Quit session and place MicroCAT in quiescent (sleep) state.
Memory Setup	**StoreData=x**	**x=Y**: Store data to FLASH memory when sampling. **x=N**: do not.
	InitLogging	Initialize logging to make entire memory available for recording.
	SampleNumber=x	**x**= sample number for last sample in memory. **SampleNumber=0** equivalent to **InitLogging**.
Output Format Setup	**OutputFormat=x**	**x=0**: raw decimal data. **x=1**: converted decimal data. **x=2**: converted decimal data in XML. **x=3**: converted binary data. **x=4**: converted decimal data, alternate format. **x=5**: converted data, BSH format.
	OutputTime=x	**x=Y**: output date and time. **x=N**: do not.
	OutputSal=x	**x=Y**: output salinity (psu). **x=N**: do not.
	OutputSV=x	**x=Y**: output sound velocity (m/sec). **x=N**: do not.
	OutputDensity=x	**x=Y**: output local density (kg/m^3). **x=N**: do not.
	OutputDepth=x	**x=Y**: output depth (meters). **x=N**: do not.
	Latitude=x	**x**= latitude (degrees) to use in depth calculation.
Operating	**SampleMode=x**	**x=1**: When command to sample, take single sample. **x=2**: When command to sample, sample at intervals defined by **SampleInterval=**. **x=3**: When command to sample, sample continuously.
	SampleInterval=x	**x** = interval between samples (6 - 21600 seconds) when **SampleMode=2**.
	AutoRun=x	**x=Y**: When power applied, automatically sample as defined by **SampleMode=**. **x=N**: When power applied, do not begin to automatically sample.
	Start	Start sampling, as defined by **SampleMode=**.
	Stop	Stop sampling. Must send **Stop** before uploading data.
Polled Sampling	**TS**	Take sample, store data in buffer, output data.
	TSH	Take sample, store data in buffer, do not output data.
	TSS	Take sample, store data in buffer and in FLASH memory, output data.
	TSn:x	Take **x** samples, output data.
	SL	Output last sample stored in buffer.
	SLT	Output last sample stored in buffer, then take new sample and store data in buffer.
Data Upload	**DDb,e**	Upload scan **b** to scan **e**, in alternate converted decimal form (**OutputFormat=4**) (regardless of user setup for **OutputFormat=**).
	GetSamples:b,e	Upload scan **b** to scan **e**, in format defined by **OutputFormat=**.
Calibration Coefficients	*See manual.*	
Hardware Configuration	*See manual.*	

CALIBRATION SHEETS

SBE 37SI Configuration - S/N 8257.................................. 1

SBE 37SI Pressure Test Certificate - S/N 8257.................. 2

SBE 37SI Temperature Calibration - S/N 8257.................. 3

SBE 37SI Conductivity Calibration - S/N 8257................. 4

SBE 37SI Pressure Calibration - S/N 8257......................... 5

SBE37-SI MicroCAT

Conductivity & Temperature Recorder
with RS-232 Serial Interface

Instrument Configuration:

Serial Number	37SI64611-8257
Pressure Sensor	350 dBar Druck, SN 3276592
Firmware Version	3.0j
Memory	8192Kb
Interface Type	RS-232
Conductivity Range	0-7 S/m
Baud Rate	9600, 8 data bits, no parity
Zero Conductivity	2708.273 Hz
Maximum Depth	**250 meters**

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

SBE

Sea-Bird Electronics, Inc.
13431 NE 20th St. 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: **6/10/2011** Description **SBE-37 Microcat**

Job Number: **64611** Customer Name **U MAINE**

SBE Sensor Information:

Model Number: **37**

Serial Number: **8257**

Pressure Sensor Information:

Sensor Type: **Druck**

Sensor Serial Number: **3276592**

Sensor Rating: **508**

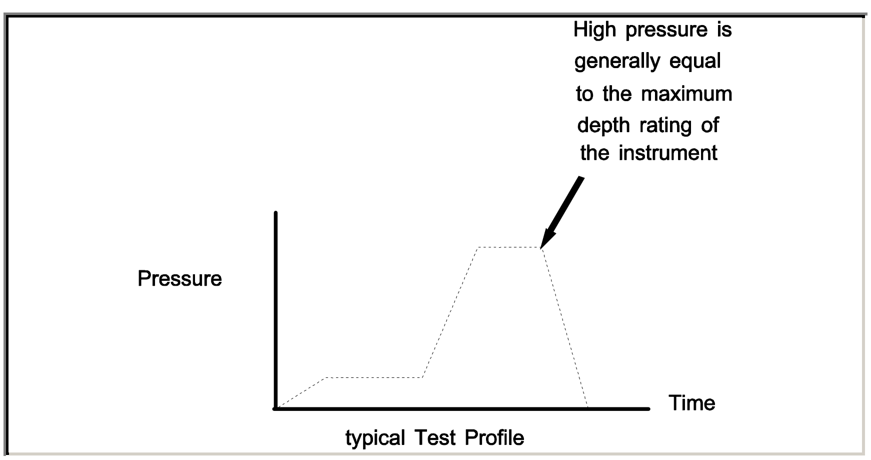
Pressure Test Protocol:

Low Pressure Test: **40** PSI Held For: **15** Minutes

High Pressure Test: **350** PSI Held For: **15** Minutes

Passed Test: ☑

Tested By: VG



SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA

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

SENSOR SERIAL NUMBER: 8257
CALIBRATION DATE: 14-Jun-11

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

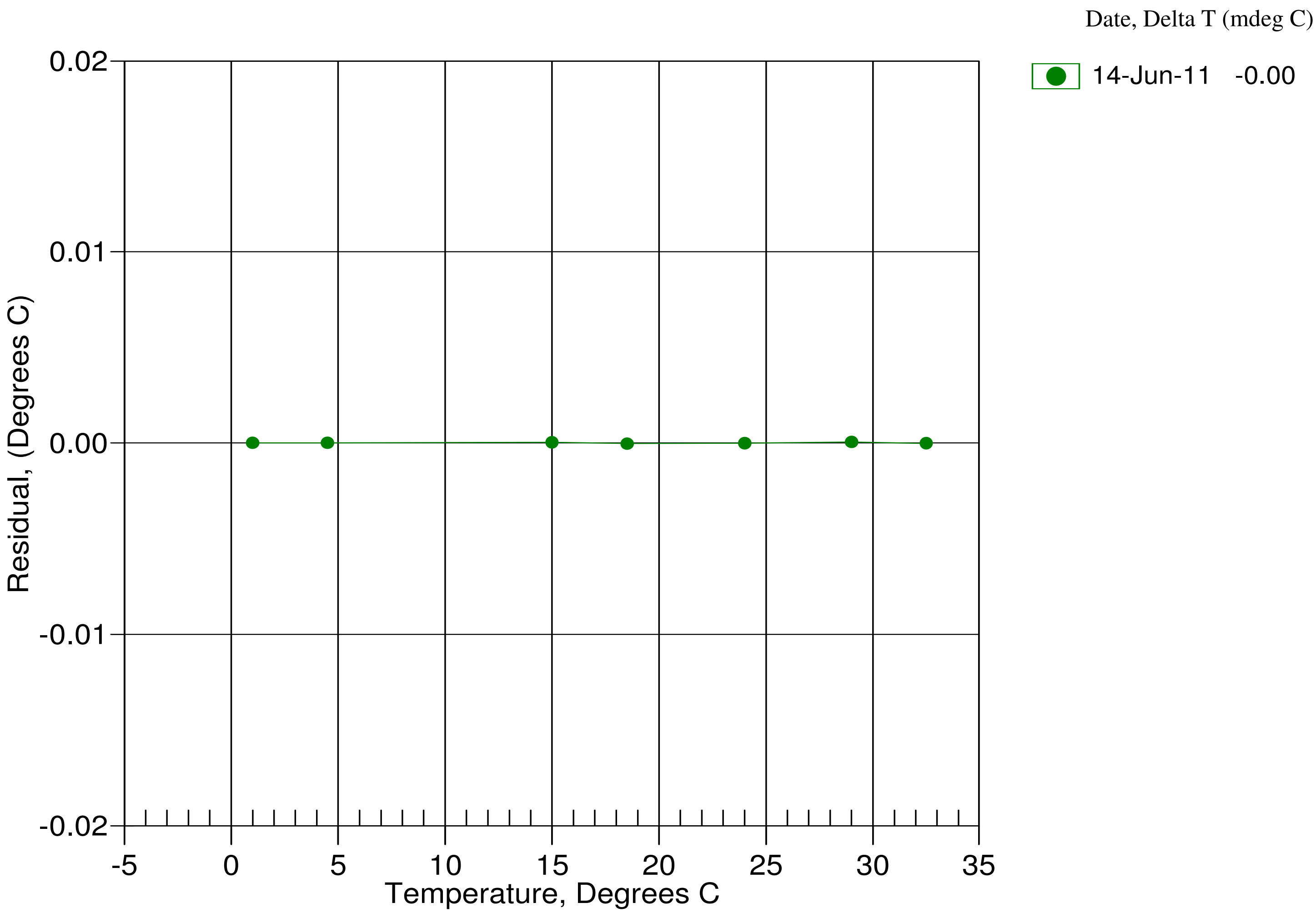
ITS-90 COEFFICIENTS

a0 = -1.231371e-004
a1 = 3.103016e-004
a2 = -4.706737e-006
a3 = 2.074994e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	573722.6	1.0000	0.0000
4.5000	490757.3	4.5000	-0.0000
15.0000	313248.6	15.0000	0.0000
18.5000	271399.8	18.5000	-0.0000
24.0000	217941.0	24.0000	-0.0000
29.0000	179632.6	29.0000	0.0000
32.5000	157423.6	32.5000	-0.0000

