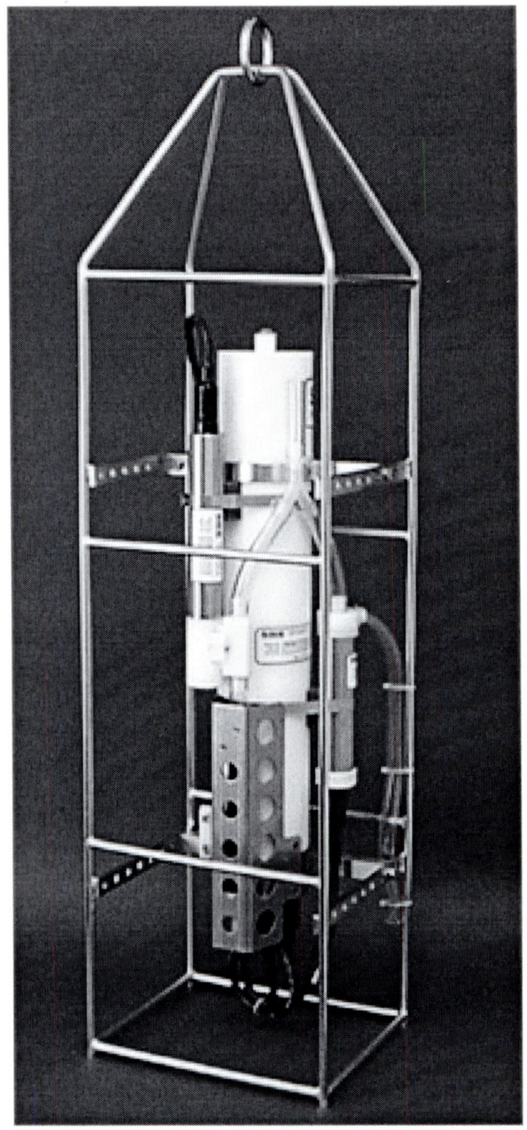
SBE 19plus
SEACAT PROFILER

Conductivity, Temperature, and Pressure Recorder with RS-232 Interface



Serial Number: 19P35153-4579

Configuration and Calibration Manual

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SBE 19plus CTD OPERATING AND REPAIR MANUAL

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Manual Generation Date: 19 March 2004

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.

WARNING !!

**Do not submerge this instrument (S/N 19P35153-4579)
beyond the depth rating of the lowest rated component listed below!**

Main Housing (Titanium)	7000 meters
Pressure Sensor (3500 dBar) Druck	**3500 meters**
Pump (SBE 5M)	10500 meters

SYSTEM CONFIGURATION 22 March 2004

Model SBE 19plus	**S/N 19P35153-4579**
Instrument Type	**SBE 19plus SeaCaT Profiler**
Firmware Version	**1.4D**
Communications	**9600 baud, 8 data bits, no parity, one stop bit**
Memory	**8192K**
Housing	**7000 meter (3AL-4V Titanium)**
0 Conductivity Raw Frequency	**2615.12 Hz**
Pressure Sensor	**Strain Gauge: 3500 dBar, S/N 5426**
Number of Voltages Sampled:	**0**
Serial RS-232C Sensor	**None**

Data Format:

Count	**Temperature**
Frequency	**Conductivity**
Count	**Pressure, Strain gauge**
Pump (SBE 5M)	**S/N 05M0617**
Voltage Delay Setting (standard)	**(standard) 0 seconds**

IMPORTANT SOFTWARE & HARDWARE CONFIGURATION INFORMATION

Sea-Bird supplies two versions of our software package for communication, real-time data acquisition, and data analysis and display:

- SEASOFT-Win32 - Windows software for PC running Win 95/98/NT/2000/XP
- SEASOFT-DOS - DOS software for IBM-PC/AT/386/486 or compatible computer with a hard drive

Detailed information on the use of the **Windows** software follows:

SEASOFT-Win32

SEASOFT-Win32 software was supplied on a CD-ROM with your CTD. This software package is designed to run on a PC running Win 95/98/NT/2000/XP. The CD-ROM also contains software manuals that describe the appropriate applications for the various programs, the procedure for installing the software, and instructions on using the programs. There are three primary programs used with the CTD for setup, data collection and retrieval, data display, and data processing:

- SEATERM - terminal program for setup of the CTD and uploading of data from the CTD memory (**Note**: If using the CTD with the 90208 Auto Fire Module or SBE 17*plus* V2 SEARAM, use SeatermAF instead of SEATERM)
- SEASAVE - real-time data acquisition program
- SBE Data Processing - data processing program

Instructions for using the software are found in their Help files.

To communicate with the CTD to set it up or to upload data from the CTD memory to the computer hard drive, **SEATERM** must have information about the CTD hardware configuration (communication parameters, internal firmware, etc.) and about the computer. To communicate with the CTD, double click on Seaterm.exe:

1. In the Configure menu, select the CTD. The Configuration Options dialog box appears.
   A. On the COM Settings tab, select the firmware version (if applicable), baud rate, data bits, and parity to match the CTD's configuration sheet. If necessary, change the com port to match the computer you are using.
   B. On the Upload Settings tab, enter upload type (all as a single file, etc.) as desired.
   For the SBE 17 and 25 only: enter the serial number for the SBE 3 (temperature) and SBE 4 (conductivity) modular sensors, exactly as they appear in the configuration (.con) file.
   C. On the Header Information tab, change the settings as desired.
   Click OK when done. SEATERM saves the settings in a SEATERM.ini file.
2. On the Toolbar, click Connect to communicate with the CTD.
3. To set up the CTD prior to deployment:
   On the Toolbar, click Status. SEATERM sends the Status command and displays the response. Verify that the CTD setup matches your desired deployment. If not, send commands to modify the setup.
4. To upload data from the CTD:
   On the Toolbar, click Upload to upload data from the CTD memory to the computer.

Sea-Bird CTDs store and/or transmit data from their primary and auxiliary sensors in the form of binary or hexadecimal number equivalents of the sensors' frequency or voltage outputs. This is referred to as the *raw* data. The calculations required to convert from *raw* data to *engineering* units of the measured parameters (temperature, conductivity, pressure, dissolved oxygen, pH, etc.) are performed using the software, either in real time, or after the data has been stored in a file. SEASAVE creates the file in real time. As noted above, SEATERM uploads the recorded data and creates the file on the computer hard drive.

To successfully store data to a file on the computer and subsequently convert it to engineering units, the software must know the CTD type, CTD configuration, and calibration coefficients for the sensors installed on the CTD. This information is unique to each CTD, and is contained in a *configuration* file. The configuration file, which has a .con extension, was written onto a floppy disk and the CD-ROM shipped with the CTD. The .con file for a given CTD is named with the last four digits of the serial number for that CTD (e.g., 1234.con). The configuration file is created or modified (e.g., changing coefficients after recalibration, or adding another sensor) by using the Configure menu in **SEASAVE** or **SBE Data Processing**. The configuration file is used by SEASAVE to convert raw data to engineering units when it acquires, stores, and displays real-time data. The configuration file is also used by some modules in SBE Data Processing (Data Conversion and Derive) that convert raw data to engineering units during data processing.

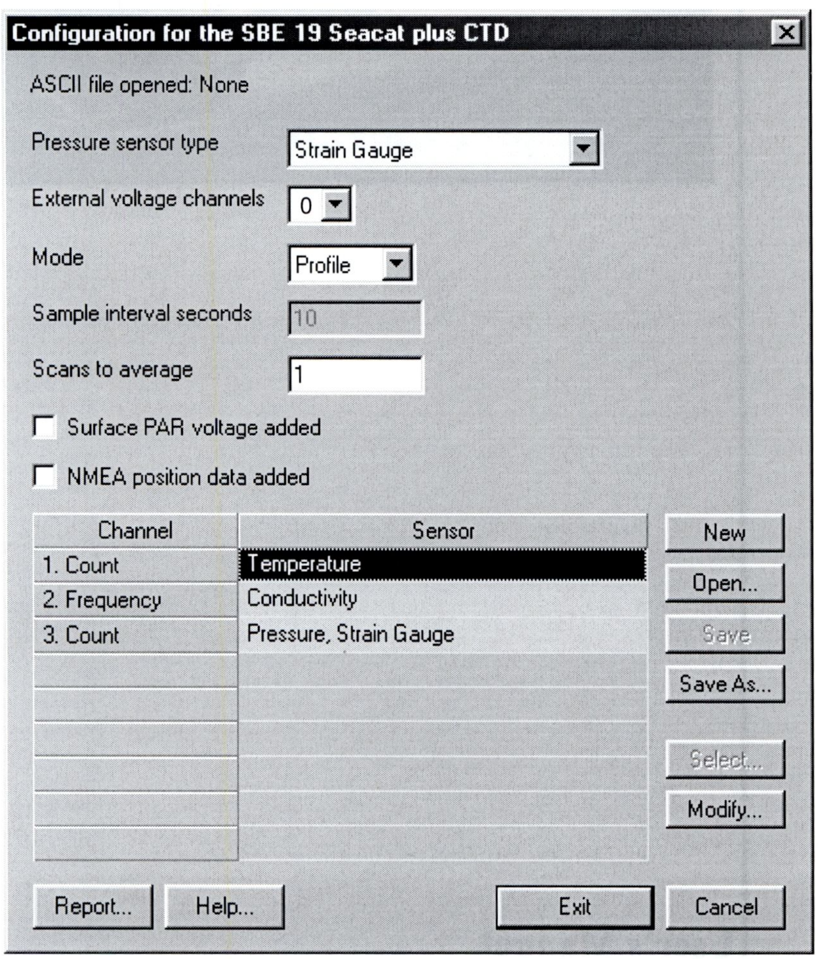
The instrument type and instrument configuration settings of the .con file and the required setup for the SEATERM.ini file for the CTD *as delivered* are documented below. The calibration coefficients for the CTD's sensors are contained in the calibration coefficient section of the CTD manual.

NOTE:

SEATERM will not upload data correctly without a properly configured SEATERM.ini file. SEASAVE and SBE Data Processing will not interpret the data correctly without the correct .con file.

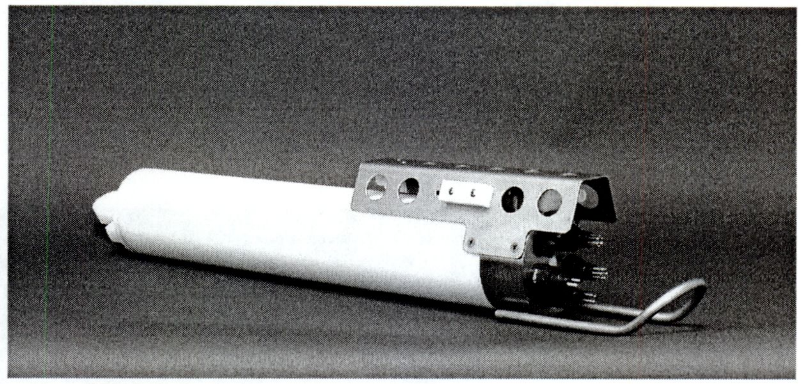
SEASOFT CONFIGURATION:

The correct instrument type for your instrument is SBE 19plus SEACAT Profiler. The correct settings for the configuration of your instrument as delivered are documented below:



SBE 19*plus* SEACAT Profiler

Conductivity, Temperature, and Pressure Recorder with RS-232 Interface



User's Manual

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Manual Version #011, 06/17/03
Firmware Version 1.4D and later

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Section 1: Introduction

This section includes contact information, Quick Start procedure, and photos of a standard SBE 19*plus* shipment.

About this Manual

This manual is to be used with the SBE 19*plus* SEACAT Profiler Conductivity, Temperature, and Pressure Recorder.

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

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

How to Contact Sea-Bird

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

Quick Start

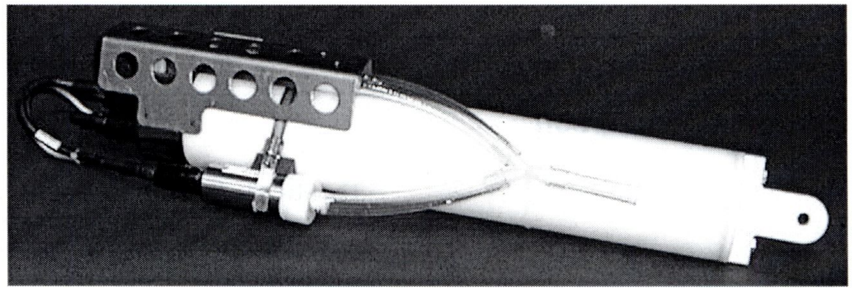
Follow these steps to get a Quick Start using the SBE 19*plus*.
The manual provides step-by-step details for performing each task:

1. Install batteries and test power and communications (see *Section 3: Power and Communications Test*).

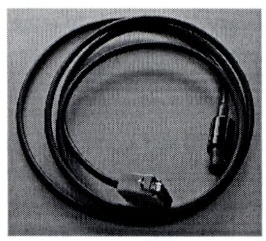
2. Deploy the SBE 19*plus* (see *Section 4: Deploying and Operating SBE 19plus*):
   A. Install new batteries if necessary.
   B. Ensure all data has been uploaded, and then send **INITLOGGING** to make entire memory available for recording if desired.
   C. Set date and time and establish setup and logging parameters.
   D. **Moored mode** - Set SBE 19*plus* to start logging now or in the future.
   E. Install dummy plugs and/or cable connectors, and locking sleeves.
   F. Remove Tygon tubing that was looped end-to-end around conductivity cell for storage. Reconnect tubing from pump to conductivity cell.
   G. **Profiling mode** - Put magnetic switch in On position, send commands to start logging now or in the future, or apply external power, as appropriate for your instrument's setup.
   H. Deploy SBE 19*plus*.

Unpacking SBE 19*plus*

Shown below is a typical SBE 19*plus* shipment.

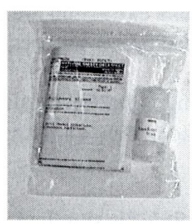


SBE 19*plus* SEACAT with SBE 5M pump



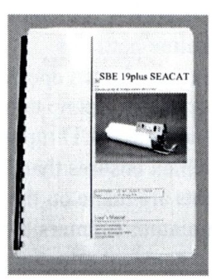
I/O Cable

Spare parts kit

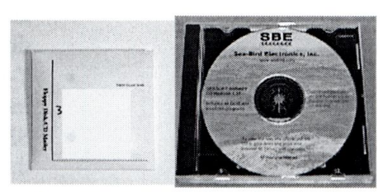


Cell cleaning solution
(Triton-X)

Cell filling and
storage kit



SBE 19*plus* Manual



Software, and Electronic Copies of
Software Manuals and User Manual

Section 2: Description of SBE 19*plus*

This section describes the functions and features of the SBE 19*plus* SEACAT Profiler, including specifications and dimensions.

System Description

The SBE 19*plus* SEACAT Profiler is designed to measure conductivity, temperature, and pressure in marine or fresh-water environments at depths up to 7000 meters (22,900 feet). The SBE 19*plus* operates in two modes:

- **Profiling mode** for acquiring vertical profiles of parameters. The SBE 19*plus* runs continuously, and samples at four scans per second (4 Hz). The SBE 19*plus* can be set to average up to 32,767 samples, storing and transmitting only the averaged data.
- **Moored mode** for acquiring time series measurements at sample rates of once every 10 seconds to once every 4 hours, adjustable in 1-second increments. Between samples, the SBE 19*plus* powers down, drawing only 30 microamps of current.

Self-powered and self-contained, the SBE 19*plus* features the proven Sea-Bird conductivity and temperature sensors and a precision, semiconductor, strain-gauge pressure sensor. Nine D-size alkaline batteries provide 60 hours operation in profiling mode; the 8 Mbyte FLASH RAM records 50 hours of conductivity, temperature, and pressure data while sampling at four scans per second (other configurations/setups vary). The SBE 19*plus*' three-wire RS-232C interface provides simultaneous, real-time monitoring. Setup, diagnostics, and data extraction are performed without opening the housing. The SBE 19*plus* can power and acquire the outputs of external sensors.

SBE 19*plus* logging is started by sliding the On/Off switch, by command via the RS-232 interface, or by applying external power, depending on your setup of the instrument.

A standard SBE 19*plus* is supplied with:

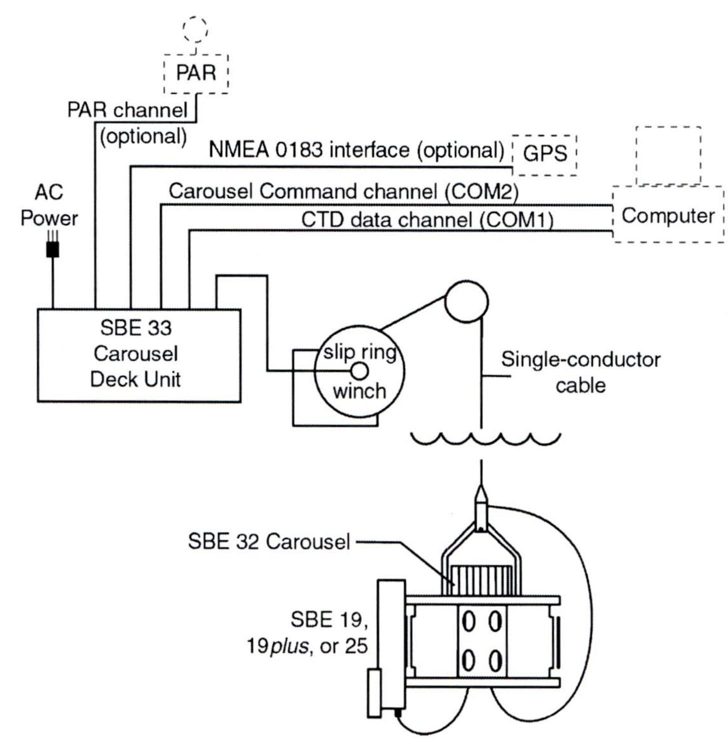
- Plastic housing for depths to 600 meters (1950 feet)
- Strain-gauge pressure sensor
- 8 Mbyte FLASH RAM memory
- 9 D-size alkaline batteries
- Impulse glass-reinforced epoxy bulkhead connectors: one 4-pin I/O connector; one 2-pin pump connector; and two 6-pin connectors (for two differential auxiliary A/D inputs each)
- T-C Duct, which ensures that Temperature and Conductivity measurements are made on the same parcel of water
- SBE 5M miniature submersible pump for pumped conductivity; by fixing the flow to a constant rate, the pump ensures a constant conductivity time response. *The duct and pump combination results in dramatically lower salinity spiking.*

SBE 19*plus* options / accessories include:

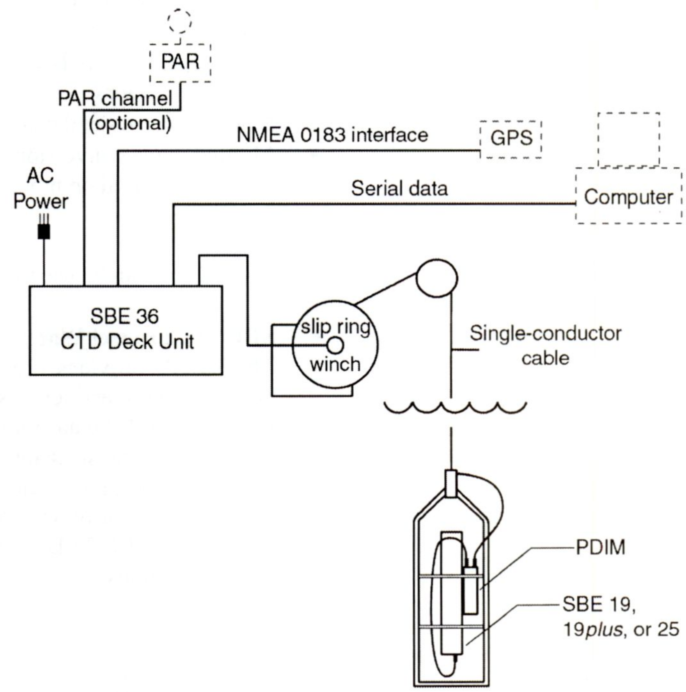
- Titanium housing for use to 7000 meters (22,900 feet)
- SBE 5T submersible pump for use with dissolved oxygen and/or other pumped sensors
- Sensors for dissolved oxygen, pH, fluorescence, light (PAR), light transmission, and turbidity
- Bulkhead connector for use with PAR sensor
- Stainless steel cage
- Wet-pluggable (MCBH) connectors in place of standard glass-reinforced epoxy connectors
- Ni-Cad batteries and charger
- Moored mode conversion kit with anti-foulant device fittings, for when SBE 19*plus* used on moorings

The SBE 19*plus* can be used with the following Sea-Bird equipment:

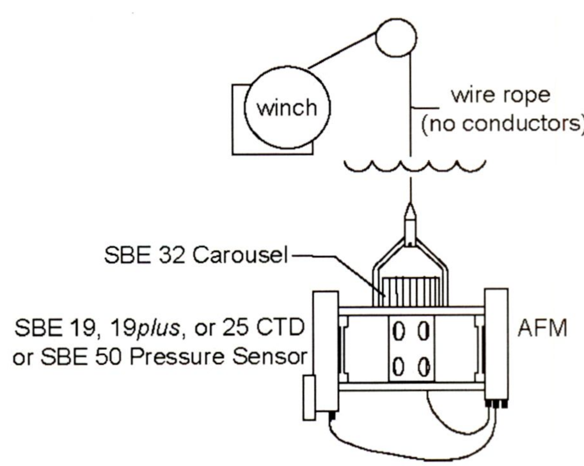
- **SBE 32 Carousel Water Sampler and SBE 33 Carousel Deck Unit** - The SBE 32 provides +15 VDC power to the SBE 19*plus* and has ample power for auxiliary sensors not normally supported by battery-powered CTDs. The CTD data from the SBE 19*plus* is converted into single-wire telemetry for transmission over long (10,000 meter [32,800 feet]) sea cables. Bottles may be closed at any depth without interrupting CTD data via software control using the SEASAVE program or from the front panel of the SBE 33 Deck Unit. See the SBE 33 manual for system operating details.



- **SBE 36 CTD Deck Unit and PN 90227 Power Data Interface Module (PDIM)** - These items provide power and real-time data handling capability over single-conductor sea cables using the same method employed in the SBE 32/SBE 33. The PDIM is a small pressure housing that is mounted on or near the SBE 19*plus*. It provides +15 VDC power to the SBE 19*plus* and interfaces two-way RS-232 communications from the SBE 19*plus* to the telemetry used on the sea cable. See the SBE 36/PDIM manual for system operating details.



- **SBE 32 Carousel Water Sampler and 90208 Auto Fire Module (AFM)** - The AFM, mounted on or near the SBE 19*plus*, allows the SBE 32 to operate autonomously on non-conducting cables. The AFM supplies the power, logic, and control commands to operate the SBE 32. The AFM monitors the pressure data recorded by the SBE 19*plus* in real-time, closing water sampler bottles at predefined pressures (depths) or whenever the system is stationary for a specified period of time. Bottle number, firing confirmation, and five scans of CTD data are recorded in the AFM memory for each bottle fired. See the AFM manual for system operating details.



User-selectable output format is raw data or engineering units, in either hexadecimal or decimal form. Additionally, the SBE 19*plus* can be *factory-configured* to emulate the older SEACAT data output format, **providing compatibility with existing customer SEACAT data processing software**.

Notes:
- Help files provide detailed information on the use of SEATERM, SeatermAF, SEASAVE, and SBE Data Processing.
- Separate software manuals on CD-ROM contain detailed information on the setup and use of SEASAVE and SBE Data Processing.
- **Sea-Bird also supplies a DOS software package, SEASOFT-DOS. However, SEASOFT-DOS' data processing modules cannot process SBE 19*plus* data because of data output format incompatibility.**

The SBE 19*plus* is supplied with a powerful Win 95/98/NT/2000/XP software package, SEASOFT-Win32, which includes:

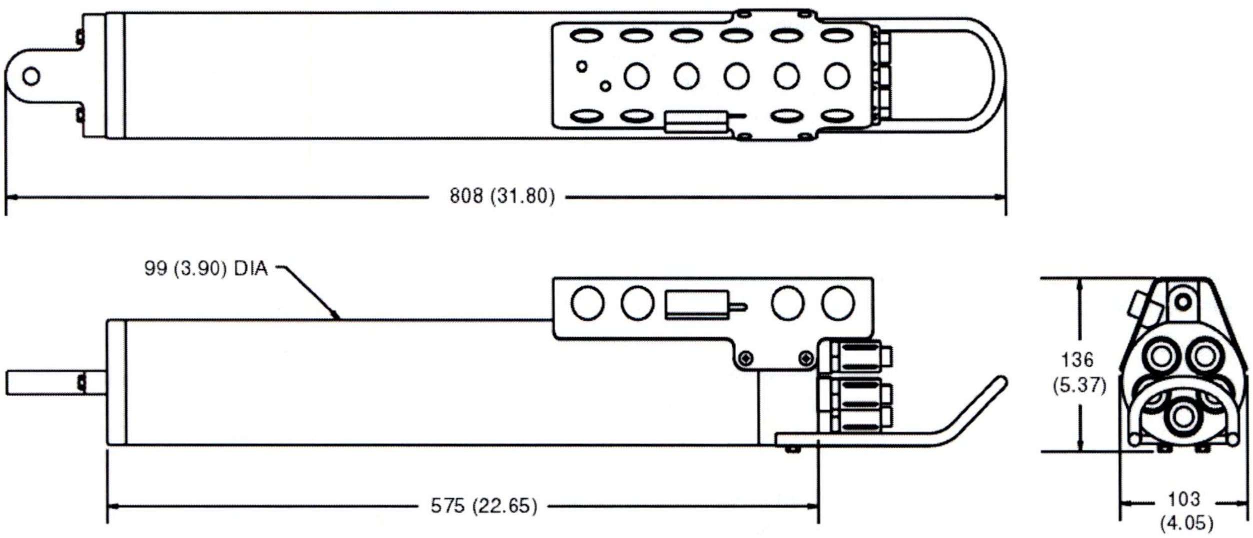
- **SEATERM** – terminal program for easy communication and data retrieval.
- **SeatermAF** – terminal program for easy communication and data retrieval *when the SBE 19plus is used with the Auto Fire Module and SBE 32 Carousel Water Sampler.*
- **SEASAVE** – program for acquiring, converting, and displaying real-time or archived raw data.
- **SBE Data Processing** - program for calculation and plotting of conductivity, temperature, pressure, auxiliary sensor data, and derived variables such as salinity and sound velocity.

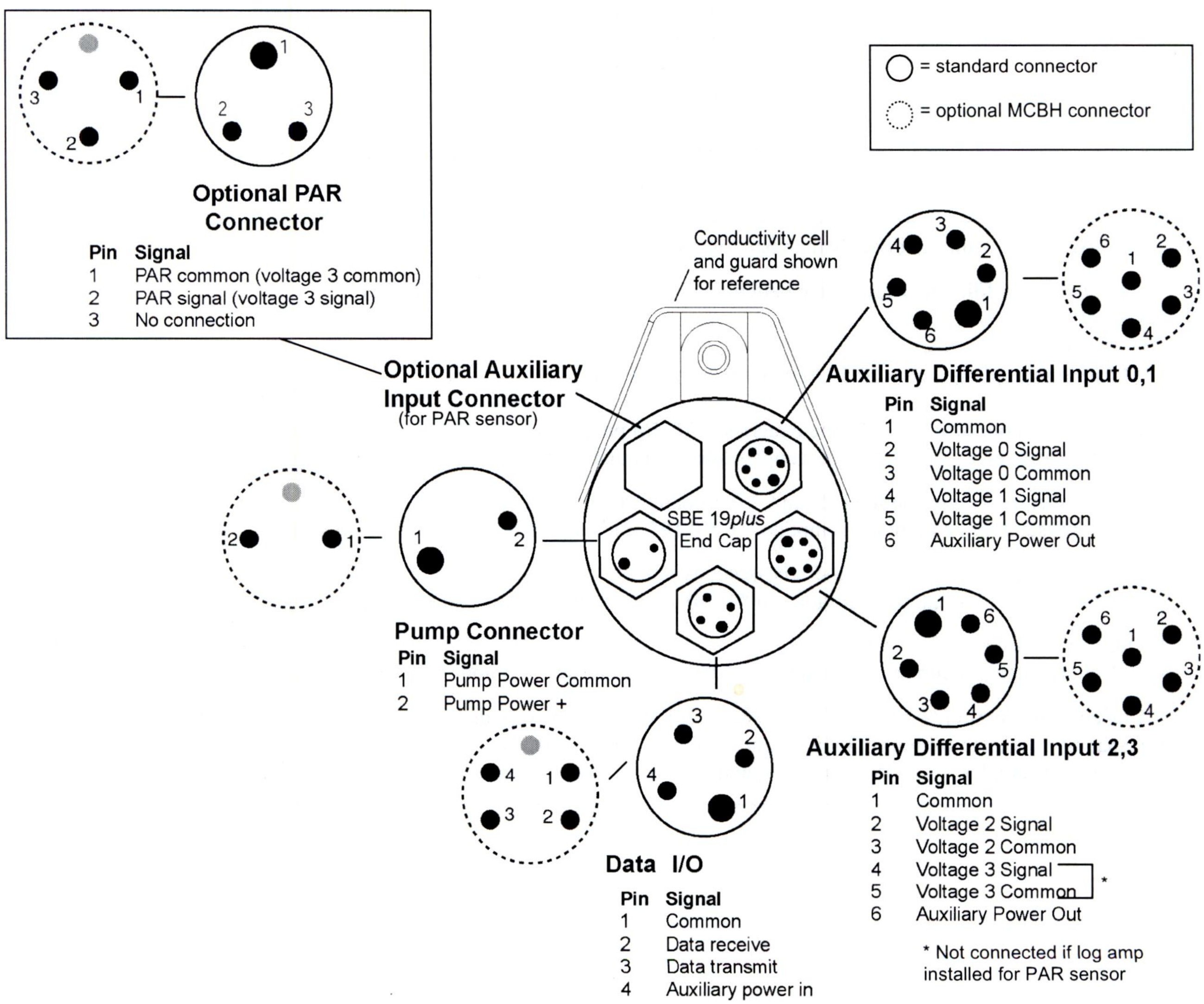
Specifications

	Temperature (°C)	Conductivity (S/m)	Strain Gauge Pressure
Measurement Range	-5 to +35	0 to 9	0 to full scale range: 20 / 100 / 350 / 1000 / 2000 / 3500 / 7000 meters
Initial Accuracy	0.005	0.0005	0.1% of full scale range
Typical Stability (per month)	0.0002	0.0003	0.004% of full scale range
Resolution	0.0001	0.00005 (most oceanic waters; resolves 0.4 ppm in salinity) 0.00007 (high salinity waters; resolves 0.4 ppm in salinity) 0.00001 (fresh waters; resolves 0.1 ppm in salinity)	0.002% of full scale range
Sensor Calibration (measurement outside these ranges may be at slightly reduced accuracy due to extrapolation errors)	+1 to +32	0 to 9; physical calibration over range 1.4 to 6 S/m, plus zero conductivity (air)	Ambient pressure to full scale range in 5 steps
Memory	8 Mbyte non-volatile FLASH memory		
Data Storage	<u>**Recorded Parameter**</u> — <u>**Bytes/sample**</u> temperature + conductivity — 6 (3 each) strain-gauge pressure — 5 each external voltage — 2 date and time (Moored mode only) — 4		
Real-Time Clock	32,768 Hz TCXO accurate to ±1 minute/year		
Internal Batteries	Nine alkaline D-cells - 60 hours continuous CTD operation (profiling mode, with no auxiliary sensors). Optional Ni-Cad battery pack - 24 hours continuous CTD operation / charge (profiling mode, with no auxiliary sensors).		
External Power Supply	9 - 28 VDC		
Power Requirements	*Sampling:* 65 mA *SBE 5M pump:* 95 mA (continuous duty, profiling mode); 0.148 amp-seconds per 0.5 second pulse (pulsed duty, moored mode) *Quiescent:* 30 µA Actual sampling (non-quiescent) time in Moored mode is 3.0 seconds/sample (if configured with no delays and 1 measurement per sample).		
Auxiliary Voltage Sensors	Auxiliary power out: up to 500 mA at 10.5 - 11 VDC A/D resolution: 14 bits Input range: 0 - 5 VDC		
Housing Materials	600 meter (1950 ft) - acetal copolymer (plastic) 7000 meter (22,900 ft) - 3AL-2.5V titanium		
Weight	With plastic housing: 7.3 kg (16 lbs) With titanium housing: 13.7 kg (30 lbs)		

Dimensions and End Cap Connectors

Dimensions in millimeters (inches)





Batteries and Auxiliary Power

A standard SBE 19*plus* uses nine D-cell alkaline batteries or rechargeable, nickel-cadmium batteries. If necessary, carbon-zinc or mercury cells can also be used. On-board lithium batteries (non-hazardous units which are unrestricted for shipping purposes) are provided to back-up the buffer and the real-time clock in the event of main battery failure or exhaustion. An auxiliary power source (9 - 28 volts DC) may be connected to the I/O bulkhead connector on the sensor end cap to permit testing and data retrieval without affecting battery capacity. The main batteries can be replaced without affecting either the real-time clock or memory.

Power Endurance

The standard alkaline battery pack has a nominal capacity of 14 amp-hours. For planning purposes, Sea-Bird recommends using a conservative value of 10.5 amp-hours.

Current consumption is as follows:

- Sampling (acquisition) current is 65 mA.
  For moored mode, sampling time is 3 seconds per sample.
- SBE 5M pump current is 95 mA (continuous duty).
  For moored mode, SBE 5M pump current is 0.148 amp-seconds/sample for a 0.5-second pulse.
- Quiescent current is 30 μA.

So, battery endurance is highly dependent on the user-programmed sampling scheme. Examples are shown below for two sampling schemes.

An SBE 19*plus* with standard alkaline batteries is set up to sample.

Example 1: **profiling** mode, alkaline batteries, SBE 5M pump, no auxiliary sensors
Operating current = 65 mA
Pump current = 95 mA
Maximum sampling time ≈ 10.5 / (0.065 + 0.095) ≈ 65 hours

Example 2: **moored** mode, alkaline batteries, SBE 5M pump, no auxiliary sensors. Assume CTD is set up to sample autonomously every 10 minutes (6 samples/hour), and that pump comes on for 0.5 seconds for each sample.

