SBE 37-SM MicroCAT
Conductivity and Temperature Recorder with RS-232 Interface

Configuration and Calibration Manual
Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, Washington 98005 USA
Tel: 425/643-9866
Fax: 425/643-9954
# SBE 37-SM MICROCAT OPERATING AND REPAIR MANUAL

## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Generation Date</td>
<td>1</td>
</tr>
<tr>
<td>Limited Liability Statement</td>
<td>2</td>
</tr>
<tr>
<td>SBE 37SM, RS-232, Manual - Version 021</td>
<td>3</td>
</tr>
<tr>
<td>SBE 37SM, RS-232, Reference Sheet – Version 006</td>
<td>65</td>
</tr>
<tr>
<td>Calibration Certificates</td>
<td>67</td>
</tr>
<tr>
<td>SBE 37SM Specification Sheet</td>
<td>99</td>
</tr>
<tr>
<td>Appnotes</td>
<td>101</td>
</tr>
<tr>
<td>Dwg 50147AExt I/O Wiring, No External Power, RS-232, Impulse</td>
<td>128</td>
</tr>
<tr>
<td>Dwg 40889ASBE 37SM 3-Pin Data I/O Molex Wiring, Impulse</td>
<td>129</td>
</tr>
<tr>
<td>Dwg 32778ACable Assembly, RMG-3FS to DB-9S, PN 801412</td>
<td>130</td>
</tr>
<tr>
<td>Warranty</td>
<td>131</td>
</tr>
<tr>
<td>Service Request Form</td>
<td>133</td>
</tr>
</tbody>
</table>
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.
SBE 37-SM MicroCAT

Conductivity and Temperature Recorder
with RS-232 Interface

User’s Manual
Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, Washington 98005 USA
Telephone: 425/643-9866
Fax: 425/643-9954
E-mail: seabird@seabird.com
Website: www.seabird.com

Manual Version #021, 02/03/04
Firmware Version 2.5 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
- How to Contact Sea-Bird ......................................................... 5
- Quick Start .............................................................................. 5
- Unpacking MicroCAT ............................................................. 6
- Shipping Precautions ............................................................. 7

## Section 2: Description of MicroCAT ........................................ 8
- System Description ............................................................... 8
- Specifications ....................................................................... 10
- Dimensions .......................................................................... 11
- End Cap Connector .............................................................. 11
- Sample Timing ...................................................................... 12
  - Autonomous Sampling ....................................................... 12
  - Polled Sampling ............................................................... 12
  - Serial Line Sync Sampling ................................................ 12
- Battery Endurance ............................................................... 13
- External Power (optional) ....................................................... 13
  - Cable Length and Optional External Power ......................... 14

## Section 3: Preparing MicroCAT for Deployment ................... 15
- Battery Installation ............................................................... 15
  - Description of Batteries and Battery Pack ......................... 15
  - Installing Batteries ......................................................... 15
- Software Installation ............................................................ 17
- Power and Communications Test ......................................... 17
  - Test Setup ........................................................................ 17
  - Test .................................................................................. 18

## Section 4: Deploying and Operating MicroCAT ..................... 22
- Sampling Modes .................................................................... 22
  - Polled Sampling .............................................................. 22
  - Autonomous Sampling (Logging commands) ....................... 23
  - Serial Line Synchronization (Serial Line Sync) .................... 24
- Real-Time Data Acquisition .................................................. 25
- Timeout Description ............................................................ 26
- Command Descriptions ....................................................... 26
- Data Output Formats ........................................................... 34
- Setup for Deployment ......................................................... 35
- Deployment .......................................................................... 36
- Recovery .............................................................................. 37
  - Physical Handling .......................................................... 37
  - Uploading Data .............................................................. 38

## Section 5: Routine Maintenance and Calibration ..................... 42
- Corrosion Precautions .......................................................... 42
- Connector Mating and Maintenance ..................................... 42
- Conductivity Cell Maintenance ............................................. 43
  - Routine Rinsing after Recovery ........................................ 43
  - Cleaning .......................................................................... 43
- Pressure Sensor (optional) Maintenance .............................. 45
- Replacing Batteries ............................................................. 45
- Replacing Anti-Foulant Devices (SBE 37-SI, SM, IM) ............. 46
- Sensor Calibration ............................................................... 47
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glossary</td>
<td>49</td>
</tr>
<tr>
<td>Appendix I: Functional Description</td>
<td>50</td>
</tr>
<tr>
<td>Sensors</td>
<td>50</td>
</tr>
<tr>
<td>Sensor Interface</td>
<td>50</td>
</tr>
<tr>
<td>Real-Time Clock</td>
<td>50</td>
</tr>
<tr>
<td>Appendix II: Electronics Disassembly/Reassembly</td>
<td>51</td>
</tr>
<tr>
<td>Appendix III: Command Summary</td>
<td>52</td>
</tr>
<tr>
<td>Appendix IV: AF24173 Anti-Foulant Device</td>
<td>55</td>
</tr>
<tr>
<td>Appendix V: Replacement Parts</td>
<td>59</td>
</tr>
<tr>
<td>Index</td>
<td>61</td>
</tr>
</tbody>
</table>
Section 1: Introduction

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

About this Manual

This manual is to be used with the SBE 37-SM MicroCAT Conductivity and Temperature Recorder (pressure optional) with RS-232 interface.

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

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

How to Contact Sea-Bird

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

Telephone: 425-643-9866 Fax: 425-643-9954
E-mail: seabird@seabird.com Website: http://www.seabird.com

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

Quick Start

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

1. Install batteries and test power and communications (Section 3: Preparing MicroCAT for Deployment).

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

Shown below is a typical MicroCAT shipment.

- SBE 37-SM MicroCAT
- Batteries
- I/O Cable
- 25-pin to 9-pin adapter (for use with computer with DB-25 connector)
- Spare hardware and o-ring kit
- Cell cleaning solution (Triton-X)
Shipping Precautions

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

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

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

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

1. Remove the battery pack assembly from the MicroCAT.
2. Remove the batteries from the battery pack assembly.
3. Pack the batteries separately to prevent accidental shorting of the battery contacts.

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

**Note:**
Batteries must be removed before returning the instrument to Sea-Bird. Do not return used batteries to Sea-Bird when shipping the MicroCAT for recalibration or repair.
Section 2: Description of MicroCAT

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

System Description

The SBE 37-SM MicroCAT is a high-accuracy conductivity and temperature recorder (pressure optional) with internal battery and non-volatile memory, and a standard RS-232 serial interface. Designed for moorings and other long-duration, fixed-site deployments, MicroCATs have non-corroding titanium housings rated for operation to 7000 meters (23,000 feet) or pressure sensor full-scale range.

Communication with the MicroCAT is over an internal, 3-wire, RS-232C link. Over 50 different commands can be sent to the MicroCAT to provide status display, data acquisition setup, data retrieval, and diagnostic tests. User-selectable operating modes include:

- **Autonomous sampling** – At pre-programmed intervals, the MicroCAT wakes up, samples, stores data in its FLASH memory, and powers off. If desired, real-time data can also be transmitted.

- **Polled sampling** – On command, the MicroCAT takes one sample and transmits the data. Polled sampling is useful for integrating the MicroCAT with satellite, radio, or wire telemetry equipment.

- **Serial line sync** – The MicroCAT wakes up, samples, transmits real-time data, and powers off in response to a pulse on the serial line. This provides an easy method for synchronizing MicroCAT sampling with other instruments such as Acoustic Doppler Current Profilers (ADCPs) or current meters, without drawing on their battery or memory resources.

The MicroCAT can be deployed in two ways:

- **Cable installed** – The MicroCAT can be remotely controlled, allowing for polled sampling or serial line sync, or for periodic requests of data from the MicroCAT memory. If desired, data can be periodically uploaded while the MicroCAT remains deployed.

- **Dummy plug installed** – The MicroCAT cannot be remotely controlled. Autonomous sampling is programmed before deployment, and data is uploaded after recovery.

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

The MicroCAT’s internal-field conductivity cell is immune to proximity errors and unaffected by external fouling. A plastic cup with threaded cover at each end of the cell retains the expendable AF24173 Anti-Foulant Device.
The MicroCAT’s optional pressure sensor, developed by Druck, Inc., has a superior new design that is entirely different from conventional ‘silicon’ types in which the deflection of a metallic diaphragm is detected by epoxy-bonded silicon strain gauges. The Druck sensor employs a micro-machined silicon diaphragm into which the strain elements are implanted using semiconductor fabrication techniques. Unlike metal diaphragms, silicon’s crystal structure is perfectly elastic, so the sensor is essentially free of pressure hysteresis. Compensation of the temperature influence on pressure offset and scale is performed by the SBE MicroCAT’s CPU.

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

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

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

<table>
<thead>
<tr>
<th></th>
<th>Temperature (°C)</th>
<th>Conductivity (S/m)</th>
<th>Optional Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurement Range</strong></td>
<td>-5 to +35</td>
<td>0 to 7 (0 to 70 mS/cm)</td>
<td>0 to full scale range: 20 / 100 / 350 / 1000 / 2000 / 3500 / 7000 meters</td>
</tr>
<tr>
<td><strong>Initial Accuracy</strong></td>
<td>0.002</td>
<td>0.0003 (0.003 mS/cm)</td>
<td>0.1% of full scale range</td>
</tr>
<tr>
<td><strong>Typical Stability</strong></td>
<td>0.0002</td>
<td>0.0003 (0.003 mS/cm)</td>
<td>0.004% of full scale range</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>0.0001</td>
<td>0.00001 (0.0001 mS/cm)</td>
<td>0.002% of full scale range</td>
</tr>
<tr>
<td><strong>Sensor Calibration</strong></td>
<td>+1 to +32</td>
<td></td>
<td>Ambient pressure to full scale range in 5 steps</td>
</tr>
</tbody>
</table>

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

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Counter Time-Base</strong></td>
<td>Quartz TCXO, ±2 ppm per year aging; ±5 ppm vs. temperature (-5 to +30 °C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td>2048K byte non-volatile FLASH memory</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Data Storage
- Converted temperature and conductivity: 5 bytes per sample (2.5 bytes each). Time: 4 bytes per sample. Pressure (optional): 2 bytes per sample.
- **Recorded Parameters**: C and T 410,000, C, T, and P 290,000, C, T, and time 225,000, C, T, P, and time 185,000.

### Real-Time Clock
Watch-crystal type 32,768 Hz; corrected for drift and aging by comparison to MicroCAT counter time-base to produce overall ± 5 ppm accuracy (±2.6 minutes/year)

### Standard Internal Batteries
Nominal 7.2 Ampere-hour pack consisting of six 9-volt lithium batteries. Provides sufficient capacity for more than 175,000 samples. When removed from MicroCAT and battery pack, and batteries packed separately, batteries can be shipped without hazardous material restrictions.

### External Input Power (optional)
40 ma at 9-24 VDC (to avoid draining the internal batteries, use an external voltage greater than 10 VDC)

### Power Requirements
- Quiescent Current: 10 microamps.
- Sampling Current: 25 milliamps.
- Acquisition Time: 1 - 3 seconds per sample (depending on sampling mode and inclusion of pressure sensor) for 1 measurement per sample (NAVG=1).

### Housing
Titanium pressure case rated at 7000 meters (23,000 feet)

### Weight
- In water: 2.3 kg (5.1 lbs)
- In air: 3.8 kg (8.3 lbs)
Dimensions

End Cap Connector

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
<th>Pin</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Common</td>
<td>1</td>
<td>Common</td>
</tr>
<tr>
<td>2</td>
<td>RS-232 data receive</td>
<td>2</td>
<td>RS-232 data receive</td>
</tr>
<tr>
<td>3</td>
<td>RS-232 data transmit</td>
<td>3</td>
<td>RS-232 data transmit</td>
</tr>
<tr>
<td>4</td>
<td>9-24 VDC (optional external power)</td>
<td>4</td>
<td>9-24 VDC (optional external power)</td>
</tr>
</tbody>
</table>
Sample Timing

Sample timing is dependent on several factors, including:
- Sampling mode – autonomous, polled, or serial line sync
- Inclusion of optional pressure sensor in MicroCAT
- Number of measurements taken per sample (NAVG)

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

Autonomous Sampling

Power on time for each sample while logging:
- **With pressure**: 1.55 seconds + (NAVG * 1.26 seconds)
- **Without pressure**: 1.44 seconds + (NAVG * 0.86 seconds)

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

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

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

Polled Sampling

Time from receipt of take sample command to beginning of reply:
- **With pressure**: 0.45 seconds + (NAVG * 1.26 seconds)
- **Without pressure**: 0.35 seconds + (NAVG * 0.86 seconds)

Minimum time (approximate) required from beginning of one sample to beginning of next sample, if NAVG=1:
- After TS command – 2 seconds
- After TSSON command – 3 seconds
- After TSS command – 5 seconds

Serial Line Sync Sampling

Power on time for each sample:
- **With pressure**: 1.55 seconds + (NAVG * 1.26 seconds)
- **Without pressure**: 1.44 seconds + (NAVG * 0.86 seconds)
Battery Endurance

The battery pack has a nominal capacity of 7.2 amp-hours. For planning purposes, Sea-Bird recommends using a conservative value of 5 amp-hours.

Current consumption is as follows:
- Sampling (acquisition) current is 25 milliamps.
- Quiescent current is less than 10 microamps (0.09 AH per year).