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

Residual = instrument temperature - bath temperature



SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA

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

SENSOR SERIAL NUMBER: 8257
CALIBRATION DATE: 14-Jun-11

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

COEFFICIENTS:

g = -1.012747e+000
h = 1.382929e-001
i = -1.558651e-004
j = 2.985086e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 1.2308e-007

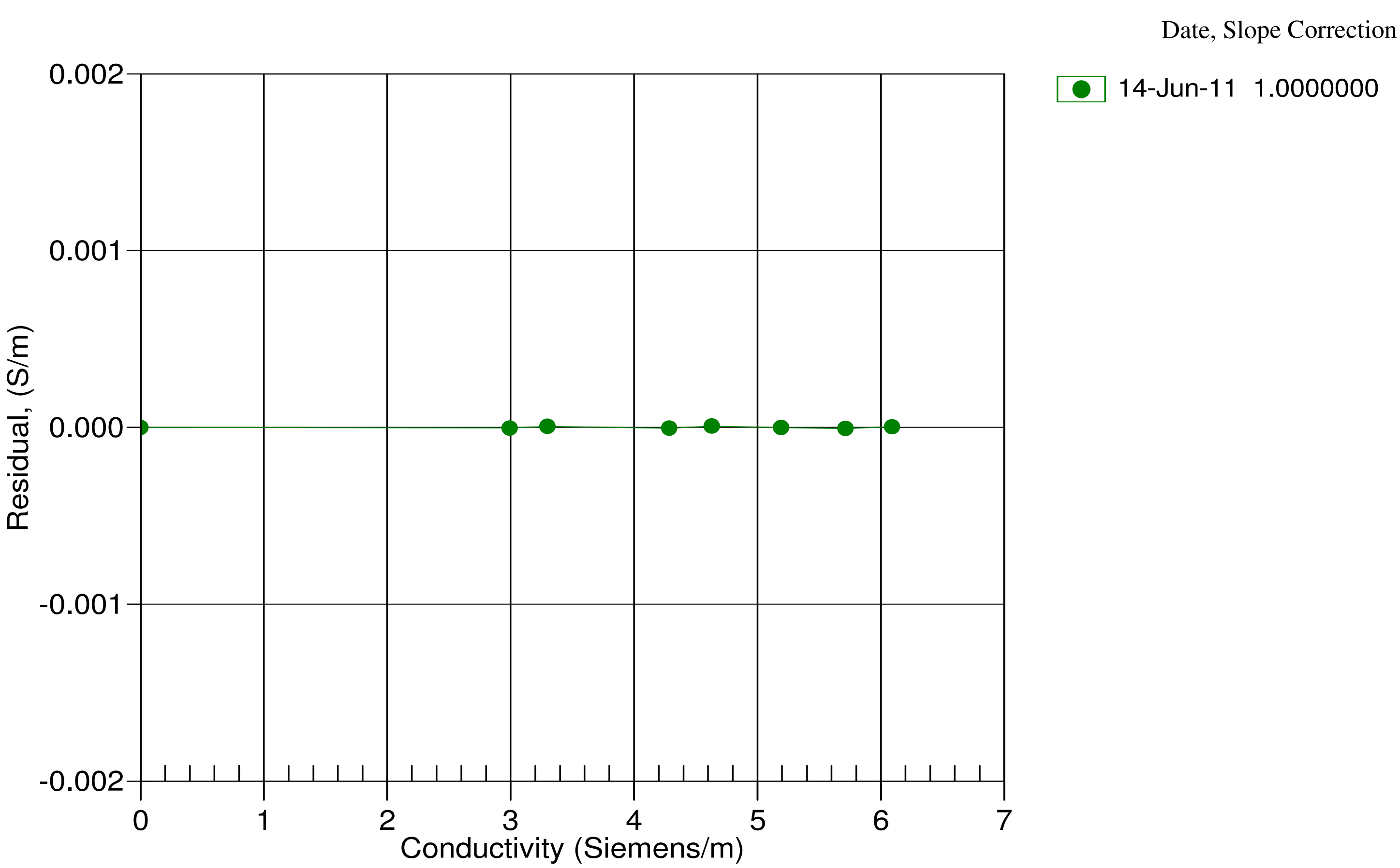
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2708.13	0.00000	0.00000
1.0000	34.9962	2.98987	5379.39	2.98987	-0.00000
4.5000	34.9757	3.29828	5582.11	3.29828	0.00000
15.0000	34.9318	4.28428	6185.07	4.28427	-0.00000
18.5000	34.9222	4.63090	6383.27	4.63090	0.00001
24.0000	34.9116	5.19123	6690.96	5.19123	-0.00000
29.0000	34.9054	5.71527	6966.12	5.71526	-0.00001
32.5000	34.9014	6.08915	7155.80	6.08915	0.00000