Sampling current consumption = 65 mA * 3 seconds = 0.195 amp-seconds
In 1 hour, sampling current consumption = 6 * 0.195 amp-seconds/sample = 1.17 amp-seconds/hour

Pump current consumption = 0.148 amp-seconds/sample
In 1 hour, pump current consumption = 6 * 0.148 amp-seconds/sample = 0.888 amp-seconds/hour

Quiescent current = 30 μA = 0.03 mA
In 1 hour, quiescent current consumption = 0.03 mA * 3600 seconds/hour = 0.108 amp-seconds/hour

Current consumption / hour = 1.17 + 0.888 + 0.108 = 2.17 amp-seconds/hour
Capacity = (10.5 amp-hours * 3600 seconds/hr) / (2.17 amp-seconds/hour) = 17,419 hours = 726 days = 2 years
Number of samples = 17,419 hours * 6 samples/hour = 104,000 samples

Data Storage

The SBE 19*plus* has an 8 Mbyte memory. Shown below are calculations of available data storage for several configurations. (See *Specifications* above for storage space required for each parameter.)

Example 1: Profiling mode, no auxiliary sensors
T & C = 6 bytes/sample Strain-gauge P = 5 bytes/sample
Storage space ≈ 8,000,000 / (6 + 5) ≈ 727,000 samples

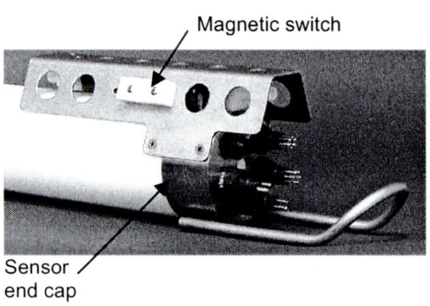
Example 2: Profiling mode, 4 external voltages
T & C = 6 bytes/sample Strain-gauge P = 5 bytes/sample
External voltages = 2 bytes/sample x 4 voltages = 8 bytes/sample
Storage space ≈ 8,000,000 / (6 + 5 + 8) ≈ 421,000 samples

Example 3: Moored mode (causes SBE 19*plus* to store date and time), 4 external voltages
T & C = 6 bytes/sample Strain-gauge P = 5 bytes/sample
External voltages = 2 bytes/sample x 4 voltages = 8 bytes/sample Date/Time = 4 bytes/sample
Storage space ≈ 8,000,000 / (6 + 5 + 8 + 4) ≈ 347,000 samples

Data I/O

The SBE 19*plus* receives setup instructions and outputs diagnostic information or previously recorded data via a three-wire RS-232C link, and is factory-configured for 9600 baud, 8 data bits, 1 stop bit, and no parity. SBE 19*plus* RS-232 levels are directly compatible with standard serial interface cards (IBM Asynchronous Communications Adapter or equal). The communications baud rate can be changed using the **BAUD=** command (see *Command Descriptions* in *Section 4: Deploying and Operating SBE 19plus*).

Magnetic Reed Switch



Notes:
- See *Command Descriptions* in *Section 4: Deploying and Operating SBE 19plus.*
- **Leave the switch in the Off position** if **IGNORESWITCH=Y** or **AUTORUN=Y**, or in Moored mode. If the switch is On, the SBE 19*plus* draws an additional 15 μA from the battery while in quiescent state.

Profiling Mode

A magnetic switch, mounted on the conductivity cell guard, can be used to start and stop logging in Profiling mode. Sliding the switch to the On position wakes up the SBE 19*plus* and starts logging. Sliding the switch to the Off position stops logging. The switch should be Off (towards the sensor end cap) when the SBE 19*plus* is not logging data; i.e., during setup, diagnostics, and data extraction.

The SBE 19*plus* can be set up to ignore the switch position:
- If **IGNORESWITCH=Y**: logging is started and stopped with commands sent through the terminal program. The switch position has no effect on logging.
- If **AUTORUN=Y**: logging is started and stopped when external power is applied and removed. The switch position has no effect on logging.

Moored Mode

In moored mode, the magnetic switch position has no effect on logging. Logging is started and stopped with commands sent through the terminal program.

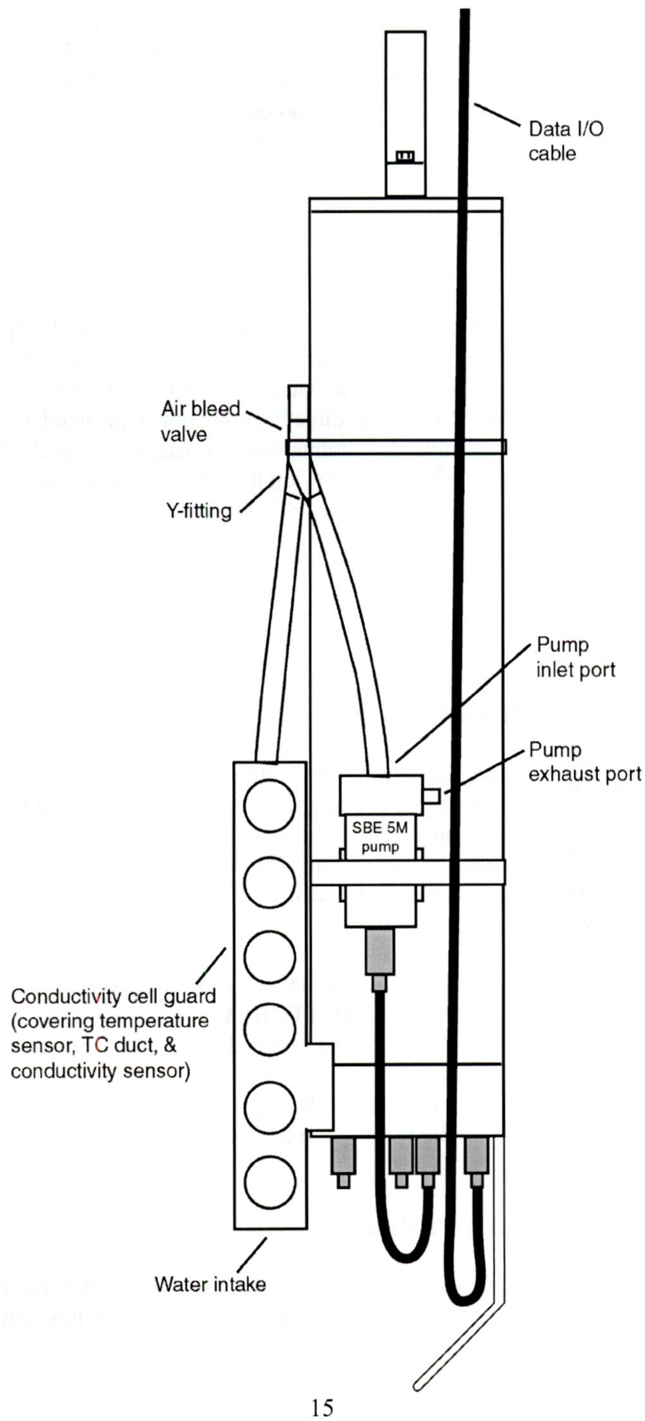
Configuration Options and Plumbing

> **Note:**
> See *Section 4: Deploying and Operating SBE 19plus* for pump setup and operation.

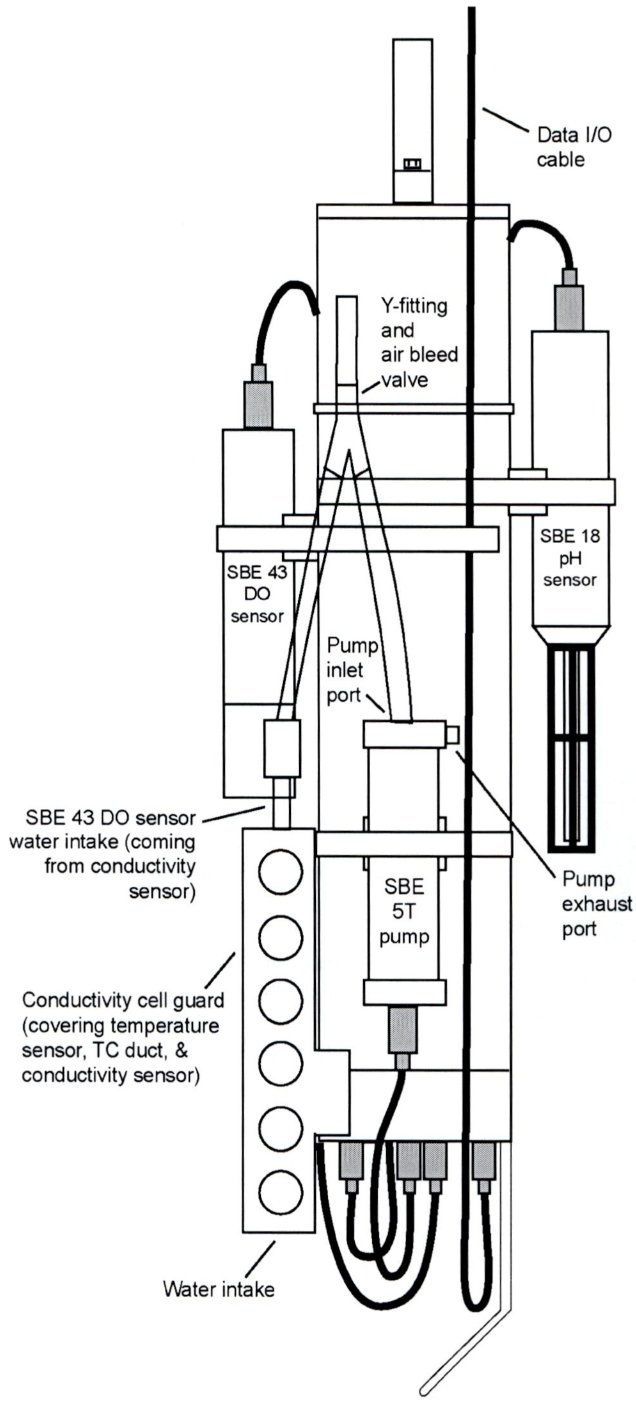
The standard SBE 19*plus* includes an externally mounted SBE 5M pump, which provides a constant flow rate through the conductivity cell regardless of descent rate. If configured with a dissolved oxygen sensor or pumped fluorometer, the more powerful SBE 5T pump is used. Either pump is powered via a cable connected to the 2-pin pump bulkhead connector on the sensor end cap.

The SBE 19*plus* can be configured with a wide range of auxiliary sensors. Two standard 6-pin bulkhead connectors on the sensor end cap serve as the input ports for the auxiliary sensor signal voltages and provide power to the sensors. An optional connector can also be provided for interfacing with a PAR sensor.

Shown below is the plumbing arrangement of an SBE 19*plus* equipped with the standard SBE 5M pump.



Shown below is the SBE 19*plus* configured with the optional SBE 5T pump, SBE 43 dissolved oxygen (DO) sensor, and SBE 18 pH sensor. Note that the SBE 43 is plumbed into the system between the conductivity cell outlet and the Y-fitting. The SBE 18 is not connected to the plumbing.



Section 3:
Power and Communications Test

This section describes software installation and the pre-check procedure for preparing the SBE 19*plus* for deployment. The power and communications test will verify that the system works, prior to deployment.

Software Installation

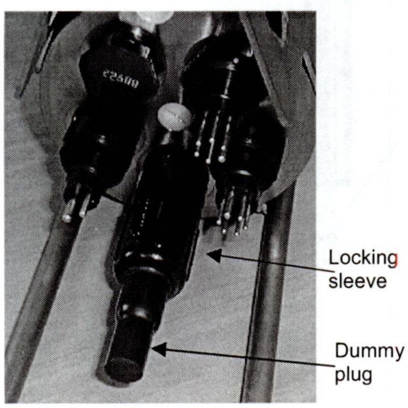
Note:
It is possible to use the SBE 19*plus* without SEATERM by sending direct commands from a dumb terminal or terminal emulator, such as Windows HyperTerminal.

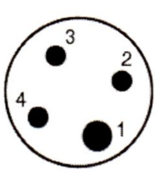
If not already installed, install SEATERM and other Sea-Bird software programs on your computer using the supplied software CD:

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

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

Test Setup





Data I/O Connector (standard)

Pin	Signal
1	Common
2	Data receive
3	Data transmit
4	Auxiliary power in

1. Remove the dummy plug and install the I/O cable:

   A. By hand, unscrew the locking sleeve from the SBE 19*plus*' I/O (4-pin) connector. If you must use a wrench or pliers, be careful not to loosen the I/O connector instead of the locking sleeve.

   B. Remove the dummy plug from the SBE 19*plus*' I/O connector by pulling the plug firmly away from the connector.

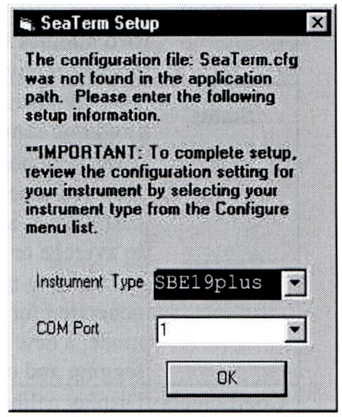
   C. **Standard Connector** - Install the I/O cable connector, aligning the raised bump on the side of the connector with the large pin (pin 1 - ground) on the SBE 19*plus*. **OR**
   MCBH Connector - Install the I/O cable connector, aligning the pins.

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

Test

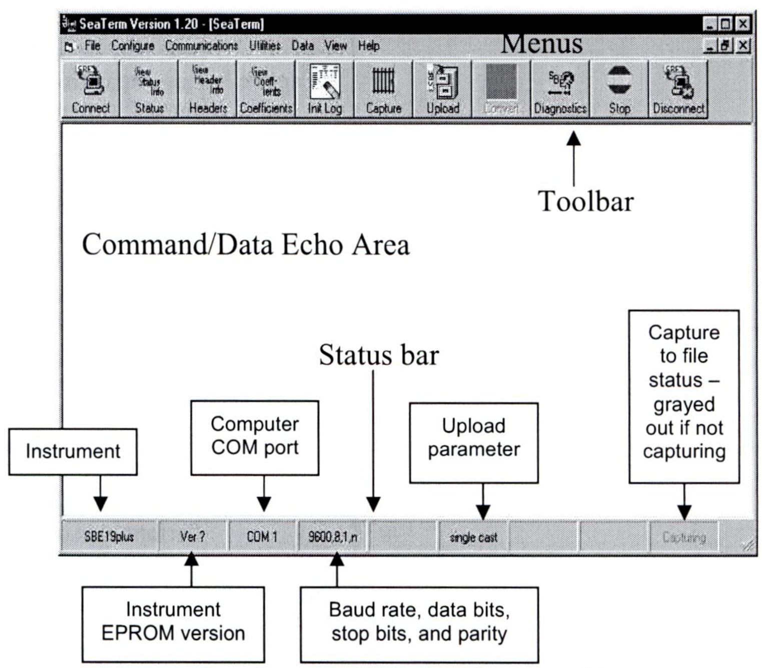
> **Note:**
> See SEATERM's help files for detailed information on the use of the program.

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



   Select the instrument type (*SBE 19plus*) and the computer COM port for communication with the SBE 19*plus*. Click OK.

2. The main screen looks like this:



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

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

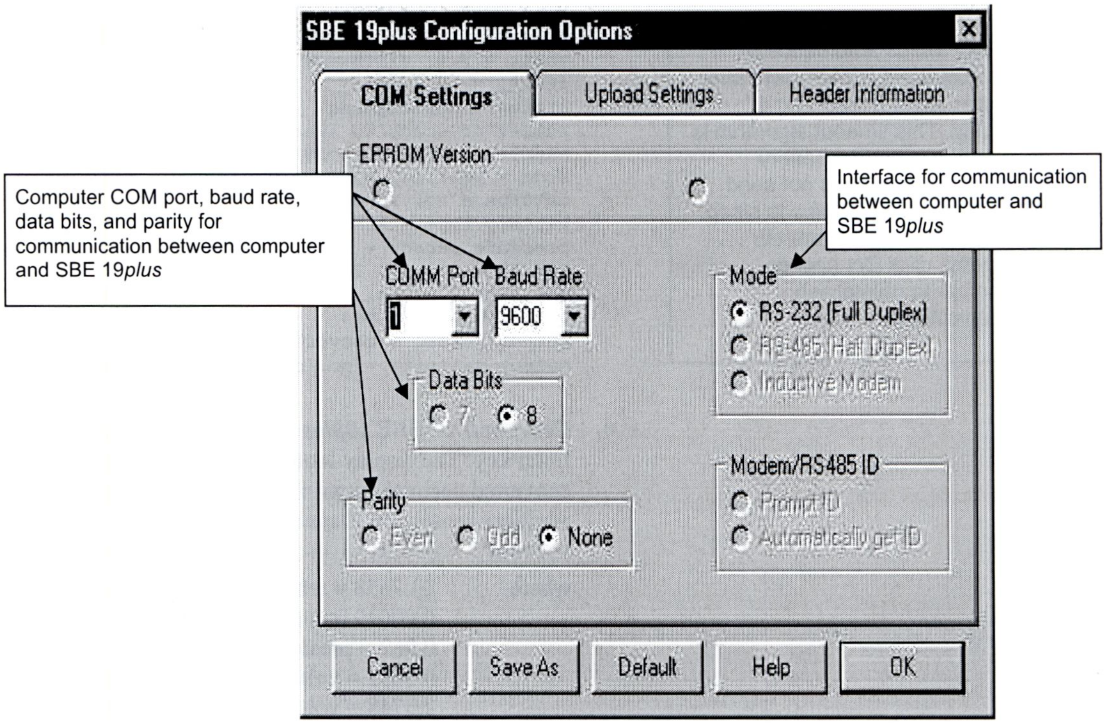
> **Note:**
> Once the system is configured and connected (Steps 3 and 4 below), to update the Status bar:
> - on the Toolbar, click Status; or
> - from the Utilities menu, select Instrument Status.
>
> SEATERM sends the status command, which displays in the Command/Data Echo Area, and updates the Status bar.

Following are the Toolbar buttons applicable to the SBE 19*plus*:

Toolbar Buttons	Description	Equivalent Command*
Connect	Re-establish communications with SBE 19*plus*. Computer responds with S> prompt. SBE 19*plus goes to sleep* after two minutes without communication from computer have elapsed.	(press Enter key)
Status	Display instrument setup and status (logging, samples in memory, etc.).	**DS**
Headers	View data headers (cast/header number, date and time, first and last sample in cast/header, and number of measurements to average or interval between samples). In Profiling mode, a new header is generated for each CTD cast. In Moored mode, a new header is generated at start of logging and every subsequent 1000 scans.	**DH**
Coefficients	Display calibration coefficients.	**DCAL**
Init Log	Reset data pointers and cast numbers. This should be performed **after existing data has been uploaded from SBE 19*plus*** and prior to recording new data.	**INITLOGGING**
Capture	Capture instrument responses on screen to file; may be useful for diagnostics. File has .cap extension. Press Capture again to turn off capture. Capture status displays in Status bar.	—
Upload	Upload data stored in memory, in format Sea-Bird's data processing software can use (raw Hex). Uploaded data has .hex extension. Before using Upload: • Configure upload and header parameters in Configure menu • **Stop logging** (Profiling mode - slide switch off, use **STOP** button, or send **STOP** command; Moored mode - use **STOP** button or send **STOP** command)	**DD** (use Upload button if you will be processing data with SBE Data Processing)
Diagnostics	Perform one or more diagnostic tests on SBE 19*plus*. Diagnostic test(s) accessed in this manner are non-destructive – they do not write over any existing instrument settings.	**DS, DCAL, TS, and TSR**
Stop	Interrupt and end current activity, such as logging, uploading, or diagnostic test.	(press Esc key or Ctrl C)
Disconnect	Free computer COM port used to communicate with SBE 19*plus*. COM port can then be used by another program.	—

*See *Command Descriptions* in *Section 4: Deploying and Operating SBE 19plus*.

3. In the Configure menu, select *SBE 19plus*. The dialog box looks like this:



Make the selections in the Configuration Options dialog box:

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

Click OK to overwrite an existing COM/Upload/Header Settings file, or click Save As to save the settings as a new filename.

4. Click the Connect button on the Toolbar. The display looks like this:

```
S>
```

This shows that correct communications between the computer and the SBE 19*plus* has been established.

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

- Click the Connect button again.
- Verify the correct instrument was selected in the Configure menu and the settings were entered correctly in the Configuration Options dialog box. Note that the baud rate is documented on the Configuration Sheet.
- Check cabling between the computer and SBE 19*plus*.

Note:
The SBE 19*plus* automatically enters quiescent (sleep) state after 2 minutes without receiving a command. This timeout algorithm is designed to conserve battery energy if the user does not send **QS** to put the SBE 19*plus* to sleep. If the system does not appear to respond, click Connect on the Toolbar to reestablish communications.

5. Display SBE 19*plus* status information by clicking the Status button on the Toolbar. The display looks like this:

```
SeacatPlus V 1.4D  SERIAL NO. 4000    12 Jun 2003  14:02:13
vbatt = 9.6, vlith = 8.6, ioper = 61.2 ma, ipump = 25.5 ma,
iext01 = 76.2 ma
status = not logging
number of scans to average = 1
samples = 0, free = 381300, casts = 0
mode = profile, minimum cond freq = 3000, pump delay = 60 sec
autorun = no, ignore magnetic switch = no
battery type = ALKALINE, battery cutoff = 7.5 volts
pressure sensor = strain gauge, range = 1000.0
SBE 38 = no, Gas Tension Device = no
Ext Volt 0 = yes, Ext Volt 1 = yes, Ext Volt 2 = no, Ext Volt 3 = no
echo commands = yes
output format = converted decimal
output salinity = no, output sound velocity = no
```

6. Command the SBE 19*plus* to take a sample by typing **TS** and pressing the Enter key. The display looks like this (if in Profiling mode, with converted decimal output format, no output salinity or sound velocity, and auxiliary sensors on channels 0 and 1):

```
23.7658, 0.00019, 0.062, 0.5632, 2.3748
```

where 23.7658 = temperature in degrees Celsius
0.00019 = conductivity in S/m
0.062 = pressure in dbars
0.5632 = voltage for auxiliary sensor channel 0
2.3748 = voltage for auxiliary sensor channel 1

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

7. Command the SBE 19*plus* to go to sleep (quiescent state) by typing **QS** and pressing the Enter key.

The SBE 19*plus* is ready for programming and deployment.

Section 4: Deploying and Operating SBE 19*plus*

Note:
Separate software manuals on CD-ROM and Help files contain detailed information on installation, setup, and use of Sea-Bird's real-time data acquisition software and data processing software.

This section includes discussions of:

- Sampling modes (Profiling and Moored), including example sets of commands
- Pump operation
- Real-time setup
- Timeout description
- Command descriptions
- Data output formats
- Optimizing data quality for Profiling applications
- Installing anti-foul fittings for Moored applications
- Deployment
- Acquiring real-time data
- Recovery - physical handling and uploading data
- Processing data

Sampling Modes

The SBE 19*plus* has two sampling modes for obtaining data:

- Profiling mode
- Moored mode

Descriptions and examples of the sampling modes follow. Note that the SBE 19*plus'* response to each command is not shown in the examples. Review the operation of the sampling modes and the commands described in *Command Descriptions* before setting up your system.

Profiling Mode

The SBE 19*plus* samples data at 4 Hz (one sample every 0.25 seconds), averages the data at pre-programmed intervals, stores the averaged data in its FLASH memory, and transmits the averaged data real-time. The SBE 19*plus* provides several methods for starting and stopping logging, depending on the settings for **IGNORESWITCH=** and **AUTORUN=** :

IGNORESWITCH=	AUTORUN=	To Start Logging:	To Stop Logging:
N	N	Slide magnetic switch on.	Slide magnetic switch off, send **STOP**, or click Stop on SEATERM's Toolbar.
Y	N	Send **STARTNOW**, or **STARTMMDDYY=**, **STARTHHMMSS=**, and **STARTLATER**.	Send **STOP** or click Stop on SEATERM's Toolbar.
Y or N	Y	Turn on external power.	• Turn off external power, or • (if you want to send commands to check or modify setup) Send **STOP**, click Stop on SEATERM's Toolbar, or type Ctrl Z.

Note:
Sea-Bird ships the SBE 19*plus* with **AUTORUN=N** (it will not automatically start sampling when external power is applied). If you send **AUTORUN=Y**:
- Send **QS** to put SBE 19*plus* in quiescent (sleep) state, and then turn power off and then on again to start sampling. **or**
- Send **STARTNOW**.

Example: SBE 19*plus* in **Profiling** mode

Wake up 19*plus*. Initialize logging to overwrite previous data in memory. Set up with strain-gauge pressure sensor and 1 voltage sensor, average every 4 samples, and output data in raw hex format. Set up with a 60-second pump turn-on delay after pump enters water, to ensure pump is primed before turning on. Set up to initiate logging with the magnetic switch. After all parameters are entered, verify setup with status command. Send power-off command.

(click Connect on Toolbar to wake up)
S>INITLOGGING
S>PTYPE=1
S>VOLT0=Y
S>NAVG=4
S>OUTPUTFORMAT=0
S>PUMPDELAY=60
S>IGNORESWITCH=N
S>DS (to verify setup)
S>QS

Start logging by putting magnetic switch in On position. Put 19*plus* in water, and allow to soak for at least time required for pump turn-on (**PUMPDELAY=60**) before beginning downcast. If desired, use SEASAVE to view real-time data. When cast is complete, stop logging by putting magnetic switch in Off position.

Upload data in memory, in format SBE Data Processing can use. Send power-off command.

(click Connect on Toolbar to wake up)
(click Upload on Toolbar – program leads you through screens to define data to be uploaded and where to store it)
S>QS

Notes:
- The SBE 19*plus* automatically enters quiescent state after 2 minutes without receiving a command.
- Set **OUTPUTFORMAT=0** if you will be using Sea-Bird's real-time data acquisition software (SEASAVE) or data processing software (SBE Data Processing).

Moored Mode

At pre-programmed intervals, the SBE 19*plus* wakes up, samples data, stores the data in its FLASH memory, and enters quiescent (sleep) state. The SBE 19*plus* goes to sleep for a minimum of 3 seconds between each sample. Logging is started with **STARTNOW** or **STARTLATER**, and is stopped with **STOP**. If real-time data is to be transmitted (**MOOREDTXREALTIME=Y**), data is transmitted after measurements are complete for that sample and before sampling begins for the next sample.

Notes:

- The SBE 19*plus* automatically enters quiescent state after 2 minutes without receiving a command.
- Set **OUTPUTFORMAT=0** if you will be using Sea-Bird's real-time data acquisition software (SEASAVE).

Example: SBE 19*plus* in **Moored** mode

Wake up 19*plus*. Initialize logging to overwrite previous data in memory. Set up with strain-gauge pressure sensor and 1 voltage sensor, take a sample every 120 seconds, take and average 4 measurements for each sample, do not transmit real-time data, and output data in raw hex format. Set up pump to run for 0.5 seconds before each sample. Set up to start logging on April 15, 2001 at 11 am. Send command to start logging at designated date and time. After all parameters are entered, verify setup with status command. Send power-off command.

(click Connect on Toolbar to wake up)
S>INITLOGGING
S>PTYPE=1
S>VOLT0=Y
S>SAMPLEINTERVAL=120
S>NCYCLES=4
S>MOOREDTXREALTIME=N
S>OUTPUTFORMAT=0
S>MOOREDPUMPMODE=1
S>STARTMMDDYY=041501
S>STARTHHMMSS=110000
S>STARTLATER
S>DS (to verify setup)
S>QS

Deploy 19*plus*. Logging starts automatically at designated date and time.

Upon recovering 19*plus*, stop logging. Upload data in memory, in format SBE Data Processing can use. Send power-off command.

(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

Pump Operation

Profiling Mode

After the conductivity cell enters the water, there is a user-programmable delay before pump turn-on so that all the air in the pump tubing can escape. If the pump motor turns on when there is air in the impeller housing, priming is uncertain and a proper flow rate cannot be ensured. The tubing extending above the air-bleed hole will contain a small reserve of water. This maintains the pump prime (for up to one minute, depending on the length of tubing above the air-bleed), even if the SBE 19*plus* is lifted up so that the cell inlet and pump outlet are **just below** the water surface. This allows beginning the actual profile very near the top of the water. **The cell inlet and pump outlet must not come above the water surface or the prime will be lost.**

- If prime is lost: Stop logging. Wait at least 5 seconds, then start logging, submerge the SBE 19*plus* completely, and wait for the pump delay time before beginning the profile. (Start and stop logging with the magnetic switch, commands, or external power, depending on your setup.)

Pump turn-on occurs when two user-programmable conditions have been met:

- **Raw conductivity frequency exceeds the minimum conductivity frequency (MINCONDFREQ=)**
  Set the minimum conductivity frequency for pump turn-on above the instrument's *zero conductivity raw frequency* (shown on the SBE 19*plus* Configuration Sheet), to prevent the pump from turning on when the SBE 19*plus* is in air.
  - For salt water and estuarine applications:
    typical value = *zero conductivity raw frequency* + 500 Hz
  - For fresh/nearly fresh water:
    typical value = *zero conductivity raw frequency* + 5 Hz

  If the minimum conductivity frequency is too close to the *zero conductivity raw frequency*, the pump may turn on when the SBE 19*plus* is in air, as a result of small drifts in the electronics. Some experimentation may be required, and in some cases it may be necessary to rely only on the pump turn-on delay time to control the pump. If so, set a minimum conductivity frequency lower than the *zero conductivity raw frequency*.

- **Pump turn-on delay time has elapsed (PUMPDELAY=)**
  Set the pump turn-on delay time to allow time for the Tygon tubing and pump to fill with water after the SBE 19*plus* is submerged. Determine the turn-on delay by immersing the SBE 19*plus* (switch off, not running) just below the air-bleed hole at the top of the Tygon tubing. Measure the time needed to completely fill the tubing (30 seconds is typical) and set the delay to approximately 1.5 times longer. When actually using the SBE 19*plus*, be sure to *soak* the instrument just under the surface for at least the time required for pump turn-on.

Pump turn-off occurs when the conductivity frequency drops below **MINCONDFREQ**.

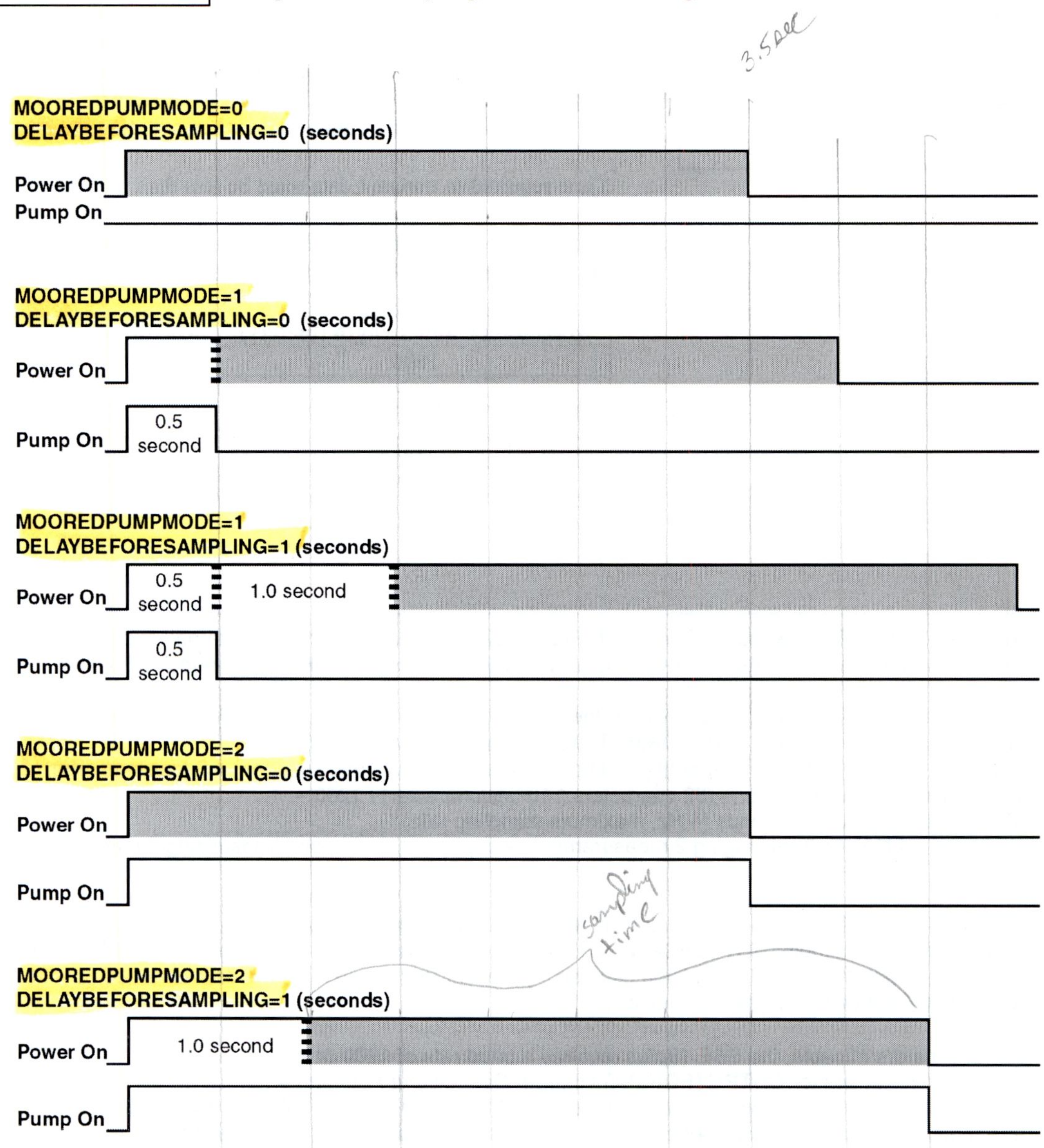
Moored Mode

> **Note:**
> When using an oxygen sensor with the SBE 19*plus*, set **MOOREDPUMPMODE=2** and set **DELAYBEFORESAMPLING** as follows:
> - **SBE 43** oxygen sensor - 15 seconds, to get fresh water into the plenum for the sample
> - **Beckman- or YSI-type** oxygen sensor - 120 to 180 seconds, to allow instrument to polarize

Pump operation is governed by two user-programmable parameters:

- **MOOREDPUMPMODE=0**, **1**, or **2**
  The SBE 19*plus* can be set up to operate with no pump (0), with a pump running for 0.5 second before each sample (1), or the pump running during each sample (2).
- **DELAYBEFORESAMPLING=**
  The SBE 19*plus* can be set up to delay sampling after turning on external voltage sensors. Some instruments, such as a Sea Tech fluorometer or a Beckman- or YSI-type oxygen sensor, require time to stabilize after power is applied, to provide good quality data.

MOOREDPUMPMODE and **DELAYBEFORESAMPLING** interact in the operation of the pump, as shown in the diagram below.



Note: ▒ **= sampling time (2.7 - 3.0 seconds)**
Sampling time includes time for the instrument to warm up as well as time to actually measure the parameters. The 2.7-3.0 second sampling time is for 1 measurement / sample (**NCYCLES=1**). Each additional measurement / sample requires an additional 0.25 seconds.