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

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

Sampling time = 1.44 seconds + (NAVG * 0.86 seconds) = 1.44 + (1 * 0.86) = 2.3 seconds
Sampling current consumption = 0.025 amps * 2.3 seconds = 0.06 amp-seconds/sample
In 1 hour, sampling current consumption = 6 * 0.06 amp-seconds/sample = 0.36 amp-seconds/hour
Quiescent current = 10 microamps = 0.01 mA
In 1 hour, quiescent current consumption = 0.01 mA * 3600 seconds/hour = 0.036 amp-seconds/hour
Total current consumption / hour = 0.36 + 0.036 = 0.4 amp-seconds/hour
Capacity = (5 amp-hours * 3600 seconds/hr) / (0.4 amp-seconds/hour) = 45000 hours = 1875 days = 5.1 years

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

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

Sampling time = 1.44 seconds + (NAVG * 0.86 seconds) = 1.44 + (20 * 0.86) = 18.64 seconds
Sampling current consumption = 0.025 amps * 18.64 seconds = 0.47 amp-seconds/sample
In 1 hour, sampling current consumption = 6 * 0.47 amp-seconds/sample = 2.82 amp-seconds/hour
Quiescent current = 10 microamps = 0.01 mA
In 1 hour, quiescent current consumption = 0.01 mA * 3600 seconds/hour = 0.036 amp-seconds/hour
Total current consumption / hour = 2.82 + 0.036 = 2.86 amp-seconds/hour
Capacity = (5 amp-hours * 3600 seconds/hr) / (2.86 amp-seconds/hour) = 6294 hours = 262 days = 0.7 years

External Power (optional)

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

Notes:
- If the MicroCAT is logging data and the battery voltage is less than 6.15 volts for ten consecutive scans, the MicroCAT halts logging and displays a low battery indication in the data.
- See Specifications above for data storage limitations.
Section 2: Description of MicroCAT

Cable Length and Optional External Power

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

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

Looking at each issue separately:

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

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

\[ V_{\text{limit}} = 1 \text{ volt} = \text{IR}_{\text{limit}} \]

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

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

Supplying Enough Power to MicroCAT

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

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

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

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

Therefore, maximum cable length is 40 ohms / 0.0257 ohms/foot = 1566 feet = 474 meters

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

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

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

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

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

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

\[ V = IR \quad 0.5 \text{ volts} = (0.025 \text{ amps} \times 0.0257 \text{ ohms/foot} \times \text{cable length}) \]

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

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

\[ V = IR \quad 0.5 \text{ volts} = (0.025 \text{ amps} \times 4 \text{ MicroCATs} \times 0.0257 \text{ ohms/foot} \times \text{cable length}) \]

Cable length = 194 ft = 59 meters (this is the cable length to the MicroCAT furthest from the power source)
Section 3: Preparing MicroCAT for Deployment

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

Battery Installation

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

Description of Batteries and Battery Pack

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

In addition to the six 9-volt batteries, the assembled battery pack consists of:
- a brass sleeve with lower printed circuit board (PCB) containing banana jacks
- upper PCB containing banana plugs

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

Installing Batteries

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

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

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

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

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

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

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

Software Installation

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

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

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

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

---

Power and Communications Test

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

Test Setup

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

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

3. Connect the I/O cable to your computer’s serial port.
Section 3: Preparing MicroCAT for Deployment

Test

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

![Setup Dialog Box]

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

2. The main screen looks like this:

![Main Screen]

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

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

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

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

<table>
<thead>
<tr>
<th>Toolbar Buttons</th>
<th>Description</th>
<th>Equivalent Command*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connect</td>
<td>Re-establish communications with MicroCAT. Computer responds with $&gt;$ prompt. MicroCAT goes to sleep after 2 minutes without communication from computer have elapsed.</td>
<td>(press Enter key)</td>
</tr>
<tr>
<td>Status</td>
<td>Display instrument setup and status (logging, number of samples in memory, etc.).</td>
<td>DS</td>
</tr>
<tr>
<td>Coefficients</td>
<td>Display calibration coefficients.</td>
<td>DC</td>
</tr>
<tr>
<td>Capture</td>
<td>Capture instrument responses on screen to file; may be useful for diagnostics. File has .cap extension. Press Capture again to turn off capture. Capture status displays in Status bar.</td>
<td>—</td>
</tr>
<tr>
<td>Upload</td>
<td>Upload data stored in memory, in format Convert utility can use to allow for post-processing by SBE Data Processing. Uploaded data has .asc extension. Before using Upload: • Configure upload and header parameters in Configure menu. • Send STOP to stop logging.</td>
<td>DDb,e (use Upload key if you will be processing data with SBE Data Processing)</td>
</tr>
<tr>
<td>Convert</td>
<td>Convert uploaded .asc data file to .cnv data file, which can be processed by SBE Data Processing.</td>
<td>—</td>
</tr>
<tr>
<td>Diagnostics</td>
<td>Perform one or more diagnostic tests on MicroCAT. Diagnostic test(s) accessed in this manner are non-destructive – they do not write over any existing instrument settings.</td>
<td>DS, DC, TS, and TSR</td>
</tr>
<tr>
<td>Stop</td>
<td>Interrupt and end current activity, such as logging, uploading, or diagnostic test.</td>
<td>—</td>
</tr>
<tr>
<td>Disconnect</td>
<td>Free computer COM port used to communicate with MicroCAT. COM port can then be used by another program.</td>
<td>—</td>
</tr>
</tbody>
</table>

*See Command Descriptions in Section 4: Deploying and Operating MicroCAT.
3. In the Configure menu, select SBE 37. The dialog box looks like this:

![Configuration Options Dialog Box]

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

Click OK to save the settings.

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

5. Click Connect on the Toolbar. SEATERM tries to connect to the MicroCAT at the baud set in Step 3. If it cannot, it cycles through all other possible baud rates to try to connect. When it connects, the display looks like this:

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

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

If the system does not respond with the S> prompt:
- Click Connect again or press the Enter key twice.
- Verify the correct instrument was selected in the Configure menu and the settings were entered correctly in the Configuration Options dialog box. Note that the baud rate is documented on the Configuration page of this manual.
- Check cabling between the computer and MicroCAT.
6. Display MicroCAT status information by clicking Status on the Toolbar. The display looks like this:

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

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

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

where

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

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

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

The MicroCAT is ready for programming and deployment.
Section 4: Deploying and Operating MicroCAT

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

Sampling Modes

The MicroCAT has three basic sampling modes for obtaining data:

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

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

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

### Polled Sampling

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

**Example: Polled Sampling** (user input in bold)

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

(click Connect on Toolbar to wake up.)

S>NAVG=4
S>TS
S>QS
Autonomous Sampling (Logging commands)

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

The MicroCAT has a lockout feature to prevent unintended interference with sampling. If the MicroCAT is logging or waiting to start logging (STARTLATER has been sent, but logging has not started yet), the MicroCAT will only accept the following commands: DS, DC, TS, TSR, SL, SLT, SLTR, QS, and STOP.

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

Note:
Use STOP to:
• stop logging
• stop waiting to start logging (after STARTLATER has been sent)
Once STOP is sent, the MicroCAT will accept all commands again.

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

(click Connect on Toolbar to wake up.)
S> SAMPLENUM=0
S> INTERVAL=60
S> NAVG=4
S> STORETIME=Y
S> TXREALTIME=N
S> STARTMMDDYY=011004
S> STARTHHMMSS=120000
S> STARTLATER
S> QS

After logging begins, look at data from last sample to check results, and then power down:
(click Connect on Toolbar to wake up.)
S> SL
S> QS

When ready to upload all data to computer, wake up MicroCAT, stop sampling, upload data, and then power down:
(click Connect on Toolbar to wake up.)
S> STOP
(Click Upload on Toolbar – program leads you through screens to define data to be uploaded and where to store it)
S> QS
Serial Line Synchronization (Serial Line Sync)

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

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

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

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

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

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

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

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

<table>
<thead>
<tr>
<th>Maximum Cable Length (meters)</th>
<th>Maximum Baud Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1600</td>
<td>600</td>
</tr>
<tr>
<td>800</td>
<td>1200</td>
</tr>
<tr>
<td>400</td>
<td>2400</td>
</tr>
<tr>
<td>200</td>
<td>4800</td>
</tr>
<tr>
<td>100</td>
<td>9600</td>
</tr>
<tr>
<td>50</td>
<td>19200</td>
</tr>
<tr>
<td>25</td>
<td>38400</td>
</tr>
</tbody>
</table>

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

Example: **Serial Line Sync** (user input in bold)

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

Send power off command.

(click Connect on Toolbar to wake up.)

S> `SAMPLENUM=0`
S> `NAVG=4`
S> `SYNCWAIT=25`
S> `SYNCMODE=Y`
S> `QS`

Take samples using serial line sync mode:

(Repeat this process at periodic intervals as desired.)

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

(Repeat this process at periodic intervals as desired.)

Notes:

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

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

Command Descriptions

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

When entering commands:

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

**DS**

Display operating status and setup parameters.

Equivalent to Status on Toolbar.

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

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

Logging status can be:

- logging not started
- logging data
- not logging: waiting to start at...
- not logging: received stop command
- not logging: low battery
- unknown status

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

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

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

WARNING: LOW BATTERY VOLTAGE!! Replace the batteries before continuing.
Section 4: Deploying and Operating MicroCAT

Setup Commands

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

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

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

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

```
S>MMDDYY=011004
or
S>DDMMYY=100104
S>HHMMSS=120000
```

**BAUD=x**

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

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

<table>
<thead>
<tr>
<th>Maximum Cable Length (meters)</th>
<th>Maximum Baud Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1600</td>
<td>600</td>
</tr>
<tr>
<td>800</td>
<td>1200</td>
</tr>
<tr>
<td>400</td>
<td>2400</td>
</tr>
<tr>
<td>200</td>
<td>4800</td>
</tr>
<tr>
<td>100</td>
<td>9600</td>
</tr>
<tr>
<td>50</td>
<td>19200</td>
</tr>
<tr>
<td>25</td>
<td>38400</td>
</tr>
</tbody>
</table>

**OUTPUTSAL=x**

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

x=N: Do not.

**OUTPUTSV=x**

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

x=N: Do not.

**FORMAT=x**

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

x=1 (default): output converted data.

ttt.tttt, cc.ccccc, pppp.ppp, sssssss, vvvv.vvv, dd mmmm yyyy, hh:mm:ss

x=2: output converted data.

ttt.tttt, cc.ccccc, pppp.ppp, sssssss, vvvv.vvv, mm-dd-yyyy, hh:mm:ss

Notes:
- The MicroCAT’s baud rate (set with BAUD=) must be the same as SEATERM’s baud rate (set in the Configure menu).

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

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

Notes:
- DDMMYY= and MMDDYY= are equivalent. Either can be used to set the date.
- If the battery pack has been removed, date and then time must be reset.
- Always set both date and then time. If a new date is entered but not a new time, the new date will not be saved. If a new time is entered without first entering a new date, the date will reset to the last date it was set for with MMDDYY= or DDMMYY=.
Section 4: Deploying and Operating MicroCAT

Setup Commands (continued)

**REFPRESS=x**

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

**NAVG=x**

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

**SAMPLENUM=x**

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

**QS**

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

Logging Commands

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

**INTERVAL=x**

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

**STORETIME=x**

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

x=N: Do not.

**TXREALTIME=x**

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

x=N: Do not.

---

**Note:**

Do not send **SAMPLENUM=0** until all data has been uploaded. **SAMPLENUM=0** does not delete the data; it just resets the data pointer. If you accidentally send this command before uploading, recover the data as follows:

1. Set **SAMPLENUM=x**, where x is your estimate of number of samples in memory.
2. Upload data. If x is more than actual number of samples in memory, data for non-existent samples will be bad, random data. Review uploaded data file carefully and delete any bad data.
3. If desired, increase x and upload data again, to see if there is additional valid data in memory.

**Note:**

If the MicroCAT is logging data and the battery voltage is less than 6.15 volts for ten consecutive scans, the MicroCAT halts logging and sets the logging status to low battery.

**Notes:**

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

---

Note:

Do not send **SAMPLENUM=0** until all data has been uploaded. **SAMPLENUM=0** does not delete the data; it just resets the data pointer. If you accidentally send this command before uploading, recover the data as follows:

1. Set **SAMPLENUM=x**, where x is your estimate of number of samples in memory.
2. Upload data. If x is more than actual number of samples in memory, data for non-existent samples will be bad, random data. Review uploaded data file carefully and delete any bad data.
3. If desired, increase x and upload data again, to see if there is additional valid data in memory.

---

Note:

If the MicroCAT is logging data and the battery voltage is less than 6.15 volts for ten consecutive scans, the MicroCAT halts logging and sets the logging status to low battery.

---

Note:

If the MicroCAT is logging data and the battery voltage is less than 6.15 volts for ten consecutive scans, the MicroCAT halts logging and sets the logging status to low battery.
### Logging Commands (continued)

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

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

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

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

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

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

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

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

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

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

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

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

**TS**
Take sample, output converted averaged data, and leave power on. Data is not stored in FLASH memory.

**TSR**
Take sample, output averaged raw data, and leave power on. Data is not stored in FLASH memory.

**TSS**
Take sample, store averaged data in FLASH memory, output converted averaged data, and turn power off. If MicroCAT is logging or waiting to log when TSS is sent, MicroCAT executes TS instead.

**TSSON**
Take sample, store averaged data in FLASH memory, output converted averaged data, and leave power on. If MicroCAT is logging or waiting to log when TSSON is sent, MicroCAT executes TS instead.

**SLT**
Output converted averaged data from last sample, then take new sample, and leave power on. Data is not stored in FLASH memory.

**SLTR**
Output raw averaged data from last sample, then take new sample, and leave power on. Data is not stored in FLASH memory.

**SL**
Output converted averaged data from last sample taken with either a Polled Sampling Command or with data logging (see Logging Commands), and leave power on.

Serial Line Sync commands

**SYNCMODE=x**
- **x=Y**: Enable serial line synchronization. When RS-232 RX line is high (3-10 VDC) for 1 to 1000 milliseconds, MicroCAT takes a sample consisting of NAVG measurements, stores averaged data in FLASH memory, transmits real-time averaged data, and powers down.
- **x=N**: Disable serial line synchronization.

**SYNCWAIT=x**
- **x=** time (seconds) MicroCAT monitors RS-232 line for commands after taking a sample in serial line sync mode. Range 0 - 120 seconds; default 0.

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

Send STOP before uploading data.

**DDb,e**

Upload data from scan b to scan e.
First sample is number 1.
As data is uploaded, screen first displays
start time =, sample interval =, and
start sample number =.
These are start time, sample interval, and
starting sample number for last set of
logged data. This information can be
useful in determining what data to review.

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

**Testing Commands**

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

**TT**
Measure temperature 100 times or until
Esc key is pressed, output converted data.

**TC**
Measure conductivity 100 times or until
Esc key is pressed, output converted data.

**TP**
Measure pressure 100 times or until Esc
key is pressed, output converted data.

**TTR**
Measure temperature 100 times or until
Esc key is pressed, output raw data.

**TCR**
Measure conductivity 100 times or until Esc
key is pressed, output raw data.

**TPR**
Measure pressure 100 times or until Esc
key is pressed, output raw data.

**TR**
Measure real-time clock frequency
30 times or until Esc key is pressed,
output data.

---

**Notes:**
- To save data to a file, click Capture on the Toolbar before entering **DDb,e**.
- See Data Output Formats after these Command Descriptions.
- Use Upload on the Toolbar or Upload Data in the Data menu to upload data that will be processed by SBE Data Processing. Manually entering **DDb,e** does not produce data with the required header information and required format for processing by our software. This command is included here for reference for users who are writing their own software.
Section 4: Deploying and Operating MicroCAT

Calibration Coefficients Commands

DC

Display calibration coefficients.
Equivalent to Coefficients on Toolbar.