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

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

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

Residual = instrument conductivity - bath conductivity



SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA

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

SENSOR SERIAL NUMBER: 8257
CALIBRATION DATE: 13-Jun-11

SBE 37 PRESSURE CALIBRATION DATA
508 psia S/N 3276592

COEFFICIENTS:

```
PA0 =     2.138318e-002
PA1 =     1.699159e-003
PA2 =     8.161333e-012
PTEMPA0 = -6.097221e+001
PTEMPA1 =  5.364641e-002
PTEMPA2 = -7.058979e-007
PTCA0 =  5.245362e+005
PTCA1 =  1.999059e+000
PTCA2 = -6.802773e-002
PTCB0 =  2.503938e+001
PTCB1 = -5.250000e-004
PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.60	533117.0	1588.0	14.59	-0.00
104.87	586219.0	1594.0	104.89	0.00
204.86	644966.0	1596.0	204.85	-0.00
304.86	703707.0	1596.0	304.85	-0.00
404.86	762416.0	1595.0	404.86	-0.00
504.85	821092.0	1596.0	504.86	0.00
404.86	762422.0	1596.0	404.87	0.00
304.87	703717.0	1596.0	304.87	-0.00
204.87	644980.0	1596.0	204.87	0.00
104.88	586220.0	1595.0	104.90	0.00
14.61	533118.0	1595.0	14.59	-0.00

THERMAL CORRECTION

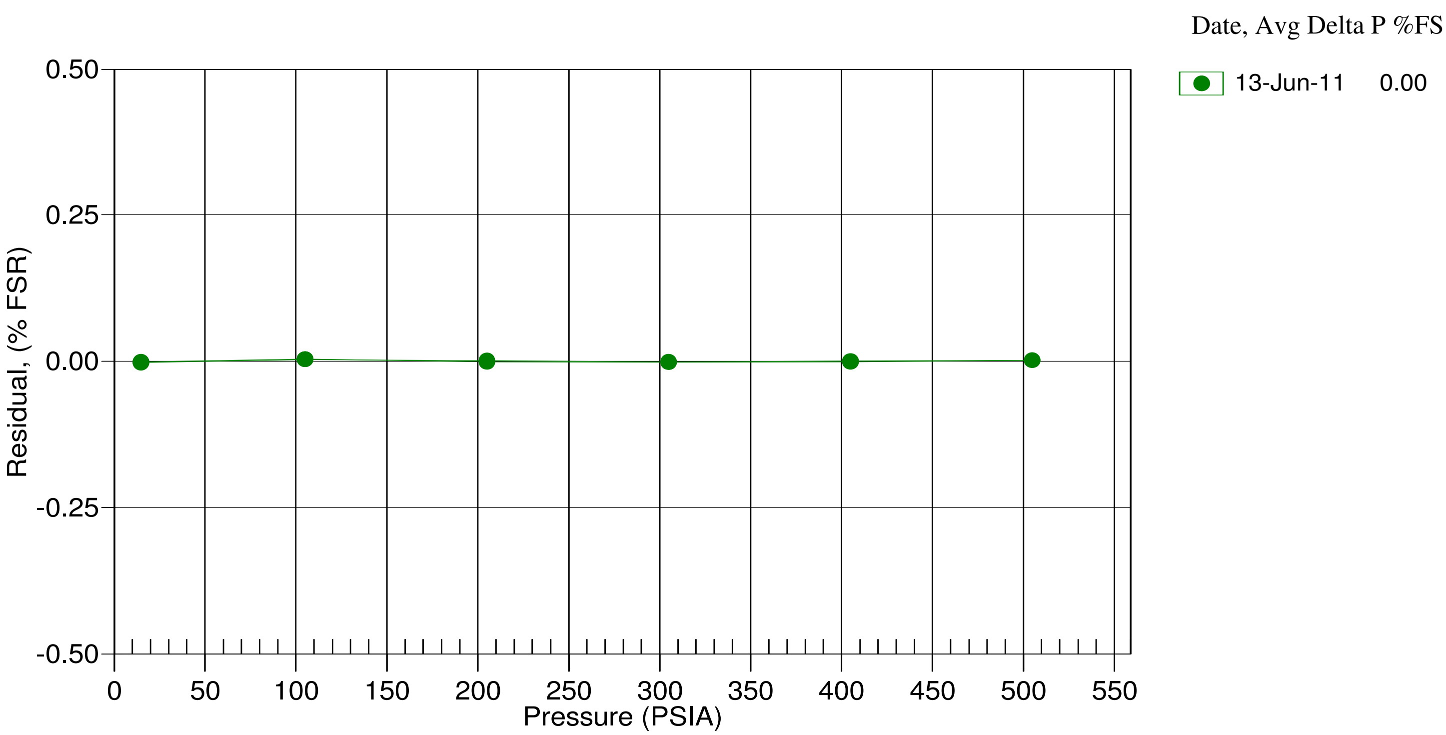
TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	1784	533491.68
29.00	1716	533499.96
24.00	1619	533507.77
18.50	1512	533512.38
15.00	1444	533513.49
4.50	1241	533506.38
1.00	1173	533500.88

TEMP(ITS90)	SPAN(mV)
-5.00	25.04
35.00	25.02

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

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

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



MicroCAT C-T Sensor (Serial Interface)

SBE 37-SI

The SBE 37-SI MicroCAT is a high-accuracy conductivity and temperature (pressure optional) sensor with **S**erial **I**nterface, which includes a non-volatile FLASH memory. Externally powered, 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.

Calibration coefficients are stored in EEPROM, allowing the MicroCAT to output data in ASCII engineering units (decimal or XML format); raw output is also available. The data 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 and SEACAT *plus* products. 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 Druck pressure sensor has a superior 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.

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

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.

COMMUNICATIONS AND INTERFACING

The MicroCAT communicates directly with a computer via a standard RS-232 serial interface. Real-time data can be transmitted up to 1600 meters (5200 feet) at 600 baud (power considerations may limit the distance), simultaneous with recording. Data can be uploaded at up to 115.2K baud. Firmware upgrades can be downloaded through the communications port by the user, without opening the instrument. 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** — The MicroCAT is pre-programmed to sample, store data in FLASH memory, and transmit data. There are two types of autonomous sampling:
  — *Continuous sampling* at the fastest rate possible (1.0 second minimum without pressure)
  — *Interval sampling* at intervals of 6 seconds to 6 hours.
- **Polled Sampling** — On command from a computer or satellite, radio, or wire telemetry equipment, the MicroCAT takes a sample and transmits data.
- **Serial Line Sync** — In response to a pulse on the serial line, the MicroCAT wakes up, samples, stores data in FLASH memory, transmits data, and goes to sleep.

SOFTWARE

The MicroCAT is supplied with a powerful Windows 2000/XP software package, SEASOFT© V2, which includes:

- SeatermV2© – terminal program for easy communication and data retrieval.
- SBE Data Processing© – programs for calculation, display, and plotting of conductivity, temperature, pressure (optional), and derived variables such as salinity and sound velocity.

MicroCAT C-T Sensor (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
Conductivity: 0.0003 S/m (0.003 mS/cm) per month
Temperature: 0.0002 °C per month
Optional Pressure: 0.05% of full scale range per year

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

Clock Stability 5 seconds/month

Memory 8 Mbyte; capacity in excess of 530,000 samples

Input Power 0.5 Amps at 8.5 - 24 VDC

Quiescent Current* 30 microAmps

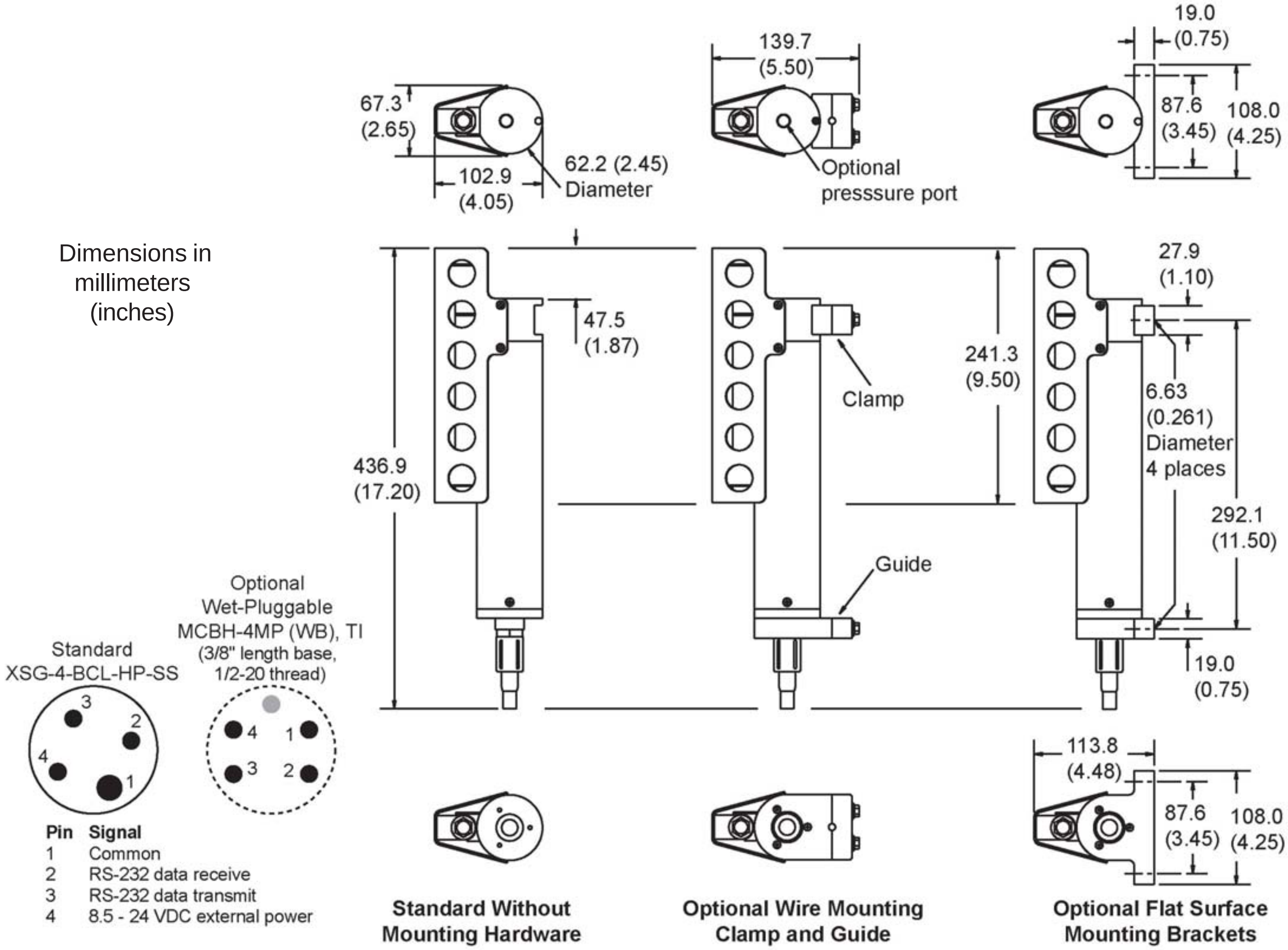
Communication Current* 4.3 milliAmps

Acquisition Current* 15 milliAmps

Acquisition Time 1.0 - 2.6 seconds/sample, *dependent on sampling mode and inclusion of pressure sensor*

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.



01/10

Sea-Bird Electronics, Inc.
13431 NE 20th Street, Bellevue, Washington 98005 USA
Website: http://www.seabird.com
E-mail: seabird@seabird.com
Telephone: (425) 643-9866
Fax: (425) 643-9954

APPLICATION NOTES

Appnote 2D Conductivity.. 1

Appnote 10 Conductivity... 6

Appnote 14 1978 Practical Salinity Scale.......................... 8

Appnote 27D Minimizing Strain Gauge Errors.................. 10

Appnote 42 ITS-90 Temperature Scale.............................. 16

Appnote 57 Connector Care... 17

Appnote 68 USB Ports... 20

Appnote 69 Pressure to Depth Conversion........................ 21

Appnote 71 Desiccant Use and Regeneration.................... 22

Appnote 73 Pressure Sensor Elevations Above Sea Level. 28

Appnote 83 Deployment of Moored Instruments.............. 34

Appnote 84 Pressure Sensors in Muddy Environments...... 39

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 2D **Revised October 2010**

Instructions for Care and Cleaning of Conductivity Cells

This application note presents new recommendations (as of October 2006), 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 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.
- **IDO MicroCATs** (37-SMP-IDO, 37-SIP-IDO, 37-IMP-IDO) have an integrated dissolved oxygen sensor. **Do not follow the rinsing, cleaning, and storage recommendations in this application note for IDO MicroCATs;** extended Triton contact with the DO sensor membrane can damage it, and the recommended solution temperature can cause a temporary increase in sensitivity. See *Application Note 64* for rinsing, cleaning, and storage recommendations for IDO MicroCATs.

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 loop 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 loop 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 loop of Tygon tubing to each end of the conductivity cell to close the cell ends and prevent 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, 37-SIP, 37-IMP-IDO, 37-SMP-IDO, or 37-SIP-IDO MicroCAT; SBE 49 FastCAT; SBE 52-MP Moored Profiler CTD; 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.

Application Note Revision History

Date	Description
January 1998	Initial release.
October 2002	Remove reference to part number for the small anti-foul cylinders (which have been eliminated) in Tygon tubing.
January 2005	Change in recommendations. Clean with bleach solution as well as Triton. Acid cleaning is not recommended in general, but some information on acid is still provided for the few cases where it is necessary. A section on Materials added, defining water, Triton, etc. in more detail.
July 2005	Include information on common names of commercially available bleach
October 2006	Update manufacturer name and website link for Triton
September 2008	Add SBE 52-MP to list of instruments with integral, internal pump that should not have acid cleaning.
October 2010	- Add reference to IDO MicroCATs, with caution to following cleaning and storage procedures in Application Note 64 instead of in this application note. - Update address.