Real-Time Setup

Notes:
- Baud rate is set with **BAUD=**.
- Data storage and real-time output rate is set with **NAVG=** (for Profiling Mode) or **SAMPLEINTERVAL=** (for Moored Mode).
- Inclusion of auxiliary sensors in the data stream is set with the **VOLTn=** commands.
- Output format is set with **OUTPUTFORMAT=**.
- Real-time data is automatically output in Profiling Mode. In Moored Mode, set **MOOREDTXREALTIME=Y** to output real-time data.

See *Command Descriptions* in this section.

Baud Rate and Cable Length

Without a Sea-Bird Deck Unit

The rate that real-time data can be transmitted from the SBE 19*plus* is dependent on the amount of data to be transmitted per scan and the serial data baud rate:

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

where

Number of characters is dependent on the included data and output format (see *Data Output Formats* in this section).
Add 2 to the number of characters shown in the output format, to account for the carriage return and line feed at the end of each scan.
For decimal output (**OUTPUTFORMAT=2** or **3**), include decimal points, commas, and spaces when counting the number of characters.

Time required to transmit data must be less than the real-time output rate.

The length of cable that the SBE 19*plus* can drive is also dependent on the baud rate. The allowable combinations are:

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

Example 1 - SBE 19*plus* without a Deck Unit. **Profiling** Mode, configured with 2 external voltages. What is the fastest rate you can transmit real-time data over 800 m with **OUTPUTFORMAT=0** (raw hexadecimal data)?

With 800 meters of cable and no Deck Unit, the SBE 19*plus* requires a baud rate of 1200 or less.
Number of characters for **OUTPUTFORMAT=0** (from *Data Output Formats*) =
6 (T) + 6 (C) + 6 (P) + 4 (P temperature compensation) + 2*4 (external voltages) + 2 (carriage return & line feed) = 32
Time required to transmit data = (32 characters * 10 bits/character) / 1200 =
0.267 seconds > 0.25 seconds (4 Hz, maximum sampling rate).
Therefore, set **NAVG=2**, averaging 2 measurements/sample and storing and transmitting 1 sample every 0.5 seconds.

Example 2 - SBE 19*plus* without a Deck Unit. **Moored** Mode, configured with 4 external voltages, 10 measurements/sample (**NCYCLES=10**), and a 15 second delay before sampling (**DELAYBEFORESAMPLING=15**). What is the smallest sample interval you can use if you want to transmit real-time data over 800 m with **OUTPUTFORMAT=0** (raw hexadecimal data)?

With 800 meters of cable, the SBE 19*plus* requires a baud rate of 1200 or less.
Number of characters for **OUTPUTFORMAT=0** (from *Data Output Formats*) =
6 (T) + 6 (C) + 6 (P) + 4 (P temperature compensation) + 4*4 (external voltages) + 8 (time) + 2 (carriage return & line feed) = 48
Time required to transmit data = (48 characters * 10 bits/character) / 1200 = 0.4 seconds
Minimum time required for each sample =
15 seconds (delay after turning on power) + 3 second warm-up & sampling time + [(10-1) * 0.25 seconds] +
0.4 seconds to transmit real-time + 3 seconds to go to sleep between samples = 23.65 seconds, round up to 24
Therefore, set **SAMPLEINTERVAL=24**, storing and transmitting one sample every 24 seconds.

With a Sea-Bird Deck Unit

Set the SBE 19*plus*' baud rate to 4800 if using the SBE 19*plus* with either of the following real-time data acquisition systems:

- SBE 36 CTD Deck Unit and Power and Data Interface Module (PDIM)
- SBE 33 Carousel Deck Unit and SBE 32 Carousel Water Sampler

The data telemetry link can drive 10,000 meters of cable while accepting 4800 baud serial data. The relationship between rate of transmission, amount of data to be transmitted, and baud rate is as described above for an SBE 19*plus* without a Deck Unit.

Example - SBE 19*plus* with an SBE 33 or 36 Deck Unit. **Profiling** Mode, configured with 2 external voltages. What is the fastest rate you can transmit data over 800 m with **OUTPUTFORMAT=0** (raw hexadecimal data)?

With a Deck Unit, the SBE 19*plus* requires a baud rate of 4800.
Number of characters (from *Data Output Formats*) =
6 (T) + 6 (C) + 6 (P) + 4 (P temperature compensation) + 2*4 (external voltages) + 2 (carriage return & line feed) = 32
Time required to transmit data = (32 characters * 10 bits/character) / 4800 =
0.067 seconds < 0.25 seconds (4 Hz, maximum sampling rate).
Therefore, set **NAVG=1**, providing 4 Hz data (one sample every 0.25 seconds) for this configuration.

Real-Time Data Acquisition

Real-time data can be acquired in either of the following ways:

- With SEASAVE (**typical method**) – Data can be viewed in SEASAVE in tabular form or as plots, as raw data or as converted (engineering units) data. Data acquired with SEASAVE can be processed with SBE Data Processing. See SEASAVE's Help files for details on setting up the program displays, baud rates, etc., and beginning data acquisition.
- With SEATERM – Click Capture on SEATERM's Toolbar. Begin logging. The data displayed in SEATERM will be saved to the designated file. Process the data as desired. Note that this file **cannot be processed by SEASAVE or SBE Data Processing, as it does not have the required headers and format for Sea-Bird's processing software**.

Timeout Description

The SBE 19*plus* has a timeout algorithm. If the SBE 19*plus* does not receive a command or sample data for 2 minutes, it powers down its main digital circuits. This places the SBE 19*plus* in quiescent state, drawing minimal current. **To re-establish control (wake up), press Connect on the Toolbar or the Enter key.** The system responds with the `S>` prompt.

Command Descriptions

Note:
Sea-Bird provides a custom EPROM to accommodate customers with an older SBE 19 (not *plus*) who need to replace the electronics but want to maintain the original instrument command set and output format. Instruments with this custom EPROM operate in Compatible State; see *Appendix IV: Compatible State*.

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 SBE 19*plus* in upper or lower case letters and register commands by pressing the Enter key.
- The SBE 19*plus* sends `?CMD` if an invalid command is entered.
- If the system does not return an `S>` prompt after executing a command, press the Enter key to get the `S>` prompt.
- If a new command is not received within 2 minutes after the completion of a command, the SBE 19*plus* returns to the quiescent (sleep) state.
- If in quiescent state, re-establish communications by pressing Connect on the Toolbar or the Enter key to get an `S>` prompt.
- If the SBE 19*plus* is transmitting data and you want to stop it, press the Esc key or Stop on the Toolbar (or type ^C). Press the Enter key to get the `S>` prompt.
- The SBE 19*plus* cannot have samples with different scan lengths (more or fewer data fields per sample) in memory. If the scan length is changed by commanding it to add or subtract a data field (such as an external voltage), the SBE 19*plus* must initialize logging. Initializing logging sets the sample number and cast number to 0, so the entire memory is available for recording data with the new scan length. **Initializing logging should only be performed after all previous data has been uploaded**. Therefore, commands that change the scan length (**MM**, **MP**, **PTYPE=**, **VOLT0=**, **VOLT1=**, **VOLT2=**, and **VOLT3=**) prompt the user for verification before executing, to prevent accidental overwriting of existing data.
- The SBE 19*plus* responds only to **DS**, **DCAL**, **TS**, **SL**, **SLT**, **QS**, and **STOP** while logging. If you wake the SBE 19*plus* while it is logging (for example, to send **DS** to check on logging progress), it temporarily stops logging. Logging resumes when it goes to sleep again (either by sending **QS** or after the 2-minute timeout).
- The SBE 19*plus* responds only to **DS**, **DCAL**, **TS**, **SL**, **SLT**, **QS**, and **STOP** while *waiting to start logging* (if you sent **STARTLATER** but logging has not started yet). To send any other commands, send **STOP**, send the desired commands to modify the setup, and then send **STARTLATER** again.

Entries made with the commands are permanently stored in the SBE 19*plus* and remain in effect until you change them.

- The only exception occurs if the electronics are removed from the housing and disconnected from the battery Molex connector (see *Appendix II: Electronics Disassembly/Reassembly*). Upon reassembly, reset the date and time (**MMDDYY=** and **HHMMSS=**) and initialize logging (**INITLOGGING**).

Status Command

Note:
If the battery voltage is below the battery cut-off voltage, the following displays in response to the status command: `WARNING: LOW BATTERY VOLTAGE!!`
Replace the batteries before continuing.

Notes:
- If the SBE 19*plus* is set up for alkaline **or** lithium batteries, the status command shows: `battery type = ALKALINE.`
- If your SBE 19*plus* includes a custom RS-232 connector for an SBE 38 or GTD, see *Addendum: Custom SBE 19plus SEACAT with Interface for RS-232 Sensor.*

DS Display operating status and setup parameters, which vary depending on whether in Profiling or Moored mode.

Equivalent to Status button on Toolbar.

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

Profiling Mode (MP)
- Firmware version, serial number, date and time [**MMDDYY=** and **HHMMSS=**]
- Voltages and currents (main and lithium battery voltages, operating and pump current, and external voltage currents)
- Logging status (not logging, logging, waiting to start at . . ., or unknown status)
- Number of scans to average [**NAVG=**]
- Number of samples, sample space, and number of casts in memory
- Profiling mode [**MP**], minimum conductivity frequency for pump turn-on [**MINCONDFREQ=**], and pump turn-on delay [**PUMPDELAY=**]
- Begin logging automatically when external power applied [**AUTORUN=**]? Ignore magnetic switch position for starting/stopping logging [**IGNORESWITCH=**]?
- Battery type [**BATTERYTYPE=**] and cut-off voltage
- Pressure sensor type [**PTYPE=**] and range [**PRANGE=**]
- Sample SBE 38 secondary temperature sensor? Sample Gas Tension Device? (custom applications)
- Sample external voltages 0, 1, 2, and 3? [**VOLT0=** through **VOLT3=**]
- Show entered commands on screen as you type [**ECHO=**]?
- Output format [**OUTPUTFORMAT=**]
- Output salinity [**OUTPUTSAL=**] and sound velocity [**OUTPUTSV=**] with each sample? (only if output format = converted decimal)
- Output sigma-t, voltage, and current [**OUTPUTUCSD=**] with each sample? (only if output format = converted decimal; only appears in response if set to Y)

Example: Profiling mode (user input shown in bold)

```
S>DS
SeacatPlus V 1.4D  SERIAL NO. 4000    12 Jun 2003  14:02:13
vbatt = 9.6, vlith 8.6, ioper = 61.2 ma, ipump = 25.5 ma, iext01 = 76.2 ma,
status = not logging
number of scans to average = 1
samples = 0, free = 381300, casts = 0
mode = profile, minimum cond freq = 3000, pump delay = 60 sec
autorun = no, ignore magnetic switch = no
battery type = ALKALINE, battery cutoff = 7.5 volts
pressure sensor = strain gauge, range = 1000.0
SBE 38 = no, Gas Tension Device = no
Ext Volt 0 = yes, Ext Volt 1 = yes, Ext Volt 2 = no, Ext Volt 3 = no
echo commands = yes
output format = converted decimal
output salinity = no, output sound velocity = no
```

Status Command (*continued*)

> **Note:**
> If your SBE 19*plus* includes a custom RS-232 connector for an SBE 38 or GTD, see *Addendum: Custom SBE 19plus SEACAT with Interface for RS-232 Sensor*.

Moored Mode (MM)

- Firmware version, serial number, date and time [**MMDDYY=** and **HHMMSS=**]
- Voltages and currents (main and lithium battery voltages, operating and pump current, and external voltage currents)
- Logging status (not logging, logging, waiting to start at . . ., or unknown status)
- Sample interval [**SAMPLEINTERVAL=**] and number of measurements to take and average per sample [**NCYCLES=**]
- Number of samples and available sample space in memory
- Moored mode [**MM**], pump turn-on parameter [**MOOREDPUMPMODE=**], and turn-on delay [**DELAYBEFORESAMPLING=**]
- Transmit data real-time? [**MOOREDTXREALTIME=**]
- Battery type [**BATTERYTYPE=**] and battery cut-off voltage
- Pressure sensor type [**PTYPE=**] and range [**PRANGE=**]
- Sample SBE 38 secondary temperature sensor? Sample Gas Tension Device? (applicable only for custom applications)
- Sample external voltages 0, 1, 2, and 3? [**VOLT0=** through **VOLT3=**]
- Show entered commands on screen as you type [**ECHO=**]?
- Output format [**OUTPUTFORMAT=**]
- Output salinity [**OUTPUTSAL=**] and sound velocity [**OUTPUTSV=**] with each sample? (only if output format = converted decimal)
- Output sigma-t, voltage, and current [**OUTPUTUCSD=**] with each sample? (only if output format = converted decimal; only appears in response if set to Y)

Example: Moored mode (user input shown in bold)

```
S>DS
SeacatPlus V 1.4D  SERIAL NO. 4000    12 Jun 2003  14:02:13
vbatt = 9.4, vlith = 8.6, ioper = 61.3 ma, ipump = 26.8 ma, iext01 = 76.2 ma,
status = not logging
sample interval = 15 seconds, number of measurements per sample = 1
samples = 0, free = 364722
mode = moored, run pump for 0.5 sec, delay before sampling = 0.0 seconds
transmit real-time = yes
battery type = ALKALINE, battery cutoff =  7.5 volts
pressure sensor = strain gauge, range = 2000.0
SBE 38 = no, Gas Tension Device = no
Ext Volt 0 = yes, Ext Volt 1 = yes, Ext Volt 2 = no, Ext Volt 3 = no
echo commands = yes
output format = converted decimal
output salinity = no, output sound velocity = no
```

General Setup Commands

Notes:
- **DDMMYY=** and **MMDDYY=** are equivalent. Either can be used to set the date.
- **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=**.

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, and second.

Example: Set current date and time to 05 October 2000 12:00:00 (user input shown in bold).

```
S>MMDDYY=100500
S>HHMMSS=120000
```

or

```
S>DDMMYY=051000
S>HHMMSS=120000
```

Note:
The SBE 19*plus'* baud rate (set with **BAUD=**) must be the same as SEATERM's baud rate (set in the Configure menu).

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

ECHO=x — x= Y: Echo characters received from computer (default) - computer monitor will show entered commands as you type.

x=N: Do not.

Note:
If the SBE 19*plus* is set up for alkaline or lithium batteries, the status command (**DS**) response shows:
`battery type = ALKALINE.`

BATTERYTYPE=x — x=0: Alkaline (or lithium) batteries. Logging stops when battery drops below 7.5 volts for 5 consecutive scans. This reduces battery load to quiescent current.

x=1: Ni-Cad batteries. Logging stops when battery drops below 7.5 volts for 5 consecutive scans or battery voltage is less than 10.2 volts and voltage drop is greater than 1 volt/minute as determined by two 30-second moving averages. This reduces battery load to quiescent current once first cell in battery pack is exhausted.

> **Notes:**
> - **INITLOGGING** and **SAMPLENUMBER=0** have identical effects. Use either to initialize logging.
> - Initializing logging sets sample, header, and cast number to 0 *internally*. However, for data output, the first sample, header, and cast number is 1.
> - **Do not initialize logging until all data has been uploaded.** These commands do not delete data; they reset the data pointer. **If you accidentally initialize logging before uploading**, recover data as follows:
>   1. Set **SAMPLENUMBER=a** and **HEADERNUMBER=b**, where **a** and **b** are your estimate of number of samples and casts in memory.
>   2. Upload data. If **a** is more than actual number of samples or **b** is more than actual number of casts in memory, data for non-existent samples/casts will be bad, random data. Review uploaded data file carefully and delete any bad data.
>   3. If desired, increase **a** and/or **b** and upload data again, to see if there is additional valid data in memory.

General Setup Commands (*continued*)

INITLOGGING

Initialize logging - after all previous data has been uploaded from 19*plus*, initialize logging before starting to log again to make entire memory available for recording. **INITLOGGING** sets sample number (**SAMPLENUMBER=**) and header and cast number (**HEADERNUMBER=**) to 0 internally. If these are not set to 0, data will be stored after last recorded sample. **Do not send INITLOGGING until all existing data has been uploaded.**

SAMPLENUMBER=x

x= sample number for first sample when logging begins. After all previous data has been uploaded from 19*plus*, send **SAMPLENUMBER=0** (sets sample, header, and cast number to 0 internally) before starting to log to make entire memory available for recording. If these are not set to 0, data will be stored after last recorded sample. **Do not send SAMPLENUMBER=0 until all existing data has been uploaded.**

HEADERNUMBER=x

x= header and cast number for first cast when logging begins. This command is typically only used to recover data if you accidentally initialize logging (using **INITLOGGING** or **SAMPLENUMBER=0**) before uploading all existing data.

FLASHINIT

Map bad blocks and erase FLASH memory, **destroying all data**. SBE 19*plus* requires you to enter command twice, to provide verification before it proceeds. All data bits are set to 1. Sample number, header number, and data pointers are set to 0.
Allow 15 minutes to initialize memory.

Send **FLASHINIT** (after uploading all data) if encountering FLASH Read errors in Status (**DS**) response. If not encountering errors, **FLASHINIT** is optional, as 19*plus* writes over recorded information when **INITLOGGING** is used before beginning logging. However, knowledge of initial memory contents (i.e., all ones) can be a useful cross-check when data is retrieved.

QS

Quit session and place 19*plus* in quiescent (sleep) state. Main power turned off. Data logging and memory retention not affected.

Notes:

- The SBE 19*plus* configuration (.con) file must match this selection of pressure sensor and external voltages when viewing real-time data in SEASAVE or processing uploaded data. View and edit the .con file in SEASAVE or SBE Data Processing. Note that these parameters are factory-set to match the ordered instrument configuration.
- External voltage numbers 0, 1, 2, and 3 correspond to wiring of sensors to a voltage channel on the SBE 19*plus* end cap (see *Dimensions and End Cap Connectors* in *Section 2: Description of SBE 19plus*). However, in the .con file, voltage 0 is the first external voltage in the data stream, voltage 1 is the second, etc.
- The SBE 19*plus* requires verification when these commands (**PTYPE=** through **VOLT3=**) are sent. Instrument responds: `this command will change the scan length and initialize logging. Proceed Y/N?` Press the Y and the Enter key to proceed. The SBE 19*plus* responds: `Scan length has changed, initializing logging`

Sensor Setup Commands

PTYPE=x

Pressure sensor type.

x=0: No pressure sensor (not applicable to 19*plus*).

x=1: Strain-gauge.

x=2: Quartz without temperature compensation (not applicable to 19*plus*).

x=3: Quartz with temperature compensation (not applicable to 19*plus*).

VOLT0=x

x=Y: Enable external voltage 0.

x=N: Do not.

VOLT1=x

x=Y: Enable external voltage 1.

x=N: Do not.

VOLT2=x

x=Y: Enable external voltage 2.

x=N: Do not.

VOLT3=x

x=Y: Enable external voltage 3.

x=N: Do not.

Example: Sample data from voltage sensors wired to channels 0 and 3 on SBE 19*plus*' end cap (user input shown in bold).

```
S>VOLT0=Y
S>VOLT1=N
S>VOLT2=N
S>VOLT3=Y
```

There will be 2 external sensor voltages in data stream. In .con file (in SBE Data Processing or SEASAVE), indicate *2* external voltage channels. Voltage 0 corresponds to sensor wired to external voltage channel 0; voltage 1 corresponds to sensor wired to external voltage channel 3.

Profiling Mode Setup Commands

> **Note:**
> The SBE 19*plus* requires verification when **MP** is sent. Instrument responds:
> `this command will change the scan length and initialize logging. Proceed Y/N?`
> Press Y and the Enter key to proceed. SBE 19*plus* responds:
> `Scan length has changed, initializing logging.`

The **profiling mode setup commands following MP apply to profiling mode only**, and have no effect on operation if the SBE 19*plus* is in moored mode.

MP — Set 19*plus* to Profiling mode.

MINCONDFREQ=x — x= minimum conductivity frequency (Hz) to enable pump turn-on, to prevent pump from turning on before 19*plus* is in water. Pump stops when conductivity frequency drops below **MINCONDFREQ**.
SBE 19*plus* Configuration Sheet lists uncorrected (raw) frequency output at 0 conductivity. Typical value (and factory-set default) for **MINCONDFREQ** for salt water and estuarine application is: (0 conductivity frequency + 500 Hz).
Typical value for **MINCONDFREQ** for fresh water applications is: (0 conductivity frequency + 5 Hz).

> **Note:**
> See *Pump Operation* in this section for pump operation details.

PUMPDELAY=x — x= time (seconds) to wait after minimum conductivity frequency (**MINCONDFREQ**) is reached before turning pump on. Pump delay time allows time for Tygon tubing and pump to fill with water after 19*plus* is submerged. Typical value is 30 - 45 seconds.
Pump starts **PUMPDELAY** seconds after conductivity cell's frequency output is greater than **MINCONDFREQ**. Default 60 seconds.

IGNORESWITCH=x — x=Y: Do not start or stop logging based on position of magnetic switch. Use **STARTNOW**, **STARTLATER**, and **STOP** to control logging.

x=N: Do not ignore magnetic switch position. Logging controlled by switch position **or** by commands.

> **Notes:**
> To start sampling immediately after you send **AUTORUN=Y** (if you were performing setup on external power):
> - Send **QS** to put SBE 19*plus* in quiescent (sleep) state, and then turn external power off and then on again. **or**
> - Send **STARTNOW**.

AUTORUN=x — x=Y: Start logging automatically when ***external power*** applied; stop logging when external power removed. Magnetic switch position has no effect on logging.

x=N: Wait for a command when external power applied. Default.

NAVG=x — x= number of samples to average (default = 1, maximum = 32,767).
SBE 19*plus* samples at 4 Hz (every 0.25 seconds) and averages **NAVG** samples; averaged data is stored in FLASH memory and transmitted real-time.

> *Example:* The SBE 19*plus* samples every 0.25 seconds. If **NAVG=2**, 19*plus* averages data from 2 samples (= 1 averaged data sample per 0.5 second), stores averaged data in FLASH memory, and transmits averaged data real-time.

Moored Mode Setup Commands

Note:
The SBE 19*plus* requires verification when **MM** is sent. Instrument responds: `this command will change the scan length and initialize logging. Proceed Y/N?` Press Y and the Enter key to proceed. SBE 19*plus* responds: `Scan length has changed, initializing logging.`

Note:
If **DELAYBEFORESAMPLING** is too high, the SBE 19*plus* will not be able to take **NCYCLES** samples within **SAMPLEINTERVAL** seconds. In that case, the SBE 19*plus* internally increases **SAMPLEINTERVAL** to the smallest feasible number.

Note:
See *Pump Operation* in this section for pump operation details.

Note:
If **NCYCLES** is too high, the SBE 19*plus* will not be able to take **NCYCLES** samples within **SAMPLEINTERVAL** seconds. In that case, the SBE 19*plus* internally increases **SAMPLEINTERVAL** to the smallest feasible number.

The **moored mode setup commands following MM apply to moored mode only**, and have no effect on operation if the SBE 19*plus* is in profiling mode.

MM — Set 19*plus* to Moored mode.

MOOREDTXREALTIME=x
x=Y: Output real-time data.
x=N: Do not.

DELAYBEFORESAMPLING=x — x= time (seconds) to wait after switching on external voltage before sampling (0-32,000 seconds). Default 0 seconds. Typical value if a Sea Tech fluorometer is installed is 15 seconds.

MOOREDPUMPMODE=x
x=0: No pump.
x=1: Run pump for 0.5 seconds before each sample.
x=2: Run pump during each sample.

SAMPLEINTERVAL=x — x= interval (seconds) between samples (10 - 14,400 seconds).

NCYCLES=x — x= number of measurements to take and average every **SAMPLEINTERVAL** seconds (default = 1). SBE 19*plus* takes and averages **NCYCLES** samples (each 0.25 seconds apart) each **SAMPLEINTERVAL** seconds; averaged data is stored in FLASH memory and (if **MOOREDTXREALTIME=Y**) transmitted real-time.

Example: If **SAMPLEINTERVAL=10** and **NCYCLES=4**, every 10 seconds 19*plus* takes 4 samples (each 0.25 seconds apart), averages data from 4 samples, and stores averaged data in FLASH memory.

Output Format Commands

> **Note:**
> **Output format does not affect how data is stored in FLASH memory.** Sea-Bird's real-time data acquisition (SEASAVE) and data processing (SBE Data Processing) software require data in raw hexadecimal (**OUTPUTFORMAT=0**).
>
> Typical use of the output format command is:
> - Before beginning a cast:
>   - If you will be using **SEASAVE** to view real-time data - **You must set output format to raw hex.**
>   - If you will be using **SEATERM** to view real-time data - Set output format to converted decimal for ease in viewing data.
> - After the cast is complete, use SEATERM's Upload button to upload data from memory. This automatically resets the format to raw hex (**OUTPUTFORMAT=0**), so the data is compatible with SBE Data Processing.

OUTPUTFORMAT=x

x=0: Output raw frequencies and voltages in Hexadecimal form. **Must use this format for acquiring and viewing real-time data in SEASAVE** and for uploading data that will be processed with SBE Data Processing. When using SEATERM's Upload button, SEATERM sends **OUTPUTFORMAT=0**. This causes 19*plus* to upload data in memory in raw hex, regardless of user-programmed **OUTPUTFORMAT**, providing data in format that SBE Data Processing can use.

x=1: Output converted (engineering units) data in Hexadecimal form.

x=2: Output raw frequencies and voltages in decimal form.

x=3: Output converted (engineering units) data in decimal form. Must use this format to output salinity, sound velocity, sigma-t, battery voltage, or operating current.

x=4: Output pressure and scan number only, in Hexadecimal form.
Typically used only for interfacing 19*plus* with 90208 Auto Fire Module.

OUTPUTSAL=x

x=Y: Calculate and output salinity (psu). Only applies if **OUTPUTFORMAT=3**.

x=N: Do not.

OUTPUTSV=x

x=Y: Calculate and output sound velocity (m/sec), using Chen and Millero formula (UNESCO Technical Papers in Marine Science #44). Only applies if **OUTPUTFORMAT=3**.

x=N: Do not.

OUTPUTUCSD=x

x=Y: Calculate and output density sigma-t (kg/m^3), battery voltage, and operating current (mA). Voltage and current measured after delay before sampling, but before sampling. Only applies if **OUTPUTFORMAT=3**.

x=N: Do not.

Notes:
- In SEATERM, to save real-time data to a file, click the Capture button on the Toolbar before beginning logging.
- If the FLASH memory is filled to capacity, data sampling and transmission of real-time data continue, but excess data is not saved in memory.
- If the SBE 19*plus* is sampling data and the voltage is less than the cut-off voltage for five consecutive scans, the SBE 19*plus* halts logging and displays `WARNING: LOW BATTERY VOLTAGE` in response to the status (**DS**) command.

Logging Commands

Logging commands direct the SBE 19*plus* to sample data at pre-programmed intervals. When commanded to start sampling, the SBE 19*plus* takes samples and stores the data in its FLASH memory. Operation is dependent on the mode and setup.

Profiling Mode (MP)

While logging, the SBE 19*plus* transmits real-time data, and does not enter quiescent (sleep) state between samples. The SBE 19*plus* provides several methods for starting and stopping logging, depending on the settings for **IGNORESWITCH=** and **AUTORUN=** . Logging starts approximately 5 seconds after it is commanded.

IGNORESWITCH=	AUTORUN=	To Start Logging:	To Stop Logging:
N	N	Slide magnetic switch on.	Slide magnetic switch off, send **STOP**, or click Stop on SEATERM's Toolbar.
Y	N	Send **STARTNOW**, or **STARTMMDDYY=**, **STARTHHMMSS=**, and **STARTLATER**.	Send **STOP** or click Stop on SEATERM's Toolbar.
Y or N	**Y**	Turn on external power.	• Turn off external power, or • (if you want to send commands to check or modify setup) Send **STOP**, click Stop on SEATERM's Toolbar, or type Ctrl Z.

Note:
Sea-Bird ships the SBE 19*plus* with **AUTORUN=N** (it will not automatically start sampling when external power is applied). If you send **AUTORUN=Y**:
- Send **QS** to put SBE 19*plus* in quiescent (sleep) state, then turn power off and then on again to start sampling, **or**
- Send **STARTNOW**.

The first time logging is started after receipt of the initialize logging command (**INITLOGGING**), data recording starts at the beginning of memory and any previously recorded data is written over. When logging is stopped, recording stops. Each time logging is started again, recording continues, with new data stored after the previously recorded data and a new header written to indicate the incremented cast number, date, time, and sample numbers contained in the cast. The maximum number of casts that can be taken is 300.

Note:
For Moored mode, the magnetic switch should be left off, but it has no effect on logging. If the switch is turned on while the SBE 19*plus* is in quiescent state, the CPU enters the awake state but logging does not begin. If no communications are established, the SBE 19*plus* times out and enters quiescent state after 2 minutes.

Moored Mode (MM)

While logging, the SBE 19*plus* transmits real-time data if **MOOREDTXREALTIME=Y**. The SBE 19*plus* enters quiescent (sleep) state between samples.

To start logging, use **STARTNOW** or **STARTLATER**. Logging starts approximately 5 seconds after receipt of **STARTNOW**. The first time logging is started after receipt of the initialize logging command (**INITLOGGING**), data recording starts at the beginning of memory and any previously recorded data is written over. When **STOP** is sent, recording stops. Each time **STARTNOW** or **STARTLATER** is sent again, recording continues, with new data stored after the previously recorded data. A new header is written each time logging starts and every 1000 samples thereafter.

Logging Commands (*continued*)

Notes:
- **STARTDDMMYY=** and **STARTMMDDYY=** are equivalent. Either can be used to set the delayed start date.
- If using **STARTNOW** or **STARTLATER** to start logging, the SBE 19*plus* must be set to Moored mode (**MM**), or if in Profiling mode (**MP**) must be set to ignore the magnetic switch (**IGNORESWITCH=Y**).
- After receiving **STARTLATER**, the 19*plus* displays `waiting to start at . . .` in reply to t**DS**. Once logging starts, the **DS** reply displays **logging**.
- If the delayed start date and time has already passed when **STARTLATER** is received, the 19*plus* executes **STARTNOW**.

STARTNOW — Start logging now.

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

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

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

STARTLATER — Start logging at time set with delayed start date and time commands.

Example: Program 19*plus* to start logging on 20 January 2001 12:00:00. (user input shown in bold)

```
S>STARTMMDDYY=012001
S>STARTHHMMSS=120000
S>STARTLATER
```

or

```
S>STARTDDMMYY=200101
S>STARTHHMMSS=120000
S>STARTLATER
```

Notes:
- You may need to send **STOP** several times to get the SBE 19*plus* to respond.
- If in Profiling mode and **IGNORESWITCH=N**, slide the magnetic switch off **or** send **STOP** to stop logging.
- You must stop logging before uploading data.

STOP — Stop logging 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**.

Data Upload Commands

Notes:
- **Use the Upload button on the Toolbar or Upload Data in the Data menu to upload data that will be processed by SBE Data Processing**. Manually entering the data upload command does not produce data with the required header information for processing by our software. These commands are included here for reference for users who are writing their own software.
- To save data to a file, click the Capture button on the Toolbar before entering **DD**, **DC**, or **DH**.
- See *Data Output Formats* after these *Command Descriptions*.

Stop logging before uploading data.

DDb,e Upload data from scan **b** to scan **e**. If **b** and **e** are omitted, all data is uploaded. First sample number is 1.

> *Example:* Upload samples 1 - 199 to a file (user input shown in bold):
> (Click Capture on Toolbar and enter desired filename in dialog box.)
> S>**DD1,199**

DCn **Profiling mode only.** Upload data from cast **n**. If **n** is omitted, data from cast 1 is uploaded. First cast number is 1.

> *Example:* Upload all data in second cast (cast 2) to a file (user input shown in bold):
> (Click Capture on Toolbar and enter desired filename in dialog box.)
> S>**DC2**

DHb,e Upload header **b** to header **e**. If **b** and **e** are omitted, all headers are uploaded. First header is 1. The header includes:
- cast/header number
- month, day, hour, minute, and second when cast was started
- first and last sample in cast/header
- number of measurements to average per sample (**NAVG**) or interval between samples (**SAMPLEINTERVAL**)
- reason logging was halted (batfail = battery voltage too low; mag switch = switch turned off; stop cmd = received **STOP** command or Home or Ctrl Z character; timeout = error condition; unknown = error condition; ?????? = error condition)

> *Examples:*
> **Profiling Mode -** Upload second header (header for cast 2) to a file:
> (Click Capture on Toolbar and enter desired filename in dialog box.)
> S>**DH2**
> SBE 19*plus* responds:
> `cast 2 30 Nov 2000 12:30:33 samples 35 to 87, avg = 4, stop = mag switch`
>
> **Moored Mode -** Upload second header to a file:
> (Click Capture on Toolbar and enter desired filename in dialog box.)
> S>**DH2**
> SBE 19*plus* responds:
> `hdr 2 30 Nov 2000 12:30:33 samples 35 to 87, int = 10, stop = stop cmd`

Sampling Commands

Notes:

- The SBE 19*plus* has a buffer that stores the most recent data samples. Unlike data in the FLASH memory, data in the buffer is erased upon removal or failure of power.
- *Leave power on* in the **SL**, **SLT**, **TS**, and **TSSON** descriptions refers to power for the SBE 19*plus* as well as for any auxiliary sensors.

These commands request a single sample. The SBE 19*plus* always stores data for the most recent sample in its buffer. Some Sampling commands also store data in FLASH memory - the SBE 19*plus* will not execute the *store data in FLASH memory* portion of those commands while logging data.

SL Output last sample from buffer (sample obtained with sampling command, or latest sample from logging), and leave power on.

SLT Output last sample from buffer, then take new sample and store data in buffer. Leave power on. **Data is not stored in FLASH memory**.

TS Take new sample, store data in buffer, output data, and leave power on. **Data is not stored in FLASH memory**.

TSS Take new sample, **store data in buffer and FLASH memory**, output data, and turn power off.

TSSON Take new sample, **store data in buffer and FLASH memory**, output data, and leave power on.

Testing Commands

The SBE 19*plus* takes and outputs 100 samples for each test (except as noted); data is **not** stored in FLASH memory. Press the Esc key or Stop on the Toolbar to stop a test.

TT Measure temperature, output converted data.

TC Measure conductivity, output converted data.

TP Measure pressure, output converted data.

TV Measure four external voltage channels, output converted data.

TTR Measure temperature, output raw data.

TCR Measure conductivity, output raw data.

TPR Measure pressure, output raw data.

TVR Measure four external voltage channels, output raw data.

PUMPON Turn pump on for testing purposes.

PUMPOFF Turn pump off for testing purposes.

Calibration Coefficients Commands

Notes:
- Dates shown are when calibrations were performed. Calibration coefficients are initially factory-set and should agree with Calibration Certificates shipped with 19*plus*.
- See individual Coefficient Commands below for definitions of the data in the example.

DCAL Display calibration coefficients. Equivalent to Coefficients button on Toolbar.