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

S>DC
SBE37-SM V 2.5 2165
temperature: 19-may-03
TA0 = -9.420702e-05
TA1 = 2.937924e-04
TA2 = -3.739471e-06
TA3 = 1.909551e-07
conductivity: 19-may-03
G = -1.036689e+00
H = 1.444342e-01
I = -3.112137e-04
J = 3.005941e-05
CPCOR = -9.570001e-08
CTCOR = 3.250000e-06
WBOTC = 1.968100e-05
rtc: 11-apr-03
RTCA0 = 9.999782e-01
RTCA1 = 1.749351e-06
RTCA2 = -3.497835e-08

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

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

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

TCALDATE=S
TA0=F
TA1=F
TA2=F
TA3=F
CALDATE=S
CG=F
CH=F
CI=F
CJ=F
WBOTC=F
CTCOR=F
CPCOR=F
PCALDATE=S
PA0=F
PA1=F
PA2=F
PTCA0=F
PTCA1=F
PTCA2=F
PTCB0=F
PTCB1=F
PTCB2=F
POFFSET=F
RCALDATE=S
RTCA0=F
RTCA1=F
RTCA2=F

S = Temperature calibration date
F = Temperature A0
F = Temperature A1
F = Temperature A2
F = Temperature A3
S = Conductivity calibration date
F = Conductivity G
F = Conductivity H
F = Conductivity I
F = Conductivity J
F = Conductivity wbote
F = Conductivity ctcor
F = Conductivity cpcor
S = Pressure calibration date
F = Pressure A0
F = Pressure A1
F = Pressure A2
F = Pressure pta0
F = Pressure pta1
F = Pressure pta2
F = Pressure ptc0
F = Pressure ptcb1
F = Pressure ptcb2
F = Pressure offset
S = Real-time clock calibration date
F = Real-time clock A0
F = Real-time clock A1
F = Real-time clock A2
Data Output Formats

Notes (for FORMAT=1 or 2):
- t = temperature (°C, ITS-90)
- c = conductivity (S/m)
- p = pressure (decibars); included only if optional pressure sensor installed
- s = salinity (psu); sent only if OUTPUTSAL=Y.
- v = sound velocity (m/sec); sent only if OUTPUTSV=Y.

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 space.
- Date and time are included with autonomous sampling data only if STORETIME=Y.
- When TXREALTIME=Y, real-time autonomous data transmitted to the computer is preceded by a # sign and a space.
- The MicroCAT’s pressure sensor is an absolute sensor, so its raw output includes the effect of atmospheric pressure (14.7 psi). As shown on the Calibration Sheet, Sea-Bird’s calibration (and resulting calibration coefficients) is in terms of psia. However, when outputting pressure in decibars, the MicroCAT outputs pressure relative to the ocean surface (i.e., at the surface the output pressure is 0 decibars). The MicroCAT uses the following equation to convert psia to decibars:

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

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

<table>
<thead>
<tr>
<th>t</th>
<th>c</th>
<th>p</th>
<th>s</th>
<th>v</th>
<th>dd mmm yyyy</th>
<th>hh:mm:ss</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1960</td>
<td>3.53255</td>
<td>2184.494</td>
<td>36.9305</td>
<td>1506.185</td>
<td>07 Nov 2003</td>
<td>14:28:00</td>
</tr>
</tbody>
</table>

(temperature,conductivity, pressure, salinity, sound velocity, date, time)
Setup for Deployment

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

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

   A. Ensure all data has been uploaded, and then set $\text{SAMPLENUM}=0$ to make the entire memory available for recording. If $\text{SAMPLENUM}$ is not reset to 0, data will be stored after the last recorded sample.

   B. Set the date and then time.

   C. Establish the setup and logging parameters.

   D. Use one of the following command sequences to initiate sampling:
      - $\text{STARTNOW}$ to start logging now, taking a sample consisting of $\text{NAVG}$ measurements every $\text{INTERVAL}$ seconds.
      - $\text{STARTMMDDYY=}$, $\text{STARTHHMMSS=}=$, and $\text{STARTLATER}$ to start logging at the specified date and time, taking a sample consisting of $\text{NAVG}$ measurements every $\text{INTERVAL}$ seconds.
      - $\text{SYNCMODE=Y}$ to place the MicroCAT in serial line sync mode, so that a simple pulse on the RS-232 line will initiate a sample consisting of $\text{NAVG}$ measurements.

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

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

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

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

3. Attach the mounting clamp and guide to the mooring cable.

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

5. Deploy the MicroCAT.
Recovery

**WARNING!**
Pressure housings may flood under pressure due to dirty or damaged o-rings, or other failed seals, causing highly compressed air to be trapped inside. If this happens, a potentially life-threatening explosion can occur when the instrument is brought to the surface. If the MicroCAT is unresponsive to commands or shows other signs of flooding or damage, carefully secure the instrument in a location away from people until it has been determined that abnormal internal pressure does not exist. Contact Sea-Bird for assistance with procedures for safely relieving internal pressure.

Physical Handling

1. Rinse the conductivity cell with fresh water. (See Section 5: Routine Maintenance and Calibration for cell cleaning and storage.)
2. Reinsert the protective plugs in the anti-foulant device cups.
3. If the batteries are exhausted, new batteries must be installed before the data can be extracted. Stored data will not be lost as a result of exhaustion or removal of batteries, but the current date and time will have to be re-entered upon redeployment. (See Section 5: Routine Maintenance and Calibration for replacement of batteries.)
4. If immediate redeployment is not required, it is best to leave the MicroCAT with batteries in place and in a quiescent state (QS), so that date and time are retained. Because the quiescent current required is only 10 microamps, the batteries can be left in place without significant loss of capacity (less than 2% loss per year).
Uploading Data

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

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

Make the selection for Upload Settings.

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

Select the desired header information option. Click OK to save the settings.
4. In the Configure menu, select Header Form to customize the header. The dialog box looks like this (default prompts are shown):

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

Enter the desired header/header prompts. Click OK.

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

```
Communication Established
```

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

If the system does not respond as shown above:
- Click Connect again.
- Check cabling between the computer and MicroCAT.
- Verify the correct instrument was selected and the COM settings were entered correctly in the Configure menu.

6. If sampling autonomously, command the MicroCAT to stop logging by pressing the Enter key and sending STOP.
7. Display MicroCAT status information by clicking Status on the Toolbar. The display looks like this:

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

8. Click Upload on the Toolbar to upload stored data. SEATERM responds as follows:

A. SEATERM sends the status (DS) command, displays the response, and writes the command and response to the upload file. This provides you with information regarding the number of samples in memory.

B. **If you selected By scan number range in the Configuration Options dialog box (Configure menu)** – a dialog box requests the range. Enter the desired value(s), and click OK.

C. SEATERM sends the calibration coefficients (DC) command, displays the response, and writes the command and response to the upload file. This displays the calibration coefficients.

D. **If you selected Prompt for header information in the Configuration Options dialog box (Configure menu)** – a dialog box with the header form appears. Enter the desired header information, and click OK.

E. In the Open dialog box, enter the desired upload file name and click OK. The upload file has a .asc extension.

F. SEATERM sends the data upload (DDb,e) command.

G. When the data has been uploaded, SEATERM shows the S> prompt.
9. Ensure all data has been uploaded from the MicroCAT by reviewing the data:

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

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

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

Notes:
To prepare for re-deployment:
1. After all data has been uploaded, send `SAMPLENUM=0`. If this is not sent, new data will be stored after the last recorded sample, preventing use of the entire memory capacity.
2. Do one of the following:
   - Send `QS` to put the MicroCAT in quiescent (sleep) state until ready to redeploy. Leaving the MicroCAT with the batteries in place and in quiescent state retains the date and time. Quiescent current is only 10 microamps, so the batteries can be left in place without significant loss of capacity.
   - Use `STARTNOW` to begin logging immediately.
   - Set a date and time for logging to start using `STARTMMDDYY=` or `STARTDDMMYY=`, `STARTHHMMSS=`, and `STARTLATER`.
Section 5: Routine Maintenance and Calibration

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

Corrosion Precautions

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

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

Connector Mating and Maintenance

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

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

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

   **MCBH Connector** – Install the plug/cable connector, aligning the pins.

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

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

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

Routine Rinsing after Recovery

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

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

Cleaning

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

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

Routine Cleaning (inside of cell not visibly dirty)

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

CAUTIONS:
- Do not store the MicroCAT with water in the conductivity cell. Freezing temperatures (for example, in Arctic environments or during air shipment) can break the conductivity cell if it is full of water.
- Do not put a brush or any object inside the conductivity cell to clean it. Putting an object inside the cell can damage and break the cell.
Acid Cleaning (visible deposits or marine growth on inside of cell)

Do not clean with acid more than once per week.

Acid Concentration, Handling, and Disposal

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

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

Example -- concentrated solution 31.5% that you want to dilute to 20%--
\[\left(\frac{31.5\%}{20\%}\right) - 1\] * \[100 + 10 \left(\frac{31.5\%}{20\%}\right)\] = 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

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

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

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

1. Remove the MicroCAT guard:
   A. Remove the two screws attaching each anti-foulant device cup to the guard.
   B. Remove the four Phillips-head screws attaching the guard to the housing and sensor end cap.
   C. Gently lift the guard away.

2. Prepare for cleaning:
   A. Remove the small section of Tygon tubing and anti-foulant device cup from one end of the cell.
   B. Place a 0.6 m (2 ft) length of 7/16 inch ID, 9/16 inch OD Tygon tubing over the end of the cell.
   C. Clamp the MicroCAT so that the cell is vertical, with the 0.6 m (2 ft) Tygon tubing at the bottom end.
   D. Loop the Tygon tubing into a ‘U’ shape, and tape the open end of the tubing in place at the same height as the top of the glass cell.

3. Clean the cell:
   A. Pour a 10% to 38% solution of HCL into the open end of the tubing until the cell is nearly filled. Let it soak for 1 minute only.
   B. Drain the acid from the cell and flush for 5 minutes with warm (not hot), clean, de-ionized water.
   C. Rinse the exterior of the instrument to remove any spilled acid from the surface.
   D. Fill the cell with a 1% solution of Triton X-100 (included with shipment) and let it stand for 5 minutes.
   E. Drain and flush with warm, clean, de-ionized water for 1 minute.
   F. Carefully remove the 0.6 m (2 ft) length of Tygon tubing.
4. Reinstall the anti-foulant device cup and the guard:
   A. Carefully reinstall the small section of Tygon tubing and anti-foulant device cup on the end of the glass cell.
   B. Carefully place the guard over the housing, aligning all holes.
   C. Reinstall the two screws attaching each anti-foulant device cup to the guard.
   D. Reinstall the four Phillips-head screws attaching the guard to the housing and sensor end cap.

5. Prepare for deployment, or
   If being stored – gently blow through the cell to remove larger water droplets. Do not use compressed air, which typically contains oil vapor. Replace the protective plugs in the anti-foulant device cups.

Pressure Sensor (optional) Maintenance

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

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

1. Unscrew the pressure port plug from the pressure port. The fitting may contain silicon oil from the factory, so there may be some spillage.

2. Rinse the pressure port with warm, de-ionized water to remove any particles, debris, etc.

3. Replace the pressure port plug.

Replacing Batteries

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

1. Remove the I/O connector end cap and battery pack assembly.

2. Remove the upper PCB from the assembly as follows:
   A. Remove the two small Phillips-head screws and lock washers from the upper PCB.
   B. Carefully pry the upper PCB away from the batteries, gently going around the circle of batteries to avoid bending the banana plugs.

3. Remove the existing batteries and replace with new batteries, banana plug end (+) first. Ensure each battery is fully inserted.

4. Reinstall the upper PCB, replace the battery pack assembly, and reinstall the end cap.
Replacing Anti-Foulant Devices (SBE 37-SI, SM, IM)

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.

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

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

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

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

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

Conductivity Sensor Calibration

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

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

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

Temperature Sensor Calibration

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

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

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

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

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

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

2. In SEATERM:
   A. Set the pressure offset to 0.0 (POFFSET=0).
   B. Send TP to measure the MicroCAT pressure 100 times and transmit converted data (decibars).

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

4. Enter the calculated offset in the MicroCAT’s EEPROM, using POFFSET= in SEATERM.

**Offset Correction Example**
Pressure measured by a barometer is 14.65 psia. Pressure displayed from MicroCAT is -2.5 dbars. Convert barometer reading to dbars using the relationship: (psia – 14.7) * 0.6894759 = dbars
Barometer reading = (14.65 – 14.7) * 0.6894759 = -0.034 dbars
Offset = -0.034 – (-2.5) = + 2.466 dbar
Enter offset in MicroCAT.

For demanding applications, or where the sensor’s air ambient pressure response has changed significantly, calibration using a dead-weight generator is recommended. The pressure sensor port uses a 7/16-20 straight thread for mechanical connection to the pressure source. Use a fitting that has an O-ring tapered seal, such as Swagelok-200-1-4ST, which conforms to MS16142 boss.
**Battery pack** – Six 9-volt (nominal 1.2 amp-hour) batteries, each containing lithium cells of the type commonly used in cameras. The battery pack also includes two small PCBs and a brass sleeve.

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

**Fouling** – Biological growth in the conductivity cell during deployment.

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

- SBE 37-IM (Inductive Modem, internal battery and memory)
- SBE 37-IMP (Inductive Modem, internal battery and memory, integral Pump)
- SBE 37-SM (Serial interface, internal battery and Memory)
- SBE 37-SMP (Serial interface, internal battery and Memory, integral Pump)
- SBE 37-SI (Serial Interface only, no internal battery or memory)
- SBE 37-SIP (Serial Interface only, no internal battery or memory, integral Pump)

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

**PCB** – Printed Circuit Board.

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

**Scan** – One data sample (consisting of NAVG averaged measurements) containing temperature, conductivity, optional pressure, and optional date and time, as well as optional derived variables (salinity and sound velocity).

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

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

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

**TCXO** – Temperature Compensated Crystal Oscillator.

**Triton X-100** – Concentrated liquid non-ionic detergent, used for cleaning the conductivity cell.
Appendix I: Functional Description

Sensors

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

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

Sensor Interface

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

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

Real-Time Clock

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

Note: Pressure ranges are expressed in meters of deployment depth capability.
Appendix II: Electronics Disassembly/Reassembly

Disassembly

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

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

Reassembly

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

2. Guide the PCB assembly into the housing and push the assembly until the edge connector is fully inserted. A gentle resistance can be felt during the last 3 mm (1/8 inch) of insertion as the PCB assembly mates to the edge connector.