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 10 **Revised March 2008**

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

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

or

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

SBE 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 37, 45, 49, and 52-MP

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

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, $f = \text{instrument frequency (kHz)} * (1.0 + WBOTC * t)^{0.5} / 1000.00$
- 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 -9.57×10^{-8} for pressure in decibars **or** -6.60×10^{-8} for pressure in psi

Note: This equation and the mathematical derivations below deal only with the pressure correction term, and do 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, $\Delta L / L = -p / 3K$.

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

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.

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

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

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

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

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

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

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

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

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

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

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

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

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

$a_1 = -0.1692$ $b_1 = -0.0056$

$a_2 = 25.3851$ $b_2 = -0.0066$

$a_3 = 14.0941$ $b_3 = -0.0375$

$a_4 = -7.0261$ $b_4 = 0.0636$

$a_5 = 2.7081$ $b_5 = -0.0144$

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: +1 425-643-9866
Fax: +1 425-643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE 27Druck **Revised October 2010**

Minimizing Strain Gauge Pressure Sensor Errors

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

- SBE 16*plus*, 16*plus*-IM, 16*plus* V2, and 16*plus*-IM V2 SEACAT (not 16*) with optional strain gauge pressure sensor
- SBE 19*plus* and 19*plus* V2 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 sensor
- SBE 37 MicroCAT (-IM, -IMP, -IMP-IDO, -SM, -SMP, -SMP-IDO, -SI, -SIP, and -SIP-IDO) 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, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 25, 37*, and 49**) and are supported by SEASOFT's Seasave V7 (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.
  *Note: SeatermV2 can upload raw data from SBE 37 MicroCATs with firmware 3.0 and all SBE 37 IDO MicroCATs. This data is compatible with SEASOFT's SBE Data processing (but not Seasave).
- **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 output in psia (including atmospheric pressure) or dbar. Calculation of dbar is as described above.
- Instruments that output **converted data in engineering units** (**SBE 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 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, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 37, 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.

For **oceanic applications**, salinity and temperature are presumed to be 35 PSU and 0^{o} C, and the compressibility of the water (with its accompanying density variation) is taken into account. This method is 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 latitude is used to estimate the magnitude of the local gravity field.

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 freshwater applications:

SEASOFT (most instruments)

In SEASOFT's Seasave V7 (real-time data acquisition) and SBE Data Processing (post-processing), the calculation of depth from pressure is dependent on the selection of saltwater depth or freshwater depth as the output variable.

- **Depth, Salt Water:**
  - Seasave V7 - User enters latitude on the Miscellaneous tab in the Configure Inputs dialog box; the entry is used if Depth [salt water] is selected as a display or output variable.
  - SBE Data Processing - User is prompted to enter latitude if Depth [salt water] is selected as an output variable in the Data Conversion or Derive module. Latitude can also be changed on the Miscellaneous tab in those modules.

  Note: For both Seasave V7 and SBE Data Processing, if the data includes NMEA data, the software uses the latitude from the NMEA data instead of the user entry for latitude when calculating depth.
- **Depth, Fresh Water:** No latitude entry is required or used in the calculation.

Some instruments can output depth directly. Setup is accomplished using one of SEASOFT's terminal programs:

- SBE 37-SI, 37-SIP, and 37-SIP-IDO – Depth can be directly output from these instruments if **OutputDepth=Y**. Latitude is entered in the instrument's EEPROM using the **Latitude=** command (use SEATERM for SBE 37-SI and 37-SIP with firmware < 3.0; use SeatermV2 for SBE 37-SI and 37-SIP with firmware $\geq$ 3.0, and all SBE 37-SIP-IDO).
  Note: The firmware does not differentiate between freshwater and saltwater applications when calculating depth; the **Latitude=** entry is always used for the depth calculation.
- 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.
  Note: The Convert utility in SEATERM does not differentiate between freshwater and saltwater applications when calculating depth; the user is always prompted to enter latitude if conversion of pressure to depth is requested.
- SBE 50 - The desired output (Depth, saltwater or Depth, freshwater) is entered in the instrument's EEPROM using the **OutputFormat=** command in SEATERM. Latitude (needed for the saltwater depth calculation) is also entered in the instrument's EEPROM using the **Latitude=** command.

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, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 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 brochure 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 configuration (.con or .xmlcon) file, using Seasave V7 or SBE Data Processing (for SBE 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 25, 49).
   - In the CTD's EEPROM, using the appropriate command in the terminal program (for SBE 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 37, 39, 39-IM, 49, 50, 52-MP).
4. Collect pressure data from the instrument using Seasave V7 or the terminal program, as appropriate (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 configuration (.con or .xmlcon) file, using Seasave V7 or SBE Data Processing (for SBE 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 25, 37 [see Note 2 below], 49). **AND**
   - In the CTD's EEPROM, using the appropriate command in the terminal program (for SBE 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 37, 39, 39-IM, 49, 50, 52-MP).

Notes:
1. For instruments that store calibration coefficients in EEPROM and **also** use a configuration (.con or .xmlcon) file (SBE 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2, and 49), set the pressure offset (Steps 3 and 6 above) in both the EEPROM and in the configuration file.
2. For SBE 37 data uploaded using SeatermV2 version 1.1 and later: SeatermV2 creates a .xmlcon configuration file when it uploads the data. Set the pressure offset (Steps 3 and 6 above) in both the EEPROM and in the configuration 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 configuration 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:

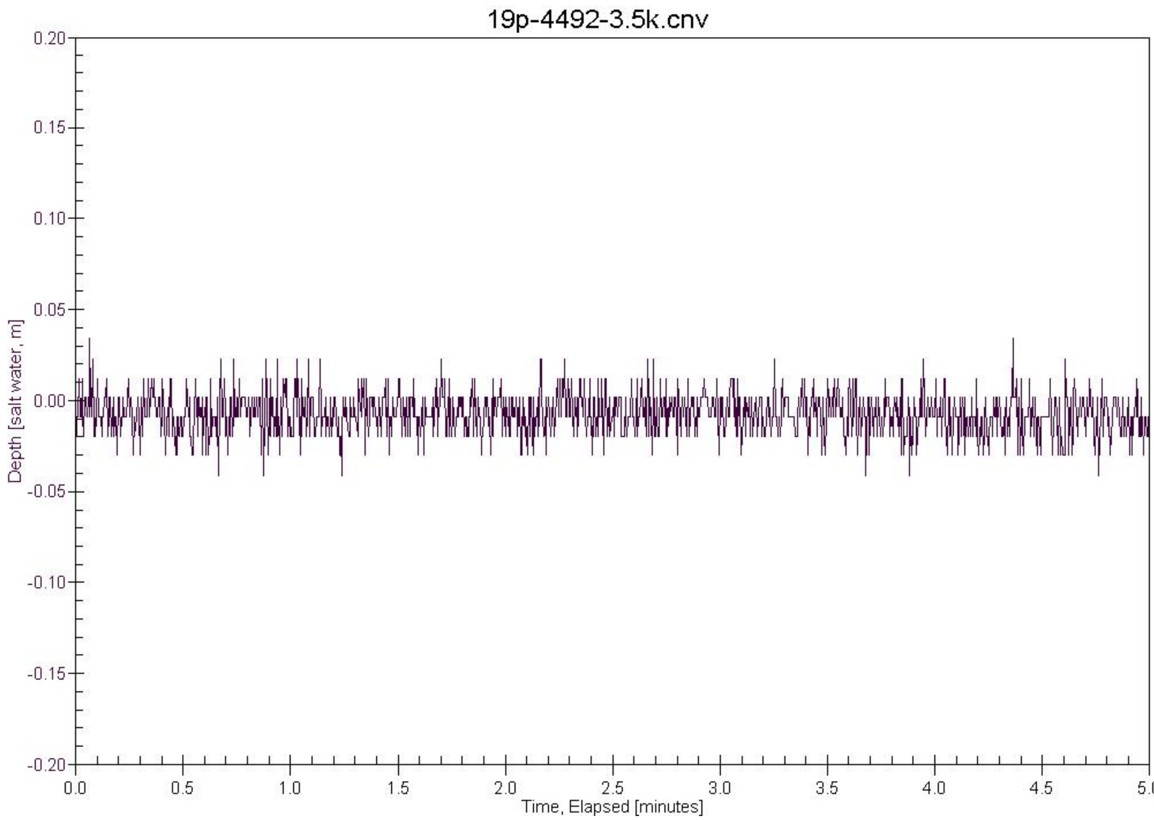