Example: Display coefficients for SBE 19*plus* (user input shown in bold).

```
S>dcal
SeacatPlus V 1.3  SERIAL NO. 4000  25 Jun 2001  14:46:05
temperature:  26-jul-00
    TA0 = -3.178124e-06
    TA1 = 2.751603e-04
    TA2 = -2.215606e-06
    TA3 = 1.549719e-07
    TOFFSET = 0.000000e+00
conductivity:  01-aug-00
    G = -9.855242e-01
    H = 1.458421e-01
    I = -3.290801e-04
    J = 4.784952e-05
    CF0 = 2.584100e+03
    CPCOR = -9.570000e-08
    CTCOR = 3.250000e-06
    CSLOPE = 1.000000e+00
pressure S/N , range = 2000 psia:  14-jul-00
    PA0 = 0.000000e+00
    PA1 = 0.000000e+00
    PA2 = 0.000000e+00
    PTEMPA0 = 0.000000e+00
    PTEMPA1 = 0.000000e+00
    PTEMPA2 = 0.000000e+00
    PTCA0 = 0.000000e+00
    PTCA1 = 0.000000e+00
    PTCA2 = 0.000000e+00
    PTCB0 = 0.000000e+00
    PTCB1 = 0.000000e+00
    PTCB2 = 0.000000e+00
POFFSET = 0.000000e+00
volt 0: offset = 0.000000e+00, slope = 1.000000e+00
volt 1: offset = 0.000000e+00, slope = 1.000000e+00
volt 2: offset = 0.000000e+00, slope = 1.000000e+00
volt 3: offset = 0.000000e+00, slope = 1.000000e+00
    EXTFREQSF = 1.000000e+00
```

Calibration Coefficients Commands (*continued*)

> **Notes:**
> - F = floating point number
>   S = string with no spaces
> - If using auxiliary A/D sensors (**VOLT0** through **VOLT3**), their calibration coefficients are not stored in the SBE 19*plus*' EEPROM, but are stored in the SBE 19*plus*' configuration (.con) file. View and/or modify the calibration coefficients using the Configure menu in SBE Data Processing or SEASAVE.

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

Temperature	
TCALDATE=S	S=calibration date
TA0=F	F=A0
TA1=F	F=A1
TA2=F	F=A2
TA3=F	F=A3
TOFFSET=F	F=offset correction
Conductivity	
CCALDATE=S	S=calibration date
CG=F	F=G
CH=F	F=H
CI=F	F=I
CJ=F	F=J
CPCOR=F	F=pcor
CTCOR=F	F=tcor
CSLOPE=F	F=slope correction
CF0=F	F=0 value (compatible state only)
Pressure - General	
PCALDATE=S	S=calibration date
PRANGE=F	F=sensor full scale range (psi)
POFFSET=F	F=offset correction
Strain-Gauge Pressure	
PA0=F	F=A0
PA1=F	F=A1
PA2=F	F=A2
PTEMPA0=F	F=pressure temperature A0
PTEMPA1=F	F=pressure temperature A1
PTEMPA2=F	F=pressure temperature A2
PTCA0=F	F=pressure temperature compensation ptca0
PTCA1=F	F=pressure temperature compensation ptca1
PTCA2=F	F=pressure temperature compensation ptca2
PTCB0=F	F=pressure temperature compensation ptcb0
PTCB1=F	F=pressure temperature compensation ptcb1
PTCB2=F	F=pressure temperature compensation ptcb2

Data Output Formats

Notes:
- If your SBE 19*plus* includes a custom RS-232 connector for an SBE 38 or GTD, see *Addendum: Custom SBE 19plus SEACAT with Interface for RS-232 Sensor.*
- See *Appendix IV: Compatible State* for information on commands and output format for Compatible State custom applications.

The SBE 19*plus* stores data in a compact machine code. Data is converted and output in the user-selected format when uploading, without affecting data in memory. Because memory data remains intact until deliberately overwritten, you can upload in one format, then choose another format and upload again.

Output format is dependent on **OUTPUTFORMAT (=0, 1, 2, 3, or 4)**, as detailed below. The inclusion of some data is dependent on the system configuration - if the system does not include the specified sensor, the corresponding data is not included in the output data stream, shortening the data string.

OUTPUTFORMAT=0 (raw frequencies and voltages in Hex)

Notes:
- If you will be using SEASAVE to acquire real-time data, you must set **OUTPUTFORMAT=0**.
- When using SEATERM's Upload button, SEATERM sends **OUTPUTFORMAT=0**. This causes the SBE 19*plus* to upload data in memory in raw hex, regardless of the user-programmed **OUTPUTFORMAT**, providing the data in a format that SBE Data Processing can use.
- Our software uses the equations shown to perform these calculations; alternatively, you can use the equations to develop your own processing software.
- The SBE 19*plus*' 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 **engineering units**, the 19*plus* outputs pressure relative to the ocean surface (i.e., at the surface the output pressure is 0 decibars).
  The SBE 19*plus* uses the following equation to convert psia to decibars:
  pressure (db) =
  [pressure (psia) - 14.7] * 0.689476

Data is output in the order listed, with no spaces or commas between parameters. Shown with each parameter is the number of digits, and how to calculate the parameter from the data (use the decimal equivalent of the hex data in the equations).

1. Temperature
   A/D counts = tttttt
2. Conductivity
   conductivity frequency (Hz) = cccccc / 256
3. Strain-gauge pressure sensor pressure (if **PTYPE=1**)
   A/D counts = pppppp
4. Strain-gauge pressure sensor pressure temperature compensation (if **PTYPE=1**)
   pressure temperature compensation voltage = vvvv / 13,107
5. External voltage 0 (if **VOLT0=Y**)
   external voltage 0= vvvv / 13,107
6. External voltage 1 (if **VOLT1=Y**)
   external voltage 1 = vvvv / 13,107
7. External voltage 2 (if **VOLT2=Y**)
   external voltage 2 = vvvv / 13,107
8. External voltage 3 (if **VOLT3=Y**)
   external voltage 3 = vvvv / 13,107
9. Time (**Moored mode [MM] only**)
   seconds since January 1, 1980 = ssssssss

Example: Profiling mode, two external voltages sampled,
example scan = ttttttccccccppppppvvvvvvvvvvvv
= 0A53711BC7220C14C17D8203050594

- Temperature = tttttt = 0A5371 (676721 decimal);
  temperature A/D counts = 676721
- Conductivity = cccccc = 1BC722 (1820450 decimal);
  conductivity frequency = 1820450 / 256 = 7111.133 Hz
- Strain-gauge pressure = pppppp = 0C14C1 (791745 decimal);
  Strain-gauge pressure A/D counts = 791745
- Strain-gauge temperature compensation =
  vvvv = 7D82 (32,130 decimal);
  Strain-gauge temperature = 32,130 / 13,107 = 2.4514 volts
- First external voltage = vvvv = 0305 (773 decimal);
  voltage = 773 / 13,107 = 0.0590 volts
- Second external voltage = vvvv = 0594 (1428 decimal);
  voltage = 1428 / 13,107 = 0.1089 volts

OUTPUTFORMAT=1 (engineering units in Hex)

Data is output in the order listed, with no spaces or commas between the parameters. Shown with each parameter is the number of digits, and how to calculate the parameter from the data (use the decimal equivalent of the hex data in the equations).

1. Temperature
   temperature (°C, ITS-90) = (tttttt / 100,000) - 10
2. Conductivity
   Conductivity (S/m) = (cccccc / 1,000,000) - 1
3. Pressure
   pressure (decibars) = (pppppp / 1,000) - 100
4. External voltage 0 (if **VOLT0=Y**)
   external voltage 0= vvvv / 13,107
5. External voltage 1 (if **VOLT1=Y**)
   external voltage 1 = vvvv / 13,107
6. External voltage 2 (if **VOLT2=Y**)
   external voltage 2 = vvvv / 13,107
7. External voltage 3 (if **VOLT3=Y**)
   external voltage 3 = vvvv / 13,107
8. Time (**Moored mode [MM] only**)
   seconds since January 1, 1980 = ssssssss

Example: Profiling mode, two external voltages sampled,
example scan = ttttttccccccppppppvvvvvvvv
= 3385C40F42FE0186DE03050594

- Temperature = tttttt = 3385C4 (3376580 decimal);
  temperature (°C, ITS-90) = (3376580 / 100,000) - 10 = 23.7658
- Conductivity = cccccc = 0F42FE (1000190 decimal);
  conductivity (S/m) = (1000190 / 1,000,000) - 1 = 0.00019
- Pressure = pppppp = 0186DE (100062 decimal);
  pressure (decibars) = (100062 / 1,000) - 100 = 0.062
- First external voltage = vvvv = 0305 (773 decimal);
  voltage = 773 / 13,107 = 0.0590 volts
- Second external voltage = vvvv = 0594 (1428 decimal);
  voltage = 1428 / 13,107 = 0.1089 volts

OUTPUTFORMAT=2 (raw frequencies and voltages in decimal)

Data is output in the order listed, with a comma followed by a space between each parameter. Shown with each parameter are the number of digits and the placement of the decimal point. Leading zeros are suppressed, except for one zero to the left of the decimal point.

1. Temperature
   A/D counts = tttttt
2. Conductivity
   conductivity frequency (Hz) = cccc.ccc
3. Strain-gauge pressure sensor pressure (if **PTYPE=1**)
   A/D counts = pppppp
4. Strain-gauge pressure sensor pressure temperature compensation (if **PTYPE=1**)
   pressure temperature compensation voltage = v.vvvv
5. External voltage 0 (if **VOLT0=Y**)
   external voltage 0= v.vvvv
6. External voltage 1 (if **VOLT1=Y**)
   external voltage 1 = v.vvvv
7. External voltage 2 (if **VOLT2=Y**)
   external voltage 2 = v.vvvv
8. External voltage 3 (if **VOLT3=Y**)
   external voltage 23 = v.vvvv
9. Time (**Moored mode [MM] only**)
   date, time = dd mmm yyyy, hh:mm:ss (day month year hour:minute:second)

Example: Profiling mode with two external voltages sampled,
example scan = tttttt, cccc.ccc, pppppp, v.vvvv, v.vvvv, v.vvvv
= 676721, 7111.133, 791745, 2.4514, 0.0590, 0.1089

- Temperature = tttttt = 676721;
  temperature A/D counts = 676721
- Conductivity = cccc.ccc = 7111.133;
  conductivity frequency = 7111.133 Hz
- Strain-gauge pressure = pppppp = 791745;
  Strain-gauge pressure A/D counts = 791745
- Strain-gauge temperature compensation = v.vvvv = 2.4514;
  Strain-gauge temperature = 2.4514 volts
- First external voltage = v.vvvv = 0.0590;
  voltage = 0.0590 volts
- Second external voltage = v.vvvv = 0.1089;
  voltage = 0.1089 volts

OUTPUTFORMAT=3 (engineering units in decimal)

Data is output in the order listed, with a comma followed by a space between each parameter. Shown with each parameter are the number of digits and the placement of the decimal point. Leading zeros are suppressed, except for one zero to the left of the decimal point.

1. Temperature
   temperature (°C, ITS-90) = ttt.tttt
2. Conductivity
   Conductivity (S/m) = cc.ccccc
3. Pressure
   pressure (decibars) = pppp.ppp
4. External voltage 0 (if **VOLT0=Y**)
   external voltage 0= v.vvvv
5. External voltage 1 (if **VOLT1=Y**)
   external voltage 1 = v.vvvv
6. External voltage 2 (if **VOLT2=Y**)
   external voltage 2 = v.vvvv
7. External voltage 3 (if **VOLT3=Y**)
   external voltage 3 = v.vvvv
8. Salinity (if **OUTPUTSAL=Y**)
   salinity (psu) = sss.ssss
9. Sound velocity (if **OUTPUTSV=Y**)
   sound velocity (meters/second) = vvvv.vvv
10. Time (**Moored mode [MM] only**)
    date, time = dd mmm yyyy, hh:mm:ss (day month year hour:minute:second)
11. Density sigma-t (if **OUTPUTUCSD=Y**)
    sigma-t (kg/m^3) = ddd.dddd
12. Battery voltage (if **OUTPUTUCSD=Y**)
    voltage = vv.v
13. Operating current (if **OUTPUTUCSD=Y**)
    current (mA) = ccc.c

Example: Profiling mode with two external voltages sampled,
example scan = ttt.tttt, cc.ccccc, pppp.ppp, v.vvvv, v.vvvv
= 23.7658, 0.00019, 0.062, 0.0590, 0.1089

- Temperature = ttt.tttt = 23.7658;
  temperature (°C, ITS-90) = 23.7658
- Conductivity = cc.ccccc = 0.00019;
  conductivity (S/m) = 0.00019
- Pressure = pppp.ppp = 0.062;
  pressure (decibars) = 0.062
- First external voltage = v.vvvv = 0.0590;
  voltage = 0.0590 volts
- Second external voltage = v.vvvv = 0.1089;
  voltage = 0.1089 volts

OUTPUTFORMAT=4 (pressure and scan number in Hex)

Data is output in the order listed, with no spaces or commas between parameters. Shown with each parameter is the number of digits, and how to calculate the parameter from the data (use the decimal equivalent of the hex data in the equations).

The SBE 19*plus* is automatically set to **OUTPUTFORMAT=4** when communicating with the **90208 Auto Fire Module (AFM)**. This allows the AFM to use the SBE 19*plus*' pressure data to determine when to close SBE 32 Carousel water bottles.

1. Pressure
   pressure (decibars) = pppp - 100
2. Scan number = ssssss

> *Example*: SBE 19*plus* used with AFM and Carousel,
> example scan = ppppssssss
> = 00C80001F0
>
> - Pressure = pppp = 00C8 (200 decimal);
>   pressure (decibars) = 200 - 100 = 100 decibars
> - Scan number = ssssss = 0001F0 (496 decimal);
>   scan number = 496

Optimizing Data Quality for Profiling Applications

A profiling speed of approximately 1 meter/second usually provides good quality data. However, the amount of ship motion, and the dynamic effect it has on data quality, must be considered as operating conditions change. Slow profiling speeds (especially with an unpumped CTD) cause reduced flushing of the conductivity cell, and *salinity spiking* can be severe in areas of strong temperature gradients. In rough seas or other conditions (small boats) where the ship's dynamic motion is large, increase the profiling speed to as much as 2 to 3 meters/second to reduce dynamic errors (spiking) caused by the rapidly changing descent/ascent rate of the SBE 19*plus* (yo-yo effect).

An SBE 19*plus* with the standard pump can get better data with slow descent rates than an unpumped CTD. Since the pump creates and maintains a constant and optimum flow, the SBE 19*plus* can be lowered more slowly to give greater vertical resolution in the data, especially on lakes or protected bays, or in other calm conditions. Adjust the descent rate for a pumped SBE 19*plus* according to the amount of ship motion (i.e., sea state). On a very calm lake, 10 cm/second is feasible if used with a constant winch speed.

In common with other CTDs, the SBE 19*plus* is intended for obtaining downcast data, and will not generally give best quality results on the upcast. If you must have good quality upcast data, invert the SBE 19*plus* so that the sensors are at the top (ignore the downcast data for this configuration). **Position the SBE 19*plus* so that other instruments, sample bottles, etc. do not thermally contaminate the water that flows past the sensors.**

When an SBE 19*plus* is installed on a water sampler, good conductivity and optional dissolved oxygen data can be collected, even when stopped to collect a water sample, because water continues to flow through the sensors. However, the manner in which the SBE 19*plus* is mounted on the water sampler can have a dramatic effect on data quality. Ensure that the SBE 19*plus* is mounted so that it is sampling undisturbed water (i.e., do not mount behind an obstruction).

Where the water temperature is very different from the temperature at which the SBE 19*plus* has been stored, better results are obtained if the SBE 19*plus* is allowed to equilibrate to the water temperature at the surface (soak) for several minutes before beginning the profile. The reason is not that the electronics are temperature sensitive - they are not - but that the thermal influence of the instrument housing on the water entering the cell will be reduced. If the difference between water and storage temperature is extreme, allow more *soak time.*

Spiking is sometimes seen in the derived values for salinity, density, or sound velocity. Spiking results largely from a response time mismatch of the conductivity and temperature sensors, especially when the profiling descent rate is non-uniform. The greatest reduction in spiking is found by using premium CTD equipment such as the SBE 9*plus*, which uses very fast sensors (0.07 second) and high speed (24 Hz) parallel signal acquisition. The SBE 19*plus'* static accuracy is the same as that of the SBE 9*plus*, but its dynamic responses are not as ideal, as a result of its simpler, less costly, and more compact design.

Note:
See the SBE Data Processing manual for information on data processing modules that can correct data for the influences of ship motion and minimize salinity spiking.

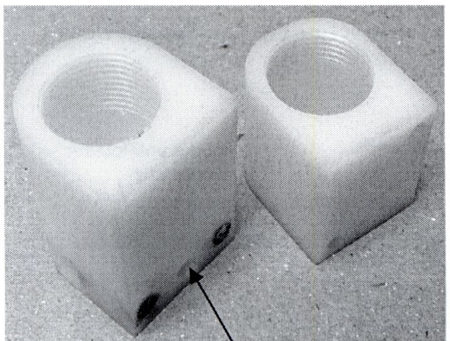
The amount of spiking depends on the temperature gradient, and is much worse when coupled surface motion causes the instrument to stop - or even reverse - its descent. In the event of heavy ship motion, it may be worth letting the instrument *free-fall.* When very heavy seas cause severe ship motion and result in periodic reversals of the instrument descent, the data set can be greatly improved by removing scans taken when the pressure is not increasing.

Installing Anti-Foul Fittings for Moored Applications

The SBE 19*plus* is intended primarily for use as a profiling instrument, and does not come standard with anti-foulant device cups and caps. Some customers, finding that they use the 19*plus* in moored mode on occasion, choose to install the optional moored mode conversion kit, which includes anti-foulant device cups and caps.

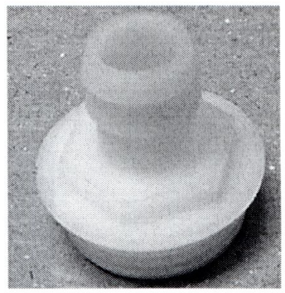
Intake anti-foulant device cup

Exhaust anti-foulant device cup

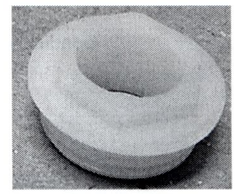


Hole for thermistor

Exhaust anti-foulant device cap (barbed) for pumped applications



Intake anti-foulant device cap for all applications and exhaust cap for non-pumped applications

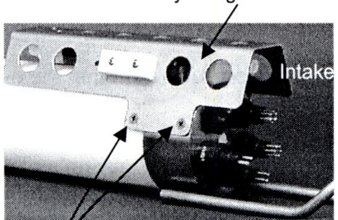


Note: The larger diameter of the intake cap / non-pumped application exhaust cap helps maintain good flow through the conductivity cell and reduces growth of biological material. **Do not use the barbed cap in its place.**

1. On pumped applications, remove the Tygon tubing from the existing conductivity cell exhaust duct.

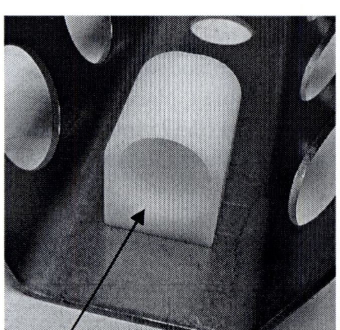
Conductivity cell guard

Exhaust



Remove screws, typical both sides

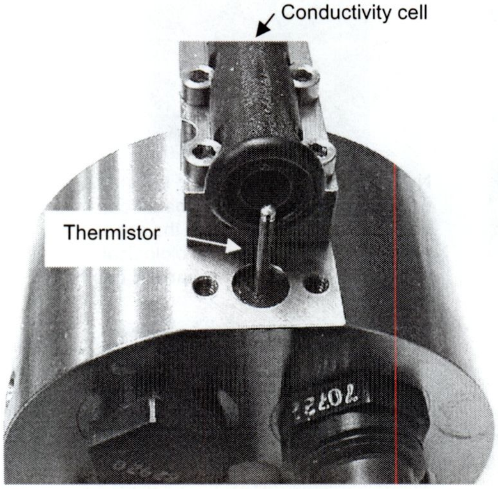
2. Remove the four Phillips-head screws attaching the conductivity cell guard to the housing and end cap. Carefully remove the conductivity cell guard.

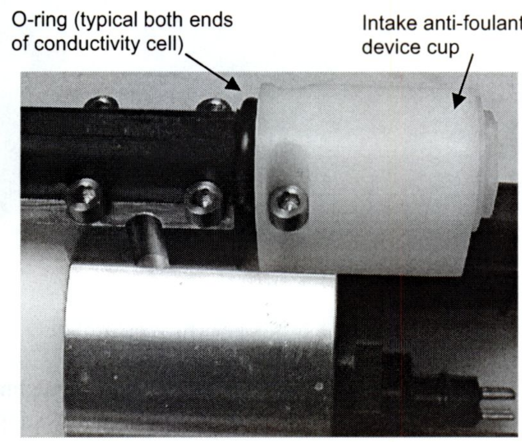


Exhaust anti-foulant device cup

3. Exhaust –
   A. On the conductivity cell guard, remove the two small screws attaching the exhaust duct to the guard.
   B. Remove the existing exhaust duct and replace with the exhaust anti-foulant device cup, reinstalling the two screws.
   C. See *Replacing Anti-Foulant Devices* in *Section 5: Routine Maintenance and Calibration* for details on handling and installing the AF24173 Anti-Foulant Device.
   D. Install the anti-foulant device cap to secure the Anti-Foulant Device in the cup.

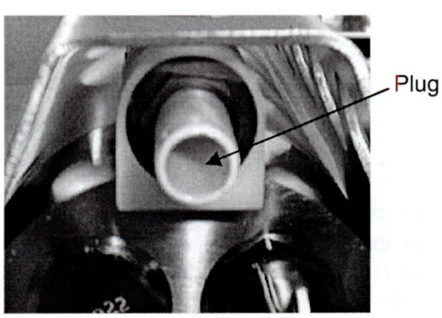
4. Intake –
   A. Remove the two hex head screws attaching the existing intake duct to the end cap.
   B. Remove the existing intake duct, pulling it straight up to avoid damaging the thermistor.
   C. Check to ensure that the o-ring at the end of the conductivity cell is still in place.
   D. Place the intake anti-foulant device cup over the thermistor and reinstall the hex head screws.
   E. See *Replacing Anti-Foulant Devices* in *Section 5: Routine Maintenance and Calibration* for details on handling and installing the AF24173 Anti-Foulant Device.
   F. Install the anti-foulant device cap to secure the Anti-Foulant Device in the cup.





5. Check the exhaust end of the conductivity cell to ensure that the o-ring is still in place.

6. Carefully reinstall the conductivity cell guard on the housing and end cap using the four Phillips-head screws.



7. If not deploying immediately, install a protective plug:
   In the intake cap, and
   (for a non-pumped application) In the exhaust cap.

8. (for a pumped application) Reconnect the plumbing to the exhaust. Note that the barbed exhaust cap has a smaller diameter than the standard exhaust cap on the SBE 19*plus* (which does not accommodate Anti-Foulant Devices). When reconnecting the plumbing, place a 25 mm (1/2 inch) long piece of Tygon tubing, 9.5 mm (0.375 inch) ID, 1.59 mm (0.0625 inch) wall on the barbed cap. Then install the existing plumbing over the Tygon.

Setup for Deployment

> **Note:**
> It is always necessary to set both date and time. **If a new date is entered but not a new time, the new date will not be saved.**

> **Note:**
> When Sea-Bird ships a new instrument, we include a .con file that reflects the current instrument configuration *as we know it*. The .con file is named with the instrument serial number, followed with the .con extension. For example, for an instrument with serial number 2375, Sea-Bird names the .con file *2375.con*. You may rename the .con file if desired; this will not affect the results.

1. Install new batteries or ensure the existing batteries have enough capacity to cover the intended deployment (see *Replacing/Recharging Batteries* in *Section 5: Routine Maintenance and Calibration*).

2. Program the SBE 19*plus* for the intended deployment using SEATERM (see *Section 3: Power and Communications Test* for connection information; see information in this section on commands and sampling modes):

   A. Set the date and then time (if not already done).

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

   C. Establish the setup and logging parameters. **If you will be using SEASAVE to acquire and view real-time data, you must set OUTPUTFORMAT = 0 (raw hexadecimal).**

   D. If desired, use **STARTMMDDYY=**, **STARTHHMMSS=**, and **STARTLATER** to establish delayed start date and time for Profiling mode (if **IGNORESWITCH=Y**) or Moored mode.

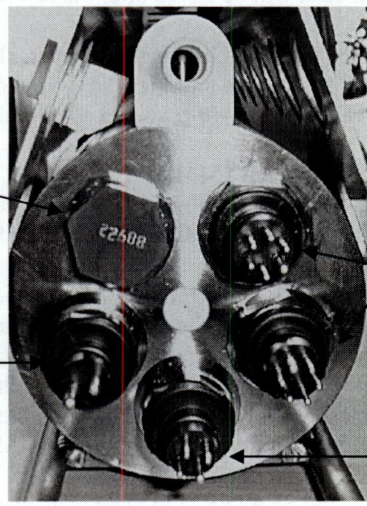
3. If you will be using SEASAVE to acquire and view real-time data, verify that the configuration (.con) file matches the instrument configuration. Sea-Bird supplies a .con file to match the factory configuration and calibrations. If the instrument is recalibrated or the configuration is changed (such as by adding external sensors), the .con file must be updated to reflect the current condition (see SEASAVE's Help files).

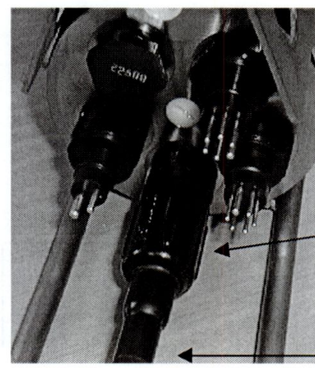
4. If you will be using SEATERM to view real-time data, press the Capture button on the Toolbar to save the data to a file.

Deployment

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

1. Install a cable or dummy plug for each connector on the SBE 19*plus* sensor end cap:
   A. Lightly lubricate the inside of the dummy plug/cable connector with silicone grease (DC-4 or equivalent).
   B. **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 SBE 19*plus*. 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/cable connector. Tighten the locking sleeve finger tight only. **Do not overtighten the locking sleeve and do not use a wrench or pliers.**





2. Connect the other end of the cables installed in Step 1 to the appropriate sensors.

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

4. If applicable, remove the Tygon tubing that was looped end-to-end around the conductivity cell for storage. Reconnect the tubing from the pump to the conductivity cell.

5. **Profiling mode** - Immediately prior to deployment:
   - (if **IGNORESWITCH=N**) Turn on the magnetic switch, **or**
   - (if **IGNORESWITCH=Y**) If not already done, send **STARTNOW** or **STARTMMDDYY**, **STARTHHMMSS**, and **STARTLATER**, **or**
   - (if **AUTORUN=Y**) With the SBE 19*plus* in quiescent (sleep) state, apply external power.

6. **Moored mode** - If not already done, send **STARTNOW** or **STARTMMDDYY**, **STARTHHMMSS**, and **STARTLATER**.

The SBE 19*plus* is ready to go into the water.

Acquiring Real-Time Data with SEASAVE

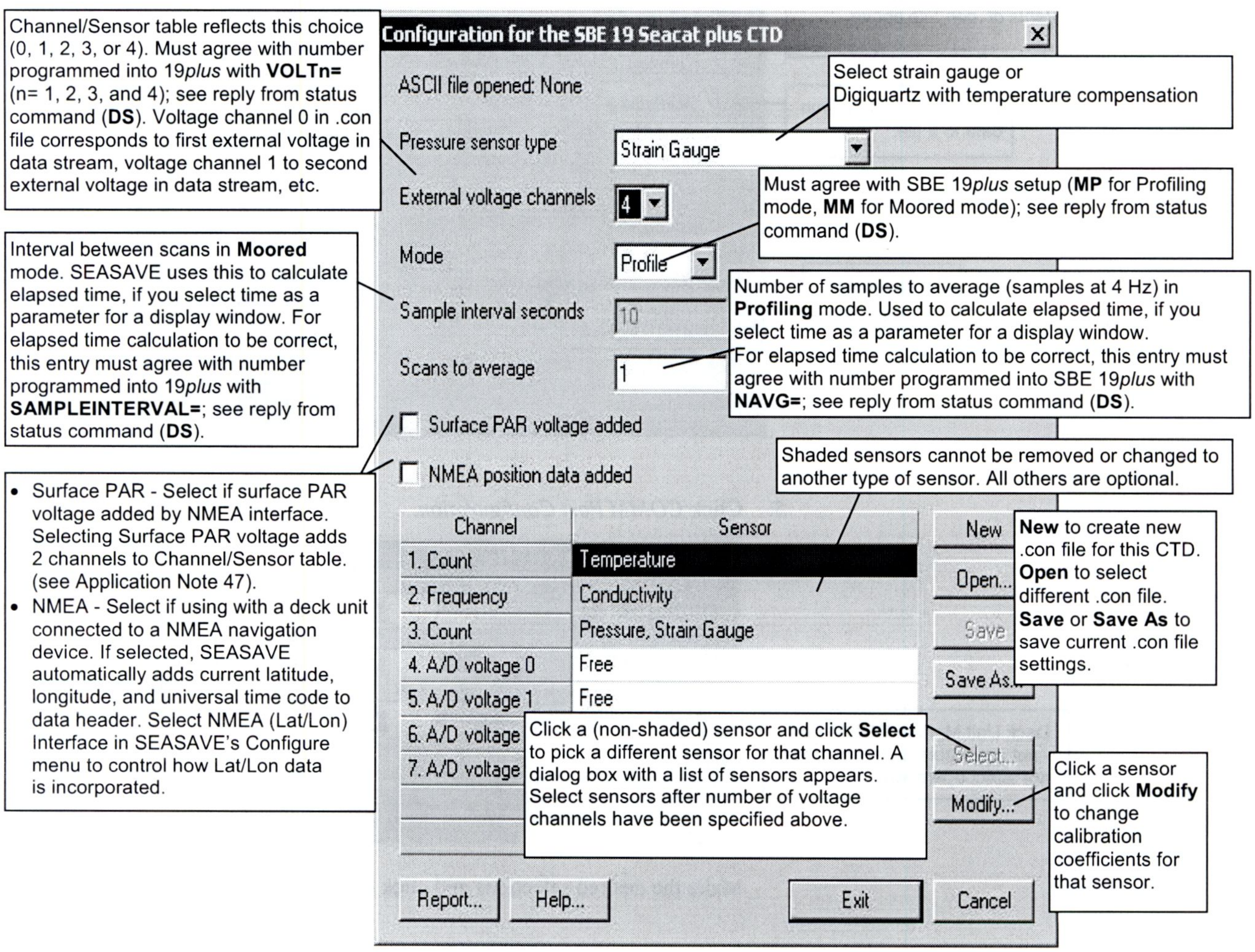
Notes:

- When we ship a new instrument, we include a .con file that reflects the current instrument configuration *as we know it*. The .con file is named with the instrument serial number, followed with the .con extension. For example, for an instrument with serial number 2375, we name the .con file *2375.con*. You may rename the .con file if desired; this will not affect the results.
- In SEATERM's setup commands, external voltage numbers 0, 1, 2, and 3 correspond to wiring of sensors to a voltage channel on the end cap (see *Dimensions and End Cap Connectors* in *Section 2: Description of SBE 19plus*). However, in the .con file, voltage 0 is the first external voltage in the data stream, voltage 1 is the second, etc.

Verify Contents of .con File

SEASAVE, Sea-Bird's real-time data acquisition and display program, requires a .con file, which defines the instrument - auxiliary sensors integrated with the instrument, and channels, serial numbers, and calibration dates and coefficients for all the sensors (conductivity, temperature, and pressure as well as auxiliary sensors). SEASAVE (as well as our data processing software) uses the information in the .con file to interpret and process the raw data. **If the .con file does not match the actual instrument configuration, the software will not be able to interpret and process data correctly.**

1. Double click on Seasave.exe.
2. In the Configure menu, select *New Style Instrument Configuration / Select Instrument Configuration*. In the dialog box, select the appropriate .con file and click Open.
3. In the Configure menu, select *New Style Instrument Configuration / Modify Selected Instrument Configuration*. The configuration dialog box appears. Verify that the sensors match those on your SBE 19*plus*, and that auxiliary sensors are assigned to the correct voltage channels. Verify that the calibration coefficients for all the sensors are up-to-date.



4. Click *Save* or *Save As* to save any changes to the .con file. Click Exit when done reviewing / modifying the .con file.

Acquiring Real-Time Data

Instructions below are for an SBE 19*plus* with a conventional single-core armored cable, used without a Sea-Bird Deck Unit. **If using the SBE 19*plus* with the SBE 33 or 36 Deck Unit, see the Deck Unit manual.**

1. Wiring - Terminate the single-core armored cable with an RMG-4FS connector. Wire the cable armor to pin 1 (large pin) and the inner conductor to pin 3 (opposite large pin) on the SBE 19*plus*' data I/O connector. On deck, wire:

Slip-ring lead	9-pin serial port
from armor	Pin 5
from inner conductor	Pin 2

2. Double click on Seasave.exe.

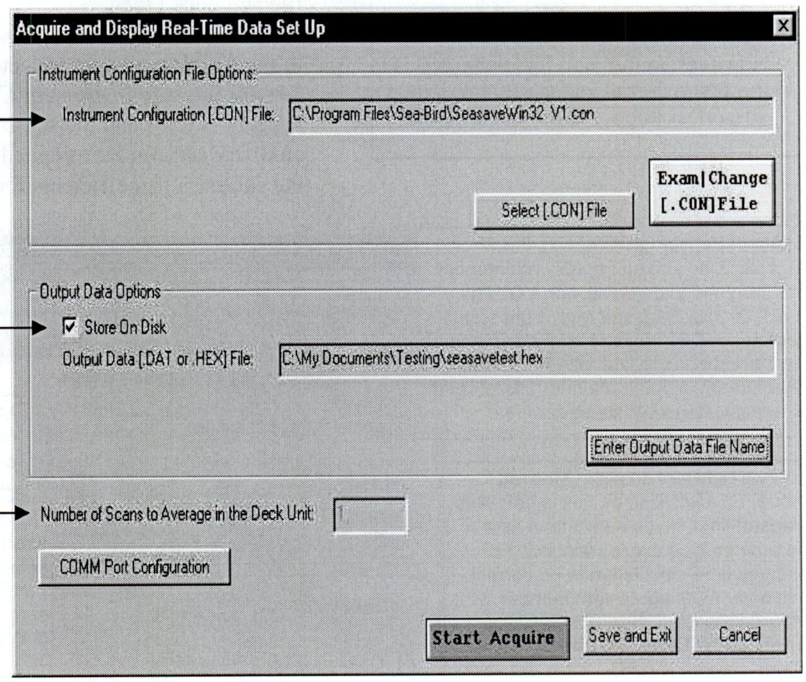
3. Perform any desired setup in the Configure and ScreenDisplay menus.