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

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

5. Reinstall the battery pack and end cap following instructions in Section 3: Preparing MicroCAT for Deployment.
## Appendix III: Command Summary

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

**Note:**

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

**Note:**

Do not set INTERVAL to less than 10 seconds if transmitting real-time data (TXREALTIME=Y).
## Appendix III: Command Summary

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

**Note:** Use Upload on the Toolbar or Upload Data in the Data menu to upload data that will be processed by SBE Data Processing. Manually entering DDb,e does not produce data with the required header information for processing by SBE Data Processing.
### Appendix III: Command Summary

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>COMMAND</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>DC</strong></td>
<td>Display calibration coefficients; all coefficients and dates listed below are included in display. Use individual commands below to modify a particular coefficient or date.</td>
</tr>
<tr>
<td></td>
<td>TCALDATE=S</td>
<td>S=Temperature calibration date.</td>
</tr>
<tr>
<td></td>
<td>TA0=F</td>
<td>F=Temperature A0.</td>
</tr>
<tr>
<td></td>
<td>TA1=F</td>
<td>F=Temperature A1.</td>
</tr>
<tr>
<td></td>
<td>TA2=F</td>
<td>F=Temperature A2.</td>
</tr>
<tr>
<td></td>
<td>TA3=F</td>
<td>F=Temperature A3.</td>
</tr>
<tr>
<td></td>
<td>CCALDATE=S</td>
<td>S=Conductivity calibration date.</td>
</tr>
<tr>
<td></td>
<td>CG=F</td>
<td>F=Conductivity G.</td>
</tr>
<tr>
<td></td>
<td>CH=F</td>
<td>F=Conductivity H.</td>
</tr>
<tr>
<td></td>
<td>CI=F</td>
<td>F=Conductivity I.</td>
</tr>
<tr>
<td></td>
<td>CJ=F</td>
<td>F=Conductivity J.</td>
</tr>
<tr>
<td></td>
<td>WBOTC=F</td>
<td>F=Conductivity wbote.</td>
</tr>
<tr>
<td></td>
<td>CTCOR=F</td>
<td>F=Conductivity ctcor.</td>
</tr>
<tr>
<td></td>
<td>CPCOR=F</td>
<td>F=Conductivity cpcor.</td>
</tr>
<tr>
<td></td>
<td>PCALDATE=S</td>
<td>S=Pressure calibration date.</td>
</tr>
<tr>
<td></td>
<td>PA0=F</td>
<td>F=Pressure A0.</td>
</tr>
<tr>
<td></td>
<td>PA1=F</td>
<td>F=Pressure A1.</td>
</tr>
<tr>
<td></td>
<td>PA2=F</td>
<td>F=Pressure A2.</td>
</tr>
<tr>
<td></td>
<td>PTCA0=F</td>
<td>F=Pressure ptca0</td>
</tr>
<tr>
<td></td>
<td>PTCA1=F</td>
<td>F=Pressure ptca1.</td>
</tr>
<tr>
<td></td>
<td>PTCA2=F</td>
<td>F=Pressure ptca2.</td>
</tr>
<tr>
<td></td>
<td>PTCB0=F</td>
<td>F=Pressure ptcb0.</td>
</tr>
<tr>
<td></td>
<td>PTCB1=F</td>
<td>F=Pressure ptcb1.</td>
</tr>
<tr>
<td></td>
<td>PTCB2=F</td>
<td>F=Pressure ptcb2.</td>
</tr>
<tr>
<td></td>
<td>POFFSET=F</td>
<td>F=Pressure offset.</td>
</tr>
<tr>
<td></td>
<td>RCALDATE=S</td>
<td>S=Real-time clock calibration date.</td>
</tr>
<tr>
<td></td>
<td>RTCA0=F</td>
<td>F=Real-time clock A0.</td>
</tr>
<tr>
<td></td>
<td>RTCA1=F</td>
<td>F=Real-time clock A1.</td>
</tr>
<tr>
<td></td>
<td>RTCA2=F</td>
<td>F=Real-time clock A2.</td>
</tr>
</tbody>
</table>

**Coefficients**

(F=floating point number; S=string with no spaces)

Dates shown are when calibrations were performed. Calibration coefficients are initially factory-set and should agree with Calibration Certificates shipped with MicroCAT.
Appendix IV: AF24173 Anti-Foulant Device

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

<table>
<thead>
<tr>
<th>AF24173 ANTIFOULANT DEVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOR USE ONLY IN SEA-BIRD ELECTRONICS' CONDUCTIVITY SENSORS TO CONTROL THE GROWTH OF AQUATIC ORGANISMS WITHIN ELECTRONIC CONDUCTIVITY SENSORS.</td>
</tr>
<tr>
<td>ACTIVE INGREDIENT:</td>
</tr>
<tr>
<td>Bis(tributyltin) oxide</td>
</tr>
<tr>
<td>OTHER INGREDIENTS:</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

**DANGER**

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

Net Contents: Two antifoulant devices (7.14 g)

Sea-Bird Electronics, Inc
1808 - 136th Place NE
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.

<table>
<thead>
<tr>
<th>FIRST AID</th>
</tr>
</thead>
<tbody>
<tr>
<td>If on skin or clothing</td>
</tr>
<tr>
<td>• Take off contaminated clothing.</td>
</tr>
<tr>
<td>• Rinse skin immediately with plenty of water for 15-20 minutes.</td>
</tr>
<tr>
<td>• Call a poison control center or doctor for treatment advice.</td>
</tr>
<tr>
<td>If swallowed</td>
</tr>
<tr>
<td>• Call poison control center or doctor immediately for treatment advice.</td>
</tr>
<tr>
<td>• Have person drink several glasses of water.</td>
</tr>
<tr>
<td>• Do not induce vomiting.</td>
</tr>
<tr>
<td>• Do not give anything by mouth to an unconscious person.</td>
</tr>
<tr>
<td>If in eyes</td>
</tr>
<tr>
<td>• Hold eye open and rinse slowly and gently with water for 15-20 minutes.</td>
</tr>
<tr>
<td>• Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.</td>
</tr>
<tr>
<td>• Call a poison control center or doctor for treatment advice.</td>
</tr>
</tbody>
</table>

HOT LINE NUMBER
Note to Physician Probable mucosal damage may contraindicate the use of gastric lavage.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. For further information call National Pesticide Telecommunications Network (NPTN) at 1-800-858-7378.

Net Contents: Two Anti-Foulant Devices (7.14 g)
PRECAUTIONARY STATEMENTS

HAZARD TO HUMANS AND DOMESTIC ANIMALS

DANGER

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

PERSONAL PROTECTIVE EQUIPMENT

USER SAFETY RECOMMENDATIONS

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

ENVIRONMENTAL HAZARDS

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

PHYSICAL OR CHEMICAL HAZARDS

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

DIRECTIONS FOR USE

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

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

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

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

CONTAINER DISPOSAL: Dispose of in a sanitary landfill or by other approved State and Local procedures.
# Appendix V: Replacement Parts

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Part Description</th>
<th>Application Description</th>
<th>Quantity in MicroCAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>801347</td>
<td>AF24173 Anti-Foulant Device</td>
<td>Bis(tributyltin) oxide device inserted into anti-foulant device cup</td>
<td>2</td>
</tr>
<tr>
<td>231459</td>
<td>Anti-foulant device cup</td>
<td>Holds AF24173 Anti-Foulant Device</td>
<td>2</td>
</tr>
<tr>
<td>231505</td>
<td>Anti-foulant device cap</td>
<td>Secures AF24173 Anti-Foulant Device in cup</td>
<td>2</td>
</tr>
<tr>
<td>30984</td>
<td>Plug</td>
<td>Seals end of anti-foulant cap when not deployed, keeping dust and aerosols out of conductivity cell during storage</td>
<td>2</td>
</tr>
<tr>
<td>30507</td>
<td>Parker 2-206N674-70 O-ring</td>
<td>O-ring between end of conductivity cell and anti-foulant device cup</td>
<td>2</td>
</tr>
<tr>
<td>60035</td>
<td>37-SM / -SMP spare hardware/ O-ring kit</td>
<td>Assorted hardware and O-rings, including:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 30900 Machine screw, 1/4-20 x 2” hex head, titanium (secures mounting clamp)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 30633 Washer, 1/4” split ring lock, titanium (for screw 30900)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 30634 Washer 1/4” flat, titanium (for screw 30900)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 31019 O-ring 2-008 N674-70 (for screw 30900 – retains mounting clamp hardware)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 31040 Screw, 8-32 x 2 FH, TI (secures cable guide base to I/O connector end cap)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 30860 Machine screw, 6-32 x 1/2 FH TI (secures cable clamp half to flat area of sensor end cap)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 30859 Machine screw, 8-32 x 3/8” FH, PH, titanium (secures housing to I/O connector end cap)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 30857 Parker 2-033E515-80 O-ring (I/O connector end cap and sensor end cap O-ring)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 30149 Machine screw, 6-32 x 5/8 PH, stainless steel (secures battery pack assembly to battery pylon)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 30243 Washer, #6 split ring lock, stainless steel (for screw 30149)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 30357 Machine screw, 2-56 x 1/4 PH, stainless steel (secures battery pack’s upper PCB to brass sleeve)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 30986 Washer, #2 split ring lock, stainless steel (for screw 30357)</td>
<td></td>
</tr>
</tbody>
</table>

*Continued on next page*
### Appendix V: Replacement Parts

**Continued from previous page**

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

* For standard XSG-type connector.
Index

A
About Sea-Bird · 5
Anti-Foulant Device · 55
  removal before shipping to Sea-Bird · 47
  replacing · 46

B
Batteries · 10, 35
  description · 15
  endurance · 13
  installing · 15
  replacing · 45
  shipping precautions · 7
Baud rate · 25, 28

C
Cable length · 14, 25
Calibration · 47
Cleaning · 43
Clock · 10
Command summary · 52
Commands
  calibration coefficients · 33
  data upload · 32
  descriptions · 26
  logging · 29
  output format · 28
  polled sampling · 31
  serial line sync · 31
  setup · 28
  status · 27
  testing · 32
Communication defaults · 20
Connector · 11, 42
Convert .asc to .cnv · 41
Corrosion precautions · 42

D
Data output format · 28, 34
Data processing · 9, 41
  installation · 17
Deployment
  installation · 36
  preparing for · 15
  setup · 35
Description · 8
Dimensions · 11

E
Electronics disassembly/reassembly · 51
End cap · 11, 42
External power · See Power, external

F
Format
  data output · 34
Functional description · 50

G
Glossary · 49
Guard
  removal · 46

L
Limited liability statement · 2

M
Maintenance · 42
Memory · 10
Modes · See Sampling modes

P
Parts
  replacement · 59
Power · 14
  external · 10, 13
Pressure sensor
  maintenance · 45

Q
Quick start · 5

R
Real-time setup
  baud rate · 25
  cable length · 25
Recovery
  physical handling · 37
  uploading data · 38
Replacement parts · 59
Index

S
Sample timing · 12
Sampling modes · 22
autonomous · 23
polled · 22
serial line sync · 24
SBE Data Processing · 9, 17, 41
SEASOFT-DOS · 9
SEASOFT-Win32 · 9, 17
SEATERM · 9, 17, 18, 38
main screen · 18
toolbar buttons · 19
Sensors · 10
Shipping precautions · 7
Software · 9
Software installation · 17
Specifications · 10
Storage · 43
System description · 8

T
Terminal program · 9
installation · 17
Testing · 17
Timeout description · 26

U
Unpacking MicroCAT · 6
Uploading data · 38

W
Wiring · 17
SBE 37-SM (RS-232) MicroCAT Reference Sheet
(see SBE 37-SM MicroCAT User’s Manual for complete details)

Sampling Modes

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

Communication Setup Parameters

1. Double click on SeaTerm.exe.
2. Once main screen appears, in Configure menu select SBE 37. Click on COM Settings tab in dialog box. Input:
   - Serial Port: COM1 through COM10 are available
   - Baud Rate: 9600 (or other if applicable)
   - Data Bits: 8
   - Parity: No Parity
   - Mode: RS-232 (Full Duplex)

Deployment

1. Batteries:
   A. **Remove I/O connector end cap**: Wipe dry housing/end cap seam. Remove 2 flat Phillips-head screws from end cap. Pull end cap out. Disconnect Molex connector connecting end cap to battery pack. Wipe dry O-ring mating surfaces in housing with lint-free cloth.
   B. **Remove battery pack and install batteries**: Remove large screw/washer from upper PCB. Lift battery pack out of housing, using handle. Remove 2 small screws/washers from upper PCB. Lift upper PCB off brass sleeve. Insert batteries onto lower PCB. Press upper PCB onto batteries, mating plugs and aligning screw holes. Refasten with two small screws/washers.
   C. **Reinstall battery pack and I/O connector end cap**: Align D-shaped opening and notch. Lower battery pack into housing; push gently to mate. Reinstall large screw/washer in upper PCB. Remove water from O-rings and mating surfaces with lint-free cloth. Inspect O-rings and mating surfaces for dirt, nicks, and cuts. Clean as necessary. Apply light coat of O-ring lubricant to O-ring and mating surfaces. Plug Molex connector together. Fit end cap into housing. Reinstall 2 flat Phillips-head screws to secure.
2. Program MicroCAT for intended deployment (see other side of this sheet for Command Instructions and List):
   A. Set time and date.
   B. Establish logging parameters.
   C. Ensure all data has been uploaded, and then set `SAMPLENUM=0` to make entire memory available for recording. If `SAMPLENUM` is not reset to zero, data will be stored after last recorded sample.
   D. Use one of following sequences to initiate logging:
      - `STARTNOW` to start logging now, taking a sample consisting of NAVG measurements every INTERVAL seconds.
      - `STARTMMDDDYY=, STARTHHMMSS=`, and `STARTLATER` to start logging at specified date and time, taking a sample consisting of NAVG measurements every INTERVAL seconds.
      - `SYNCMODE=Y` to place MicroCAT in serial line sync mode, so that a simple pulse on RS-232 line will initiate a sample consisting of NAVG measurements.
3. Wiring to MicroCAT – deploy with dummy plug or I/O cable (for optional external power and/or serial communication during deployment):
   A. Standard connector: Align raised bump on side of dummy plug/connector with large pin on MicroCAT.
   B. Install locking sleeve.
Command Instructions and List

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

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

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

SBE 37SM Configuration - S/N 3526................................................. 1
SBE 37SM Pressure Test Certificate - S/N 3526......................... 2
SBE 37SM Temperature Calibration - S/N 3526......................... 3
SBE 37SM Conductivity Calibration - S/N 3526......................... 4
SBE 37SM Real Time Clock Calibration - S/N 3526................. 5

SBE 37SM Configuration - S/N 3596................................................. 7
SBE 37SM Pressure Test Certificate - S/N 3596......................... 8
SBE 37SM Temperature Calibration - S/N 3596......................... 9
SBE 37SM Conductivity Calibration - S/N 3596......................... 10
SBE 37SM Real Time Clock Calibration - S/N 3596................. 11

SBE 37SM Configuration - S/N 3597................................................. 13
SBE 37SM Pressure Test Certificate - S/N 3597......................... 14
SBE 37SM Temperature Calibration - S/N 3597......................... 15
SBE 37SM Conductivity Calibration - S/N 3597......................... 16