1. **Immediately** before beginning the profile, take a pre-cast *in air* pressure reading.
2. **Immediately** after ending the profile, take a post-cast *in air* pressure reading with the instrument at the same elevation and orientation. This reading reflects the change in the instrument temperature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

Application Note Revision History

Date	Description
November 2003	Initial release.
July 2005	• Add 0 – 600 meter range. • Add information on SBE 37-SIP, 26*plus*, 39-IM, and 52-MP.
April 2008	• Add information on V2 Seacats. • Update descriptions of Seasave V7 and SBE Data Processing regarding depth and latitude.
February 2010	• Add information about SeatermV2 for newer SBE 37-SI and 37-SIP. • Add information about .xmlcon configuration files. • Update address.
October 2010	• Add information on IDO MicroCATs. • Add information on .xmlcon files for MicroCATs with data uploaded using SeatermV2 1.1 and later.

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 42 **Revised February 2010**

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 V2 suite of software programs, edit the CTD configuration (.con or .xmlcon) 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. When selecting temperature as a display/output variable, you must select 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 or .xmlcon) 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 configuration 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 configuration 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*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 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 temperature 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* V2) - 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 must select which standard (T90 or T68) is to be used to compute temperature.

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 57 **Revised February 2010**

Connector Care and Cable Installation

This Application Note describes the proper care of connectors and installation of cables for Sea-Bird instruments. The Application Note is divided into three sections:

- Connector Cleaning and Inspection, and Cable / Dummy Plug Installation
- Locking Sleeve Installation
- Cold Weather Tips

Note: All photos in this Application Note show standard Impulse XSG/AG connectors. Except as noted, all procedures apply to standard XSG/AG connectors as well as to optional *wet-pluggable* MCBH connectors.

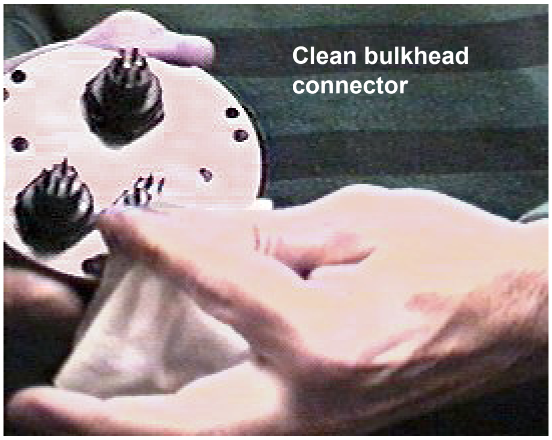
Connector Cleaning and Inspection, and Cable / Dummy Plug Installation

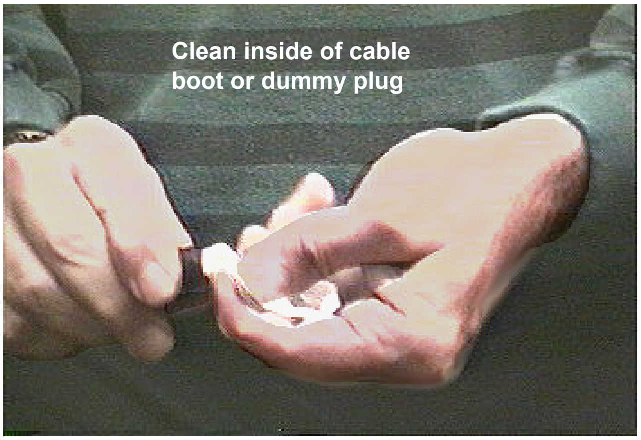
Clean and inspect connectors, cables, and dummy plugs:

- Before every cruise.
- During the cruise – This is a good practice if you have a few days of down time between casts.
- After every cruise – This is the best way to find and remove any corrosion on connector pins before severe corrosion develops.
- As part of your yearly equipment maintenance.

Follow this procedure:

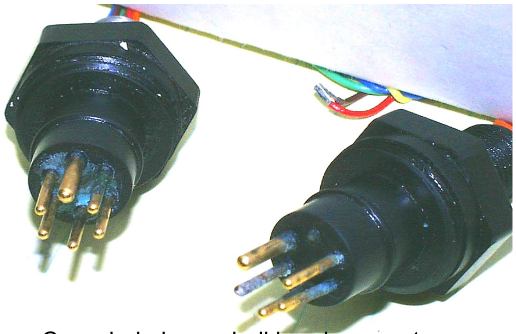
1. Carefully clean the bulkhead connector and the inside of the mating cable's boot or the dummy plug with a Kim wipe. Remove all grease, hair, dirt, and other contamination.





2. Inspect the connector and cable boot or dummy plug:
   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 cable boot or dummy plug for cuts, nicks, breaks, or other problems that may compromise the seal.

   Replace severely corroded or otherwise damaged connectors, cables, and dummy plugs - contact Sea-Bird for instructions and a Return Material Authorization (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), grease the bulkhead connector and the cable boot or dummy plug.

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

   A. Squeeze the silicone grease -- approximately half the size of a pea -- onto the end of your finger. 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 cable boot or dummy plug.

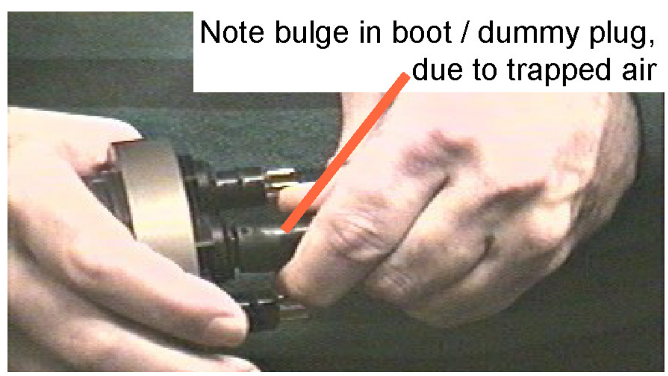
   B. Squeeze approximately half the size of a pea of the silicone grease onto the end of your finger. Apply a light, even coating of grease to the inside of the cable boot or dummy plug.

4. *Standard XSG/AG connectors only:* Align the *bump* on the cable boot or dummy plug with the large pin on the bulkhead connector, and align the sockets with the pins.

   Optional wet-pluggable MCBH connectors only: Align the non-conducting guide pin and the conducting pins with the mating sockets.

   - Do not twist the cable boot or dummy plug on the bulkhead connector; twisting can lead to bent pins, which will soon break.

5. Push the cable boot or dummy plug all the way onto the bulkhead connector.
   - *Standard XSG/AG connectors only:* You may note a bulge in the boot or dummy plug, which is due to trapped air. There may be an audible pop, which is good. With some newer cables or dummy plugs, or in cold weather, there may not be an initial audible pop.

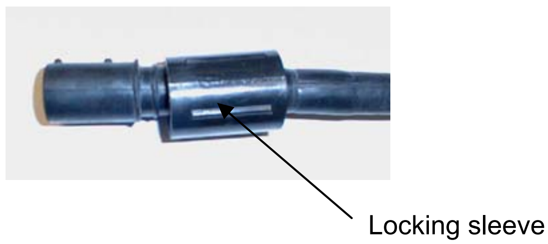


6. *Standard XSG/AG connectors only:* After the cable or dummy plug is mated, run your fingers along the cable boot or dummy plug toward the bulkhead connector, *milking* any trapped air out of the boot or plug. You should hear the air being ejected.
   CAUTION:
   Failure to eject the trapped air will result in the connector leaking.

Locking Sleeve Installation

After the cable boot or dummy plug is mated to the bulkhead connector, install the locking sleeve. The locking sleeve secures the cable or dummy plug to the bulkhead connector and prevents them it 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. Over-tightening 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 a day's casts, remove the locking sleeve, slide it up the cable, and rinse the connection (still mated) with fresh water. This will prevent premature cable failure.



Cold Weather Tips

In cold weather, the cable or dummy plug may be hard to install and remove.

Removing a *Frozen* Cable Boot or Dummy Plug:

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

Installing a Standard XSG/AG Cable or Dummy Plug:

When possible, install cables and dummy plugs in warm environments. If not, warm the cable boot or dummy plug sufficiently so it is flexible. A flexible cable boot or dummy plug will install properly.

Note about Wet-Pluggable (MCBH) Connectors:

As an option, Sea-Bird offers *wet-pluggable* (MCBH) connectors in place of the standard Impulse XSG/AG connectors. Wet-pluggable connectors have a non-conducting guide pin to assist pin alignment and require less force to mate, making them **easier to mate reliably under dark or cold conditions**, compared to our standard connectors. Wet-pluggable connectors may be mated in wet conditions; their pins do not need to be dried before mating. By design, water on the connector pins is forced out as the connector is mated. However, they must not be mated or un-mated while submerged. Like standard connectors, wet-pluggables need proper lubrication and require care during use to avoid trapping water in sockets.

If desired, Sea-Bird can retrofit your existing instruments with wet-pluggable connectors; contact Sea-Bird for pricing information.

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 68

Revised **June 2009**

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, most 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 several manufacturers on computers at Sea-Bird, and verified compatibility with our instruments. These manufacturers and the tested adapters are:

- **FTDI** (www.ftdichip.com) -
  "ChiPi" USB-RS232 Converter (model # FTDI UC232R-10).