4. In the RealTime Data menu, select *Start Acquisition.*

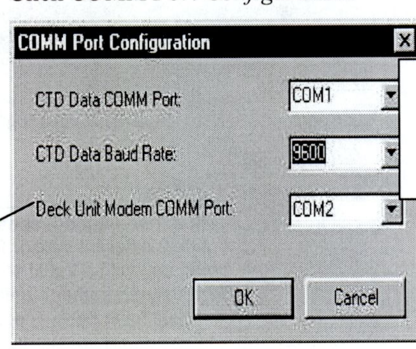
Configuration file defines the auxiliary sensors integrated with the instrument, and channels, serial numbers, and calibration dates and coefficients for all the integrated sensors (conductivity, temperature, and pressure as well as auxiliary sensors). Verify that .con file matches your instrument setup. See *Verify Contents of .con File* above.

Select to save real-time data to a file.

Not applicable.



5. Click *COMM Port Configuration.*



COMM Port and baud rate for communication between SBE 19*plus* and computer. Baud rate must match baud rate set in SBE 19*plus* with **BAUD=**.

Deck Unit Modem COMM Port - not applicable (selection does not affect operation)

Make the desired selections and click OK.

6. In the Acquire and Display Real Time Data Set Up dialog box, click *Start Acquire*.
   A. If SEASAVE was set up to prompt for header information (Configure menu / Header Form), the Header Information dialog box appears. Fill in the desired information to be added to the real-time data file header, and click OK.
   B. SEASAVE prompts *Turn on the SBE 19plus using the magnetic switch.* If you have already started logging data to memory, ignore the prompt; otherwise, slide the switch to the On position. Real-time data then starts appearing in the screen display(s).

7. When done acquiring data, in the RealTime Data menu, select *Stop Acquisition*.

8. Stop logging:
   - (if **IGNORESWITCH=N**) Put the magnetic switch in the Off position, **or**
   - (if **IGNORESWITCH=Y**) Send the **STOP** in SEATERM, **or**
   - (if **AUTORUN=Y**) Remove external power.

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 SBE 19*plus* 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. 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. (See *Section 5: Routine Maintenance and Calibration* for replacement of batteries.)

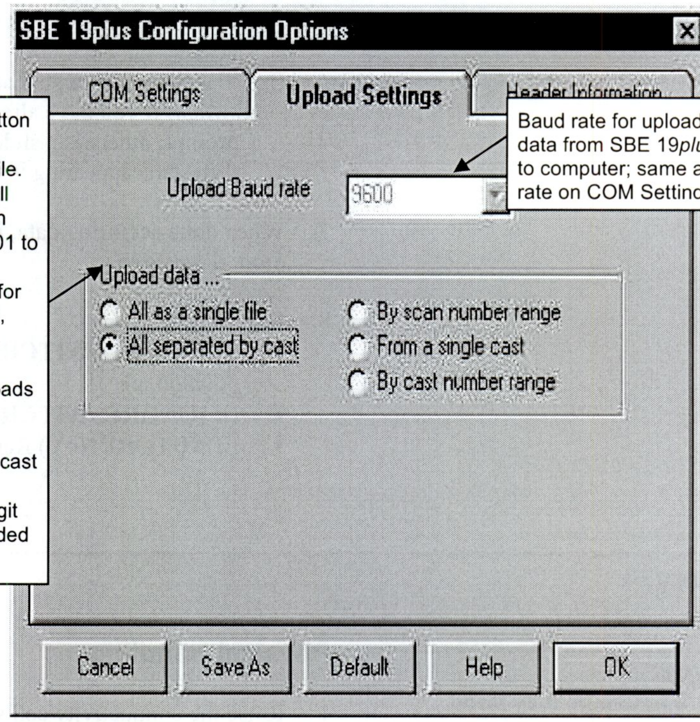
3. If immediate redeployment is not required, it is best to leave the SBE 19*plus* with batteries in place and in a quiescent state (**QS**). Because the quiescent current required is only 30 microamps, the batteries can be left in place without significant loss of capacity.

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

Uploading Data

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

2. In the Configure menu, select *SBE 19plus*. Click on the Upload Settings tab. The dialog box looks like this:



Defines data upload type when using Upload button on Toolbar or Upload Data in Data menu:

- All as single file – All data uploaded into one file.
- All separated by cast (Profiling mode only) - All data uploaded. Separate file is written for each cast, with 3-digit cast identification number (001 to 301) appended to user-selected file name
- By scan number range – SEATERM prompts for beginning and ending scan (sample) numbers, and uploads all data within range into one file.
- From a single cast (Profiling mode only) - SEATERM prompts for cast number, and uploads all data from that cast into one file.
- By cast number range (Profiling mode only) - SEATERM prompts for beginning and ending cast numbers, and uploads data within that range. Separate file is written for each cast, with 3-digit cast identification number (001 to 301) appended to user-selected file name.

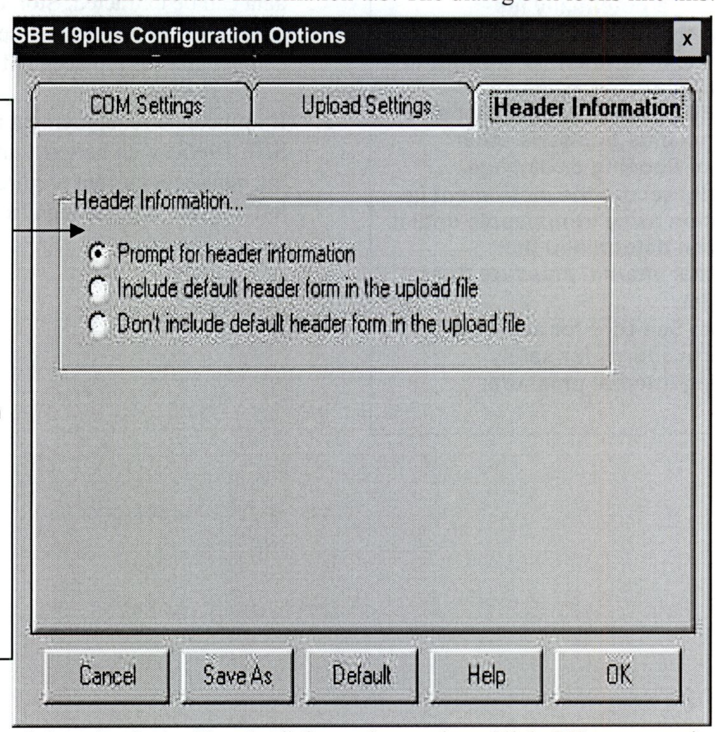
Baud rate for uploading data from SBE 19*plus* to computer; same as baud rate on COM Settings tab.

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

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

Make the selection for Upload Settings.

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

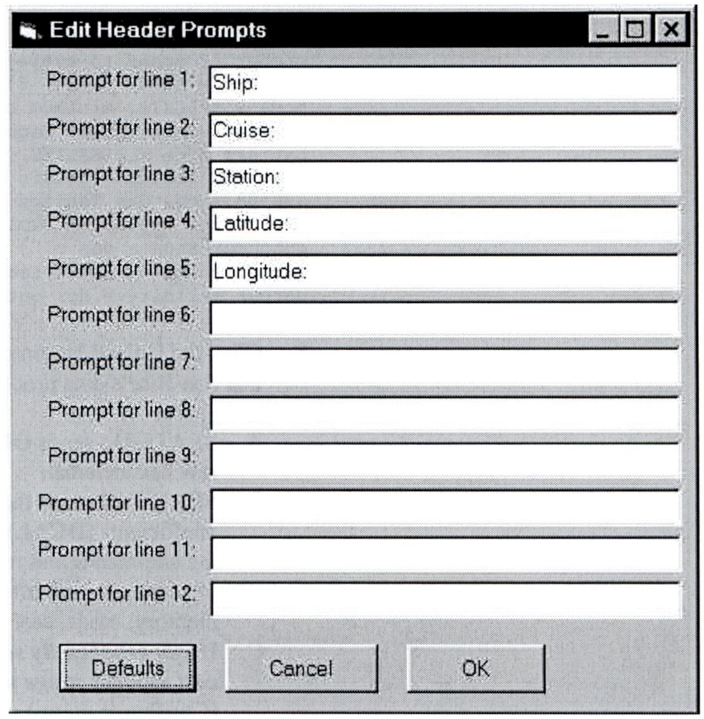


Defines header information included with uploaded data:

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

Select the desired header information option. Click OK to overwrite an existing COM/Upload/Header Settings file, or click Save As to save the settings as a new filename.

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



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

Enter the desired header/header prompts. Click OK.

5. Click Connect on the Toolbar to begin communications with the SBE 19*plus*. The display looks like this:

```
S>
```

This shows that correct communications between the computer and the SBE 19*plus* has been established.
If the system does not respond as shown above:
- Click Connect again.
- Check cabling between the computer and the SBE 19*plus*.
- Verify the correct instrument was selected and the COM settings were entered correctly in the Configure menu.

6. Command the SBE 19*plus* to stop data logging by the method applicable to your instrument's setup:
- Pressing the Enter key and sending **STOP**, or
- Moving the magnetic switch to the Off position (only applicable in Profiling mode, if **IGNORESWITCH=N**)

7. Display SBE 19*plus* status information by clicking Status on the Toolbar. The display looks like this (if in Profiling mode):

```
SeacatPlus V 1.4D  SERIAL NO. 4000    12 Jun 2003  14:02:13
vbatt = 9.6, vlith = 0.0, ioper = 61.2 ma, ipump = 25.5 ma,
iext01 = 76.2 ma,
status = not logging
number of scans to average = 1
samples = 5000, free = 376300, casts = 1
mode = profile, minimum cond freq = 3000, pump delay = 60 sec
autorun = no, ignore magnetic switch = no
battery type = ALKALINE, battery cutoff = 7.5 volts
pressure sensor = strain gauge, range = 1000.0
SBE 38 = no, Gas Tension Device = no
Ext Volt 0 = yes, Ext Volt 1 = no, Ext Volt 2 = no, Ext Volt 3 = no
echo commands = yes
output format = converted decimal
output salinity = no, output sound velocity = no
```

8. Click the Upload button on the Toolbar to upload stored data in a form that Sea-Bird's data processing software can use. SEATERM responds as follows:
   A. SEATERM sends **OUTPUTFORMAT=0** to set the output format to raw hexadecimal.
   B. SEATERM sends the status (**DS**), header (**DH**), and calibration coefficients (**DCAL**) commands, displays the responses, and writes the commands and responses to the upload file. These commands provide you with information regarding the number of samples in memory, mode, cast numbers, etc.
   C. **If you selected *By scan number range, From a single cast,* or *By cast number range* in the Configuration Options dialog box (Configure menu)** – a dialog box requests the range or cast number, as applicable. Enter the desired value(s), and click OK.
   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. SEATERM writes the header information to the upload file.
   E. In the Open dialog box, enter the desired upload file name and click OK. The upload file has a .hex extension.
      If you selected ***All separated by cast*** or ***By cast number range***, SEATERM will automatically append the 3-digit cast identification number to the upload file name (for example, if you specify the upload file name as *test* and upload casts 1 and 2, SEATERM will create test001.hex and test002.hex).
   F. SEATERM sends the data upload command (**DCn** or **DDb,e** as applicable).
   G. **If you selected *Prompt for header information* in the Configuration Options dialog box (Configure menu)** – SEATERM repeats Steps D and F for each cast.
   H. When the data has been uploaded, SEATERM shows the S> prompt.

9. Ensure all data has been uploaded from the SBE 19*plus* by reviewing and processing the data:
   A. Use **SEASAVE** to display the *raw* hexadecimal data from the SBE 19*plus* in engineering units (see SEASAVE's manual/ Help files).
   B. Use **SBE Data Processing** to process and plot the data (see SBE Data Processing manual/Help files).

Notes:
To prepare for redeployment:
1. After all data has been uploaded, send **INITLOGGING**. If this command is not sent, new data will be stored after the last recorded sample, preventing use of the entire memory capacity.
2. Send **QS** to put the SBE 19*plus* in quiescent (sleep) state until ready to redeploy. Quiescent current is only 30 microamps, so the batteries can be left in place without significant loss of capacity.

Processing Data

Sea-Bird provides software, SBE Data Processing, for converting the raw .hex data file into engineering units, editing (aligning, filtering, removing bad data, etc.) the data, calculating derived variables, and plotting the processed data.

However, sometimes users want to edit the raw .hex data file before beginning processing, to remove data at the beginning of the file corresponding to instrument *soak* time, to remove blocks of bad data, to edit the header, or to add explanatory notes about the cast. **Editing the raw .hex file can corrupt the data, making it impossible to perform further processing using Sea-Bird software.** Sea-Bird strongly recommends that you first convert the data to a .cnv file (using the DATA CONVERSION module in SBE Data Processing), and then use other SBE Data Processing modules to edit the .cnv file as desired.

> **Note:**
> Although we provide this technique for editing a raw .hex file, **Sea-Bird's strong recommendation, as described above, is to always convert the raw data file and then edit the converted file.**

The procedure for editing a .hex data file described below has been found to work correctly on computers running Windows 98, 2000, and NT. **If the editing is not performed using this technique, SBE Data Processing may reject the edited data file and give you an error message.**

1. **Make a back-up copy of your .hex data file before you begin.**
2. Run **WordPad**.
3. In the File menu, select Open. The Open dialog box appears. For *Files of type*, select *All Documents (*.*)*. Browse to the desired .hex data file and click Open.
4. Edit the file as desired, **inserting any new header lines after the System Upload Time line**. Note that all header lines must begin with an asterisk (*), and *END* indicates the end of the header. An example is shown below (for an SBE 21), with the added lines in bold:

```
* Sea-Bird SBE 21 Data File:
* FileName = C:\Odis\SAT2-ODIS\oct14-19\oc15_99.hex
* Software Version Seasave Win32 v1.10
* Temperature SN = 2366
* Conductivity SN = 2366
* System UpLoad Time = Oct 15 1999  10:57:19
* Testing adding header lines
* Must start with an asterisk
* Place anywhere between System Upload Time & END of header
* NMEA Latitude = 30 59.70 N
* NMEA Longitude = 081 37.93 W
* NMEA UTC (Time) = Oct 15 1999  10:57:19
* Store Lat/Lon Data = Append to Every Scan and Append
to .NAV File When <Ctrl F7> is Pressed
** Ship:        Sea-Bird
** Cruise:      Sea-Bird Header Test
** Station:
** Latitude:
** Longitude:
*END*
```

5. In the File menu, select Save (**not** Save As). If you are running Windows 2000, the following message displays:

```
You are about to save the document in a Text-Only
format, which will remove all formatting. Are you sure
you want to do this?
```

   Ignore the message and click *Yes*.

6. In the File menu, select Exit.

Section 5: Routine Maintenance and Calibration

This section reviews corrosion precautions, connector mating and maintenance, plumbing maintenance, replacing/recharging batteries, conductivity cell storage and cleaning, pressure sensor maintenance, replacing optional Anti-Foulant Devices, and sensor calibration. The accuracy of the SBE 19*plus* is sustained by the care and calibration of the sensors and by establishing proper handling practices.

Corrosion Precautions

Rinse the SBE 19*plus* with fresh water after use and prior to storage.

For both the plastic and titanium housing, all exposed metal is titanium (the plastic housing has a titanium end cap). No corrosion precautions are required, but avoid direct electrical connection of the titanium to dissimilar metal hardware.

Connector Mating and Maintenance

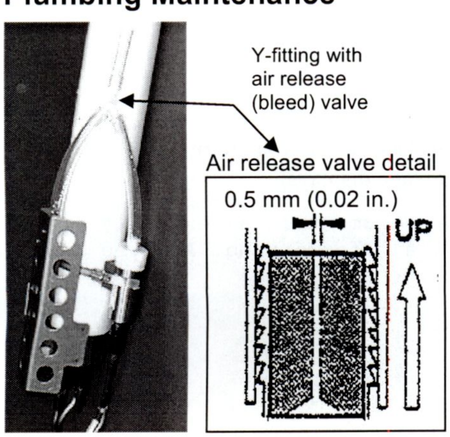
CAUTION:
Do not use WD-40 or other petroleum-based lubricants, as they will damage the connectors.

Mated connectors do not require periodic disassembly or other attention. Inspect connectors that are 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 SBE 19*plus*. 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 for each connector on the system before deployment.

Plumbing Maintenance

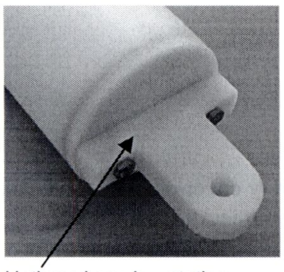


Periodically clean the air release valve with a fine wire. **A clogged air release valve can trap air, preventing the pump from functioning properly**; this will affect the data quality.

Replacing / Recharging Batteries

Note:
If changing from alkaline to Ni-Cad batteries, or vice versa, send **BATTERYTYPE=** to indicate the new battery type.

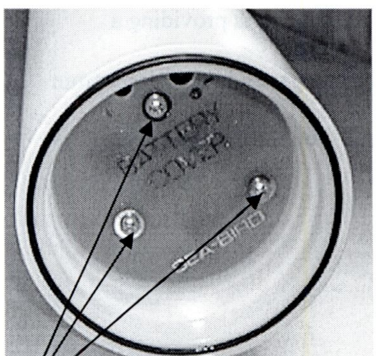
Leave the batteries in place when storing the SBE 19*plus* to prevent depletion of the back-up lithium batteries by the real-time clock. Even *exhausted* main batteries will power the clock (30 microamperes) almost indefinitely. If the SBE 19*plus* is to be stored for long periods, leave the batteries in place and replace them yearly.



Unthread cap by rotating counter-clockwise

Replacing Alkaline Batteries

1. Remove the battery end cap (end cap without connectors):
   A. Wipe the outside of the end cap and housing dry, being careful to remove any water at the seam between them.
   B. Unthread the end cap by rotating counter-clockwise (use a wrench on the white plastic bar if necessary).
   C. Remove any water from the O-ring mating surfaces inside the housing with a lint-free cloth or tissue.
   D. Put the end cap aside, being careful to protect the O-ring from damage or contamination.



Remove Phillips-head screws and washers

2. Remove the battery cover plate from the housing:
   A. Remove the three Phillips-head screws and washers from the battery cover plate inside the housing.
   B. The battery cover plate will pop out. Put it aside.

3. Turn the SBE 19*plus* over and remove the batteries.

4. Install the new batteries, with the + terminals against the flat battery contacts and the - terminals against the spring contacts.

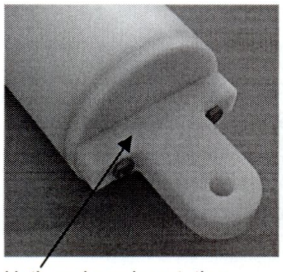
5. Reinstall the battery cover plate in the housing:
   A. Align the battery cover plate with the housing. The posts inside the housing are not placed symmetrically, so the cover plate fits into the housing only one way. Looking at the cover plate, note that one screw hole is closer to the edge than the others, corresponding to the post that is closest to the housing.
   B. Reinstall the three Phillips-head screws and washers, while pushing hard on the battery cover plate to depress the spring contacts at the bottom of the battery compartment. **The screws must be fully tightened, or battery power to the circuitry will be intermittent**.

6. Check the battery voltage at BAT + and BAT - on the battery cover plate. It should be approximately 13.5 volts.

7. Reinstall the battery end cap:
   A. Remove any water from the O-rings and mating surfaces with a lint-free cloth or tissue. Inspect the O-rings and mating surfaces for dirt, nicks, and cuts. Clean or replace as necessary. Apply a light coat of o-ring lubricant (Parker Super O Lube) to O-rings and mating surfaces.
   B. Carefully fit the end cap into the housing and rethread the end cap into place. Use a wrench on the white plastic bar to ensure the end cap is tightly secured.

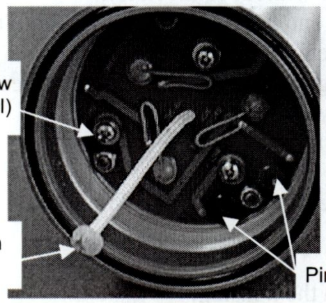
Verify that the magnetic switch on the conductivity cell guard is in the Off position, so the SBE 19*plus* will be in quiescent (sleep) state.

Recharging Optional Nickel-Cadmium Batteries



Unthread cap by rotating counter-clockwise

1. Remove the battery end cap (end cap without connectors):
   A. Wipe the outside of the end cap and housing dry, being careful to remove any water at the seam between them.
   B. Unthread the end cap by rotating counter-clockwise (use a wrench on the white plastic bar if necessary).
   C. Remove any water from the O-ring mating surfaces inside the housing with a lint-free cloth or tissue.
   D. Put the end cap aside, being careful to protect the O-ring from damage or contamination.



To remove battery pack from housing (not necessary for recharging):
1. Remove 3 Phillips-head machine screws and washers
2. Pull on plastic tab on center cord.

To reinstall battery pack in housing:
1. Align battery pack with housing. Posts inside housing are not placed symmetrically, so battery pack fits into housing only one way. Looking at battery bottom cover, note that one circular cutout is closer to edge than others, corresponding to post that is closest to housing.
2. Reinstall 3 Phillips-head screws and washers, while pushing hard on top of battery pack to depress spring contacts at bottom of compartment. **Screws must be fully tightened, or battery power to circuitry will be intermittent.**

2. Recharge the batteries:
   A. Connect the battery charger leads to the battery cover pin jacks, matching black-to-black and red-to-red (the pin jacks are different sizes to prevent cross-wiring).
   B. Plug the battery charger into a suitable AC mains power source.
   C. The red **Charge** LED on the charger comes on. Recharging takes approximately 15 hours. When recharging is complete, the yellow **Trickle** LED comes on, indicating the charger is providing a maintenance level charge.
   D. Disconnect the battery pack from the charger and the charger from the power source.
   E. Check the voltage at BAT + and BAT – on the battery cover. It should be approximately 10.8 volts.

3. Reinstall the battery end cap:
   A. Remove any water from the O-rings and mating surfaces with a lint-free cloth or tissue. Inspect the O-rings and mating surfaces for dirt, nicks, and cuts. Clean or replace as necessary. Apply a light coat of O-ring lubricant (Parker Super O Lube) to O-rings and mating surfaces.
   B. Carefully fit the end cap into the housing and rethread the end cap into place. Use a wrench on the white plastic bar to ensure the end cap is tightly secured.

Verify that the magnetic switch on the conductivity cell guard is in the Off position, so the SBE 19*plus* will be in quiescent (sleep) state.

Conductivity Cell Maintenance

> CAUTIONS:
> - **Do not put a brush or any object inside the conductivity cell to dry it or clean it.** Touching and bending the electrodes can change the calibration. Large bends and movement of the electrodes can damage the cell.
> - **Do not store the SBE 19*plus* with water in the conductivity cell.** Freezing temperatures (for example, in Arctic environments or during air shipment) can break the cell if it is full of water.

The SBE 19*plus'* conductivity cell is shipped dry to prevent freezing in shipping. Sea-Bird recommendations follow for three situations:

- Active use - storing for one day or less between uses
- Storage - storing for longer than one day
- Cleaning

Active Use (storing for one day or less)

1. After each recovery, rinse the cell with clean, de-ionized water and drain.
   - 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.

2. Fill the cell with a **0.1%** solution of Triton X-100 (included with shipment), using a length of Tygon tubing attached to each end of the cell to close the cell ends.
   - The Triton X-100 solution is a mild, non-ionic detergent that keeps contamination from ocean surface film, aerosols, and spray/wash on the ship deck from harming the cell calibration.

Storage (storing for longer than one day)

1. Rinse the cell with clean, de-ionized water and drain. Remove larger droplets of water by blowing through the cell. **Do not use compressed air**, which typically contains oil vapor.

2. Attach a length of Tygon tubing from one end of the conductivity cell to the other, to prevent dust and aerosols from entering the cell during storage.

3. When ready to deploy again - Fill the cell with a **0.1%** solution of Triton X-100 for 1 hour before deployment. Then remove the looped Tygon tubing, and reconnect the tubing connecting the pump to the conductivity cell.

Cleaning

The rinse and soak procedure recommended for Active Use is generally sufficient. However, occasionally the cell becomes contaminated and requires more intensive cleaning. We recommend two procedures, depending on the type of contamination:

Triton Cleaning for Ocean Surface Films or Oily Contamination

1. Heat a stronger (**1%-2%**) solution of Triton X-100 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 clean, de-ionized water for 1 minute. Then:
   - Prepare for deployment, **or**
   - Follow recommendations above for storage.

Acid Cleaning for Biological or Mineral Contamination

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

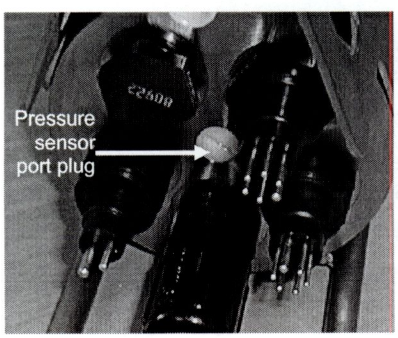
1. Prepare for cleaning:
   A. Place a 0.6 m (2 ft) length of Tygon tubing over the end of the cell.
   B. Clamp the SBE 19*plus* so that the cell is vertical, with the Tygon tubing at the bottom end.
   C. Loop the Tygon tubing into a *U* shape, and tape the open end of the tubing in place at the same height as the top of the glass cell.

2. Clean the cell:
   A. Pour **muriatic acid (37% 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.
   C. Rinse the exterior of the SBE 19*plus* to remove any spilled acid from the surface.
   D. Flush the cell for 5 minutes with warm (not hot), clean, de-ionized water.
   E. Fill the cell with a **1%** solution of Triton X-100 and let it stand for 5 minutes.
   F. Drain and flush with warm, clean, de-ionized water for 1 minute.

3. Prepare for deployment, **or**
   Follow recommendations above for storage.

Repeat this procedure a few times for reluctant contamination. Return to Sea-Bird for cleaning if three acid rinses do not restore the cell's calibration. We recommend that you do not clean with acid more than once per week.

Pressure Sensor Maintenance



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

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**.

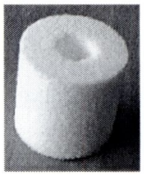
Periodically (approximately once a year) inspect the pressure port to remove any particles, debris, etc:

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 Anti-Foulant Devices (SBE 16*plus*, SBE 19*plus*)



AF24173
Anti-Foulant
Device

The SBE 16*plus* and 19*plus* (moored option) have an anti-foulant device cup and cap on each end of the conductivity cell. A new SBE 16*plus* (or moored option 19*plus*) is shipped with an Anti-Foulant Device and a protective plug pre-installed in each cup.

WARNING!

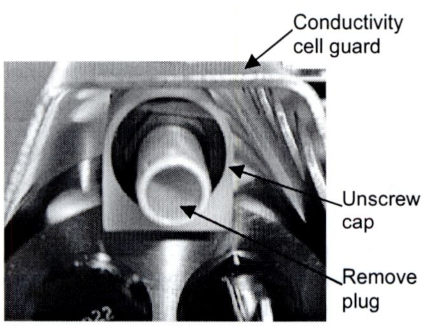
AF24173 Anti-Foulant Devices contain bis(tributyltin) oxide. Handle the devices only with rubber or latex gloves. Wear eye protection. Wash with soap and water after handling.

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

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

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

1. Remove the protective plug;
2. Unscrew the cap with a 5/8-inch socket wrench;
3. Remove the old Anti-Foulant Device. If the old Anti-Foulant Device is difficult to remove:
   - Use needle-nose pliers and carefully break up material;
   - If necessary, remove the conductivity cell 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. Replace the protective plug if not ready to redeploy.



CAUTION:

One of the anti-foulant device cups is attached to the guard and connected to the conductivity cell. **Removing the guard without disconnecting the cup from the guard will break the cell.** If the guard must be removed:

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

Sensor Calibration

Note:
After recalibration, Sea-Bird enters the new calibration coefficients in the SBE 19*plus*' EEPROM, and ships the instrument back to the user with Calibration Certificates showing the new coefficients. The user must enter the coefficients in the instrument configuration (.con) file in the Configure menu in SEASAVE or SBE Data Processing.

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, temperature, and pressure sensors on the SBE 19*plus* are supplied fully calibrated, with coefficients stored in EEPROM in the SBE 19*plus* and printed on their respective Calibration Certificates (see back of manual).

We recommend that the SBE 19*plus* be returned to Sea-Bird for calibration.

Conductivity Sensor Calibration

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

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

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

Temperature Sensor Calibration

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

Pressure Sensor Calibration

The SBE 19*plus* includes a strain-gauge pressure sensor. This sensor is capable of meeting the SBE 19*plus'* error specification with some allowance for aging and ambient-temperature induced drift.

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

Section 6: Troubleshooting

This section reviews common problems in operating the SBE 19*plus*, and provides the most likely causes and solutions.

Each SBE 19*plus* is shipped with a configuration (.con) file that matches the configuration of the instrument (number and type of auxiliary sensors, etc.) and includes the instrument calibration coefficients.

Problem 1: Unable to Communicate

The `S>` prompt indicates that communications between the SBE 19*plus* and computer have been established. Before proceeding with troubleshooting, attempt to establish communications again by clicking the Connect button on SEATERM's toolbar or hitting the Enter key several times.

Cause/Solution 1: The I/O cable connection may be loose. Check the cabling between the SBE 19*plus* and computer for a loose connection.

Cause/Solution 2: The instrument type and/or its communication settings may not have been entered correctly in SEATERM. Select the SBE 19*plus* in the Configure menu and verify the settings in the Configuration Options dialog box. The settings should match those on the instrument Configuration Sheet.

Cause/Solution 3: The I/O cable may not be the correct one. The I/O cable supplied with the SBE 19*plus* permits connection to standard RS-232 9-pin interfaces.

Problem 2: No Data Recorded

Cause/Solution 1: The SBE 19*plus'* memory may be full; once the memory is full, no further data is recorded. Verify that the memory is not full using **DS** (*free = 0* or *1* if memory is full). Sea-Bird recommends that you upload all previous data before beginning another deployment. Once the data is uploaded, use **INITLOGGING** to reset the memory. After the memory is reset, **DS** will show *samples = 0*.

Problem 3: Nonsense or Unreasonable Data

The symptom of this problem is an uploaded file that contains nonsense values (for example, 9999.999) or unreasonable values (for example, values that are outside the expected range of the data).

Cause/Solution 1: An uploaded data file with nonsense values may be caused by incorrect instrument configuration in the .con file. Verify that the settings in the instrument .con file match the instrument Configuration Sheet.

Cause/Solution 2: An uploaded data file with unreasonable (i.e., out of the expected range) values for temperature, conductivity, etc. may be caused by incorrect calibration coefficients in the instrument .con file. Verify the calibration coefficients in the instrument .con file match the instrument Calibration Certificates.

Problem 4: Program Corrupted

> **Note:**
> Using the reset switch does not affect the SBE 19*plus'* memory - data in memory and user-programmable parameter values are unaffected.

Cause/Solution 1: In rare cases, the program that controls the SBE 19*plus'* microprocessor can be corrupted by a severe static shock or other problem. This program can be initialized by using the reset switch. Proceed as follows to initialize:

1. Open the battery end cap and remove the batteries (see *Replacing /Recharging Batteries* in *Section 5: Routine Maintenance and Calibration*).
2. There is a small, pushbutton switch on the battery compartment bulkhead, which is visible after the batteries are removed. The switch is used to disconnect the internal lithium batteries from the electronics. Push the switch in for 1 second.
3. Reinstall or replace the batteries, and close the battery end cap.
4. Establish communications with the SBE 19*plus* (see *Section 3: Power and Communications Test*). Use **DS** to verify that the date and time and sample number are correct.

Glossary

Batteries – Nine alkaline D-cells standard. Available with optional Ni-Cad batteries.

Fouling – Biological growth in the conductivity cell during deployment. Typically a concern when SBE 19*plus* is used in a moored application; install moored mode conversion kit with AF24173 Anti-Foulant Devices for these applications.

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 pressure, data from auxiliary sensors, and derives variables such as salinity and sound velocity.

Scan – One data sample containing temperature, conductivity, pressure, date and time (moored mode only), and optional auxiliary inputs.

SEACAT*plus* – High-accuracy conductivity, temperature, and pressure recorder. The SEACAT*plus* is available as the SBE 16*plus* (moored applications) and SBE 19*plus* (profiling or moored applications). A *plus* version of the SBE 21 (thermosalinograph) is under development.

SEASAVE – Sea-Bird's Win 95/98/NT/2000/XP software used to acquire, convert, and display real-time or archived raw data.

SEASOFT-DOS – Sea-Bird's complete DOS software package, which includes software for communication, real-time data acquisition, and data analysis and display. SEASOFT-DOS' modules for real-time data acquisition and data analysis are not compatible with the SBE 19*plus*' data output formats (except for an SBE 19*plus* operating in Compatible State).

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 terminal program used to communicate with the SBE 19*plus*.

SeatermAF – Sea-Bird's Win 95/98/NT/2000/XP terminal program used to communicate with the SBE 19*plus* when it is used with a 90208 Auto Fire Module (AFM). See the AFM manual.

TCXO – Temperature Compensated Crystal Oscillator.

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

Appendix I: Functional Description and Circuitry

Sensors

The SBE19*plus* 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 the original SEACAT design. The SBE19*plus* differs from the SBE 19 in that it uses three independent channels to digitize temperature, conductivity, and pressure concurrently. Multiplexing is not used for these channels.

The pressure sensor is a Druck strain-gauge sensor.

Sensor Interface

Temperature is acquired by applying an AC excitation to a bridge circuit containing an ultra-stable aged thermistor with a drift rate of less than 0.002 °C per year. The other elements in the bridge are VISHAY precision resistors. A 24-bit A/D converter digitizes the output of the bridge. AC excitation and ratiometric comparison avoids errors caused by parasitic thermocouples, offset voltages, leakage currents, and reference errors.

Conductivity is acquired using an ultra-precision Wein-Bridge oscillator to generate a frequency output in response to changes in conductivity.