Calibration Manual Generation Date:  12 August 2004
CALIBRATION SHEETS

SBE 37SM Real Time Clock Calibration - S/N 3597........... 17
.................................................................................................................. 18
SBE 37SM Configuration - S/N 3598................................. 19
SBE 37SM Pressure Test Certificate - S/N 3598.............. 20
SBE 37SM Temperature Calibration - S/N 3598............. 21
SBE 37SM Conductivity Calibration - S/N 3598............. 22
SBE 37SM Real Time Clock Calibration - S/N 3598........... 23
.................................................................................................................. 24
SBE 37SM Configuration - S/N 3599................................. 25
SBE 37SM Pressure Test Certificate - S/N 3599.............. 26
SBE 37SM Temperature Calibration - S/N 3599............. 27
SBE 37SM Conductivity Calibration - S/N 3599............. 28
SBE 37SM Real Time Clock Calibration - S/N 3599........... 29
.................................................................................................................. 30

Calibration Manual Generation Date:  12 August 2004
SBE37-SM MicroCAT

Conductivity & Temperature Recorder with RS-232 Serial Interface

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

Instrument Configuration:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial Number</td>
<td>37SM36540-3526</td>
</tr>
<tr>
<td>Pressure Sensor</td>
<td>None</td>
</tr>
<tr>
<td>Firmware Version</td>
<td>2.5</td>
</tr>
<tr>
<td>Memory</td>
<td>2048Kb</td>
</tr>
<tr>
<td>Interface Type</td>
<td>RS-232</td>
</tr>
<tr>
<td>Conductivity Range</td>
<td>0-7 S/m</td>
</tr>
<tr>
<td>Baud Rate</td>
<td>9600</td>
</tr>
<tr>
<td>Maximum Depth</td>
<td>7000m</td>
</tr>
</tbody>
</table>

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

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

Job Number: 36540  Customer Name: NOAA/OLYMPIC

SBE Sensor Information:
- Model Number: 37
- Serial Number: 3526

Pressure Sensor Information:
- Sensor Type: None
- Sensor Serial Number: None
- Sensor Rating: 0

Pressure Test Protocol:
- Low Pressure Test: 50 PSI  Held For 15 Minutes
- High Pressure Test: 10000 PSI  Held For 15 Minutes

Passed Test: ✔

Tested By: PCC
**SEA-BIRD ELECTRONICS, INC.**
1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

**SENSOR SERIAL NUMBER: 3526  SBE 37 TEMPERATURE CALIBRATION DATA**
**ITS-90 TEMPERATURE SCALE**

**ITS-90 COEFFICIENTS**
- $a_0 = -1.763479e-004$
- $a_1 = 3.078888e-004$
- $a_2 = -4.437235e-006$
- $a_3 = 2.064047e-007$

<table>
<thead>
<tr>
<th>BATH TEMP (ITS-90)</th>
<th>INSTRUMENT OUTPUT</th>
<th>INST TEMP (ITS-90)</th>
<th>RESIDUAL (ITS-90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0001</td>
<td>656478.3</td>
<td>1.0001</td>
<td>0.0000</td>
</tr>
<tr>
<td>4.5000</td>
<td>563058.7</td>
<td>4.5000</td>
<td>-0.0000</td>
</tr>
<tr>
<td>15.0000</td>
<td>362118.7</td>
<td>15.0001</td>
<td>0.0001</td>
</tr>
<tr>
<td>18.5000</td>
<td>314480.2</td>
<td>18.5000</td>
<td>-0.0000</td>
</tr>
<tr>
<td>23.9999</td>
<td>253432.7</td>
<td>23.9999</td>
<td>-0.0000</td>
</tr>
<tr>
<td>28.9999</td>
<td>209526.4</td>
<td>28.9999</td>
<td>0.0000</td>
</tr>
<tr>
<td>32.5000</td>
<td>183998.5</td>
<td>32.5000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

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

Residual = instrument temperature - bath temperature

![Graph showing residual vs temperature](image-url)
**SEA-BIRD ELECTRONICS, INC.**
1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

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

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

**COEFFICIENTS:**
- \( g = -1.032525 \times 10^0 \)  
- \( h = 1.423927 \times 10^{-1} \)  
- \( i = -1.269920 \times 10^{-4} \)  
- \( j = 3.121209 \times 10^{-5} \)  
- \( CPcor = -9.57000 \times 10^{-8} \)  
- \( CTcor = 3.25000 \times 10^{-6} \)  
- \( WBOTC = -1.22450 \times 10^{-5} \)

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

\[ f = INST \text{ FREQ} \times \sqrt{1.0 + WBOTC \times t} / 1000.0 \]

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

t = temperature\(^\circ\)C; \( p = \) pressure\(\text{decibars}\); \( \delta = CTcor; \epsilon = CPcor; \)

Residual = instrument conductivity - bath conductivity

---

**Date, Slope Correction**

[Graph with data points showing conductivity vs. residual]
### Sensor Calibration Data

**Sensor Serial Number:** 3526  
**Calibration Date:** 16-Jun-04

#### ITS-90 Temperature Scale

**Coefficients:**
- $rtca_0 = 9.999831 \times 10^{-1}$
- $rtca_1 = 1.736568 \times 10^{-6}$
- $rtca_2 = -3.351996 \times 10^{-8}$

<table>
<thead>
<tr>
<th>Bath Temp (ITS-90)</th>
<th>RTC Freq (Hz)</th>
<th>Computed Freq (Hz)</th>
<th>Residual (PPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0001</td>
<td>0.9999850</td>
<td>0.9999848</td>
<td>-0.2</td>
</tr>
<tr>
<td>4.5000</td>
<td>0.9999900</td>
<td>0.9999902</td>
<td>0.2</td>
</tr>
<tr>
<td>15.0000</td>
<td>1.0000010</td>
<td>1.0000016</td>
<td>0.6</td>
</tr>
<tr>
<td>18.5000</td>
<td>1.0000040</td>
<td>1.0000037</td>
<td>-0.3</td>
</tr>
<tr>
<td>23.9999</td>
<td>1.0000060</td>
<td>1.0000054</td>
<td>-0.6</td>
</tr>
<tr>
<td>28.9999</td>
<td>1.0000050</td>
<td>1.0000052</td>
<td>0.2</td>
</tr>
<tr>
<td>32.5000</td>
<td>1.0000040</td>
<td>1.0000041</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**RTC frequency** = $rtca_0 + rtca_1 \times t + rtca_2 \times t^2$  
**Residual** = (Computed RTC frequency - Measured RTC frequency) * 1e6

---

**Graph:**  
- Date: 16-Jun-04  
- Delta F ppm: -0.00

---

**Sea-Bird Electronics, Inc.**
1808 136th Place N.E., Bellevue, Washington, 98005 USA  
Phone: (425) 643-9866  
Fax: (425) 643-9954  
Email: seabird@seabird.com
SBE37-SM MicroCAT

Conductivity & Temperature Recorder
with RS-232 Serial Interface

Instrument Configuration:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial Number</td>
<td>37SM36540-3596</td>
</tr>
<tr>
<td>Pressure Sensor</td>
<td>None.</td>
</tr>
<tr>
<td>Firmware Version</td>
<td>2.5</td>
</tr>
<tr>
<td>Memory</td>
<td>2048Kb</td>
</tr>
<tr>
<td>Interface Type</td>
<td>RS-232</td>
</tr>
<tr>
<td>Conductivity Range</td>
<td>0-7 S/m</td>
</tr>
<tr>
<td>Baud Rate</td>
<td>9600</td>
</tr>
<tr>
<td>Maximum Depth</td>
<td>7000m</td>
</tr>
</tbody>
</table>

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

Test Date: 4/6/2004  Description  SBE-37 Microcat
Job Number: 36540  Customer Name  NOAA/OLYMPIC

SBE Sensor Information:
Model Number: 37
Serial Number: 3596

Pressure Sensor Information:
Sensor Type: None
Sensor Serial Number: None
Sensor Rating: 0

Pressure Test Protocol:
Low Pressure Test: 50 PSI  Held For 15 Minutes
High Pressure Test: 10000 PSI  Held For 15 Minutes
Passed Test: ✓

Tested By: PCC
SENSOR SERIAL NUMBER: 3596  
CALIBRATION DATE: 16-Jun-04  

ITS-90 COEFFICIENTS  
a0 = -2.351946e-004  
a1 = 3.090708e-004  
a2 = -4.528129e-006  
a3 = 2.057073e-007  

<table>
<thead>
<tr>
<th>BATH TEMP (ITS-90)</th>
<th>INSTRUMENT OUTPUT</th>
<th>INST TEMP (ITS-90)</th>
<th>RESIDUAL (ITS-90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0001</td>
<td>804905.5</td>
<td>1.0001</td>
<td>-0.0000</td>
</tr>
<tr>
<td>4.5000</td>
<td>690333.8</td>
<td>4.5000</td>
<td>0.0000</td>
</tr>
<tr>
<td>15.0000</td>
<td>443918.3</td>
<td>15.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>18.5000</td>
<td>385501.4</td>
<td>18.5000</td>
<td>-0.0000</td>
</tr>
<tr>
<td>23.9999</td>
<td>310644.9</td>
<td>23.9999</td>
<td>0.0000</td>
</tr>
<tr>
<td>28.9999</td>
<td>256811.5</td>
<td>28.9999</td>
<td>-0.0000</td>
</tr>
<tr>
<td>32.5000</td>
<td>225512.0</td>
<td>32.5000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Temperature ITS-90 = \(1/\left[ a_0 + a_1[ln(n)] + a_2[ln^2(n)] + a_3[ln^3(n)] \right] - 273.15 \) (°C)  
Residual = instrument temperature - bath temperature

Date, Delta T (mdeg C)
16-Jun-04 -0.00
SENSOR SERIAL NUMBER: 3596
CALIBRATION DATE: 16-Jun-04

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

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

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

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

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

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

Residual = instrument conductivity - bath conductivity

Date, Slope Correction
16-Jun-04  1.0000000
 SENSOR SERIAL NUMBER: 3596  
CALIBRATION DATE: 16-Jun-04

SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

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

<table>
<thead>
<tr>
<th>BATH TEMP (ITS-90)</th>
<th>RTC FREQ (Hz)</th>
<th>COMPUTED FREQ (Hz)</th>
<th>RESIDUAL (PPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0001</td>
<td>0.9999830</td>
<td>0.9999829</td>
<td>-0.1</td>
</tr>
<tr>
<td>4.5000</td>
<td>0.9999880</td>
<td>0.9999881</td>
<td>0.1</td>
</tr>
<tr>
<td>15.0000</td>
<td>0.9999990</td>
<td>0.9999991</td>
<td>0.1</td>
</tr>
<tr>
<td>18.5000</td>
<td>1.0000010</td>
<td>1.0000011</td>
<td>0.1</td>
</tr>
<tr>
<td>23.9999</td>
<td>1.0000030</td>
<td>1.0000026</td>
<td>-0.4</td>
</tr>
<tr>
<td>28.9999</td>
<td>1.0000020</td>
<td>1.0000022</td>
<td>0.2</td>
</tr>
<tr>
<td>32.5000</td>
<td>1.0000010</td>
<td>1.0000010</td>
<td>-0.0</td>
</tr>
</tbody>
</table>

RTC frequency = rtca0 + rtca1 * t + rtca2 * t^2  
Residual = (Computed RTC frequency - Measured RTC frequency) * 1e6

Date, Delta F ppm

[Graph showing residual vs. temperature]
SBE37-SM MicroCAT

Conductivity & Temperature Recorder
with RS-232 Serial Interface

Instrument Configuration:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial Number</td>
<td>37SM36540-3597</td>
</tr>
<tr>
<td>Pressure Sensor</td>
<td>None.</td>
</tr>
<tr>
<td>Firmware Version</td>
<td>2.5</td>
</tr>
<tr>
<td>Memory</td>
<td>2048Kb</td>
</tr>
<tr>
<td>Interface Type</td>
<td>RS-232</td>
</tr>
<tr>
<td>Conductivity Range</td>
<td>0-7 S/m</td>
</tr>
<tr>
<td>Baud Rate</td>
<td>9600</td>
</tr>
<tr>
<td>Maximum Depth</td>
<td>7000m</td>
</tr>
</tbody>
</table>

CAUTION - The maximum deployment depth will be limited by the measurement range of the optional pressure sensor, if installed.
Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com

SBE Pressure Test Certificate

Test Date: 4/6/2004  Description: SBE-37 Microcat
Job Number: 36540  Customer Name: NOAA/OLYMPIC

SBE Sensor Information:
Model Number: 37
Serial Number: 3597

Pressure Sensor Information:
Sensor Type: None
Sensor Serial Number: None
Sensor Rating: 0

Pressure Test Protocol:
Low Pressure Test: 50 PSI Held For 15 Minutes
High Pressure Test: 10000 PSI Held For 15 Minutes
Passed Test: ✓

Tested By: PCC
ITS-90 Coefficients

\[ a_0 = -2.176875 \times 10^{-4} \]
\[ a_1 = 3.092916 \times 10^{-4} \]
\[ a_2 = -4.542004 \times 10^{-6} \]
\[ a_3 = 2.073325 \times 10^{-7} \]

Bath Temp | Instrument Output | Inst Temp (ITS-90) | Residual (ITS-90)
--- | --- | --- | ---
0.9999 | 748011.1 | 0.9999 | 0.0000
4.5000 | 641590.4 | 4.5000 | -0.0000
15.0000 | 412677.6 | 15.0001 | 0.0001
18.5000 | 358401.7 | 18.5000 | -0.0000
24.0000 | 288842.8 | 24.0000 | -0.0000
29.0000 | 238812.8 | 29.0000 | 0.0000
32.5000 | 209724.1 | 32.5000 | -0.0000

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

Residual = instrument temperature - bath temperature

Date, Delta T (mdeg C)

10-Jun-04 0.00
**SBE 37 CONDUCTIVITY CALIBRATION DATA**

**PSS 1978: C(35,15,0) = 4.2914 Siemens/meter**

**COEFFICIENTS:**

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

<table>
<thead>
<tr>
<th>BATH TEMP (ITS-90)</th>
<th>BATH SAL (PSU)</th>
<th>BATH COND (Siemens/m)</th>
<th>INST FREQ (Hz)</th>
<th>INST COND (Siemens/m)</th>
<th>RESIDUAL (Siemens/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.0000</td>
<td>0.0000</td>
<td>0.00000</td>
<td>2681.98</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
<tr>
<td>0.9999</td>
<td>34.7624</td>
<td>2.97179</td>
<td>5265.83</td>
<td>2.97180</td>
<td>0.00001</td>
</tr>
<tr>
<td>4.5000</td>
<td>34.7414</td>
<td>3.27835</td>
<td>5462.77</td>
<td>3.27837</td>
<td>-0.00001</td>
</tr>
<tr>
<td>15.0000</td>
<td>34.6962</td>
<td>4.25844</td>
<td>6048.84</td>
<td>4.25843</td>
<td>-0.00001</td>
</tr>
<tr>
<td>18.5000</td>
<td>34.6865</td>
<td>4.60300</td>
<td>6241.57</td>
<td>4.60299</td>
<td>-0.00001</td>
</tr>
<tr>
<td>24.0000</td>
<td>34.6755</td>
<td>5.15999</td>
<td>6540.85</td>
<td>5.16001</td>
<td>0.00002</td>
</tr>
<tr>
<td>29.0000</td>
<td>34.6695</td>
<td>5.68097</td>
<td>6808.58</td>
<td>5.68099</td>
<td>0.00002</td>
</tr>
<tr>
<td>32.5000</td>
<td>34.6668</td>
<td>6.05286</td>
<td>6993.23</td>
<td>6.05285</td>
<td>-0.00002</td>
</tr>
</tbody>
</table>

\[
f = \text{INST FREQ} \times \sqrt{1.0 + \text{WBOTC} \times t} / 1000.0
\]