  Note: This adapter can also be purchased from Sea-Bird, as Sea-Bird part # 20200.
  Drivers for this adapter can be found at http://www.ftdichip.com/Drivers/VCP.htm.

- **IOGEAR** (www.iogear.com) –
  USB 1.1 to Serial Converter Cable (model # GUC232A).
  Note: We have had several reports from customers that they could not communicate with their instrument using a laptop computer and this adapter.

- **Keyspan** (www.keyspan.com) -
  USB 4-Port Serial Adapter (part # USA-49WLC, replacing part # USA-49W)
  Note: We have one report from a customer that he could not communicate with his instrument using a notebook computer and this adapter. He was able to successfully communicate with the instrument using an XH8290 DSE Serial USB Adapter (www.dse.co.nz).

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

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

We recommend testing 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.

See Application Note 56: Interfacing to RS-485 Sensors for information on using a USB port to communicate with a Sea-Bird instrument that communicates via RS-485 telemetry.

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

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:

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

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

Then, depth is calculated from pressure:

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

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

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 71 Revised March 2008

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.

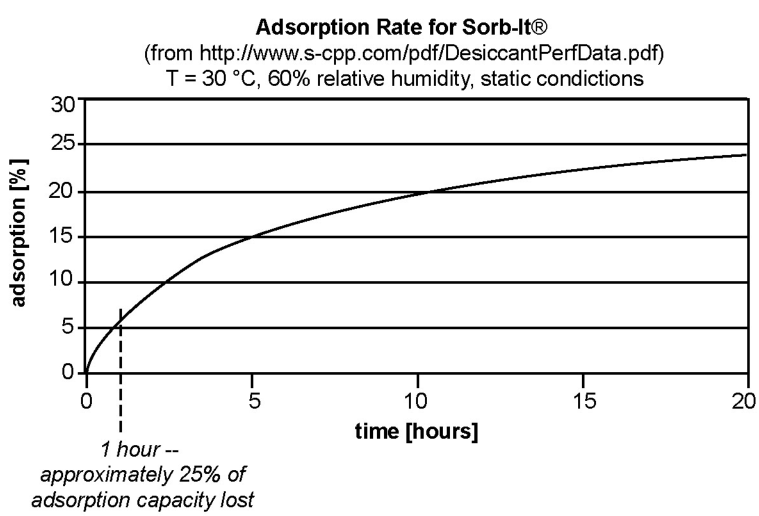
What do we mean by *expose the electronics*?

- For most battery-powered Sea-Bird instruments (such as SBE 16, 16*plus*, 16*plus* V2, 16*plus*-IM, 16*plus*-IM V2, 17*plus*, 19, 19*plus*, 19*plus* V2, 25, 26, 26*plus*, 37-SM, 37-SMP, 37-IM, 37-IMP, 44, 53, 54, 55, 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 and 5P, 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* V2, 16*plus*-IM, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 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, 54, 55, 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

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

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

SECTION I -- PRODUCT IDENTIFICATION

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

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

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

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

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

SECTION III -- PHYSICAL DATA

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

SÜD-CHEMIE
Creating Performance Technology
ISO 9002 CERTIFIED

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

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

SECTION 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.

SÜD-CHEMIE
Creating Performance Technology
ISO 9002 CERTIFIED

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

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

NOTE TO PHYSICIAN: This product is a desiccant and generates heat as it adsorbs water. The used product can contain material of hazardous nature. Identify that material and treat accordingly.

SECTION VI -- REACTIVITY DATA

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

SECTION VII --SPILL OR LEAK PROCEDURES

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

SECTION VIII -- SPECIAL PROTECTION INFORMATION

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

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

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

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

SECTION IX -- SPECIAL PRECAUTIONS

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

SÜD-CHEMIE
Creating Performance Technology

ISO 9002 CERTIFIED

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

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

* No Information Available

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

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

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

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 73 **Revised October 2010**

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*** and **16*plus* V2 (RS-232 versions)** SEACAT C-T (pressure optional) Recorder, SBE **19*plus*** and **19*plus*** **V2** SEACAT Profiler CTD, and SBE **49** FastCAT CTD Sensor
- SBE **16*plus*** and **16*plus* V2 (RS-485 versions)** SEACAT C-T (pressure optional) Recorder, and SBE **16*plus*-IM** and **16*plus*-IM V2** SEACAT C-T (pressure optional) Recorder
- SBE **37** MicroCAT (all IDO models and all other models with firmware version ≥ 3.0)
- SBE **37** MicroCAT (all models with firmware version < 3.0, except IDO models)
- 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 real-time data acquisition software (Seasave) and post-processing software (SBE Data Processing) use calibration coefficients programmed in a configuration (.con or .xmlcon) 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 or .xmlcon 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 or .xmlcon file.

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

SBE 16*plus* and 16*plus* V2 (RS-232 versions), 19*plus* and 19*plus* V2, and 49

Sea-Bird real-time data acquisition software (Seasave) and post-processing software (SBE Data Processing) use calibration coefficients programmed in a configuration (.con or .xmlcon) 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 or .xmlcon 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 or .xmlcon file.
6. Also enter the calculated offset in the instrument (using the **POffset=** command in the terminal program*).
   *Note: SBE 16*plus* V2 and 19*plus* V2 use SeatermV2 terminal program; the other instruments use SEATERM.

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

SBE 16*plus* and 16*plus* V2 (RS-485 versions), and 16*plus*-IM and 16*plus*-IM V2

Sea-Bird real-time data acquisition software (Seasave) and post-processing software (SBE Data Processing) use calibration coefficients programmed in a configuration (.con or .xmlcon) 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 the terminal program*, set the pressure offset to 0.0 (**#iiPOffset=0**) and set the output format to converted data in decimal form (**#iiOutputFormat=3**).
   *Note: 16*plus* V2 and 16*plus*-IM V2 use SeatermV2; the other instruments use SEATERM.
3. Acquire data using the **#iiTP** command.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the instrument (using the **#iiPOffset=** command).
6. Also enter the calculated offset in the .con or .xmlcon 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 or .xmlcon file and in instrument.

SBE 37 (all IDO [Integrated Dissolved Oxygen] models, and all other models with firmware version ≥ 3.0)

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. If using SeatermV2 (version 1.1 and later) to upload data, SeatermV2 creates a configuration (.xmlcon) file along with a .hex data file. Sea-Bird post-processing software (SBE Data Processing) uses the calibration coefficients in the .xmlcon file to convert raw data to engineering units.

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 the SeatermV2 terminal program, 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 SeatermV2. *
6. If you have already uploaded data, also enter the calculated offset in the .xmlcon 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 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 **