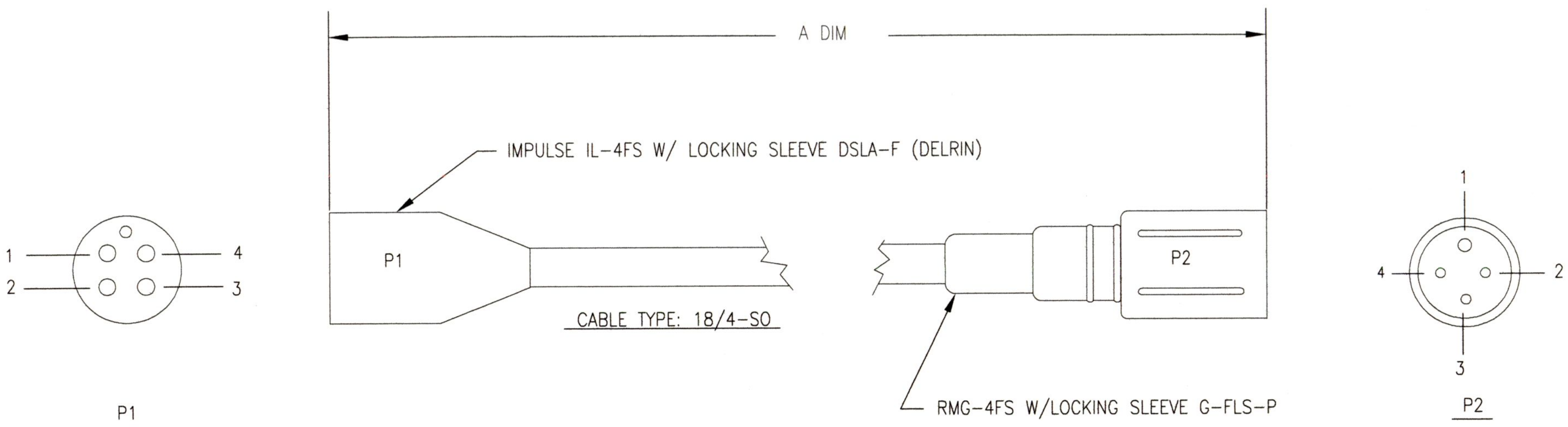
Strain-gauge pressure is acquired by applying an AC excitation to the pressure bridge. A 24-bit A/D converter digitizes the output of the bridge. AC excitation and ratiometric comparison avoids errors caused by parasitic thermocouples, offset voltages, leakage currents, and reference errors. A silicon diode embedded in the pressure bridge is used to measure the temperature of the pressure bridge. This temperature is used to perform offset and span corrections on the measured pressure signal.

The four external 0 to 5 volt DC voltage channels are processed by differential amplifiers with an input resistance of 50K ohms and are digitized with a 14-bit A/D converter.

Real-Time Clock

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

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
1/94	A	ADDED DIM TABLE		BMC	
10/94	B	ADD DELRIN L.S.		BMC	



P1 IL-4FS	P2 RMG-4FS
PIN 1	PIN 1
PIN 2	PIN 2
PIN 3	PIN 3
PIN 4	PIN 4

SBE PART NO	A DIM
17616	43 INCHES
17775	15 INCHES
171901	36 INCHES

TOLERANCES	SEA-BIRD ELECTRONICS, INC			
FRACTIONAL	P/N SEE TABLE	SCALE –	DRAWN BY BMC / APPROVED BY	
DECIMAL	TITLE DATA I/O – PATCH CABLE			
ANGULAR	DATE 8/92	DRAWING NUMBER 31429		REV B

D. Instrument status capture (**.cap**) file, showing the setup programmed into the instrument as it was when the instrument was shipped. The .cap file shows the results of the status (DS) command and, as applicable, the calibration coefficients command (DC or DCAL), diagnostic command (J), and various other diagnostic commands. The file is named dsdc****.cap or dsj****.cap, where **** is the instrument serial number. For example, for an SBE 19*plus* with serial number 2375, we name the file dsdc237 results. You may rename the .cap file if desired.

E. (Only for SBE 26)
Configuration (**.ini**) file, which contains calibration coefficients as well as Comm port and upload baud rate. The .ini file is used by SeatermW, our Windows software. The .ini file is named ****.ini, where **** is the instrument serial number. For example, for an instrument with serial number 2375, we name the file 2375.ini. You may rename the .ini file if desired.

F. **Manual** - Job-specific manual(s) in Adobe Acrobat .pdf form. This includes the generic instrument manual as well as instrument configuration, calibration coefficients, schematics, pressure test certificates, application notes, etc. specific to your instrument. The manual is named manual-xx-****.pdf, where xx is the instrument type and **** is the instrument serial number. For example, for an SBE 19*plus* with serial number 2375, we name the file manual-19p-2375.pdf.
NOTE: Sea-Bird creates 1 CD-ROM per system. For example, if you ordered an SBE 19*plus* with an SBE 33 Deck Unit and SBE 32 Carousel Water Sampler, the CD-ROM contains job-specific manuals for the 19*plus*, 33, and 32. The CD-ROM is typically packed with the CTD, if a CTD is part of the order.

6. (Only for SBE 16*plus* and 19*plus*)
LOADSCP.exe - program to reload calibration coefficients into a .con file, if the .con file was inadvertently deleted or changed. Contact Sea-Bird if you need to use this program.

7. (Only for instruments that store calibration coefficients internally)
Prog.exe** - program to reload calibration coefficients into an instrument, if the coefficients were inadvertently deleted or changed. There are many versions of this program, depending on the instrument type. Contact Sea-Bird if you need to use this program. Only the program corresponding to your instrument is on the CD:

Prog11v2 - SBE 11*plus* V2
Prog16im - SBE 16*plus*-IM
Prog35 - SBE 35 and 35RT
Prog37 - SBE 37-SM and 37-SI (RS-232 versions)
Prog37im - SBE 37-IM
Prog37o - older SBE 37-SM and 37-SI (RS-232 versions)
Prog37imo - older SBE 37-IM
Prog38 - SBE 38
Prog39T - SBE 39 without pressure sensor
Prog39 - SBE 39 with pressure sensor
Prog48 - SBE 48
Prog485 - SBE 37-SM and 37-SI (RS-485 versions)
Prog485o – older SBE 37-SM and 37-SI (RS-485 versions)
Prog49 - SBE 49
Prog50 - SBE 50
Progscp - SBE 16*plus* and 19*plus*

8. **readmefirst.txt** – a file containing this text

9. **sbe.ico** - graphic used by our software installation program (for Windows software)

10. **Seasoft-Win32.exe** - 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 the following stand-alone programs (install any or all of these):

A. SEATERM (terminal program for communication with most of our instruments)

B. SeatermAF (terminal program for SBE 17*plus* V2 and PN 90208 Auto Fire Module)

C. SEASAVE (real-time data acquisition and display program)

D. SBE Data Processing (data processing program)

E. Plot39 (plotting program for SBE 39 data)

11. **SeatermW_V*_**.exe** - Windows 95/98/NT/2000/XP software for SBE 26, which provides pre-deployment planning, setup and data retrieval, and separation of uploaded data into separate wave and tide files (*_** in the file name indicates the software revision number).
NOTE: SeatermW includes some of the functions in SEASOFT for Waves - DOS; see our website for future availability of a Windows version of the remaining DOS modules.

REMOVING EXISTING SEA-BIRD SOFTWARE

To ensure a *clean* installation, remove any older versions of the software on your system before you install the new software. If running Windows 98:

1. Remove Windows software from system -
   A. Click Start/Settings/Control Panel.
   B. Double click Add/Remove Programs.
   C. On the Install/Uninstall tab, click software you want to remove and then click the Add/Remove button.

2. Remove Windows software from Start menu -
   A. Click Start/Programs/Sea-Bird.
   B. Right click software you want to remove, and then click Delete.

INSTALLING SEA-BIRD SOFTWARE

1. Insert the CD-ROM in the CD-ROM drive.

2. Windows Software - Open Windows Explorer and navigate to your CD-ROM drive:
   A. (all instruments except SBE 26) Double click on Seasoft-Win32.exe. The application will guide you through the installation process.
   B. (SBE 26) Double click on SeatermW_V*_**.exe. The application will guide you through the installation process.

3. DOS Software -
   A. (all instruments except SBE 26) Copy seasoft.dos to the desired location on your hard drive. In a DOS window, run SINSTALL.bat to install the software.
   B. (SBE 26) Copy sswaves.dos to the desired location on your hard drive. In a DOS window, run SETUP26.bat to install the software.

INSTALLING INSTRUMENT-SPECIFIC FILES

1. Insert the CD-ROM in the CD-ROM drive.

2. Copy the instrument-specific files to the directory where you plan to store your instrument's data. Instrument-specific files include, as applicable: .cal, .con, .cap, .cfg, .ini, and .pdf file.

CD CONTENTS

1. **Adobe Acrobat** directory - Free software needed to open .pdf files (job-specific manual as well as manuals and other documentation on our website).

2. **seasoft.dos** directory – SEASOFT-DOS software package, which includes software for communication, real-time data acquisition, and data analysis and display.

3. **sswaves.dos** directory - SEASOFT for Waves - DOS software package for SBE 26 Wave and Tide Recorder, which provides pre-deployment planning, setup and data retrieval, separation of uploaded data into separate wave and tide files, plotting, auto-spectrum, time series analysis, and statistics reporting.

4. **Website** directory - Our entire website for off-line reference. Double click on ***index.htm*** to access the website home page; the off-line home page will open in your Internet browser (such as Internet Explorer or Netscape Navigator).

5. **Instrument-specific files:**

   A. (only for instruments that store calibration coefficients internally)
   Calibration (**.cal**) file, which defines the calibration coefficients. The .cal file is used with Prog**.exe to reload coefficients into the instrument if they were inadvertently deleted or changed. Contact Sea-Bird if you need to use this file. The file is named ****.cal, where **** is the instrument serial number. For example, for an instrument with serial number 2375, we name the file 2375.cal. You may rename the .cal file if desired.

   B. (only for SBE 26, on special request)
   Configuration (**Term26.cfg**) file, which contains calibration coefficients as well as Comm port and upload baud rate. The .cfg file is used by the TERM26 module in SEASOFT for Waves - DOS. **Do not rename** the .cfg file.
   NOTE: SeatermW (Windows software) replaces the functions in SEASOFT for Waves - DOS which require the .cfg file. Therefore, we only supply a .cfg file on special request.

   C. (only for configurable instruments - SBE 9/9*plus*, 16/16*plus*, 19/19*plus*, 21, 25, 31)
   Configuration (**.con**) file, which defines the instrument configuration and calibration coefficients. The .con file is needed by SEASAVE for real-time data acquisition and by SBE Data Processing for post-processing of the data. The file is named ****.con, where **** is the instrument serial number. For example, for an instrument with serial number 2375, we name the file 2375.con. You may rename the .con file if desired.
   NOTE: A copy of the .con file is also included on a floppy disk that ships with the instrument.

Battery Wiring

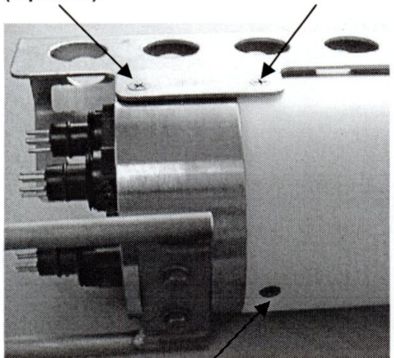
SBE 19*plus'* main battery is a series connection of D-cells that drop into the battery compartment as a cluster of end-to-end stacks, three batteries each (standard 9-cell battery pack has three stacks). The positive battery connections are contact areas on double-thick printed circuit disks that form the internal bulkhead and battery retainer plates. Battery negative contacts are heavy beryllium-copper springs. The three cell stacks are aligned by plastic insulated aluminum spacers which also serve as electrical interconnects. The battery-to-circuit card connection is made by means of a Molex-type 3-pin pc board connector (JP3 on the power PCB).

The Power PCB contains three series-connected lithium cells (non-hazardous) which are diode OR'd with the main battery (and external power source, if used). The lithium supply is capable of supporting all SBE 19*plus* functions and serves to permit orderly shutdown in the event of failed or exhausted main batteries. The main batteries can be changed without disturbing memory or the real-time clock.

Appendix II: Electronics Disassembly/Reassembly

> **CAUTION:**
> Use caution during disassembly and reassembly to avoid breaking the conductivity cell.

Disassembly



1. As a precaution, upload any data in memory before beginning.

2. Remove the two Phillips-head screws holding the conductivity cell guard to the housing. **Do not remove the two screws holding the conductivity cell guard to the sensor end cap.**

3. Remove the Phillips-head screw holding the sensor end cap to the housing on the side opposite the conductivity cell guard.

4. Remove the sensor end cap (with attached conductivity cell and cell guard) and electronics:
   A. Wipe the outside of the sensor end cap and housing dry, being careful to remove any water at the seam between them.
   B. Slide the end cap and attached electronics out of the housing.
   C. The electronics are electrically connected to the battery compartment bulkhead with a Molex connector. Disconnect the Molex connector.
   D. Remove any water from the O-rings and mating surfaces inside the housing with a lint-free cloth or tissue.
   E. Be careful to protect the O-rings from damage or contamination.

Reassembly

> **Note:**
> Before delivery, a desiccant package is inserted in the electronics chamber, and the chamber is filled with dry Argon gas. These measures help prevent condensation. **If the electronics are exposed to the atmosphere, dry gas backfill with Argon and replace the desiccant package.** See *Application Note 71: Desiccant Use and Regeneration (drying)* for desiccant information. Battery replacement does not affect desiccation of the electronics, as no significant gas exchange is possible unless the electronics PCBs are actually removed from the housing.

1. Reinstall the sensor end cap, conductivity cell and guard, and electronics:
   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 or replace as necessary. Apply a light coat of O-ring lubricant (Parker Super O Lube) to the O-rings and mating surfaces.
   B. Plug the Molex connector onto the pins on the battery compartment bulkhead. Verify the connector holes and pins are properly aligned.
   C. Carefully fit the end cap and electronics into the housing until the O-rings are fully seated.

2. Reinstall the three screws to secure the end cap.

3. Reset the date and time (**MMDDYY=** and **HHMMSS=**) and initialize logging (**INITLOGGING**) before redeploying. No other parameters should have been affected by the electronics disassembly (send **DS** to verify).

Appendix III: Command Summary

> **Note:**
> See *Command Descriptions* in *Section 4: Deploying and Operating SBE 19plus* for detailed information and examples.

CATEGORY	COMMAND	DESCRIPTION
Status	**DS**	Display status and setup parameters.
General Setup	**MMDDYY=mmddyy**	Set real-time clock month, day, year. Follow with **HHMMSS=** or it will not set date.
	DDMMYY=ddmmyy	Set real-time clock day, month, year. Follow with **HHMMSS=** or it will not set date.
	HHMMSS=hhmmss	Set real-time clock hour, minute, second.
	BAUD=x	**x=** baud rate (1200, 2400, 4800, 9600, 19200, or 38400). Default 9600.
	ECHO=x	**x=Y**: Echo characters as you type. **x=N**: Do not.
	BATTERYTYPE=x	**x=0**: Alkaline (or optional lithium) batteries. **x=1**: Ni-Cad batteries.
	INITLOGGING	After all previous data has been uploaded, send this command before starting to log to make entire memory available for recording. If not sent, data stored after last sample. Equivalent to **SAMPLENUMBER=0**.
	SAMPLENUMBER=x	**x=** sample number for first sample when logging begins. After all previous data has been uploaded, set to 0 before starting to log to make entire memory available for recording. If not reset to 0, data stored after last sample. Equivalent to **INITLOGGING**.
	HEADERNUMBER=x	**x=** header and cast number for first cast when logging begins.
	FLASHINIT	Map bad blocks and erase FLASH memory, **which destroys all data in SBE 19*plus***.
	QS	Enter quiescent (sleep) state. Main power turned off, but data logging and memory retention unaffected.
Sensor Setup	**PTYPE=x**	**x=1**: Strain-gauge pressure sensor.
	VOLT0=x	**x=Y**: Enable external voltage 0. **x=N**: Do not.
	VOLT1=x	**x=Y**: Enable external voltage 1. **x=N**: Do not.
	VOLT2=x	**x=Y**: Enable external voltage 2. **x=N**: Do not.
	VOLT3=x	**x=Y**: Enable external voltage 3. **x=N**: Do not.
Profiling Mode Setup (commands do not affect moored mode operation)	**MP**	Set to Profiling mode.
	MINCONDFREQ=x	**x=** minimum conductivity frequency (Hz) to enable pump turn-on.
	PUMPDELAY=x	**x=** time (seconds) to wait after minimum conductivity frequency is reached before turning pump on. Default 60 seconds.
	IGNORESWITCH=x	**x=Y**: Ignore magnetic switch position for starting or stopping logging. Use **STARTNOW**, **STARTLATER**, and **STOP** to control logging. **x=N**: Do not ignore magnetic switch position.
	AUTORUN=x	**x=Y**: Automatically wake up and start logging when external power is applied; stop logging when external power is removed. Magnetic switch position has no effect on logging. **x=N**: Do not automatically start logging when external power is applied.
	NAVG=x	**x=** number of samples to average. SBE 19*plus* samples at 4 Hz and averages **NAVG** samples. Default =1.

CATEGORY	COMMAND	DESCRIPTION
Moored Mode Setup (commands do not affect profiling mode operation)	**MM**	Set to Moored mode.
	MOOREDTXREALTIME =x	**x=Y**: Output real-time data. **x=N**: Do not.
	DELAYBEFORESAMPLING =x	**x=** time (seconds) to wait after switching on external voltage before sampling (0-32,000 seconds). Default 0 seconds.
	MOOREDPUMPMODE =x	**x=0**: No pump. **x=1**: Run pump for 0.5 seconds before each sample. **x=2**: Run pump during each sample.
	SAMPLEINTERVAL=x	**x=** interval (seconds) between samples (10 - 14,400).
	NCYCLES=x	**x=** number of measurements to take and average every **SAMPLEINTERVAL** seconds. Default = 1.
Output Format Setup	**OUTPUTFORMAT=x**	**x=0**: output raw frequencies and voltages in Hex (required if using SEASAVE). **x=1**: output converted data in Hex. **x=2**: output raw frequencies and voltages in decimal. **x=3**: output converted data in decimal. **x=4**: output pressure and scan number in Hex.
	OUTPUTSAL=x	**x=Y**: Calculate and output salinity (psu). Only applies if **OUTPUTFORMAT=3**. **x=N**: Do not.
	OUTPUTSV=x	**x=Y**: Calculate and output sound velocity (m/sec). Only applies if **OUTPUTFORMAT=3**. **x=N**: Do not.
	OUTPUTUCSD=x	**x=Y**: Calculate and output density sigma-t (kg/m^3), battery voltage, and operating current (mA). Only applies if **OUTPUTFORMAT=3**. **x=N**: Do not.
Logging	**STARTNOW**	Start logging now.
	STARTMMDDYY =mmddyy	Delayed logging start: month, day, year. Must follow with **STARTHHMMSS=**.
	STARTDDMMYY =ddmmyy	Delayed logging start: day, month, year. Must follow with **STARTHHMMSS=.**
	STARTHHMMSS =hhmmss	Delayed logging start: hour, minute, second.
	STARTLATER	Start logging at delayed logging start date and time.
	STOP	Stop logging or stop waiting to start logging. Press Enter key to get **S>** prompt before entering **STOP**. Must stop logging before uploading data. If in Profiling mode and **IGNORESWITCH=N**, can also turn magnetic switch Off to stop logging.
Data Upload Stop logging before uploading.	**DDb,e**	Upload data from scan b to scan e.
	DCn	**Profiling mode only.** Upload data from cast n.
	DHb,e	Upload headers from header b to header e.
Sampling	**SL**	Output last sample from buffer and leave power on.
	SLT	Output last sample from buffer, then take new sample and store data in buffer. Leave power on.
	TS	Take sample, store data in buffer, output data, and leave power on.
	TSS	Take sample, **store in buffer and FLASH memory**, output data, and turn power off.
	TSSON	Take sample, **store in buffer and FLASH memory**, output data, and leave power on.

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

CATEGORY	COMMAND	DESCRIPTION
Testing Takes and outputs 100 samples for each test. Press Esc key or Stop on Toolbar to stop test.	**TT**	Measure temperature, output converted data.
	TC	Measure conductivity, output converted data.
	TP	Measure pressure, output converted data.
	TV	Measure four external voltage channels, output converted data.
	TTR	Measure temperature, output raw data
	TCR	Measure conductivity, output raw data.
	TPR	Measure pressure, output raw data.
	TVR	Measure four external voltage channels, output raw data.
	PUMPON	Turn pump on for testing purposes.
	PUMPOFF	Turn pump off for testing purposes.
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 SBE 19*plus*.	**DCAL**	Display calibration coefficients; all coefficients and dates listed below are included in display (as applicable). Use individual commands below to modify a particular coefficient or date.
	TCALDATE=S	S=Temperature calibration date.
	TAO=F	F=Temperature A0.
	TA1=F	F=Temperature A1.
	TA2=F	F=Temperature A2.
	TA3=F	F=Temperature A3.
	TOFFSET=F	F=Temperature offset correction.
	CCALDATE=S	S=Conductivity calibration date.
	CG=F	F=Conductivity G.
	CH=F	F=Conductivity H.
	CI=F	F=Conductivity I.
	CJ=F	F=Conductivity J.
	CPCOR=F	F=Conductivity pcor.
	CTCOR=F	F=Conductivity tcor.
	CSLOPE=F	F=Conductivity slope correction.
	CF0=F	F=Conductivity 0 value (Compatible State only).
	PCALDATE=S	S=Pressure calibration date.
	PRANGE=F	F=Pressure sensor full scale range (psi).
	POFFSET=F	F=Pressure offset correction.
	PA0=F	F=Strain-gauge pressure A0.
	PA1=F	F=Strain-gauge pressure A1.
	PA2=F	F=Strain-gauge pressure A2.
	PTEMPA0=F	F=Strain-gauge pressure temperature A0.
	PTEMPA1=F	F=Strain-gauge pressure temperature A1.
	PTEMPA2=F	F=Strain-gauge pressure temperature A2.
	PTCA0=F	F=Strain-gauge pressure temperature compensation ptca0.
	PTCA1=F	F=Strain-gauge pressure temperature compensation ptca1.
	PTCA2=F	F=Strain-gauge pressure temperature compensation ptca2.
	PTCB0=F	F=Strain-gauge pressure temperature compensation ptcb0.
	PTCB1=F	F=Strain-gauge pressure temperature compensation ptcb1.
	PTCB2=F	F=Strain-gauge pressure temperature compensation ptcb2.

Appendix IV: Compatible State

Sea-Bird can provide a custom EEPROM for the SBE 19*plus* to accommodate customers with older SBE 19s who need to replace the electronics but want to maintain the command set and output format of the original instrument. Instruments with this custom EEPROM operate in Compatible State, and can then be set to operate in Profiling or Moored mode.

Compatible State Commands

Notes:
The following Compatible State commands have equivalent commands in the SBE 19*plus* command set:
- **IL** = **INITLOGGING**
- **GL** = **INITLOGGING** followed by **STARTNOW**
- **RL** = **STARTNOW**
- **QL** = **STOP**

- Commands marked with * (* is not part of the command) alter the SBE 19*plus'* memory and require verification before executing, to prevent accidental modifications.
  After the command entry, the SBE 19*plus* responds:
  'message' Y/N Type **Y** and press the Enter key.
  The SBE 19*plus* then responds:
  Are you sure ^Y/N Hold down the Ctrl key and type **Y** (any other response aborts command).
- Braces [ ] indicate optional command parameters. Items enclosed in braces need not be entered.

NRC

x=Y: Set conductivity channel to narrow range (fresh water, 0 - 0.6 S/m). If set to narrow range, **DS** indicates *Narrow Range Conductivity*.

x=N: Set conductivity channel to standard range (salt water, 0 - 6.5 S/m).

IL *

Initialize logging - after all previous data has been uploaded from SBE 19*plus*, initialize logging before starting to log again to make entire memory available for recording. **IL** resets sample number, header number, and cast number all to 0. If **IL** is not sent, data will be stored after last recorded sample. **Do not send IL until all existing data has been uploaded.**

GL *

Start logging now, overwriting existing data. First scan is set to 0, so any previously recorded data will be over-written, regardless of whether memory has been initialized or not.

Note:
Profiling mode - The CPU must be active (not in quiescent state) and the magnetic switch must be turned on before using **GL** or **RL**.

RL *

Resume logging now; do not overwrite existing data.
Profiling mode - New cast is started (data is stored after last previously stored cast, and a header is written to provide cast information).
Moored mode - Data is stored after last previously stored sample.

Notes:
- To quit logging in Profiling mode, slide the magnetic switch off or press Ctrl Z or Home key.
- You must quit logging before uploading data.

Notes:
- To save data to a file, click the Capture button on the Toolbar before entering **DD**, **DC**, or **DH**.
- In all upload commands, **B** is upload baud rate (1= 600 baud, 2 = 1200 baud, 3 = 9600 baud, 4 = 19200 baud, 5 = 38400 baud).
- See *Data Output Formats* after these *Command Descriptions*.
- **Use the Upload button on the Toolbar or Upload Data in the Data menu to upload data that will be processed by SEASOFT.** Manually entering the data upload command does not produce data in the correct format for processing by SEASOFT.

QL *

Moored mode - Quit logging. Press Enter key to get **S>** prompt before entering **QL**.

DD[Bb,e]

Upload raw data from scan **b** to scan **e,** at baud rate **B**. If **B** is omitted, baud rate that you are currently communicating with is used. If **b** and **e** are omitted, all data is uploaded. First sample is number 0.

> *Example:* Upload samples 0 through 199 at 38400 baud to a file:
> (Click Capture on Toolbar and enter desired filename in dialog box.)
> **S>DD50,199**

DC[Bn]

Applicable to Profiling mode only - Upload raw data from cast **n**, at baud rate **B**. If **B** is omitted, baud rate that you are currently communicating with is used. If **n** is omitted, data from cast 0 is uploaded. First cast number is 0.

> *Example:* Upload all data in second cast (cast 1) at 38400 baud to a file:
> (Click Capture on Toolbar and enter desired filename in dialog box.)
> **S>DC51**

DH[b,e]

Upload headers from **b** to **e**. Baud rate is baud rate that you are communicating with currently. If **b** and **e** are omitted, all headers are uploaded. First header is 0. The header includes:
- cast number
- month, day, hour, minute, and second when cast was started
- first and last sample in cast
- sample rate (Profiling mode) or interval (Moored mode)
- reason logging was halted
  (batfail = battery voltage too low;
  switch off = switch turned off;
  recv cmd = received **QL** command or Home or Ctrl Z character;
  timeout = error condition;
  unknown = error condition;
  ?????? = error condition)

Compatible State Output Format

> **Note:**
> Sea-Bird's data processing software (SEASOFT-DOS) uses the equations shown to perform these calculations; alternatively, you can use the equations to develop your own processing software.

In Compatible State, data is always output in Hexadecimal form in the order listed below, with no spaces or commas between parameters. Shown with each parameter are the number of digits, and how to calculate the parameter from the data (use the decimal equivalent of the hex data in the equations).

The parameters are defined as follows:
- tttt = 2 bytes of temperature frequency
- cccc = 2 bytes of conductivity frequency
- pppp = 2 bytes of pressure data for Paine strain-gauge pressure sensor
- pppppp = 3 bytes of pressure data for Quartz pressure sensor
- dddd = 2 bytes of pressure temperature data for Quartz pressure sensor
- uuu, vvv, xxx, and yyy = 12 bits each, representing first, second, third, and fourth stored voltage respectively

Shown below are the data formats:

Profiling Mode

- No external voltages sampled:
  With Paine pressure sensor - ttttccccpppp
  With Quartz pressure sensor - ttttccccppppppdddd
- Two external voltages sampled:
  With Paine pressure sensor - ttttccccuuuvvvpppp
  With Quartz pressure sensor - ttttccccppppppuuuvvvdddd
- Four external voltages sampled:
  With Paine pressure sensor - ttttccccuuuvvvxxxyyypppp
  With Quartz pressure sensor - ttttccccppppppuuuvvvxxxyyydddd

The following equations define the calculation of the parameters from the data (use the decimal equivalent of the hex data in the equations):
- Raw temperature frequency = (tttt / 17) + 1950
- Raw standard conductivity frequency =
  square root [(cccc * 2900) + 6,250,000]
- Raw narrow range conductivity frequency (older models) =
  square root [(cccc * 303) + 6,250,000]
- Voltage = voltage number (such as uuu) / 819
- Paine pressure = decimal equivalent of bits 0 - 13 of pppp.
  Bit 14 is sign bit: + if bit 14 = 0; - if bit 14 = 1.
- Quartz pressure = pppppp / 256
- Quartz pressure temperature =
  {[(dddd / 819) + 9.7917] * 23.6967} - 273.15

> *Example*: SBE 19*plus* in Profiling mode with Quartz pressure sensor and two external voltages sampled,
> example scan = 69CC43228D1B8003005908AA
>
> - tttt = 69CC (27084 decimal);
>   temperature frequency = (27084 / 17) + 1950 = 3543.176Hz
> - cccc = 4322 (17186 decimal); conductivity frequency =
>   square root [(17186 * 2900) + 6250000] = 7489.286 Hz
> - pppppp = 8D1B80 (9247616 decimal);
>   Quartz pressure = 9247616 / 256 = 36123.5
> - uuu = 030 (48 decimal); voltage = 48 / 819 = 0.059 volts
> - vvv = 059 (89 decimal); voltage = 89 / 819 = 0.109 volts
> - dddd = 08AA (2218 decimal); Quartz pressure temperature =
>   {[(2218 / 819) + 9.7917] * 23.6967} - 273.15 = 23.0

Reference Data for Profiling Mode

If profiling in Compatible State, the SBE 19*plus* contains reference scans that allow for the calculation of corrected frequencies for temperature and conductivity. The reference data is in scans 5 and 6, and then in two scans after every additional 120 scans. For each set of reference scans, one scan contains a high frequency reference and the other scan contains a low frequency reference.

The data format for the reference scans is:

- **With strain-gauge pressure sensor -** xxrrrrrruuuvvvxxxyyypppp
- **With Quartz pressure sensor -** xxrrrrrrppppppuuuvvvxxxyyydddd

where

- Most significant bit of pressure data (pppp for strain-gauge or pppppp for Quartz) indicates whether the scan is a reference scan.
  If the most significant bit is 1, the scan contains reference resistor frequency information.
- rrrrrr = reference data
- xx = indicator of type of reference data and conductivity range:
  xx = 05 for scans containing high frequency reference data, with Standard conductivity range
  xx = 08 for scans containing high frequency reference data, with Narrow conductivity range
  xx = FF for scans containing low frequency reference data
- u, v, x, y, p, and d are as defined above. Note that if there are no external voltages (or only two), the corresponding terms will be omitted.

The following equations define the calculation of the corrected frequencies from the reference data (use the decimal equivalent of the hex data in the equations):

fcor = square root {[((fraw * fraw) - b) / a] - PC}

where

- fcor = corrected frequency
- fraw = raw frequency
- a = (fhisq - flowsq) / X3
- b = flowsq - (a / X2)
- fhisq = refhi * refhi (where refhi = high frequency reference data)
- flowsq = reflow * reflow (where reflow = low frequency reference data)
- KK = 2.4018669e-11
- X1 = 9.6036247e-9
- X2 = 1.1949587e-7
- X3 = (X2 - X1) / (X2 * X1)
- PC = 1 / (1e6 * KK)

Reference Data and Corrected Frequencies Example:
no external voltages sampled, strain-gauge pressure sensor

scan 4 (CTD data) = 69CC43220EA4
- tttt = 69CC (27084 decimal);
  temperature frequency = (27084 / 17) + 1950 = 3543.176 Hz
- cccc = 4322 (17186 decimal);
  conductivity frequency =
  square root [(17186 * 2900) + 6250000] = 7489.286 Hz
- pppp = 0EA4 (3748 decimal); pressure = 3748

scan 5 (reference scan) = 052A34398EA5
- xx = 05
  (high frequency, standard conductivity reference indicator)
- rrrrrr = 2A3439 (2765881 decimal);
  high reference frequency = 2765881 / 256 = 10804.225 = refhi
- pppp = 8EA5; converting 8 to binary yields 1000. Most significant bit (1) indicates that this is a reference scan. Remainder of pressure is real data 0EA5 (3749 decimal); pressure = 3749

scan 6 (reference scan) = FF0B45808EA4
- xx = FF (low frequency reference indicator)
- rrrrrr = 0B4580 (738688 decimal);
  low reference frequency = 738688 / 256 = 2885.500 = reflow
- pppp = 8EA4; converting 8 to binary yields 1000. Most significant bit (1) indicates that this is a reference scan. Remainder of pressure is real data 0EA4 (3748 decimal); pressure = 3748

scan 7 (CTD data) = 69CE431E0EA5
- tttt = 69CE (27086 decimal);
  temperature frequency = (27086 / 17) + 1950 = 3543.294 Hz
- cccc = 431E (17182 decimal);
  conductivity frequency =
  square root [(17182 * 2900) + 6250000] = 7488.511 Hz
- pppp = 0EA5 (3749 decimal); pressure = 3749

The correction equations shown above the example would be applied to the temperature and conductivity frequencies.

Moored Mode

Moored mode temperature and conductivity data are stored as corrected frequencies. The reference information is not stored with the data. The equations for calculating temperature and standard range conductivity are different than in Profiling Mode; data format and other equations are unchanged from those for Profiling Mode.

The following equations define the calculation of temperature frequency and standard range conductivity frequency from the data (use the decimal equivalent of the hex data in the equations):

Temperature frequency = (tttt / 19) + 2100
Standard conductivity frequency = square root [(cccc * 2100) + 6250000]

Appendix V: AF24173 Anti-Foulant Device

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

AF24173 ANTIFOULANT DEVICE

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

ACTIVE INGREDIENT:

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

DANGER

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

Net Contents: Two antifoulant devices (7.14 g)

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

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

AF24173 Anti-Foulant Device

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

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

DANGER
See Precautionary Statements for additional information.