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

\[
t = \text{temperature}[\degree C] \quad \text{p = pressure[decibars]} \quad \delta = \text{CTcor} \quad \varepsilon = \text{CPcor}
\]

Residual = instrument conductivity - bath conductivity

---

**Date, Slope Correction**

10-Jun-04  1.0000000
SBE 37 RTC CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

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

<table>
<thead>
<tr>
<th>BATH TEMP (ITS-90)</th>
<th>RTC FREQ (Hz)</th>
<th>COMPUTED FREQ (Hz)</th>
<th>RESIDUAL (PPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9999</td>
<td>0.9999740</td>
<td>0.9999740</td>
<td>0.0</td>
</tr>
<tr>
<td>4.5000</td>
<td>0.9999790</td>
<td>0.9999790</td>
<td>0.0</td>
</tr>
<tr>
<td>15.0000</td>
<td>0.9999900</td>
<td>0.9999899</td>
<td>-0.1</td>
</tr>
<tr>
<td>18.5000</td>
<td>0.9999920</td>
<td>0.9999921</td>
<td>0.1</td>
</tr>
<tr>
<td>24.0000</td>
<td>0.9999940</td>
<td>0.9999942</td>
<td>0.2</td>
</tr>
<tr>
<td>29.0000</td>
<td>0.9999950</td>
<td>0.9999947</td>
<td>-0.3</td>
</tr>
<tr>
<td>32.5000</td>
<td>0.9999940</td>
<td>0.9999941</td>
<td>0.1</td>
</tr>
</tbody>
</table>

RTC frequency = rtca0 + rtca1 * t + rtca2 * t^2
Residual = (Computed RTC frequency - Measured RTC frequency) * 1e6

Date, Delta F ppm
10-Jun-04, -0.00
This page intentionally left blank.
CAUTION - The maximum deployment depth will be limited by the measurement range of the optional pressure sensor, if installed.
## SBE Pressure Test Certificate

**Test Date:** 4/6/2004  
**Description:** SBE-37 Microcat  
**Job Number:** 36540  
**Customer Name:** NOAA/OLYMPIC

### SBE Sensor Information:
- **Model Number:** 37  
- **Serial Number:** 3598

### Pressure Sensor Information:
- **Sensor Type:** None  
- **Sensor Serial Number:** None  
- **Sensor Rating:** 0

### Pressure Test Protocol:
- **Low Pressure Test:** 50 PSI  
  Held For 15 Minutes  
- **High Pressure Test:** 10000 PSI  
  Held For 15 Minutes  
  Passed Test: ✔

**Tested By:** PCC
SENSOR SERIAL NUMBER: 3598
CALIBRATION DATE: 10-Jun-04

SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

<table>
<thead>
<tr>
<th>a0</th>
<th>a1</th>
<th>a2</th>
<th>a3</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2.373659e-005</td>
<td>2.834051e-004</td>
<td>-2.852970e-006</td>
<td>1.706652e-007</td>
</tr>
</tbody>
</table>

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

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

Residual = instrument temperature - bath temperature

Date, Delta T (mdeg C)

10-Jun-04 -0.00
SBE 37 CONDUCTIVITY CALIBRATION DATA
PSS 1978: \( \frac{C(35,15,0)}{1} = 4.2914 \) Siemens/meter

COEFFICIENTS:

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

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

\[ f = \text{INST FREQ} \times \sqrt{1.0 + \text{WBOTC} \times t} / 1000.0 \]

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

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

Residual = instrument conductivity - bath conductivity

---

**Date, Slope Correction**

10-Jun-04 \( 1.0000000 \)
### SBE 37 RTC Calibration Data

**ITS-90 Temperature Scale**

**Coefficients:**
- $rtca_0 = 9.999805e-001$
- $rtca_1 = 1.587001e-006$
- $rtca_2 = -2.869549e-008$

<table>
<thead>
<tr>
<th>Bath Temp (ITS-90)</th>
<th>RTC Freq (Hz)</th>
<th>Computed Freq (Hz)</th>
<th>Residual (PPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9999</td>
<td>0.9999820</td>
<td>0.9999820</td>
<td>0.0</td>
</tr>
<tr>
<td>4.5000</td>
<td>0.9999870</td>
<td>0.9999870</td>
<td>0.0</td>
</tr>
<tr>
<td>15.0000</td>
<td>0.9999980</td>
<td>0.9999978</td>
<td>-0.2</td>
</tr>
<tr>
<td>18.5000</td>
<td>1.0000000</td>
<td>1.0000000</td>
<td>0.0</td>
</tr>
<tr>
<td>24.0000</td>
<td>1.0000020</td>
<td>1.0000020</td>
<td>0.0</td>
</tr>
<tr>
<td>29.0000</td>
<td>1.0000020</td>
<td>1.0000024</td>
<td>0.4</td>
</tr>
<tr>
<td>32.5000</td>
<td>1.0000020</td>
<td>1.0000017</td>
<td>-0.3</td>
</tr>
</tbody>
</table>

RTC frequency = $rtca_0 + rtca_1 \times t + rtca_2 \times t^2$

Residual = (Computed RTC frequency - Measured RTC frequency) $\times 1e6$

**Graph**

- **Date, Delta F ppm**
  - 10-Jun-04 0.00
This page intentionally left blank.
SBE37-SM MicroCAT

Conductivity & Temperature Recorder
with RS-232 Serial Interface

Instrument Configuration:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial Number</td>
<td>37SM36540-3599</td>
</tr>
<tr>
<td>Pressure Sensor</td>
<td>None.</td>
</tr>
<tr>
<td>Firmware Version</td>
<td>2.5</td>
</tr>
<tr>
<td>Memory</td>
<td>2048Kb</td>
</tr>
<tr>
<td>Interface Type</td>
<td>RS-232</td>
</tr>
<tr>
<td>Conductivity Range</td>
<td>0-7 S/m</td>
</tr>
<tr>
<td>Baud Rate</td>
<td>9600</td>
</tr>
<tr>
<td>Maximum Depth</td>
<td>7000m</td>
</tr>
</tbody>
</table>

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

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

Job Number: 36540  Customer Name: NOAA/OLYMPIC

SBE Sensor Information:
- Model Number: 37
- Serial Number: 3599

Pressure Sensor Information:
- Sensor Type: None
- Sensor Serial Number: None
- Sensor Rating: 0

Pressure Test Protocol:
- Low Pressure Test: 50 PSI  Held For 15 Minutes
- High Pressure Test: 10000 PSI  Held For 15 Minutes

Passed Test: ✓

Tested By: PCC
SBE 37 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

**ITS-90 COEFFICIENTS**

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( a_0 )</td>
<td>(-2.331607 \times 10^{-4})</td>
</tr>
<tr>
<td>( a_1 )</td>
<td>(3.157429 \times 10^{-4})</td>
</tr>
<tr>
<td>( a_2 )</td>
<td>(-5.047280 \times 10^{-6})</td>
</tr>
<tr>
<td>( a_3 )</td>
<td>(2.213422 \times 10^{-7})</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bath Temp (ITS-90)</th>
<th>Instrument Output</th>
<th>Inst Temp (ITS-90)</th>
<th>Residual (ITS-90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9999</td>
<td>713930.8</td>
<td>0.9999</td>
<td>-0.0000</td>
</tr>
<tr>
<td>4.5000</td>
<td>612389.1</td>
<td>4.5000</td>
<td>0.0000</td>
</tr>
<tr>
<td>15.0000</td>
<td>393949.2</td>
<td>15.0000</td>
<td>-0.0000</td>
</tr>
<tr>
<td>18.5000</td>
<td>342148.3</td>
<td>18.5000</td>
<td>0.0000</td>
</tr>
<tr>
<td>24.0000</td>
<td>275761.9</td>
<td>23.9999</td>
<td>-0.0001</td>
</tr>
<tr>
<td>29.0000</td>
<td>228009.8</td>
<td>29.0001</td>
<td>0.0001</td>
</tr>
<tr>
<td>32.5000</td>
<td>200245.7</td>
<td>32.5000</td>
<td>-0.0000</td>
</tr>
</tbody>
</table>

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

Residual = instrument temperature - bath temperature

Date, Delta T (mdeg C)

<table>
<thead>
<tr>
<th>Date, Delta T (mdeg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-Jun-04 -0.00</td>
</tr>
</tbody>
</table>
SENSOR SERIAL NUMBER: 3599  
CALIBRATION DATE: 10-Jun-04

COEFFICIENTS:
\[ g = -1.004796 \times 10^0 \]
\[ h = 1.342870 \times 10^{-1} \]
\[ i = -1.477162 \times 10^{-4} \]
\[ j = 3.139689 \times 10^{-5} \]

PSS 1978: \[ C(35,15,0) = 4.2914 \] Siemens/meter

SBE 37 CONDUCTIVITY CALIBRATION DATA

<table>
<thead>
<tr>
<th>BATH TEMP (ITS-90)</th>
<th>BATH SAL (PSU)</th>
<th>BATH COND (Siemens/m)</th>
<th>INST FREQ (Hz)</th>
<th>INST COND (Siemens/m)</th>
<th>RESIDUAL (Siemens/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>2737.59</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>0.9999</td>
<td>34.7624</td>
<td>2.9717</td>
<td>5439.26</td>
<td>2.9718</td>
<td>-0.0001</td>
</tr>
<tr>
<td>4.5000</td>
<td>34.7414</td>
<td>3.2783</td>
<td>5644.33</td>
<td>3.2783</td>
<td>-0.0001</td>
</tr>
<tr>
<td>15.0000</td>
<td>34.6962</td>
<td>4.2584</td>
<td>6254.26</td>
<td>4.2584</td>
<td>-0.0001</td>
</tr>
<tr>
<td>18.5000</td>
<td>34.6865</td>
<td>4.6030</td>
<td>6454.74</td>
<td>4.6029</td>
<td>-0.0001</td>
</tr>
<tr>
<td>24.0000</td>
<td>34.6755</td>
<td>5.1599</td>
<td>6765.98</td>
<td>5.1600</td>
<td>0.0002</td>
</tr>
<tr>
<td>29.0000</td>
<td>34.6695</td>
<td>5.6809</td>
<td>7044.32</td>
<td>5.6809</td>
<td>0.0002</td>
</tr>
<tr>
<td>32.5000</td>
<td>34.6668</td>
<td>6.0528</td>
<td>7236.25</td>
<td>6.0528</td>
<td>-0.0002</td>
</tr>
</tbody>
</table>

\[ f = \text{INST FREQ} \times \sqrt{1.0 + \text{WBOTC} \times \text{t}} / 1000.0 \]

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

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

Residual = instrument conductivity - bath conductivity

Date, Slope Correction

Date: 10-Jun-04  Slope Correction: 1.0000000
### Sensor Serial Number: 3599
### Calibration Date: 10-Jun-04

#### SBE 37 RTC Calibration Data

**ITS-90 Temperature Scale**

**Coefficients:**
- $rtca0 = 9.999761 \times 10^{-1}$
- $rtca1 = 1.736438 \times 10^{-6}$
- $rtca2 = -3.098022 \times 10^{-8}$

<table>
<thead>
<tr>
<th>Bath Temp (ITS-90)</th>
<th>RTC Freq (Hz)</th>
<th>Computed Freq (Hz)</th>
<th>Residual (PPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9999</td>
<td>0.9999780</td>
<td>0.9999778</td>
<td>-0.2</td>
</tr>
<tr>
<td>4.5000</td>
<td>0.9999830</td>
<td>0.9999833</td>
<td>0.3</td>
</tr>
<tr>
<td>15.0000</td>
<td>0.9999950</td>
<td>0.9999952</td>
<td>0.2</td>
</tr>
<tr>
<td>18.5000</td>
<td>0.9999980</td>
<td>0.9999976</td>
<td>-0.4</td>
</tr>
<tr>
<td>24.0000</td>
<td>1.0000000</td>
<td>0.9999999</td>
<td>-0.1</td>
</tr>
<tr>
<td>29.0000</td>
<td>1.0000000</td>
<td>1.0000004</td>
<td>0.4</td>
</tr>
<tr>
<td>32.5000</td>
<td>1.0000000</td>
<td>0.9999998</td>
<td>-0.2</td>
</tr>
</tbody>
</table>

**RTC Frequency** = $rtca0 + rtca1 \times t + rtca2 \times t^2$

**Residual** = (Computed RTC frequency - Measured RTC frequency) $\times 10^6$

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

Calibration coefficients are stored in EEPROM, and uploaded data is presented in ASCII engineering units. The data always includes Conductivity, Temperature, and Pressure (if optional pressure sensor is installed). If desired, time can be added to each scan, and the MicroCAT can calculate and output salinity and sound velocity (Chen-Millero). The MicroCAT retains the temperature and conductivity sensors used in our time-proven SEACAT products; however, new acquisition techniques provide increased accuracy and resolution while reducing power consumption. Electrical isolation of the conductivity electronics eliminates any possibility of ground-loop noise.

The MicroCAT’s unique internal-field conductivity cell permits the use of expendable anti-foulant devices. The aged and pressure-protected thermistor has a long history of exceptional accuracy and stability.