MicroCATs with Inductive Modem (IM) or RS-485 telemetry	**#iiPOffset=**	**#iiOutputFormat=1**	**#iiTSn:100** (measures and outputs data 100 times)
MicroCATs with RS-232 telemetry	**POffset=**	**OutputFormat=1**	**TSn:100** (measures and outputs data 100 times)

** See MicroCAT manual for location of pressure data in output data string.

SBE 37 (all models with firmware version < 3.0, *except* IDO [Integrated Dissolved Oxygen] 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. These SBE 37s do not use a configuration (.con or .xmlcon) 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 the SEATERM terminal program, 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
MicroCATs with Inductive Modem (IM) or RS-485 telemetry	**#iiPOffset=**	**#iiFormat=1**	**#iiTP** (measures and outputs pressure 30 times)
MicroCATs with RS-232 telemetry	**POffset=**	**Format=1**	**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 configuration (.con or .xmlcon) 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 the SEATERM terminal program, 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 configuration (.con or .xmlcon) 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 the SEATERM terminal program, 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 configuration (.con or .xmlcon) 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 the SEATERM terminal program, 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 configuration (.con or .xmlcon) 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	1800
100	145	14.5	0.2	No where on Earth!
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 1800 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 1800 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.

Application Note Revision History

Date	Description
June 2004	Initial release.
July 2005	Add information on SBE 39-IM, 52-MP, and 53.
February 2009	• Add information on V2 Seacats and newer MicroCATs (version 3 and greater firmware). • Add information on SeatermV2 software.
October 2010	• Add information on IDO MicroCATs (37-SMP-IDO, SIP-IDO, IMP-IDO). • Add information on creation of .xmlcon file for MicroCATs with data uploaded using SeatermV2 1.1 and later. • Add information on .xmlcon files for all instruments that use configuration files. • Update address.

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 83 **revised October 2010**

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*, 16*plus*-IM, 16*plus* V2, and 16*plus*-IM V2 SEACAT Conductivity and Temperature Recorder
- SBE 19*plus* and 19*plus* V2 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 37 (-IMP-IDO, -SMP-IDO, -SIP-IDO) MicroCAT Conductivity, Temperature, and Dissolved Oxygen 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 I/O cable for real-time data or 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, 16*plus* V2, 16*plus*-IM V2, 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, 16*plus* V2, 16*plus*-IM V2, 19*plus*, and 19*plus* V2.

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 in terminal program 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, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2), 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 in terminal program 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: Connector Care and Cable 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 terminal program 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 (for *some* instruments, pump turns off automatically when conductivity frequency is below programmed minimum value). **	
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 instruments with integral pump or integral pump and dissolved oxygen sensor (37-SMP, -SMP-IDO, -SIP, -SIP-IDO, -IMP, -IMP-IDO): Rinse all internal plumbing in addition to conductivity cell. If not rinsed between uses, salt crystals may form on pump impeller and/or on oxygen sensor membrane.	
For instrument with external pump (16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2): 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 storage of all instruments *except* IDO MicroCATs, see *Application Note 2D: Instructions for Care and Cleaning of Conductivity Cells*. For IDO MicroCATs, see *Application Note 64: SBE 43 Dissolved Oxygen Sensor*.	
Upload data in memory. 1. Connect to instrument in terminal program. 2. If you have not already done so, send command to stop sampling (**Stop** or **#iiStop**). ** 3. Click Upload in terminal program to upload data in memory. 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. For all instruments *except* IDO MicroCATs, see *Application Note 2D: Instructions for Care and Cleaning of Conductivity Cells*. For IDO MicroCATs, see *Application Note 64: SBE 43 Dissolved Oxygen Sensor*.	
For instrument with external pump (16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2): 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. Return instrument to Sea-Bird for recalibration. Between lab 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.	

Application Note Revision History

Date	Description
December 2005	Initial release.
April 2006	• Add information on cleaning instrument exterior before shipping for calibration. • Add reference to document governing shipping instruments with lithium batteries.
March 2008	• Add information on V2 Seacats. • Make references to terminal program more generic (SEATERM not used with V2 Seacats)..
October 2010	• Add references to Application Note 64 for cleaning IDO MicroCATs (37-SMP-IDO, SIP-IDO, IMP-IDO). • Update address.

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

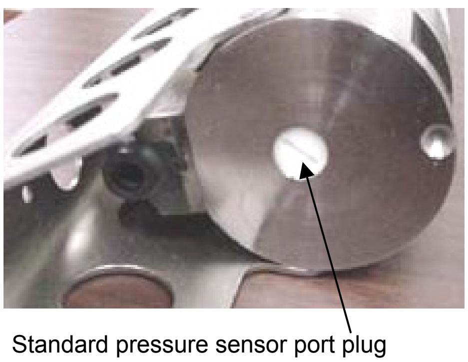
Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

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



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.

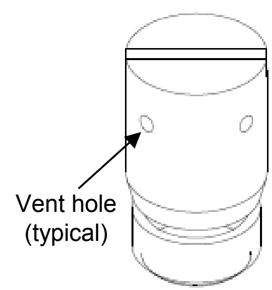
- If the instrument is deployed in a **high-sediment (muddy)** environment **with the pressure sensor end up**, the pressure port may partially fill with sediment (through the vent hole) over time, causing a delay in the pressure response.
- If the instrument is deployed in a **biologically productive** 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

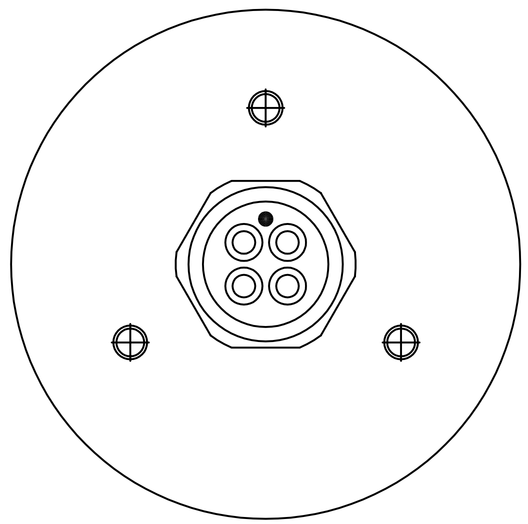
1. Unscrew the standard pressure port plug from the pressure port.
2. Rinse the pressure port with warm, de-ionized water to remove any particles, debris, etc. **Do not put a brush or any object in the pressure port;** doing so may damage or break the pressure sensor.
3. Install the *high-head* pressure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

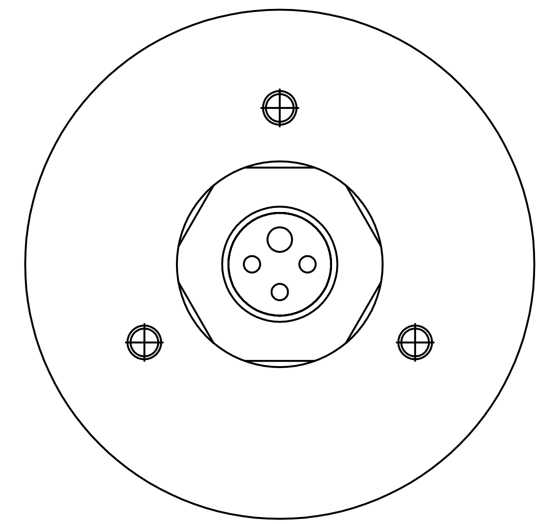
Note: Until several years ago, Sea-Bird filled the pressure port with silicon oil at the factory. For **Druck** pressure sensors, we determined that this was unnecessary, and no longer do so. It is not necessary to refill the oil in the field. However, for **Paine** or **Paroscientific Digiquartz** pressure 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	

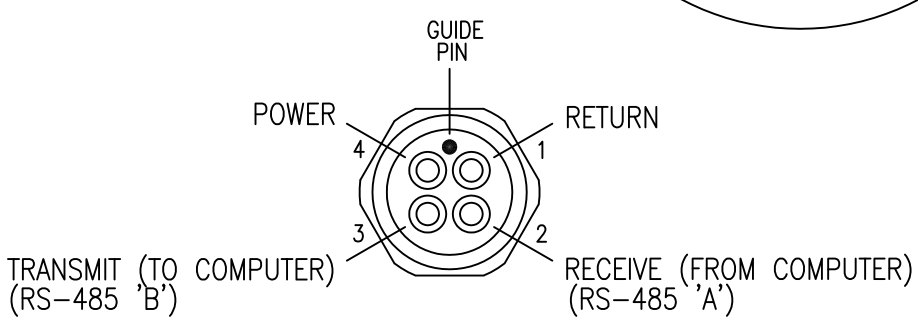
WET-MATABLE (SUBCONN) CONNECTOR OPTIONS

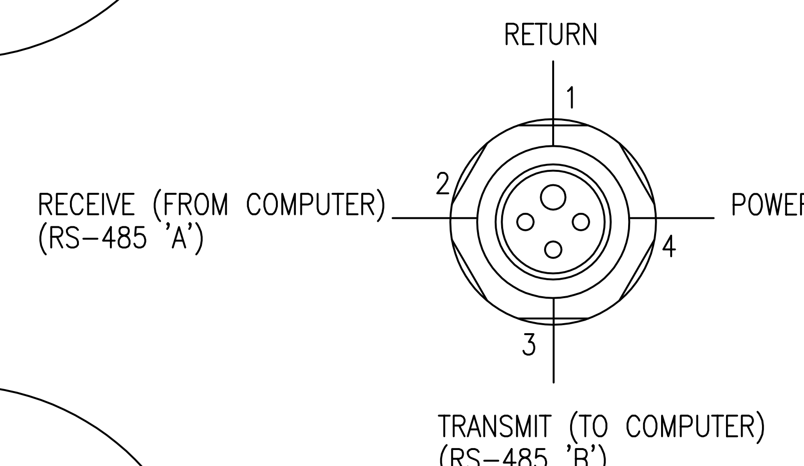
STANDARD (IMPULSE) CONNECTOR OPTIONS

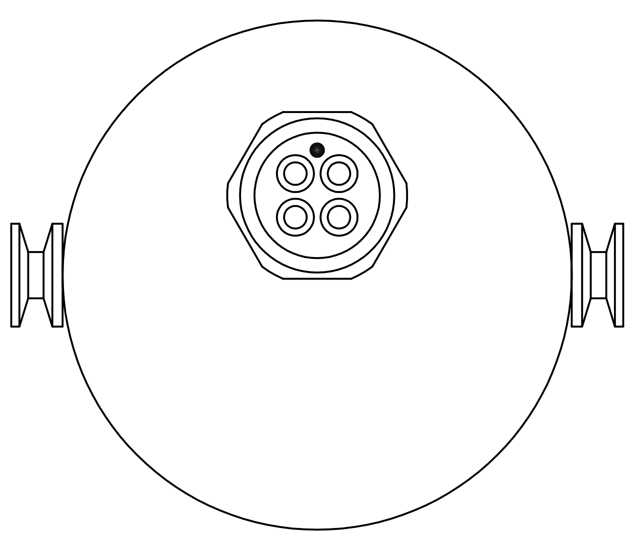


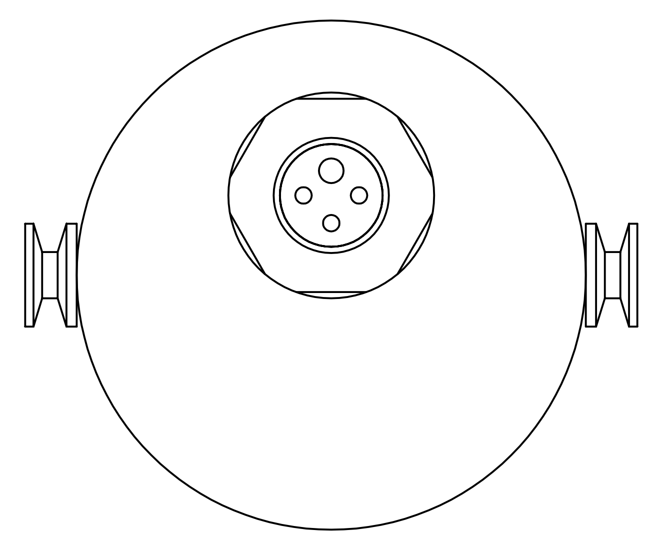


Standard SBE37/49 Endcap Design,
for CTDs with Modular Housings





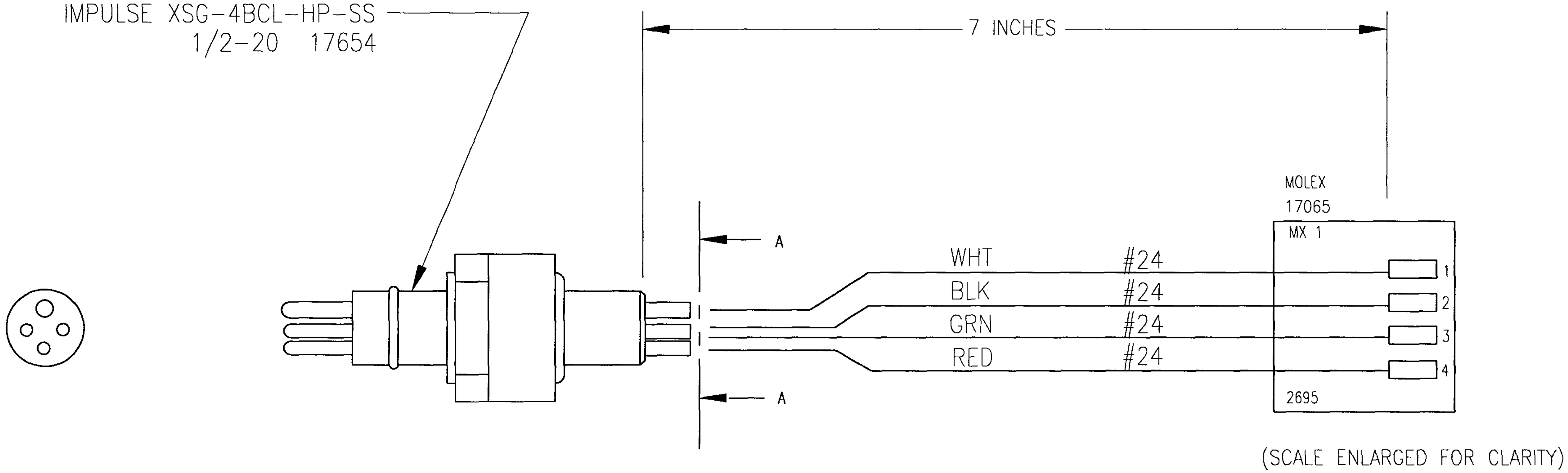


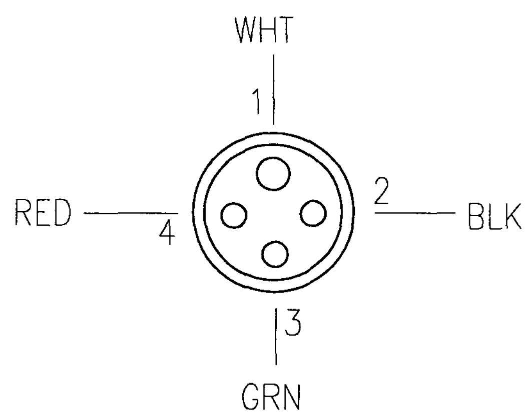


SBE37 Only Endcap Design,
for Microcats with Potted Housings

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	

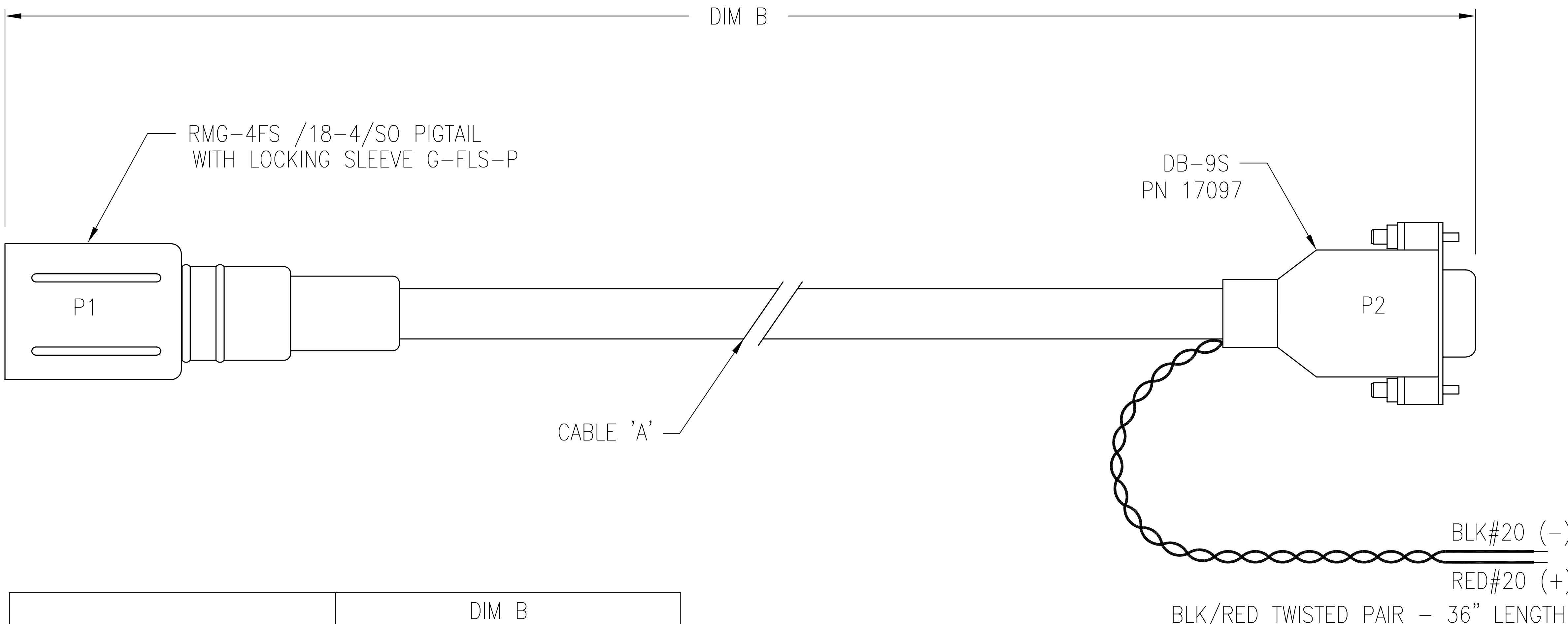