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

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

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

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

PRECAUTIONARY STATEMENTS

HAZARD TO HUMANS AND DOMESTIC ANIMALS

DANGER

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

PERSONAL PROTECTIVE EQUIPMENT

USER SAFETY RECOMMENDATIONS

Users should:

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

ENVIRONMENTAL HAZARDS

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

PHYSICAL OR CHEMICAL HAZARDS

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

DIRECTIONS FOR USE

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

STORAGE AND DISPOSAL

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

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

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

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

Sea-Bird Electronics/label revised 10-5-02

Appendix VI: Replacement Parts

Part Number	Part	Application Description	Quantity in 19*plus*
30816	Parker 2-234E603-70	O-ring - Battery end cap to housing piston seal (1), sensor end cap to housing seals (2)	3
30090	Parker 2-153N674-70	O-ring - Battery end cap to housing face seal	1
30507	Parker 2-206N674-70	O-ring - Each end of conductivity cell	2
31090	Screw, 10-32 x 5/8 flat Phillips-head, titanium	Secures conductivity cell guard to housing	2
31089	Screw, 10-32 x 1/2 flat Phillips-head, titanium	Secures sensor end cap to housing (side opposite conductivity cell guard)	1
30145	Screw, 6-32 x 1/2 Phillips-head, stainless steel	Secures battery cover plate to battery posts	3
30242	Washer, #6 flat, stainless steel	For screw 30145 (secure battery cover plate to battery posts)	3
41124	Battery cover plate	Retains alkaline batteries	1
22018	Batteries, alkaline D-cell	Power SBE 19*plus*	9
80256	Ni-Cad battery pack	Rechargeable 9-battery pack	1
17133*	2-pin RMG-2FS to 2-pin RMG-2FS cable, 1.1 m (3.7 ft)	From SBE 19*plus* to pump	1
801225*	4-pin RMG-4FS to 9-pin DB-9S I/O cable, 2.4 m (8 ft)	From SBE 19*plus* to computer	1
17043*	Locking sleeve	Locks I/O cable or dummy plug in place	4
17044*	2-pin dummy plug	For when pump not used	1
17046*	4-pin dummy plug	For when I/O cable not used	1
17047*	6-pin dummy plug	For when auxiliary differential input sensors not used	2
50091	Triton X-100	Conductivity cell cleaning solution	1
60021	Spare battery end cap parts	Assorted o-rings and hardware	-
90087	Pump air bleed valve assembly	Y fitting, air bleed valve, cable ties, vinyl tubing	1
50273	Spare hardware kit	Assorted hardware	-
50274	Spare o-ring kit	Assorted o-rings	-
50275	Spare magnetic switch assembly	For starting/stopping logging in Profiling mode	-
50276*	Seaspares kit	Includes 50273, 50274, and 50275 as well as bulkhead connectors, dummy plugs, and other parts	-
50288	Moored Mode Conversion Kit	Anti-foulant device fittings for moored applications (order AF24173 Anti-Foulant Devices separately)	-
801347	AF24173 Anti-Foulant Device	bis(tributyltin) oxide device inserted into anti-foulant device cup, for moored applications	2

* For standard bulkhead connectors

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SBE 19*plus* SEACAT Profiler Reference Sheet

(see SBE 19*plus* User's Manual for complete details)

Sampling Modes

- **Profiling (MP)** –Vertical profiles, sampling at 4 Hz. SBE 19*plus* runs continuously.
- **Moored (MM)** – Time series measurements once every 10 seconds to once every 4 hours. SBE 19*plus* powers down between samples.

Communication Setup Parameters

1. Double click on SeaTerm.exe.

2. Once main screen appears, in Configure menu select SBE 19*plus*. 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: None
   - Mode: RS-232 (Full Duplex)

Deployment

1. Batteries:
   A. *Remove battery end cap*: Wipe dry housing/end cap seam. Unthread end cap by rotating counter-clockwise. Wipe dry O-ring mating surfaces in housing with lint-free cloth.
   B. *Remove and replace battery cover plate and batteries*: Remove three Phillips-head screws and washers from battery cover plate, and remove cover plate. Turn SBE 19*plus* over and remove batteries. Install new batteries, + terminals against flat contacts and - terminals against spring contacts. Align battery cover plate with housing. Reinstall three Phillips-head screws and washers, while pushing hard on battery cover plate to depress spring contacts at bottom of battery compartment.
   C. *Reinstall battery end cap*: Remove water from O-rings and mating surfaces with lint-free cloth. Inspect O-rings and mating surfaces for dirt, nicks, and cuts. Clean/replace as necessary. Apply light coat of O-ring lubricant to O-ring and mating surfaces. Fit end cap into housing and rethread into place, using a wrench to ensure end cap is tightly secured.

2. Program SBE 19*plus* for intended deployment (see other side of this sheet for *Command Instructions and List*):
   A. Set date and time.
   B. Ensure all data has been uploaded, and then send **INITLOGGING** to make entire memory available for recording. If **INITLOGGING** is not sent, data will be stored after last recorded sample.
   C. Establish setup and logging parameters. Use **STARTMMDDYY=**, **STARTHHMMSS=**, and **STARTLATER** to establish delayed start date and time for Moored mode, or for Profiling mode (if **IGNORESWITCH=Y**).

3. Install a cable or dummy plug for each connector on SBE 19*plus* sensor end cap. Install a locking sleeve over each plug/cable connector. Connect other end of cables to appropriate sensors.

4. Verify hardware and external fittings are secure.

5. Remove Tygon tubing that was looped end-to-end around conductivity cell for storage. Reconnect Tygon tubing from pump to conductivity cell.

6. To start logging in **Profiling mode** –
   - (if **IGNORESWITCH=N**) Turn on magnetic switch;
   - (if **IGNORESWITCH=Y**) If not already done, send **STARTNOW** or **STARTMMDDYY=**, **STARTHHMMSS=**, and **STARTLATER**;
   - (if **AUTORUN=Y**) Turn on power.

7. To start logging in **Moored mode** - If not already done, send **STARTNOW** or **STARTMMDDYY=**, **STARTHHMMSS=**, and **STARTLATER**.

Command Instructions and List

- Input commands in upper or lower case letters and register commands by pressing Enter key.
- SBE 19*plus* 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, SBE 19*plus* returns to quiescent (sleep) state.
- If in quiescent (sleep) state, re-establish communications by clicking Connect on Toolbar or pressing Enter key to get `S>` prompt.

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

CATEGORY	COMMAND	DESCRIPTION
Status	**DS**	Display status and setup parameters.
General Setup	**MMDDYY=mmddyy**	Set real-time clock month, day, year. Must follow with **HHMMSS=**.
	DDMMYY=ddmmyy	Set real-time clock day, month, year. Must follow with **HHMMSS=**.
	HHMMSS=hhmmss	Set real-time clock hour, minute, second.
	BAUD=x	x= baud rate (1200, 2400, 4800, 9600, 19200, 38400). Default 9600.
	ECHO=x	**x=Y**: Echo characters as you type. **x=N**: Do not.
	BATTERYTYPE=x	**x=0**: Alkaline batteries. **x=1**: Ni-Cad batteries.
	INITLOGGING	After uploading data, initialize logging to make entire memory available for recording.
	SAMPLENUMBER=x	x= sample number for first sample when logging begins.
	HEADERNUMBER=x	x= header and cast number for first cast when logging begins.
	FLASHINIT	Map bad blocks and erase FLASH memory, destroying all data.
	QS	Place SBE 19*plus* in quiescent (sleep) state. Logging and memory retention not affected.
Sensor Setup	**PTYPE=x**	**x=1**: Strain gauge pressure.
	VOLT0=x **VOLT1=x** **VOLT2=x** **VOLT3=x**	**x=Y**: Sample external voltage (voltage 0, 1, 2, or 3). **x=N**: Do not.
Profiling Mode Setup (no effect if in moored mode)	**MP**	Set to Profiling mode.
	MINCONDFREQ=x	x= minimum conductivity frequency (Hz) to enable pump turn-on.
	PUMPDELAY=x	x= time (seconds) to wait after minimum conductivity frequency reached before turning pump on.
	IGNORESWITCH=x	**x=Y**: Ignore switch for starting/stopping logging. **x=N**: Do not.
	AUTORUN=x	**x=Y:** Start / stop logging when external power applied / removed. **x=N:** Do not.
	NAVG=x	x= number of samples to average (always samples at 4 Hz).
Moored Mode Setup (no effect if in profiling mode)	**MM**	Set to Moored mode.
	MOOREDTXREALTIME=x	**x=Y**: Output real-time data. **x=N**: Do not.
	DELAYBEFORESAMPLING=x	x= time (seconds) to wait after switching on external voltage before sampling.
	MOOREDPUMPMODE=x	**x=0**: No pump. **x=1**: Run pump for 0.5 seconds before each sample. **x=2**: Run pump during each sample.
	SAMPLEINTERVAL=x	x = interval (seconds) between samples (10 - 14,400).
	NCYCLES=x	x= number of measurements to take and average every **SAMPLEINTERVAL** seconds.
Output Format	**OUTPUTFORMAT=x**	**x=0**: Output raw frequencies/voltages in Hex. **x=1**: output converted data in Hex. **x=2**: Output raw frequencies/voltages in decimal. **x=3**: Output converted data in decimal. **x=4**: Output pressure and scan number in Hex.
	OUTPUTSAL=x	x=Y: Output salinity (psu). **x=N**: Do not.
	OUTPUTSV=x	x=Y: Output sound velocity (m/sec). **x=N**: Do not.
	OUTPUTUCSD=x	x=Y: Output sigma-t (kg/m^3), battery voltage, operating current (mA). **x=N**: Do not.
Logging	**STARTNOW**	Start logging now.
	STARTMMDDYY=mmddyy	Delayed logging start: month, day, year. Must follow with **STARTHHMMSS=**.
	STARTDDMMYY=ddmmyy	Delayed logging start: day, month, year. Must follow with **STARTHHMMSS=.**
	STARTHHMMSS=hhmmss	Delayed logging start: hour, minute, second.
	STARTLATER	Start logging at delayed start time.
	STOP	Stop logging or waiting to start logging. Press Enter key to get **S>** prompt before entering command. Must stop logging before uploading data.
Data Upload	**DDb,e**	Upload data from scan b to scan e.
	DCn	**Profiling mode.** Upload data from cast n.
	DHb,e	Upload headers from header b to header e
Sampling	**SL**	Output last sample from buffer and leave power on.
	SLT	Output last sample from buffer, take new sample and store in buffer. Leave power on.
	TS	Take sample, store in buffer, output data. Leave power on.
	TSS	Take sample, **store in buffer and FLASH memory**, output data, turn power off.
	TSSON	Take sample, **store in buffer and FLASH memory**, output data, leave power on.
Coefficients	**DCAL**	Display calibration coefficients.

SPECIFICATIONS

SBE 19plus Specifications.. 1

SBE 5M Pump.. 3

SEACAT Profiler

SBE 19*plus*

The SBE 19*plus* is the next generation *Personal CTD*, bringing numerous improvements in accuracy, resolution (in fresh as well as salt water), reliability, and ease-of-use to the wide range of research, monitoring, and engineering applications pioneered by its legendary SEACAT predecessor. The 19*plus* samples faster (4 Hz vs 2), is more accurate (0.005 vs 0.01 in T, 0.0005 vs 0.001 in C, and 0.1% vs 0.25% — with *seven* times the resolution — in D), and has more memory (8 Mbyte vs 1). There is more power for auxiliary sensors (500 ma vs 50), and they are acquired at higher resolution (14 bit vs 12). Cabling is simpler and more reliable because there are four differential auxiliary inputs on two separate connectors, and a dedicated connector for the pump. All exposed metal parts are titanium, instead of aluminum, for long life and minimum maintenance.

The 19*plus* can be operated without a computer from even the smallest boat, with data recorded in non-volatile FLASH memory and processed later on your PC. Simultaneous with recording, real-time data can be transmitted over single-core, armored cable directly to your PC's serial port (maximum transmission distance dependent on number of auxiliary sensors, baud rate, and cable properties). The 19*plus'* faster sampling and pump-controlled TC-ducted flow configuration significantly reduces salinity spiking caused by ship heave, and allows slower descent rates for improved resolution of water column features. Auxiliary sensors for dissolved oxygen, pH, turbidity, fluorescense, PAR, and ORP can be added, and for moored deployments the 19*plus* can be set to *time-series* mode using software commands. External power and two-way real-time communication over 10,000 meters of cable can be provided with the SBE 36 CTD Deck Unit and Power and Data Interface Module (PDIM).

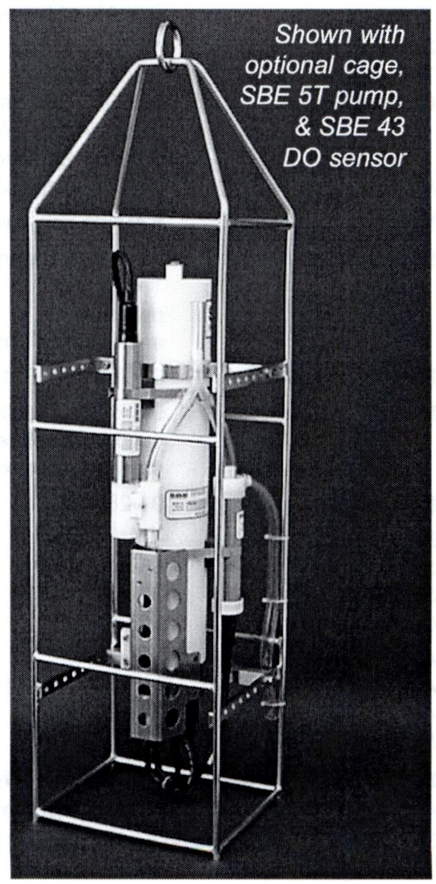
The 19*plus* uses the same temperature and conductivity sensors proven in 5000 SEACAT and MicroCAT instruments, and a superior new micro-machined silicon strain gauge pressure sensor developed by Druck, Inc. Improvements in design, materials, and signal acquisition techniques yield a low-cost instrument with superior performance that is also easy to use. Calibration coefficients, obtained in our computer-controlled high-accuracy calibration baths, are stored in EEPROM memory. They permit data output in ASCII engineering units (degrees C, Siemens/m, decibars, Salinity [PSU], sound velocity [m/sec], etc.). The 19*plus* can be factory-configured to emulate the .hex output format and 2 Hz data rate of old SEACATs for compatibility with existing software or instrument fleets.

Accuracy, convenience, portability, software, and support; compelling reasons why the 19*plus* is today's best low-cost CTD.

CONFIGURATION AND OPTIONS

A standard SBE 19*plus* is supplied with:
- Plastic housing for depths to 600 meters
- Strain-gauge pressure sensor
- 8 Mbyte FLASH RAM memory
- 9 D-size alkaline batteries
- Impulse glass-reinforced epoxy bulkhead connectors: 4-pin I/O, 2-pin pump, and two 6-pin (two differential auxiliary A/D inputs each)
- SBE 5M miniature pump and T-C Duct

Options include:
- Titanium housing for depths to 7000 meters
- Sensors for oxygen, pH, fluorescence, light (PAR), light transmission, and turbidity
- SBE 5T pump in place of SBE 5M for use with dissolved oxygen and/or other pumped sensors
- Stainless steel cage
- MCBH *Micro* connectors
- Ni-Cad batteries and charger


Shown with optional cage, SBE 5T pump, & SBE 43 DO sensor

SOFTWARE

SEASOFT©-Win32, our complete Windows 95/98/NT/2000/XP software package, is included at no extra charge. Its modular programs include:
- SEATERM© — communication and data retrieval
- SEASAVE© — real-time data acquisition and display
- SBE Data Processing© — filtering, aligning, averaging, and plotting of CTD and auxiliary sensor data and derived variables

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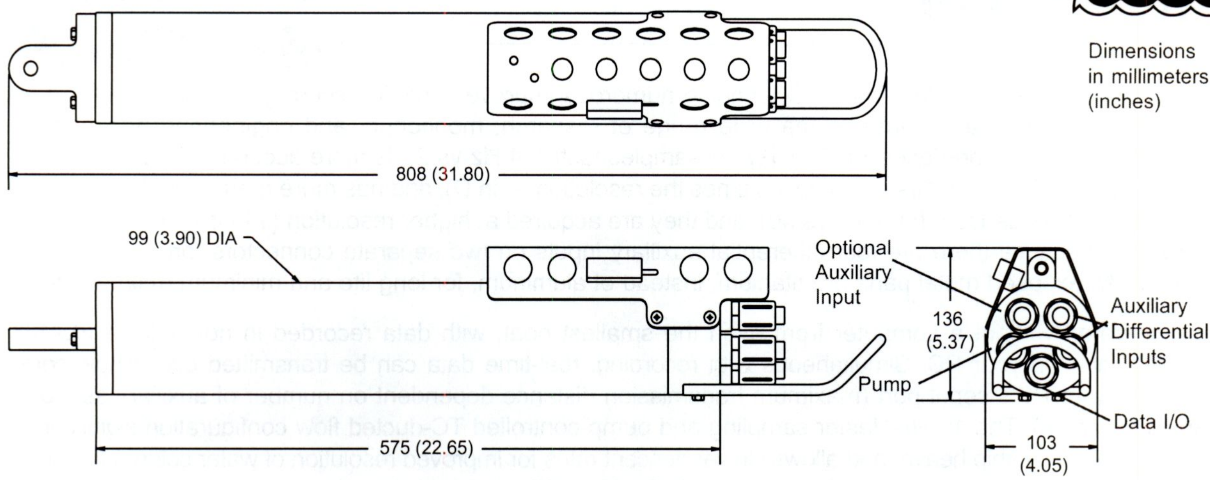
SEACAT Profiler

SBE 19*plus*



SPECIFICATIONS

Measurement Range

Temperature	-5 to +35 °C
Conductivity	0 to 9 S/m
Pressure	0 to 20 / 100 / 350 / 1000 / 2000 / 3500 / 7000 meters

Initial Accuracy

Temperature	0.005 °C
Conductivity	0.0005 S/m
Pressure	0.1% of full scale range

Typical Stability (*per month*)

Temperature	0.0002 °C
Conductivity	0.0003 S/m
Pressure	0.004% of full scale range

Resolution

Temperature	0.0001 °C
Conductivity	0.00005 S/m (most oceanic waters; resolves 0.4 ppm in salinity) 0.00007 S/m (high salinity waters; resolves 0.4 ppm in salinity) 0.00001 S/m (fresh waters; resolves 0.1 ppm in salinity)
Pressure	0.002% of full scale range

Memory 8 Mbyte non-volatile FLASH memory

Data Storage

Recorded Parameter	Bytes/Sample
T + C	6
pressure	5
each external voltage	2

Real-Time Clock 32,768 Hz TCXO accurate to ±1 minute/year

Internal Batteries 9 alkaline D-cells provide 60 hours continuous CTD operation; optional 9-cell rechargeable nickel-cadmium battery pack provides approximately 24 hours operation per charge

External Power Supply 9 - 28 VDC

Power Requirements

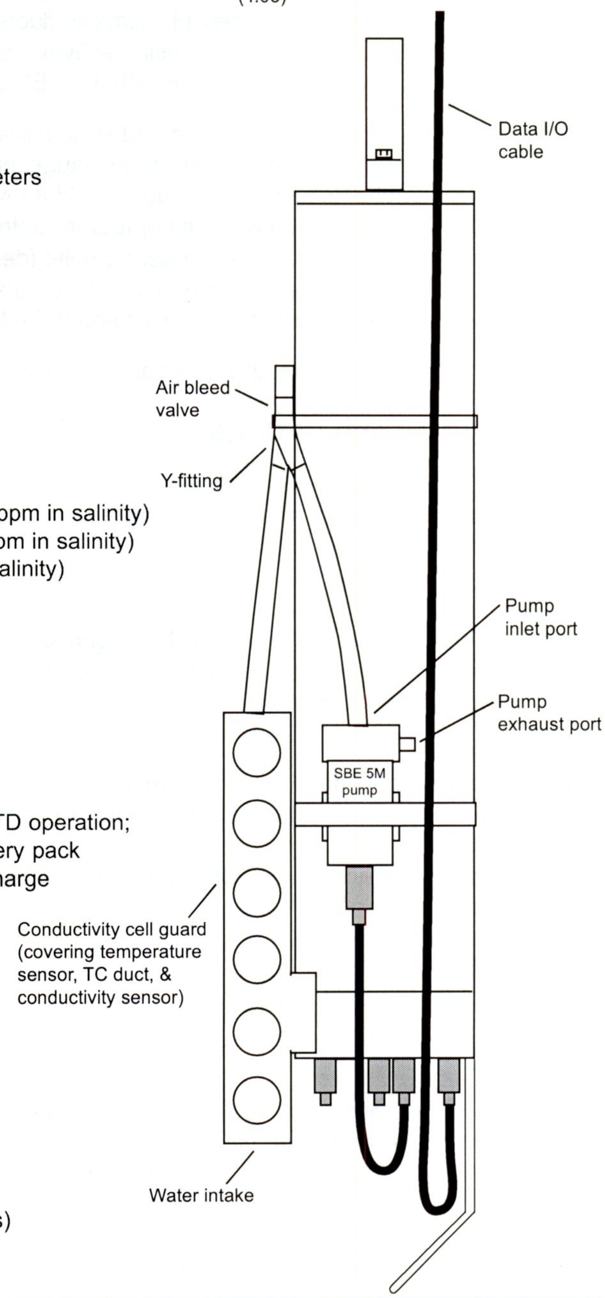
Sampling	65 mA
SBE 5M pump	95 mA
Quiescent	30 μA

Auxiliary Voltage Sensors

Auxiliary power out	up to 500 mA at 10.5 - 11 VDC
A/D resolution	14 bits
Input range	0 - 5 VDC

Housing Materials — Depth Rating — Weight

Acetal Copolymer *Plastic* housing — 600 meter (1950 feet) — 7.3 kg (16 lbs)
3AL-2.5V *Titanium* housing — 7000 meter (22,900 feet) — 13.7 kg (30 lbs)



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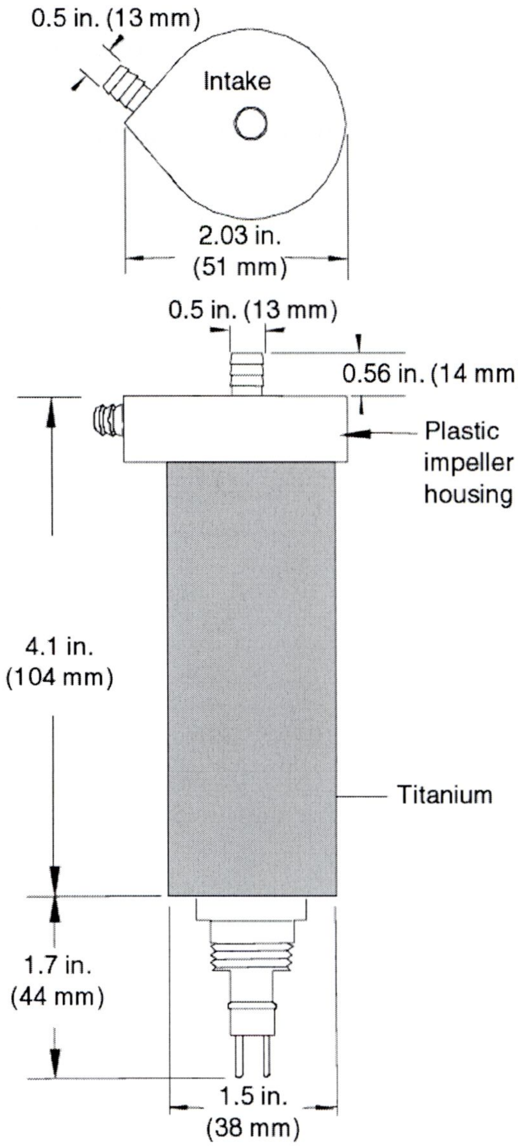
Mini Submersible Pump

SBE 5M

The SBE 5M pump module consists of a centrifugal pump head and a long-life, DC ball bearing motor contained in a compact, titanium, pressure housing usable to 10,500 meters deep. The pump impeller and electric drive motor are coupled magnetically through the housing, providing high reliability by eliminating moving seals. Motor speed and pumping rate remain constant over the entire input voltage range. The motor drive electronics is intrinsically protected against accidental reversed polarity.



APPLICATIONS

The SBE 5M is standard on the SBE 19 and 19*plus* SEACAT Profiler CTD. It is optional on the SBE 16, 16*plus*, and 16*plus*-IM SEACAT C-T Recorder. The pump flushes water through the conductivity cell at a constant rate, independent of the CTD's motion, improving dynamic performance. For applications requiring pumping through additional sensors (for example, a dissolved oxygen sensor), use the SBE 5T pump instead.

Specify:

- Option 5M-1 for profiling (continuous duty) applications such as the SBE 19*plus*.
- Option 5M-2 for moored (pulsed duty) applications such as the SBE 16*plus* or 16*plus*-IM.

Contact Sea-Bird for use in other applications.

SPECIFICATIONS

Option 5M-1 (continuous duty):
Input voltage range 9 - 18 VDC

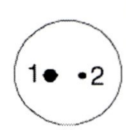
Flow Rate 25 ml/s supply current 95 ma

Note: Supply current is independent of operating voltage.

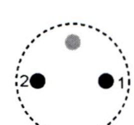
Option 5M-2 (pulsed duty):
Input voltage range 6 - 18 VDC

Pulse Duration	*Flow Volume*	*Electrical Charge*
0.5 seconds	15 ml	0.148 amp-seconds
1.0 seconds	21 ml	0.283 amp-seconds
1.5 seconds	31 ml	0.418 amp-seconds
2.0 seconds	40 ml	0.553 amp-seconds

XSG-2BCL-HP-SS



Pin	Signal
(1)	Ground
(2)	+ Power



Optional wet-pluggable connector, MCBH-2MTI

Weight

In Air:	0.42 kg (0.91 lbs)
In Water:	0.28 kg (0.60 lbs)

06/03

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CALIBRATION SHEETS

Temperature Calibration - S/N 4579.................................. 1

Conductivity Calibration - S/N 4579.................................. 2

Pressure Calibration - S/N 4579.. 3

SBE 5M Configuration - S/N 0617..................................... 4

Calibration Manual Generation Date: 19 March 2004

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

SENSOR SERIAL NUMBER: 4579
CALIBRATION DATE: 03-Mar-04

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.245964e-003
a1 = 2.614570e-004
a2 = 3.875130e-007
a3 = 1.403289e-007

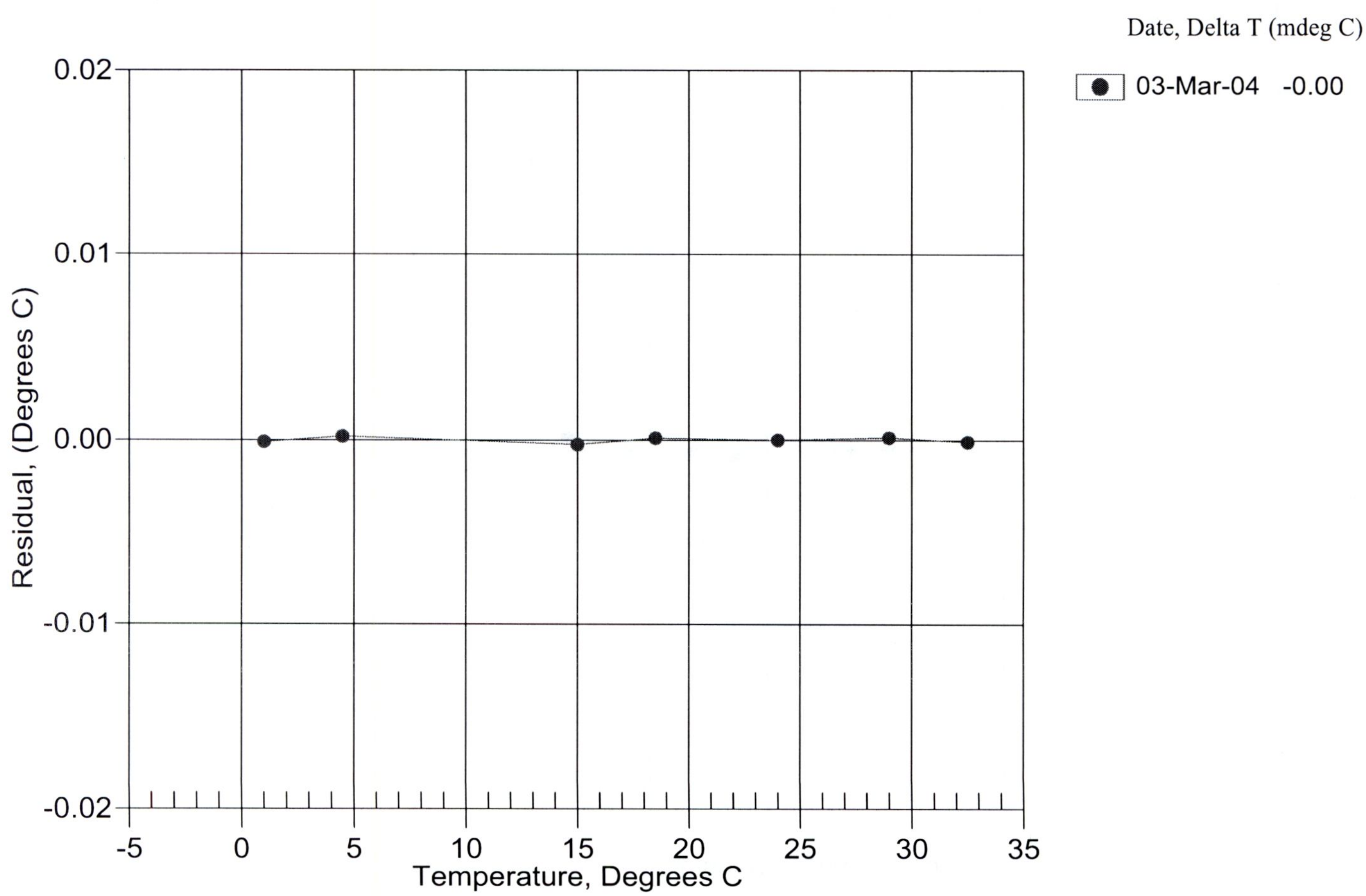
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0001	612456.760	1.0000	-0.0001
4.5000	544190.117	4.5002	0.0002
15.0000	374789.615	14.9998	-0.0002
18.5000	329266.352	18.5001	0.0001
24.0000	267420.094	24.0000	0.0000
29.0000	220283.560	29.0001	0.0001
32.5001	191781.969	32.5000	-0.0001

MV = (n - 524288) / 1.6e+007

R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)

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

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 4579
CALIBRATION DATE: 03-Mar-04

SBE19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g = -1.039859e+000
h =  1.525724e-001
i = -3.087511e-004
j =  4.549101e-005

CPcor = -9.5700e-008
CTcor =  3.2500e-006
```

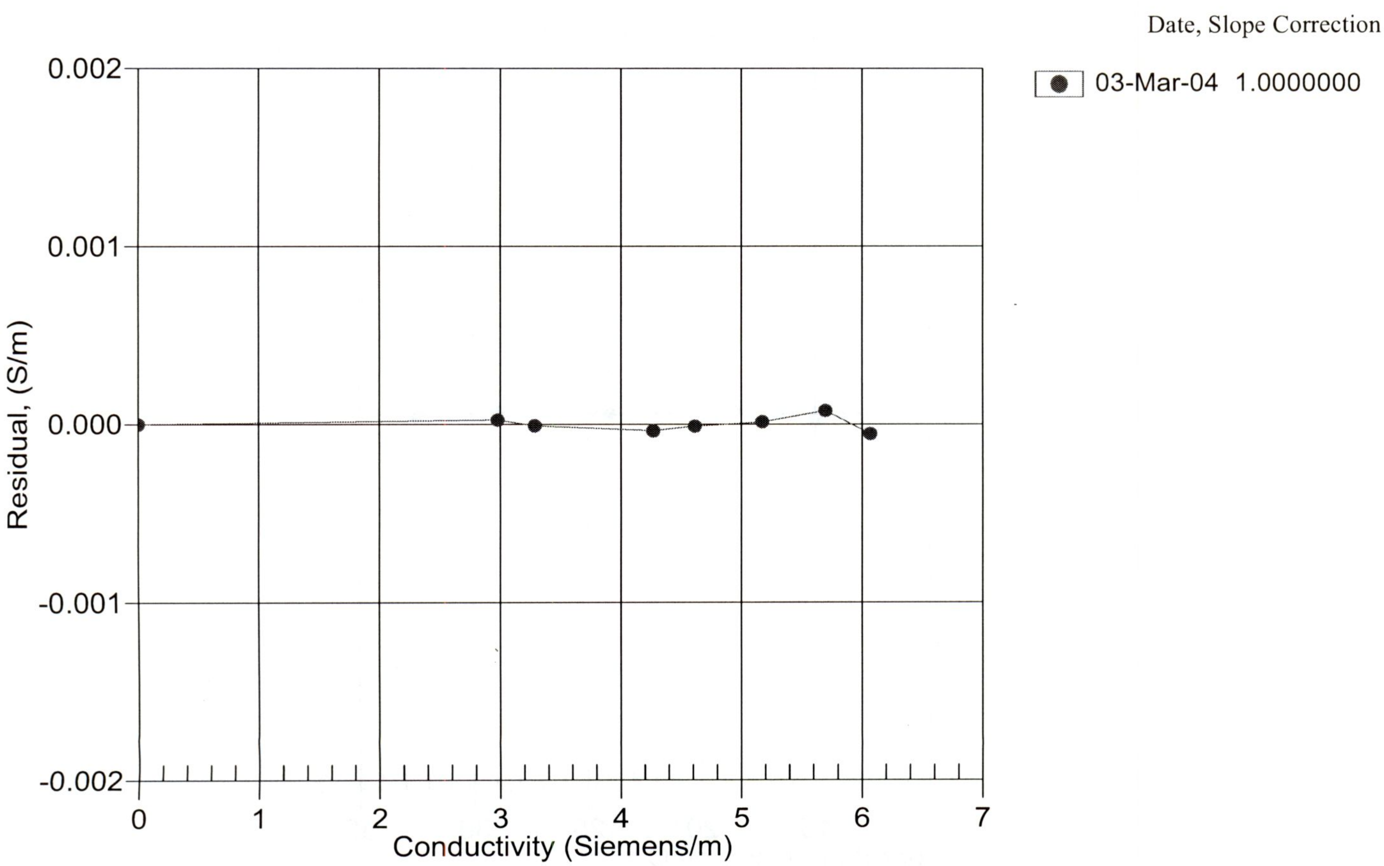
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2614.91	-0.0000	-0.00000
1.0001	34.8664	2.97985	5139.37	2.9799	0.00002
4.5000	34.8465	3.28729	5331.73	3.2873	-0.00001
15.0000	34.8030	4.27015	5904.11	4.2701	-0.00004
18.5000	34.7937	4.61569	6092.34	4.6157	-0.00001
24.0000	34.7835	5.17429	6384.60	5.1743	0.00001
29.0000	34.7780	5.69675	6646.04	5.6968	0.00008
32.5001	34.7754	6.06967	6826.27	6.0696	-0.00006

f = INST FREQ / 1000.0

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

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

Residual = instrument conductivity - bath conductivity



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

SENSOR SERIAL NUMBER: 4579
CALIBRATION DATE: 06-Mar-04

SBE19plus PRESSURE CALIBRATION DATA
5076 psia S/N 5426

COEFFICIENTS:

```
PA0 =      7.259045e-001        PTCA0 =  5.245836e+005
PA1 =      1.557097e-002        PTCA1 = -2.839069e-001
PA2 =     -6.694936e-010        PTCA2 =  1.219245e-001
PTEMPA0 = -6.457844e+001        PTCB0 =  2.494400e+001
PTEMPA1 =  5.148719e+001        PTCB1 = -1.000000e-003
PTEMPA2 = -3.209760e-001        PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.80	525519.0	1.7	14.61	-0.00
1115.03	596324.0	1.7	1114.56	-0.01
2115.21	661086.0	1.7	2114.75	-0.01
3115.36	726225.0	1.7	3115.10	-0.01
4115.46	791730.0	1.7	4115.33	-0.00
5115.58	857604.0	1.7	5115.40	-0.00
4115.44	791760.0	1.7	4115.79	0.01
3115.31	726268.0	1.7	3115.76	0.01
2115.16	661130.0	1.7	2115.43	0.01
1115.01	596370.0	1.7	1115.27	0.01
14.78	525553.0	1.7	15.13	0.01