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

**SENSOR INTERFACE ELECTRONICS**

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

**COMMUNICATIONS AND INTERFACING**

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

User-selectable operating modes include:

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

**SOFTWARE**

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

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

Converted temperature and conductivity are stored 5 bytes per sample, time 4 bytes per sample, and optional pressure 2 bytes per sample; memory capacity is in excess of 185,000 samples. The MicroCAT is powered by a 7.2 Ampere-Hour (nominal) battery pack consisting of six 9-volt lithium batteries which, when removed from the MicroCAT, can be shipped without hazardous material restrictions. The pack provides sufficient internal battery capacity for more than 300,000 samples. *

SPECIFICATIONS

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

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

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

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

Time Resolution 1 second
Clock Accuracy 13 seconds/month
Quiescent Current * 10 microamps

Sampling and Communication Current *
Without external power option
Communication 38 milliamps
Sampling 20 milliamps for autonomous or serial line sync sampling; 39 milliamps for polled sampling

With external power option
Communication 35 milliamps
Sampling 35 milliamps

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

Optional External Input Power 0.5 Amps at 9-24 VDC

Housing Titanium

Depth Capability 7000 m (23,000 feet)

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

* Power consumption / battery endurance values are for standard RS-232 interface; for optional RS-485 interface, see RS-485 manual.
<table>
<thead>
<tr>
<th>Application Notes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appnote 2D Conductivity</td>
<td>1</td>
</tr>
<tr>
<td>Appnote 10 Conductivity</td>
<td>3</td>
</tr>
<tr>
<td>Appnote 141978 Practical Salinity Scale</td>
<td>5</td>
</tr>
<tr>
<td>Appnote 27D Minimizing Strain Gauge Errors</td>
<td>7</td>
</tr>
<tr>
<td>Appnote 42 ITS-90 Temperature Scale</td>
<td>11</td>
</tr>
<tr>
<td>Appnote 57 Connector Care</td>
<td>12</td>
</tr>
<tr>
<td>Appnote 68 USB Ports</td>
<td>15</td>
</tr>
<tr>
<td>Appnote 69 Pressure to Depth Conversion</td>
<td>16</td>
</tr>
<tr>
<td>Appnote 71 Desiccant Use and Regeneration</td>
<td>17</td>
</tr>
<tr>
<td>Appnote 73 Pressure Sensors at Elevations Above Sea Level</td>
<td>23</td>
</tr>
</tbody>
</table>
APPLICATION NOTE NO. 2D  
Revised December 2002

INSTRUCTIONS FOR CARE AND CLEANING OF CONDUCTIVITY CELLS

Since any conductivity sensor’s output reading is proportional to its dimensions, it is important to keep the cell clean of internal coatings. Also, cell electrodes contaminated with oil, biological growths, or other foreign material will cause low conductivity readings.

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

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

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

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

PRECAUTIONS!!!!!!

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

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

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

Routine Cleaning (inside of cell not visibly dirty)

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

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

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

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

*Triton X-100 (a trade name of J. T. Baker, Inc) is a concentrated liquid non-ionic detergent available at most chemical or scientific supply stores. Other liquid detergents can probably also be used, but scientific grades are preferable because of their known composition. It is better to use a non-ionic detergent since conductivity readings taken immediately after use are less likely to be affected by any residual detergent left in the cell.
Sea-Bird conductivity sensors provide precise characterization of deep ocean water masses. To achieve the accuracy of which the sensors are capable, an accounting for the effect of hydrostatic loading (pressure) on the conductivity cell is necessary. Conductivity calibration certificates show an equation containing the appropriate pressure-dependent correction term, which has been derived from mechanical principles and confirmed by field observations. The form of the equation varies somewhat, as shown below:

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

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

or

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

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

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

**where**

- a, b, c, d, m, and CPcor are the calibration coefficients used for older sensors (prior to January 1995); Sea-Bird continues to calculate and print these coefficients on the calibration sheets for use with old software, but recommends use of the g, h, i, j, CTcor, CPcor form of the equation for most accurate results
- g, h, i, j, CTcor, and CPcor are the calibration coefficients used for newer sensors
- CPcor is the correction term for pressure effects on conductivity
- slope and offset are correction coefficients used to make corrections for sensor drift between calibrations; set to 1.0 and 0 respectively on initial calibration by Sea-Bird (see Application Note 31 for details on calculating slope and offset)
- f is the instrument frequency (kHz)
- t is the water temperature (°C)
- p is the water pressure (decibars)

Sea-Bird CTD data acquisition, display, and post-processing software SEASOFT automatically implements these equations.
DISCUSSION OF PRESSURE CORRECTION

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

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

$$1 + s$$

where $s = (C_{P\text{cor}})(p)$

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

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

MATHEMATICAL DERIVATION OF PRESSURE CORRECTION

For a cube under hydrostatic load:

$$\Delta L / L = s = p (1 - 2 ν) / E$$

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, $\rho$ is volume resistivity, $L$ is length, and $A$ is cross-sectional area. For the conductivity cell $A = π r^2$, 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:

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

Since conductivity is $1/R$:

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

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:

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

where

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

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

\[
R_F = \frac{R}{R_{P}} ; R_P = 1 + \frac{P \times (A_1 + A_2 P + A_3 P^2)}{1 + B_1 T + B_2 T^2 + B_3 R + B_4 R T}
\]

\(R_T = c_0 + c_1 T + c_2 T^2 + c_3 T^3 + c_4 T^4\)

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

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

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

\[
B_4 = -3.107 \times 10^{-3}
\]

\[
c_0 = 6.766697 \times 10^{-1}
\]

\[
c_1 = 2.00564 \times 10^{-2}
\]

\[
c_2 = 1.104259 \times 10^{-4}
\]

\[
c_3 = -6.9698 \times 10^{-7}
\]

\[
c_4 = 1.0031 \times 10^{-9}
\]

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

\[
a_0 = 0.0080 \quad b_0 = 0.0005 \quad k = 0.0162.
\]

\[
a_1 = -0.1692 \quad b_1 = -0.0056
\]

\[
a_2 = 25.3851 \quad b_2 = -0.0066
\]

\[
a_3 = 14.0941 \quad b_3 = -0.0375
\]

\[
a_4 = -7.0261 \quad b_4 = 0.0636
\]

\[
a_5 = 2.7081 \quad b_5 = -0.0144
\]
Minimizing Strain Gauge Pressure Sensor Errors

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

- SBE 16plus and 16plus-IM SEACAT (not 16*) with optional strain gauge pressure sensor
- SBE 19plus SEACAT Profiler (not 19*)
- SBE 25 SEALOGGER CTD, which uses SBE 29 Strain-Gauge Pressure Sensor (built after March 2001)
- SBE 37 MicroCAT (37-IM, -IMP, -SM, -SMP, and -SI) with optional pressure sensor (built after September 2000)
- SBE 39 Temperature Recorder with optional pressure sensor (built after September 2000)
- SBE 49 FastCAT CTD Sensor
- SBE 50 Digital Oceanographic Pressure Sensor

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

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

DEFINITION OF PRESSURE TERMS

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

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

Some oceanographers express pressure in Newtons/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:

- For CTDs that output **raw data** (SBE 16plus, 16plus-IM, 19plus, 25, and 49) and are supported by SEASOFT’s SEASEAVE (real-time data acquisition) and SBE Data Processing (data processing) software – In SEASOFT, user selects pressure output in psi (not psia) or dbar. SEASOFT subtracts 14.7 psi from the raw absolute reading and outputs the remainder as psi or converts the remainder to dbar.
- For the **SBE 50** – User selects pressure output in psia (including atmospheric pressure) or dbar. Calculation of dbar is as described above.
- For all other instruments that can output **converted data in engineering units** (SBE 16plus, 16plus-IM, 19plus, 37, 39, and 49) – Instrument subtracts 14.7 psi from the raw absolute reading and converts the remainder to dbar. **Note**: SBE 16plus, 16plus-IM, 19plus, and 49 can output raw or converted data.

RELATIONSHIP BETWEEN PRESSURE AND DEPTH

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

- For oceanic applications, salinity is presumed to be 35 PSU, temperature to be 0°C, and the compressibility of the water (with its accompanying density variation) is taken into account. This is the method recommended in UNESCO Technical Paper No. 44 and is a logical approach in that by far the greatest part of the deep-ocean water column approximates these values of salinity and temperature. Since pressure is also proportional to gravity and the major variability in gravity depends on latitude, the user’s latitude entry is used to estimate the magnitude of the local gravity field.
  - SBE 16+plus, 16+plus-IM, 19+plus, 25, and 49 - User is prompted to enter latitude if Depth [salt water] is selected as a display variable in SEASAVE or as an output variable in the Data Conversion or Derive module of SBE Data Processing.
  - SBE 37-SI and 50 - Latitude is entered in the instrument’s EEPROM using the LATITUDE= command in SEASOFT’s SEATERM (terminal program) software.
  - SBE 39 – User is prompted to enter latitude if conversion of pressure to depth is requested when converting an uploaded .asc file to a .cnv file in SEATERM.

- For fresh water applications, compressibility is not significant in the shallow depths encountered and is ignored, as is the latitude-dependent gravity variation. Fresh water density is presumed to be 1 gm/cm, and depth (in meters) is calculated as 1.019716 * pressure (in dbars).

CHOOSING THE RIGHT SENSOR

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

<table>
<thead>
<tr>
<th>Range (meters)</th>
<th>Maximum Initial Error (meters)</th>
<th>SBE 16+plus, 16+plus-IM, 19+plus, 37, 39, 49, &amp; 50 - Resolution (meters)</th>
<th>SBE 25 - Resolution (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 20</td>
<td>0.02</td>
<td>0.0004</td>
<td>0.003</td>
</tr>
<tr>
<td>0 – 100</td>
<td>0.10</td>
<td>0.002</td>
<td>0.015</td>
</tr>
<tr>
<td>0 – 350</td>
<td>0.35</td>
<td>0.007</td>
<td>0.052</td>
</tr>
<tr>
<td>0 – 1000</td>
<td>1.0</td>
<td>0.02</td>
<td>0.15</td>
</tr>
<tr>
<td>0 – 2000</td>
<td>2.0</td>
<td>0.04</td>
<td>0.30</td>
</tr>
<tr>
<td>0 – 3500</td>
<td>3.5</td>
<td>0.07</td>
<td>0.52</td>
</tr>
<tr>
<td>0 – 7000</td>
<td>7.0</td>
<td>0.14</td>
<td>1.05</td>
</tr>
</tbody>
</table>

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) subject 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

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

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

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

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

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

5. Compare the instrument output to the reading from a good barometer placed at the same height as the pressure sensor. Calculate \( \text{offset (decibars)} = \text{barometer reading (converted to decibars)} - \text{instrument reading (decibars)} \).

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

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

**Offset Correction Example**

<table>
<thead>
<tr>
<th>Pressure measured by a barometer is 14.65 psia. Pressure displayed from instrument is -2.5 dbars.</th>
<th>Convert barometer reading to dbars using the relationship: ( (\text{psia} - 14.7) \times 0.6894759 \text{ = dbar} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barometer reading = (14.65 – 14.7) \times 0.6894759 = -0.034 dbars</td>
<td>Offset = -0.034 – (-2.5) = + 2.466 dbar</td>
</tr>
<tr>
<td>Enter offset in .con file (if applicable) and in instrument EEPROM (if applicable).</td>
<td></td>
</tr>
</tbody>
</table>

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

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

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

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

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

**Power Turn-On Transient**

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

![Power Turn-On Transient Plot](19p-4492-3.5k.cnv)

**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 NO. 42

ITS-90 TEMPERATURE SCALE

Beginning January 1995, Sea-Bird temperature calibration certificates list a new set of coefficients labeled $g$, $h$, $i$, $j$, and $F_0$. These coefficients correspond to ITS90 (T90) temperatures and should be entered by those researchers working with SEASOFT-DOS Versions 4.208 and higher (and all versions of SEASOFT-Win32). For the convenience of users who prefer to use older SEASOFT versions, the new certificates also list $a$, $b$, $c$, $d$, and $F_0$ coefficients corresponding to IPTS68 (T68) temperatures as required by SEASOFT-DOS versions older than 4.208.

It is important to note that the international oceanographic research community will continue to use T68 for computation of salinity and other seawater properties. Therefore, following the recommendations of Saunders (1990) and as supported by the Joint Panel on Oceanographic Tables and Standards (1991), SEASOFT-DOS 4.200 and later and all versions of SEASOFT-Win32 convert between T68 and T90 according to the linear relationship:

$$ T_{68} = 1.00024 \times T_{90} $$

The use of T68 for salinity and other seawater calculations is automatic in all SEASOFT programs. However, when selecting temperature as a display/output variable, you will be prompted to specify which standard (T90 or T68) is to be used to compute temperature. SEASOFT recognizes whether you have entered T90 or T68 coefficients in the configuration (.con) file, and computes T90 temperature directly or calculates it from the Saunders linear approximation, depending on which coefficients were used and which display variable type is selected.

For example, if $g$, $h$, $i$, $j$, $F_0$ coefficients (T90) are entered in the .con file and you select temperature variable type as T68, SEASOFT computes T90 temperature directly and multiplies it by 1.00024 to display T68. Conversely, if $a$, $b$, $c$, $d$, and $F_0$ coefficients (T68) are entered in the .con file and you select temperature variable type as T90, SEASOFT computes T68 directly and divides by 1.00024 to display T90.

Note: The CTD configuration (.con) file is edited using the Configure menu (in SEASAVE or SBE Data Processing in our SEASOFT-Win32 suite of programs) or SEACON (in SEASOFT-DOS).

Also beginning January 1995, Sea-Bird's own temperature metrology laboratory (based upon water triple-point and gallium melt cell, SPRT, and ASL F18 Temperature Bridge) converted to T90. These T90 standards are now employed in calibrating all Sea-Bird temperature sensors, and as the reference temperature used in conductivity calibrations. Accordingly, all calibration certificates show T90 ($g$, $h$, $i$, $j$) coefficients that result directly from T90 standards, and T68 coefficients ($a$, $b$, $c$, $d$) computed using the Saunders linear approximation.
I/O Connector Care and Installation

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

The Application Note is divided into three sections:
- Connector Cleaning and Installation
- Locking Sleeve Installation
- Cold Weather Tips

Connector Cleaning and Installation

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

   ![Clean bulkhead connector](image1)
   ![Clean inside of connector](image2)

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

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

   ![Corroded pins on bulkhead connectors](image3)
   ![Connector on right has a missing pin](image4)
3. Using a tube of 100% silicone grease (Dow DC-4 or equivalent), squeeze approximately half the size of a pea onto the end of your finger.

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

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

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

6. Push the connector all the way onto the bulkhead. There may be an audible pop, which is good. With some newer cables, or in cold weather, there may not be an initial audible pop.

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

**CAUTION:**
Failure to eject the trapped air will result in the connector leaking.
Locking Sleeve Installation

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

- Tighten the locking sleeve by hand. Do not use a wrench or pliers to tighten the locking sleeve. Overtightening will gall the threads, which can bind the locking sleeve to the bulkhead connector. Attempting to remove a tightly bound locking sleeve may instead result in the bulkhead connector actually unthreading from the end cap. A loose bulkhead connector will lead to a flooded instrument. Pay particular attention when removing a locking sleeve to ensure the bulkhead connector is not loosened.

- It is a common misconception that the locking sleeve provides watertight integrity. It does not, and continued re-tightening of the locking sleeve will not fix a leaking connector.

- As part of routine maintenance at the end of every cruise, remove the locking sleeve, slide it up the cable, and rinse the connection (still mated) with fresh water. This will prevent premature cable failure.