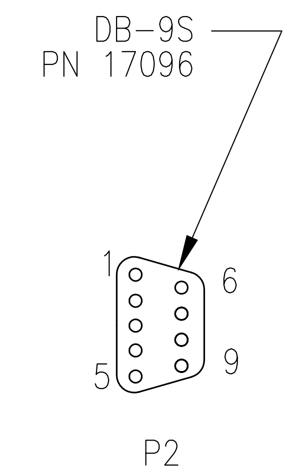


VIEW A-A

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 METER
801461	17106	35 FT	10.6 METER
801560	17117	98.5 FT	30 METER
801735	172349	131 FT	40 METER
801814	171333	20 FT	6 METER
801835	171592	50 FT	15.24 METER
801894	171632	25 FT	7.6 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 2010

PRODUCT WARRANTY

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 (or longer, depending on conditions of use). Anytime during the warranty period (typically after 3 years), the SBE 43 will be refurbished once without charge, 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. The pH sensor electrode used in the SBE 18 pH sensor and SBE 27 pH/ORP sensor has a limited design life caused by depletion of their chemical constituents during normal storage and use, and is covered under warranty for the first 90 days only. Other components of the sensor (housing, electronics, etc.) are covered for 5 years.

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

4. Water sample bottles manufactured by other companies, and PVC plastic bottle parts used to make Sea-Bird Improved Sample Bottles are warranted only to the limit of the warranties provided by their original manufacturers, typically one year. The mounting bracket (except stainless steel band clamp) used in Sea-Bird Improved Sample Bottles is covered for 5 years.

5. Batteries, zinc anodes, anti-foulant devices, or other consumable/expendable items are not covered under this warranty.

6. Electrical cables, dummy plugs, and stainless steel band clamps are warranted to function properly and be free of defects in materials and workmanship for 1 year.

7. 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.

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

WARRANTY ADMINISTRATION POLICY

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

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

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

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

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

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

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

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

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

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

SOFTWARE WARRANTY

SOFTWARE LICENSE AGREEMENT

By downloading or installing any of our software, you expressly agree to the following:

Sea-Bird's SEASOFT© software is provided free of charge to Sea-Bird users and is not subject to any license. SEASOFT is protected by copyright laws and international copyright treaties, as well as other intellectual property laws and treaties. All title and copyrights in and to SEASOFT and the accompanying printed materials, and any copies of SEASOFT, are owned by Sea-Bird Electronics. There are no restrictions on its use or distribution, provided such use does not infringe on our copyright.

Note: SEASOFT is a modular program that includes SEASOFT V2 (Seasave V7, Seasave-Win32, SBE Data Processing, SeatermV2, Seaterm, SeatermAF, SeatermV2, Plot39, and Deployment Endurance Calculator), SEASOFT for Waves - Win32, SEASOFT-DOS, and SEASOFT for Waves - DOS.

SOFTWARE WARRANTY

Sea-Bird Electronics expressly disclaims any warranty for software. Software and any related documentation is provided "as is" without warranty of any kind, either expressed or implied, including and without limitation, the implied warranties or merchantability, fitness for a particular purpose, or non infringement. The entire risk arising out of use or performance of SEASOFT remains with you.
In no event shall Sea-Bird Electronics or its representatives or suppliers be liable for any damages whatsoever (including, without limitation, damages for loss of business profits, business interruption, loss of business information, or any other pecuniary loss) arising out of the use of or inability to use this Sea-Bird Electronics product, even if Sea-Bird has been advised of the possibility of such damages.

Sea-Bird Service Request Form

To return instruments for calibration or other service, please provide the information below, so we can serve you better and prevent delays in the return of the instruments:

1. Get a Returned Material Authorization (RMA) number from Sea-Bird (seabird@seabird.com, phone [+1] 425-643-9866, fax [+1] 425-643-9954). Reference the RMA number on this form, on the outside shipping label for the instruments, and in all related correspondence.
2. Include this form when shipping the instruments to Sea-Bird for servicing.
3. E-mail or fax us a copy of this form on the day you ship. seabird@seabird.com or fax [+1] 425-643-9954

RMA Number:______________________________ **Date equipment needed:**____________________

Do you need a written quote? [ ] No [ ] Yes

IMPORTANT! Was this equipment deployed in the Gulf of Mexico during/after the Spring 2010 oil spill?
[ ] No [ ] Yes (specify serial numbers if not applicable to all instruments in shipment)____________________________

CONTACT INFORMATION

Your Name:___________________________Institution/Company:____

Shipping/Delivery address for packages:____

____

____

Phone:________________________Fax:________________________E-mail:____

SERVICE INFORMATION

Date Shipped:______________Sea-Bird Model Numbers (i.e., SBE 37-SM, etc.):_____________________________________

Quantity:__________________Serial Numbers:____

____

Special Instructions – for example, if specific services are required for some instruments (i.e., if 10 instruments need calibration, and 1 also needs repairs, specify the serial number for the instrument needing repairs):

____

____

____

[ ] Calibration Services (includes basic diagnostic):

[ ] Temperature [ ] Conductivity [ ] Pressure [ ] Oxygen [ ] pH

[ ] Other (i.e., fluorometer, turbidity, par, etc.):____

____

[ ] Additional Services (additional charges apply; specify serial numbers):

[ ] Internal Inspection & O-Ring Replacement (includes hydrostatic pressure test)___________________________

____

____

[ ] System Upgrade or Conversion____

____

[ ] Diagnose & Repair Problems (provide as much information as possible - description(s), configuration [.con or .xmlcon] file and raw data [.hex or .dat] file showing problems, etc.)_____________________________________

____

____

____

[ ] Download Data from instrument Memory____

____

PAYMENT/BILLING INFORMATION

[ ] **Credit Card (Sea-Bird accepts payment by VISA, Master Card, or American Express)**

Name on Card:____

Please call Cheryl Reed (425-644-3244) with credit card information.

[ ] **Purchase Order (P.O.)**

P.O. Number:____

Billing Address (If different than shipping address):________________________

____

____

____

Instructions for Returning Goods to Sea-Bird

Note: Sea-Bird moved in January 2010; use the new address (shown below).

1. **Domestic Shipments (USA) - Ship prepaid** (via UPS, FedEx, DHL, etc.) directly to:
   Sea-Bird Electronics, Inc.
   13431 NE 20th Street
   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.
   13431 NE 20th Street
   Bellevue, WA 98005, USA
   Telephone: [+1] 425-643-9866, Fax: [+1] 425-643-9954, E-mail: seabird@seabird.com

   Notify: MTI Worldwide Logistics for Customs Clearance
   Seattle, WA, USA
   Telephone: [+1] 206-431-4366 Fax: [+1] 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 (see address above)**:
   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 $50 to $150 for the replacement crate, based on the crate type. 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.