Cold Weather Tips

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

Removing a frozen inline connector:

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

Installing an inline connector:

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

By following these procedures, you will have many years of reliable service from your cables!
Using USB Ports to Communicate with Sea-Bird Instruments

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

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

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

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

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

Other USB adapters from these manufacturers, and adapters from other manufacturers, may also be compatible with Sea-Bird instruments. We recommend testing of any other adapters with the instrument before deployment, to verify that there is no problem.
Conversion of Pressure to Depth

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

Sea-Bird uses the following algorithms for calculating depth:

**Fresh Water Applications**

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

\[
\text{depth (meters)} = \text{pressure (decibars)} \times 1.019716
\]

**Seawater Applications**

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

The gravity variation with latitude and pressure is computed as:

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

*where*

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

\[
p = \text{pressure (decibars)}
\]

Then, depth is calculated from pressure:

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

*where*

\[
p = \text{pressure (decibars)}
\]

\[
g = \text{gravity (m/sec}^2\)
APPLICATION NOTE NO. 71

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, 16plus, 16plus-IM, 17plus, 19, 19plus, 25, 37-SM, 37-SMP, 37-IM, 37-IMP, 44; PN 90208 Auto Fire Module [AFM]), there is a bulkhead between the battery and electronics compartments. Battery replacement does not affect desiccation of the electronics, as the batteries are removed without removing the electronics and no significant gas exchange is possible through the bulkhead. Therefore, opening the battery compartment to replace the batteries does not expose the electronics; you do not need to install a new desiccant bag in the electronics compartment each time you open the battery compartment. For these instruments, install a new desiccant bag if you open the electronics compartment to access the printed circuit boards.

- For the SBE 39 and 48, the electronics must be removed or exposed to access the battery. Therefore, install a new desiccant bag each time you open the housing to replace a battery.

Storage and Handling

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

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

Replacement desiccant bags are available from Sea-Bird:

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

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

**MIL-D-3464 Desiccant Regeneration Procedure**

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

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

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

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

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

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

**NOTE:** Use only a metal or glass container with a tight fitting metal or glass lid to store the regenerated desiccant. Keep the container lid **closed tightly** to preserve adsorption properties of the desiccant.
MATERIAL SAFETY DATA SHEET – August 13, 2002  
SORB-IT®  
Packaged Desiccant

SECTION I -- PRODUCT IDENTIFICATION

<table>
<thead>
<tr>
<th>Trade Name and Synonyms:</th>
<th>Silica Gel, Synthetic Amorphous Silica, Silicon, Dioxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Family:</td>
<td>Synthetic Amorphous Silica</td>
</tr>
<tr>
<td>Formula:</td>
<td>SiO₂ₓ H₂O</td>
</tr>
</tbody>
</table>

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>CAS No</th>
<th>%</th>
<th>ACGIH/TLV (PPM)</th>
<th>OSHA-(PEL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amorphous Silica</td>
<td>63231-67-4</td>
<td>&gt;99</td>
<td>PEL - 20 (RESPIRABLE), TLV – 5</td>
<td>LIMIT – NONE, HAZARD - IRRITANT</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance and Odor:</td>
<td>White granules; odorless.</td>
</tr>
<tr>
<td>Melting Point:</td>
<td>&gt;1600 Deg C; &gt;2900 Deg F</td>
</tr>
<tr>
<td>Solubility in Water:</td>
<td>Insoluble.</td>
</tr>
<tr>
<td>Bulk Density:</td>
<td>&gt;40 lbs./cu. ft.</td>
</tr>
<tr>
<td>Percent Volatile by Weight @ 1750 Deg F:</td>
<td>&lt;10%.</td>
</tr>
</tbody>
</table>
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.
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.
* No Information Available

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

<table>
<thead>
<tr>
<th>Category</th>
<th>HMIS Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Hazard</td>
<td>0</td>
</tr>
<tr>
<td>Flammability</td>
<td>0</td>
</tr>
<tr>
<td>Reactivity</td>
<td>0</td>
</tr>
<tr>
<td>Personal Protection</td>
<td>HMIS assigns choice of personal protective equipment to the customer, as the raw material supplier is unfamiliar with the condition of use.</td>
</tr>
</tbody>
</table>

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.
Using Instruments with Pressure Sensors at Elevations Above Sea Level

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

Background

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

\[ \text{Pressure (db)} = \left[ \text{pressure (psia)} - 14.7 \right] \times 0.689476 \]

where 14.7 psia is the assumed atmospheric pressure (based on atmospheric pressure at sea level).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

*Offset Correction Example:*
Pressure displayed at elevation is -1.655 db. \( \text{Offset} = 0 - (-1.655) = +1.655 \text{ db} \)
Enter offset in .con file and in instrument.
**SBE 37 (all models)**

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

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

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

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

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Pressure Offset Command</th>
<th>Output Format Command</th>
<th>Command to Acquire Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBE 37-IM and 37-IMP, and RS-485 version of SBE 37-SM, 37-SMP, 37-SI, and 37-SIP</td>
<td>#iiOFFSET=</td>
<td>#iiFORMAT=1 or #iiFORMAT=2</td>
<td>#iiTP (measures and outputs pressure 30 times)</td>
</tr>
<tr>
<td>RS-232 version of SBE 37-SM, 37-SMP, 37-SI, and 37-SIP</td>
<td>OFFSET=</td>
<td>FORMAT=1 or FORMAT=2</td>
<td>TP (measures and outputs pressure 100 times)</td>
</tr>
</tbody>
</table>

**SBE 50**

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

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

*Offset Correction Example:*
Pressure displayed at elevation with OUTPUTFORMAT=2 (db) is -1.655 db.  
Offset = 0 – (-1.655) = + 1.655 db  
Enter offset in the SBE 50.
The SBE 39 directly outputs data that is already converted to engineering units, using calibration coefficients that are programmed into the SBE 39. The SBE 39 does not use a .con file. The SBE 39 is a special case, because its programmed calibration coefficients do not currently include a pressure offset term. The lack of a pressure offset term creates two difficulties when deploying at elevations above sea level:

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

<table>
<thead>
<tr>
<th>Range (m or db) *</th>
<th>Range (psi) = (\text{Range (db)} / 0.689476)</th>
<th>0.1 * Range (psi)</th>
<th>Atmospheric Pressure (psi) at elevation at which error occurs = [14.7 - 0.1 * \text{Range (psi)}]</th>
<th>Approximate Corresponding Elevation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>29</td>
<td>2.9</td>
<td>11.8</td>
<td>1570</td>
</tr>
<tr>
<td>100</td>
<td>145</td>
<td>14.5</td>
<td>0.2</td>
<td>7885</td>
</tr>
<tr>
<td>350</td>
<td>507</td>
<td>50.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1000</td>
<td>1450</td>
<td>145</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2000</td>
<td>2900</td>
<td>290</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3500</td>
<td>5076</td>
<td>507</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7000</td>
<td>10152</td>
<td>1015</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

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

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

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

*Example 1:* You want to deploy the SBE 39 with a 20 m pressure sensor in a mountain lake at 1400 meters (4590 feet). This is lower than 1570 meters shown in the table, so you do not need to adjust the sensor range. After the data is recorded and uploaded, perform post-processing to adjust for the pressure offset.

*Example 2:* You want to deploy the SBE 39 with a 20 m pressure sensor in a mountain lake at 2000 meters (6560 feet). This is higher than 1570 meters shown in the table, so you need to adjust the sensor range. In SEATERM, set PRANGE=100 to allow use of the SBE 39 at this elevation. After the data is recorded and uploaded, perform post-processing to adjust for the pressure offset.

### SBE 26plus

Unlike our other instruments that include a pressure sensor, the SBE 26plus outputs absolute pressure (i.e., at the surface the output pressure is atmospheric pressure at the deployment elevation). Therefore, no corrections are required when using the SBE 26plus above sea level. SBE 26plus software (SEASOFT for Waves) includes a module that can subtract measured barometric pressures from tide data, and convert the resulting pressures to water depths.
IMPULSE XSG-38CL-HP-SS
1/2-20 17653

3 INCHES

A

WHT

#24

1

BLK

#24

2

GRN

#24

3

2695

WILCOX

17956

WE1-12

1

2

3

(Scale enlarged for clarity)

WHT

1

GRN

3

BLK

2

VIEW A-A

SEA-BIRD ELECTRONICS, INC

N/A

1:1

SBE 37 3 PIN DATA I/O

MOLEX WIRING

40889

1 of 1

A
SHIELDED
CONSOLIDATED 1702 PIGTAIL, DWG 30584

<table>
<thead>
<tr>
<th>SBE PART NO.</th>
<th>A DIM</th>
<th>PIGTAIL PN</th>
</tr>
</thead>
<tbody>
<tr>
<td>801493</td>
<td>50 m</td>
<td>17390</td>
</tr>
<tr>
<td>801498</td>
<td>50 ft</td>
<td>17205</td>
</tr>
</tbody>
</table>

NON-SHIELDED
18/3-30 PIGTAIL, DWG 30580

<table>
<thead>
<tr>
<th>SBE PART NO.</th>
<th>A DIM</th>
<th>PIGTAIL PN</th>
</tr>
</thead>
<tbody>
<tr>
<td>801412</td>
<td>8 FT</td>
<td>17030</td>
</tr>
<tr>
<td>801526</td>
<td>20 m</td>
<td>17156</td>
</tr>
</tbody>
</table>

RMG-3FS W/LOCKING SLEEVE G-FLS-P (PIGTAIL PER DRAWING 30580)

PN 17097, CONN, HOOD, 40-9709H AIM, 9 PIN
PN 17096, CONN, 9 PIN
FEMALE SOLDER CUP D09S-TG
WARRANTY POLICY

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, whichever is longer. Certain products and components have modified coverage under this warranty as described below.

MODIFICATIONS / EXCEPTIONS / EXCLUSIONS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

RETURNED MATERIAL AUTHORIZATION (RMA) NUMBER
RMA Number: ________________________________________________

CONTACT INFORMATION
Your name: ____________________________________________________________________________________________
Institution/Organization/Company: ______________________________________________________________________
Shipping/Delivery address for packages: __________________________________________________________________

Telephone: ______________________ Fax: ________________________________
e-mail: _____________________________________________________________________________________________

SERVICE INFORMATION
Date Shipped: _______________________________________________________________________________________
Sea-Bird Model Number (for example, SBE 37-SM): ________________________________
Quantity: _________________________________________________________________________________________
Serial Numbers: ______________________________________________________________________________________

(Note: Specify instrument serial numbers below if specific services are required for some instruments. For example, if 10 instruments are being returned for calibration, and 1 of the 10 also requires repairs, specify the serial number for the instrument requiring the repairs in the appropriate section of the form.)

SEASOFT Version you have been using with this instrument(s): ________________________________

[ ] Perform Routine Services:
   ____Calibration (includes basic diagnostic):
       ____Temperature  ____Conductivity  ____Pressure  ____DO  ____pH
       (Please allow a minimum of 3 weeks after we receive the instrument(s) to complete calibration.)
       ____Full System Diagnostic and Check Out
       ____Other (specify):

[ ] System Upgrade or Conversion:
   Specify (include instrument serial number if multiple instruments are part of shipment):

[ ] Diagnose and Repair Operational Faults:
   Please send a disk containing the raw data (.hex or .dat files) which shows the problems you describe. Also send the .con files you used to acquire or display the data.
   Problem Description (continue on additional pages if needed; include instrument serial number if multiple instruments are part of shipment):

______________________________________________________________________________________________
______________________________________________________________________________________________
______________________________________________________________________________________________
______________________________________________________________________________________________
______________________________________________________________________________________________
______________________________________________________________________________________________
PAYMENT/BILLING INFORMATION
Credit Card: Sea-Bird accepts payment by VISA, MasterCard, or American Express.
[ ] MasterCard  [ ] Visa  [ ] American Express
Account Number: ___________________________ Expiration Date: _____________
Credit Card Holder Name (printed or typed): ____________________________________________
Credit Card Holder Signature: _______________________________________________________
Credit Card Billing Address (if different than shipping address):
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Invoice/Purchase Order: If you prefer us to invoice you, please complete the following or enclose a copy
of your Purchase Order:
Purchase Order Number: _____________________________________________________________
Billing Address (if different than shipping address):
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Instructions for Returning Goods to Sea-Bird

You can ship any of the following ways:

1. **Domestic Shipments (USA)** - Ship prepaid (via UPS, FedEx, DHL, etc.) directly to:
   Sea-Bird Electronics, Inc.
   1808 136th Place NE
   Bellevue, WA  98005, USA
   Telephone: (425) 643-9866  Fax: (425) 643-9954

2. **Foreign Shipments** - Ship via prepaid airfreight to:
   Sea-Bird Electronics, Inc.
   1808 136th Place NE
   Bellevue, WA  98005, USA
   Telephone: (425) 643-9866  Fax: (425) 643-9954
   **Notify: MTI Worldwide Logistics for Customs Clearance**
   Seattle, WA, USA
   Telephone: (206) 431-4366  Fax: (206) 431-4374
   (Please note Airport of Destination: **SEA** for Seattle, WA)

3. **Ship via EXPRESS COURIER directly to Sea-Bird Electronics** (UPS, FedEx, or DHL;
   do not ship via TNT SKYPACK). Courier services will clear Customs and deliver the package to
   Sea-Bird. It is not necessary to notify our customs broker.
   Include a **commercial invoice** showing the description of the instruments, and **value for Customs
   purposes only**. On the invoice, include the statement that “Goods are of USA Origin”.
   Failure to include this statement in your invoice will result in US Customs assessing duties on
   the shipment, which we will in turn pass on to the customer/shipper.

Note:
Due to changes in regulations, if Sea-Bird receives an instrument from outside the U.S. in a crate
containing non-approved (i.e., non-heat-treated) wood, we will return the instrument in a new crate that
meets the requirements of ISPM 15 (see [http://www.seabird.com/customer_support/retgoods.htm](http://www.seabird.com/customer_support/retgoods.htm) for
details). We will charge for the replacement crates based on the dimensions of the crate we receive. The
charge will be determined as follows:
1. Multiply the crate length x width x height in centimeters (overall volume in cm3, not internal volume).
2. Determine the price based on your calculated overall volume and the following chart:

<table>
<thead>
<tr>
<th>Overall Volume (cm3)</th>
<th>Example Instrument</th>
<th>Price (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 52,000</td>
<td>37-SM MicroCAT</td>
<td>$45</td>
</tr>
<tr>
<td>52,000 to less than 65,000</td>
<td>SEACAT, no cage</td>
<td>$70</td>
</tr>
<tr>
<td>65,000 to 240,000</td>
<td>CTD in cage</td>
<td>$125</td>
</tr>
<tr>
<td>more than 240,000</td>
<td>--</td>
<td>consult factory</td>
</tr>
</tbody>
</table>

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