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	1.91	525601.58
29.00	1.84	525573.53
24.00	1.74	525543.43
18.50	1.63	525517.99
15.00	1.56	525503.56
4.50	1.35	525483.49
1.00	1.28	525479.28

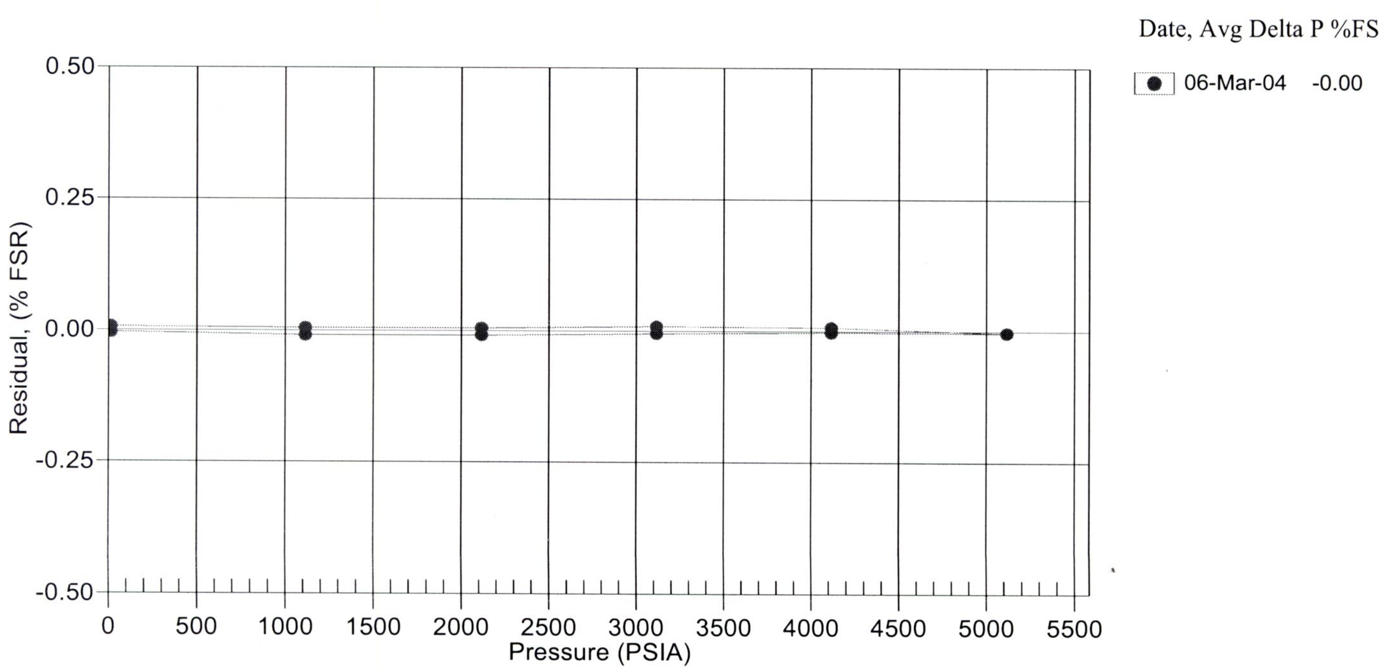
TEMP(ITS90)	SPAN(mV)
-5.00	24.95
35.00	24.91

y = thermistor output; t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2

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

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

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



SBE

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SBE 5T MINI SUBMERSIBLE PUMP CONFIGURATION SHEET

Serial Number: 0617

Job Number: 35153

Customer: CAN F&O/ST JOHNS

Delivery Date: 3/22/2004

Single Connector Housing with Titanium screws

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

P/N 90337, Motor PN 20130 (Low power 6 VDC, 2000 RPM MAX) ☐

P/N 90335, Motor PN 20130 (Low power 9 VDC, 2000 RPM MAX) ☑

Vin 15V voltage across C2:	7.99	VDC	Current	8.28	mA
Vin 9V voltage across C2:	7.988	VDC	Current	7.91	mA
Vin 6V voltage across C2:	5.874	VDC	Current	6.71	mA

Pump submerged test, no load, Vin 12VDC Average current draw in water: 121 mA

PRESSURE TEST CERTIFICATES

SBE 19plus Pressure Test Certificate - S/N 4579............... 1

SBE 5M Pressure Test Certificate - S/N 0617.................... 2

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SBE Pressure Test Certificate

Test Date: **3/10/2004** Description **SBE-19 SeaCat Profiler**

Job Number: **35153** Customer Name **CAN F&O/ST JOHNS**

SBE Sensor Information:

Model Number: **19**

Serial Number: **4579**

Pressure Sensor Information:

Sensor Type: **Druck**

Sensor Serial Number: **5426**

Sensor Rating: **5076**

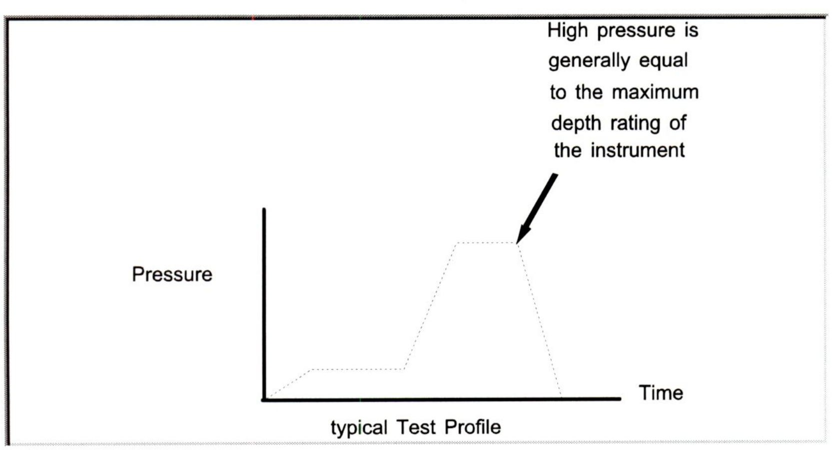
Pressure Test Protocol:

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

High Pressure Test: **5000** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: PC



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SBE Pressure Test Certificate

Test Date: **12/8/2003** Description **SBE-5M Mini-Submersible Pump**

Job Number: **35153** Customer Name **CAN F&O/ST JOHNS**

SBE Sensor Information:

Model Number: **5M**
Serial Number: **0617**

Pressure Sensor Information:

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

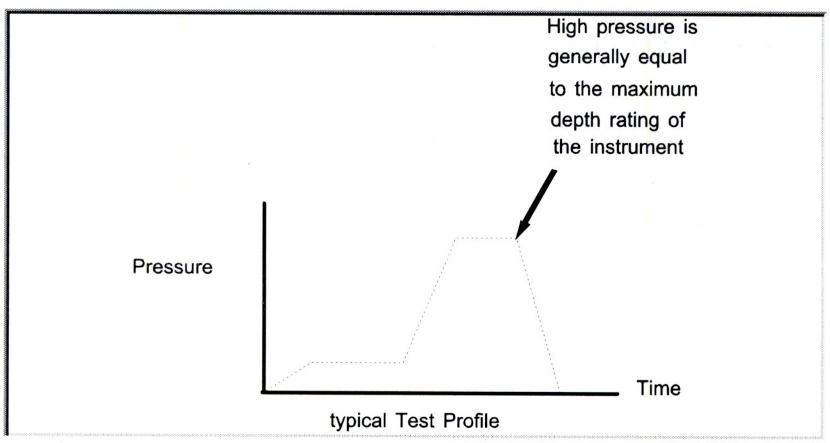
Pressure Test Protocol:

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

High Pressure Test: **10000** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: DF



typical Test Profile

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APPLICATION NOTE NO. 2D **Revised December 2002**

INSTRUCTIONS FOR CARE AND CLEANING OF CONDUCTIVITY CELLS

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

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

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

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

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

PRECAUTIONS!!!!!!

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

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

If a cell is filled with water, do not subject it to low temperatures that will freeze the water and break the cell. **Remove the water before shipment during the winter, or to polar regions at any season**. No adverse 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.

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APPLICATION NOTE NO. 6 July 1994

DETERMINATION OF SOUND VELOCITY FROM CTD DATA

Use of CTD measurement for determination of sound velocity is appealing because these instruments are simpler and more rugged and because their resolution, accuracy, and stability lead to far better precision than can be obtained with direct SV measuring devices. For example, specifications of 0.01 mS/cm conductivity, 0.01 degrees C temperature, and 1 meter in depth are readily achieved with good quality CTD equipment. Assuming that the relationship between C, T, and D on the one hand and SV on the other is exactly known (see below), the resulting uncertainty in SV would be as follows:

from temperature error (0.01 deg C)	0.021 meters/second
from conductivity error (0.01 mS/cm)	0.011 meters/second
from salinity error (0.01 psu)	0.012 meters/second
from depth error (1 meter)	0.017 meters/second

The equivalent SV errors (considered at 15 degrees C, 42.9 mS/cm, 35 psu, and 0 pressure, i.e, typical open-ocean surface conditions) are much smaller than those usually claimed for direct-measurement instruments.

The question about the absolute accuracy of the inference of SV from CTD data is more difficult to answer. The main reason for this is apparently the result of differences in the instrumentation used by various researchers and is compounded by the difficulty of performing direct measurements of sound velocity under controlled conditions of temperature, salinity, and (especially) pressure. For example, 3 widely used equations (Wilson, 1959; Del Grosso, 1972; Millero and Chen, 1977) show differences in absolute sound speed on the order of 0.5 meter/second for various combinations of water temperature, salinity, and pressure, despite being based on careful measurements made under laboratory conditions.

The work of Millero and Chen is, however, the most modern, and it builds upon and attempts to incorporate the work of earlier investigators. Accordingly, the SV/CTD relationship described by these researchers in their paper of 1977 was used as a major component in the derivation of the Equation of State (Unesco technical papers in marine science no. 44). Millero and Chen's 1977 equation is also the one endorsed by the Unesco/SCOR/ICES/IASPO Joint Panel on Oceanographic Tables and Standards which comprises the internationally recognized authority for measurements of ocean parameters (in Sea-Bird's SEASOFT software, users may select any of the 3 equations mentioned above).

We draw the following conclusions from the research papers listed above:

1) Investigators using specialized equipment under scrupulously controlled laboratory conditions report measurements of SV vs. changes in temperature, salinity, and pressure which differ by 0.5 meters/second and more. *It is unrealistic to expect that commercial direct-measurement instruments will be more accurate under field conditions than the laboratory equipment used by successions of careful researchers.*

2) The claimed 'accuracy' of commercial direct-measurement SV probes probably more legitimately represents their 'precision' (compare with CTD/SV uncertainties tabulated above) than their absolute accuracy. The relationship between what these instruments read and true sound velocity is probably just as dependent on the same vagaries that are also the only significant sources of error when employing the CTD approach.

3) Because of the uncertainties in the time-delays associated with the acoustic transducers and electronics (and because of the difficulty of measuring with sufficient accuracy the length of the acoustic path), direct-measurement probes must be calibrated in water. As suggested by the research under controlled laboratory conditions, this is not an easy task, especially over a range of temperature, pressure, and salinity. On the other hand, a CTD probe can easily be calibrated using accepted methods.

4) A CTD can predict absolute SV to something better than 0.5 meter/second (a judgement seconded by Professor Millero in a private conversation), while its relative accuracy (precision) is probably better than 0.05 meter/s under the most demanding conditions of field use.

5) The very high precision associated with CTD measurements and the existence of an internationally accepted relationship (even if imperfect) between CTD and SV permits very consistent intercomparison and a high degree of uniformity among CTD-derived SV data sets, no matter when and where taken.

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APPLICATION NOTE NO. 10 **Revised March 2001**

COMPRESSIBILITY COMPENSATION OF SEA-BIRD CONDUCTIVITY SENSORS

There is growing recognition of the Sea-Bird SBE 911*plus* CTD system's suitability for ultra-precise characterization of deep ocean water masses. To achieve the accuracy of which the system is capable, an accounting for the effect of hydrostatic loading (pressure) on the conductivity cell is necessary. Conductivity calibration certificates now show an equation containing the appropriate pressure-dependent correction term, which has been derived from mechanical principles and confirmed by field observations.

The new equation is:

Conductivity (Siemens/meter) = $(af^m + bf^2 + c + dt) / [10 (1 - 9.57 (10^{-8}) p)]$

where
a, b, c, d, and m are the calibration coefficients,
f is the instrument frequency (kHz),
t is the water temperature (°C), and
p is the water pressure (decibars).

The new equation should be used for all Sea-Bird fine structure conductivity instruments, including the SBE 4 Conductivity Sensor, SBE 9*plus* CTD Underwater Unit (which employs the SBE 4 sensor), SBE 16/16*plus* SEACAT, SBE 19/19*plus* SEACAT Profiler, and SBE 25 SEALOGGER. Sea-Bird CTD data acquisition, display, and post-processing software *SEASOFT* -- beginning with Version 3.2 -- will automatically implement this equation.

DISCUSSION

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 (0.028 mS/cm) 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 σ (Poisson's ratio). For the Sea-Bird conductivity cell, E = 9.1 x 10^6 psi, σ = 0.2, and the ratio of indicated conductivity divided by true conductivity will be:

1 + s

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 σ (Poisson's ratio). For the Sea-Bird conductivity cell, $E = 9.1 \times 10^6$ psi, σ = 0.2, and the ratio of indicated conductivity divided by true conductivity will be:

$1 + s$

where
$s = - 6.60(\text{pressure, psi})(10^{-8})$ <u>or</u> $- 9.57(\text{pressure, dBars})(10^{-8})$

MATHEMATICAL DERIVATION

The rigorous derivation of the pressure term s is as follows:

For a cube under hydrostatic load:

$$\Delta l / l = s = -p\,(1 - 2\sigma) / E$$

where
p is the hydrostatic pressure,
E is Young's modulus,
σ is Poisson's ratio, and
$\Delta l / l$ and s are strain (change in length per unit length).

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

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

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

Since conductivity is 1/R:

$$C_p = C_0 (1 + s) \text{ and } C_0 = C_p / (1 + s) = C_p / (1 - 9.57\,(10^{-8})\,p)$$

where
C_0 is conductivity at 0 pressure, and
C_p is the conductivity measured at pressure.

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

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

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

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

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APPLICATION NOTE NO. 14 **January 1989**

1978 PRACTICAL SALINITY SCALE

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

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

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

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

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

CONCLUSIONS

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

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

T in °C (IPTS '68), P in decibars.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$a_2 = 25.3851$ $b_2 = -0.0066$

$a_3 = 14.0941$ $b_3 = -0.0375$

$a_4 = -7.0261$ $b_4 = 0.0636$

$a_5 = 2.7081$ $b_5 = -0.0144$

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APPLICATION NOTE 27Druck **NOVEMBER 2003**

Minimizing Strain Gauge Pressure Sensor Errors

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

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

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

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

DEFINITION OF PRESSURE TERMS

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

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

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

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

RELATIONSHIP BETWEEN PRESSURE AND DEPTH

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

SEASOFT 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:

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

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

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

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

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

MINIMIZING ERRORS

Offset Errors

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

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

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

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

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

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

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

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

Offset Correction Example
Pressure measured by a barometer is 14.65 psia. Pressure displayed from instrument is -2.5 dbars.
Convert barometer reading to dbars using the relationship: (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 .con file (if applicable) and in instrument EEPROM (if applicable).

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

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

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

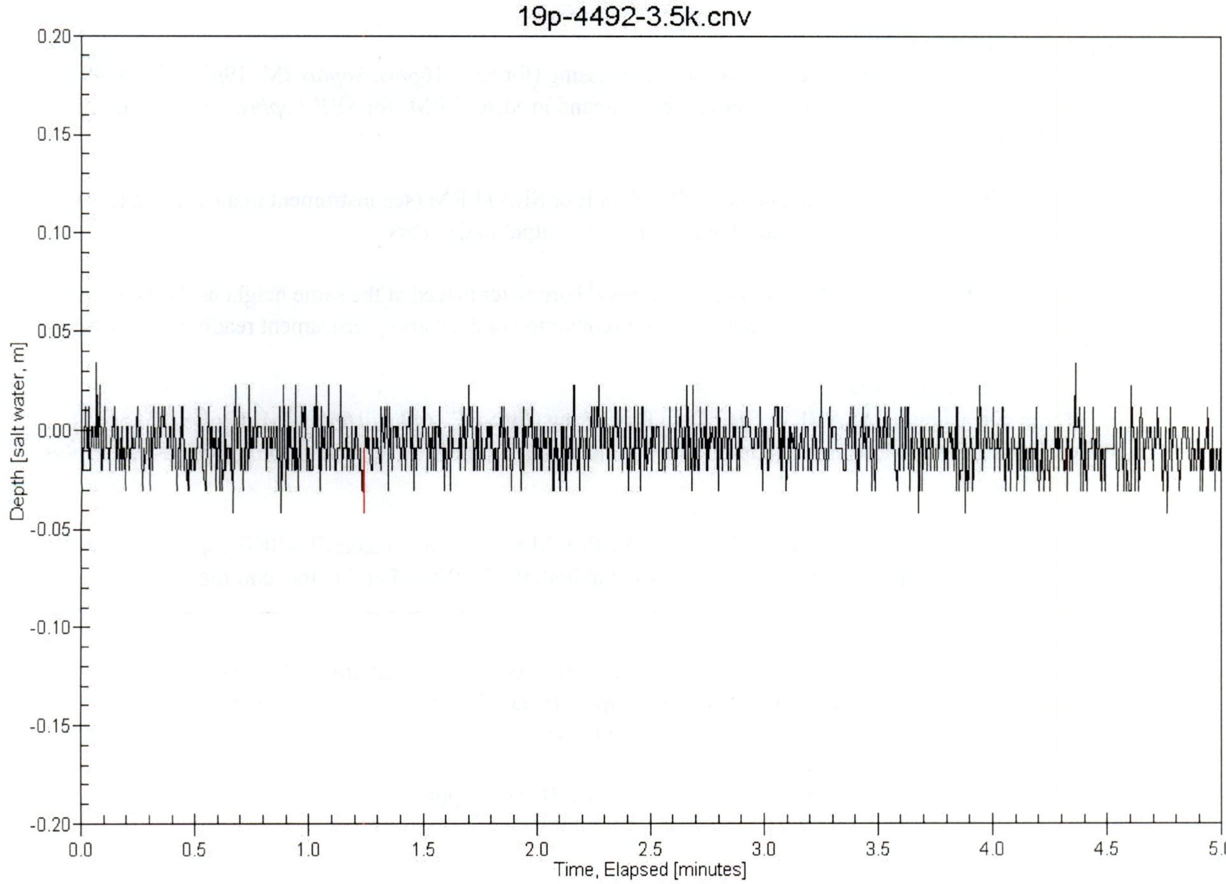
3. Calculate the average of the pre- and post-cast readings. Enter the negative of the average value (in decibars) as the *offset* in the .con file.

Hysteresis Errors

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

Power Turn-On Transient

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



Thermal Transient

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

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

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APPLICATION NOTE NO. 31 **September 2001**

Computing Temperature and Conductivity *Slope* and *Offset* Correction Coefficients from Laboratory Calibrations and Salinity Bottle Samples

Conductivity Sensors

SEASOFT's prompt for *slope* and *offset* values when the conductivity sensor is selected when setting up the configuration (.con) file permits the user to make corrections for sensor drift between calibrations. For newly calibrated sensors use slope = 1.0, offset = 0.0. The correction formula is:

(corrected conductivity) = slope * (computed conductivity) + offset

The conductivity sensor usually drifts by changing span (the slope of the calibration curve), and changes are typically toward lower conductivity readings with time. Offset error in conductivity (error at 0 S/m) is usually due to electronics drift, which is usually less than ±0.0001 S/m per year. Offsets greater than ±0.0002 S/m are symptomatic of sensor malfunction. Sea-Bird, therefore, recommends drift corrections to conductivity sensors be made by assuming no offset error, unless there is strong evidence to the contrary or a special need.

As an example of computing these correction coefficients, if we had the following calibration data:

true conductivity:	3.5 S/m
instrument reading:	3.49965 S/m

slope = 3.5 / 3.49965 = 1.000100

Correcting for Conductivity Drift Based on Pre- and Post-Cruise Laboratory Calibrations

Suppose a conductivity sensor is calibrated (pre-cruise), then immediately used at-sea, and then returned for post-cruise calibration. The pre- and post-cruise calibration data can be used to generate a slope correction for data taken between the pre- and post-cruise calibrations.

If α is the conductivity computed from the **pre-cruise bath data** (temperature and frequency) using **post-cruise calibration coefficients** and β is the true conductivity in the **pre-cruise bath**, then:

$$\textbf{Postslope} = \frac{\sum_{i=1}^{n} (\alpha_i)(\beta_i)}{\sum_{i=1}^{n} (\alpha_i)(\alpha_i)} \qquad \text{(postslope is typically < 1.0)}$$

Beginning in February 1995, the value for postslope was calculated and printed on the conductivity calibration sheet.

To correct conductivity data taken between pre- and post-cruise calibrations:

Let:

n = number of days between pre- and post-cruise calibrations
b = number of days between pre-cruise calibration and the cast to be corrected
islope = interpolated slope; this is the value to enter in the .con file
postslope = slope from calibration sheet as calculated above

islope = 1.0 + (b / n) ((1 / postslope) - 1.0)

In the .con file, use the **pre-cruise calibration coefficients** and use **islope** for the value of slope.*

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).

For typical conductivity drift rates (equivalent to -0.003 PSU/month), islope would not need to be recalculated more frequently than at weekly intervals.

* You can also calculate preslope. If α is the conductivity computed from the **post-cruise bath data** (temperature and frequency) using **pre-cruise calibration coefficients** and β is the true conductivity in the **post-cruise bath**, then:

$$\textbf{Preslope} = \frac{\sum_{i=1}^{n} (\alpha_i)(\beta_i)}{\sum_{i=1}^{n} (\alpha_i)(\alpha_i)} \qquad \text{(preslope is typically > 1.0)}$$

In this case, pre-cruise calibration coefficients would be used and:
islope = 1.0 + (b / n) (preslope - 1.0)

Correcting for Conductivity Drift Based on Salinity Bottles Taken At-Sea

For this situation the **pre-cruise** calibration coefficients are used to compute conductivity and CTD salinity. Salinity samples are obtained using water sampler bottles during CTD profiles, and the difference between CTD salinity and bottle salinity is used to determine the drift in conductivity.

In using this method to correct conductivity, it is important to realize that differences between CTD salinity and hydrographic bottle salinity are due to errors in conductivity, temperature, and pressure measurements (as well as errors in obtaining and analyzing bottle salinity values). All CTD temperature and pressure errors and bottle errors must first be corrected before attributing the remaining salinity difference as CTD conductivity error and proceeding with conductivity corrections.

Suppose that at a Pacific Ocean station, three salinity bottles are taken during a CTD profile and assume for this discussion that shipboard analysis of the bottle salinities is perfect. The bottle salinities and the **uncorrected** CTD data might be:

Approximate Depth (m)	Bottle Salinity	CTD Raw Salinity	CTD Raw Conductivity (S/m)	CTD Temperature (°C)	CTD Pressure (dbar)
200	34.9770	34.9705	4.63421	18.3924	202.7
1000	34.4710	34.4634	3.25349	3.9841	1008.8
4000	34.6850	34.6778	3.16777	1.4527	4064.1

The uncorrected salinity differences (CTD salinity - bottle salinity) are approximately -0.007 ppt. To determine conductivity drift, the CTD temperature and pressure data must first be corrected. Suppose that the error in temperature measurements is +0.0015 C uniformly at all temperatures, and the error in pressure is +0.5 dbar uniformly at all pressures. The drift offsets are obtained by projecting the drift history of both sensors from pre-cruise calibrations. If these offsets are entered in the .con file, the correct CTD temperature and pressure will be the reported *raw* values and will need no further correction. In addition, the CTD *raw* salinity will be reported using the correct CTD temperature and pressure. This correction method also assumes that the pressure coefficient for the conductivity cell is correct. The CTD data with **corrected** temperature and pressure are:

Correct CTD Pressure (dbar)	Correct CTD Temperature (°C)	CTD Conductivity (S/m)	CTD Salinity T,P Corrected	Bottle Salinity
202.2	18.3909	4.63421	34.9719	34.9770
1008.3	3.9826	3.25349	34.4652	34.4710
4063.6	1.4512	3.16777	34.6796	34.6850

The (CTD-bottle) salinity difference of -0.005 ppt is now properly assigned as conductivity error, equivalent to about -0.0005 S/m at 4.0 S/m. By plotting the conductivity error versus conductivity, it is evident that the drift is primarily a slope change.

The program SEACALC (in SEASOFT-DOS) can be used to compute bottle conductivity. Enter bottle salinity for *salinity*, CTD corrected temperature for *temperature*, and CTD corrected pressure for *pressure*.

CTD Conductivity (S/m)	Bottle Conductivity (S/m)	[CTD - Bottle] Conductivity (S/m)
4.63421	4.63481	-0.00060
3.25349	3.25398	-0.00049
3.16777	3.16821	-0.00044

If α is the CTD conductivity computed with **pre-cruise** coefficients and β is the true bottle conductivity then:

$$\textbf{slope} = \frac{\sum_{i=1}^{n} (\alpha_i)(\beta_i)}{\sum_{i=1}^{n} (\alpha_i)(\alpha_i)} \qquad \text{(slope is typically > 1.0)}$$

Using the above data, the slope correction coefficient for conductivity at this station is **slope = +1.000137**. Following Sea-Bird's recommendation of assuming no offset error in conductivity, **offset is set to 0.0**.

For typical Sea-Bird sensors that are calibrated regularly, 70 - 90% of the CTD salinity error is due to conductivity calibration drift, 10 - 30% is due to temperature calibration drift, and only 0% - 10% is due to pressure calibration drift.

Temperature Sensors

SEASOFT's prompt for *slope* and *offset* values when the temperature sensor is selected when setting up the configuration (.con) file permits the user to make corrections for sensor drift between calibrations. For newly calibrated sensors, use slope = 1.0, offset = 0.0. The correction formula is:

(corrected temperature) = slope * (computed temperature) + offset

where :
slope = (true temperature span) / (instrument temperature span)
offset = (true temperature - instrument reading) * slope *measured at 0.0 °C*

As an example of computing the correction coefficients, if we had the following calibration data:

true temperature	0.0 °C	25.0 °C
instrument reading	0.0015 °C	25.0013 °C

slope = (true temperature span) / (instrument temperature span)
= (25.0 - 0.0) / (25.0013 - 0.0015) = 1.000008000

offset = (true temperature - instrument reading) * slope *measured at 0.0 °C*
= (0.0 - 0.0015) * (1.000008000) = -0.00150002

For this example Sea-Bird would recommend the drift correction values (entered in the .con file)
slope = 1.0 offset = -0.0015

Sea-Bird temperature sensors usually drift by changing offset (an error of equal magnitude at all temperatures). In general, the drift can be toward higher or lower temperature with time; however, for a specific sensor the drift will remain the same sign (direction) for many consecutive years. A large span error (change in calibration slope) indicates an unusual aging of electronic components and is symptomatic of sensor malfunction. Sea-Bird therefore recommends that drift corrections to temperature sensors be made by assuming no slope error, unless there is strong evidence to the contrary or a special need.

Sensors with serial numbers less than 1050 drift more typically toward higher temperature with time, while sensors with serial numbers greater than 1050 drift more typically toward lower temperature with time. Many years of experience with hundreds of sensors indicates that the drift is smooth and uniform with time, allowing users to make very accurate drift corrections to field data based only on pre- and post-cruise laboratory calibrations.

Calibration checks at-sea are advisable for consistency checks of the sensor drift rate and for early detection of sensor malfunction. However, data from reversing thermometers is rarely accurate enough to make calibration corrections that are better than those possible by shore-based laboratory calibrations. A proven alternate consistency check is to use dual SBE 3 temperature sensors on a CTD and to track the difference in drift rates between the two sensors. In the deep ocean, where temperatures are uniform, the difference in temperature measured by two sensors can be resolved to better than 0.0002 °C and will change smoothly with time as predicted by the difference in drift rates of the two sensors.

The temperature sensors rarely exhibit span errors larger than 0.005 °C over the range -5 to 35 °C even after years of drift. A span error that increases by more than ±0.0002 [°C per °C per year] is symptomatic of sensor malfunction. Previous to January 1993 some calibrations have been delivered that include span errors up to 0.004 °C in 30 °C (span error of 0.000133) because of undetected systematic errors in calibration. Temperature calibrations preformed at Sea-Bird after January 1995 have span error less than 0.0002 °C in 30 °C.

Correcting for Temperature Drift Based on Pre- and Post-Cruise Laboratory Calibrations

Suppose a temperature sensor is calibrated (pre-cruise), then immediately used at-sea for 4 months, and then returned for post-cruise calibration. Converting the **post-cruise calibration data** using the **pre-cruise coefficients**, we obtain the estimates:

Real Temperature........ 0.0°....... 25.0°C
Instrument Reading..... 0.002°... 25.001°C

These calibration data correspond to offset error = +0.002 °C, and span error = -0.00004 [°C per °C] at the end of 4 months of use. The correction coefficients are **slope= 1.000040002, offset= -0.00200008.** Note the difference between the error value and the value of the correction coefficient.

For preliminary work at sea, use the **pre-cruise calibration coefficients** and **slope = 1.0, offset = 0.0**. Temperature data obtained during the cruise is corrected for drift using properly scaled values of correction coefficients. Data from the end of the second month at sea would be converted using **pre-cruise coefficients** and **slope=1.00002, offset= -0.001**. At the end of the 4-month cruise, data could be converted by either using **pre-cruise** coefficients and **slope=1.00004, offset= -0.002**, or by using **post-cruise** coefficients and **slope= +1.0, offset = 0.0**.

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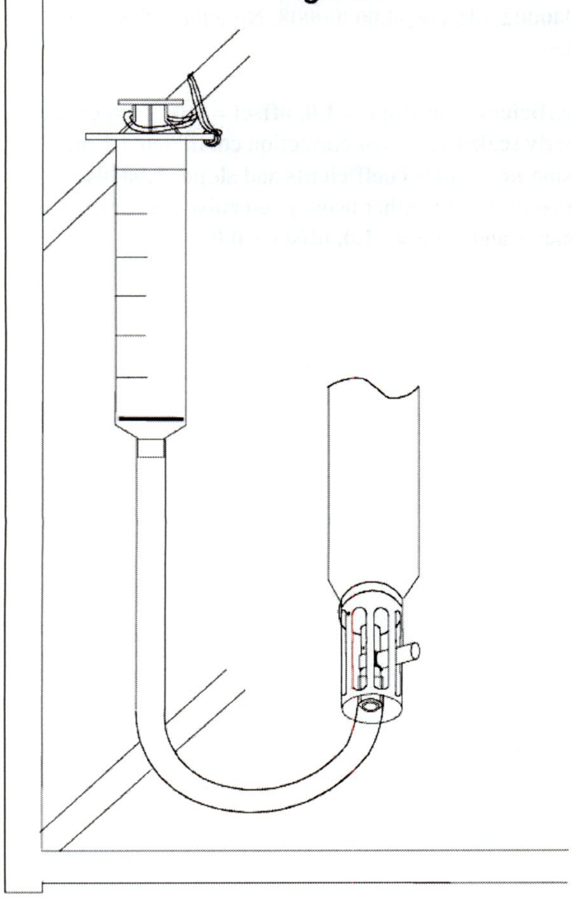
APPLICATION NOTE NO. 34 **January 1992**

CONDUCTIVITY CELL FILLING AND STORAGE DEVICE P/N 50087 INSTRUCTIONS FOR USE

Figure 1



Sea-Bird recommends keeping the conductivity cell full of purified water (except in freezing environments) during periods when the CTD is not being used. This is important in keeping the cell free from contamination and in keeping the electrodes wetted and ready for immediate use.

CTDs with pumped conductivity cells (SBE 911, SBE 25, and some SEACATs) are shipped with syringe and tubing assembly (P/N 50087) as an accessory for filling and storing the conductivity cell. The tubing assembly consists of a length of 1/4 inch I.D. tube connected to a short piece of 7/16 inch I.D. tube by a plastic reducing union.

To fill the conductivity cell, draw about 40-60 cc of purified water into the syringe, connect the plastic tubing to the TC duct intake on the temperature sensor [Figure 1], (or to the open end of the conductivity cell on systems without the TC duct [Figure 2]) and inject water into the cell and pump plumbing.

For CTDs with a TC duct, remove the plastic reducing union and connect the smaller diameter tubing directly to the TC duct. For CTDs without a TC duct, leave the reducing union and large diameter tubing attached and carefully connect the tubing directly to the end of the glass conductivity cell [Figure 2].

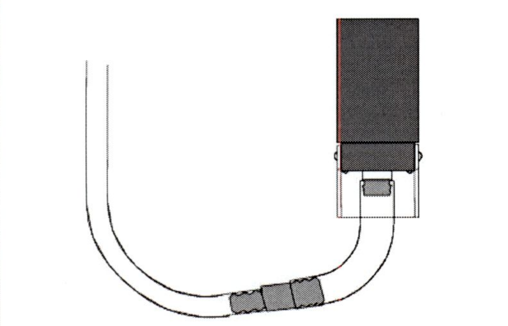


Figure 2

After filling the conductivity cell, loop the rubber band around a bar on the CTD cage and back over the top of the syringe to secure the apparatus for storage.

REMEMBER TO REMOVE THE SYRINGE AND TUBING ASSEMBLY BEFORE DEPLOYMENT!

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APPLICATION NOTE NO. 40 **Revised November 2002**

SBE 5T PUMP SPEED ADJUSTMENT INSTRUCTIONS

Equipment: DC power supply
Frequency counter

Drawings: 31441 (schematic)
40630 (3000 rpm pump)
40631 (1300 rpm pump)

The pump housing must be disassembled to adjust the pump speed. Referencing above drawings:

1. Remove the white plastic end cap retainer ring located at the connector end of the pump by twisting in a counter-clockwise motion.

2. Install a 2-pin dummy plug with locking sleeve (P/N 17044.1) over the bulkhead connector. This will provide a good grip on the pump connector and will protect the connector pins.
Rotate the connector back and forth while carefully pulling the end cap away from the housing. Pull the end cap (piston o-ring seal) out of the housing. The motor and electronics assembly are attached to the end cap and will come out as a unit.

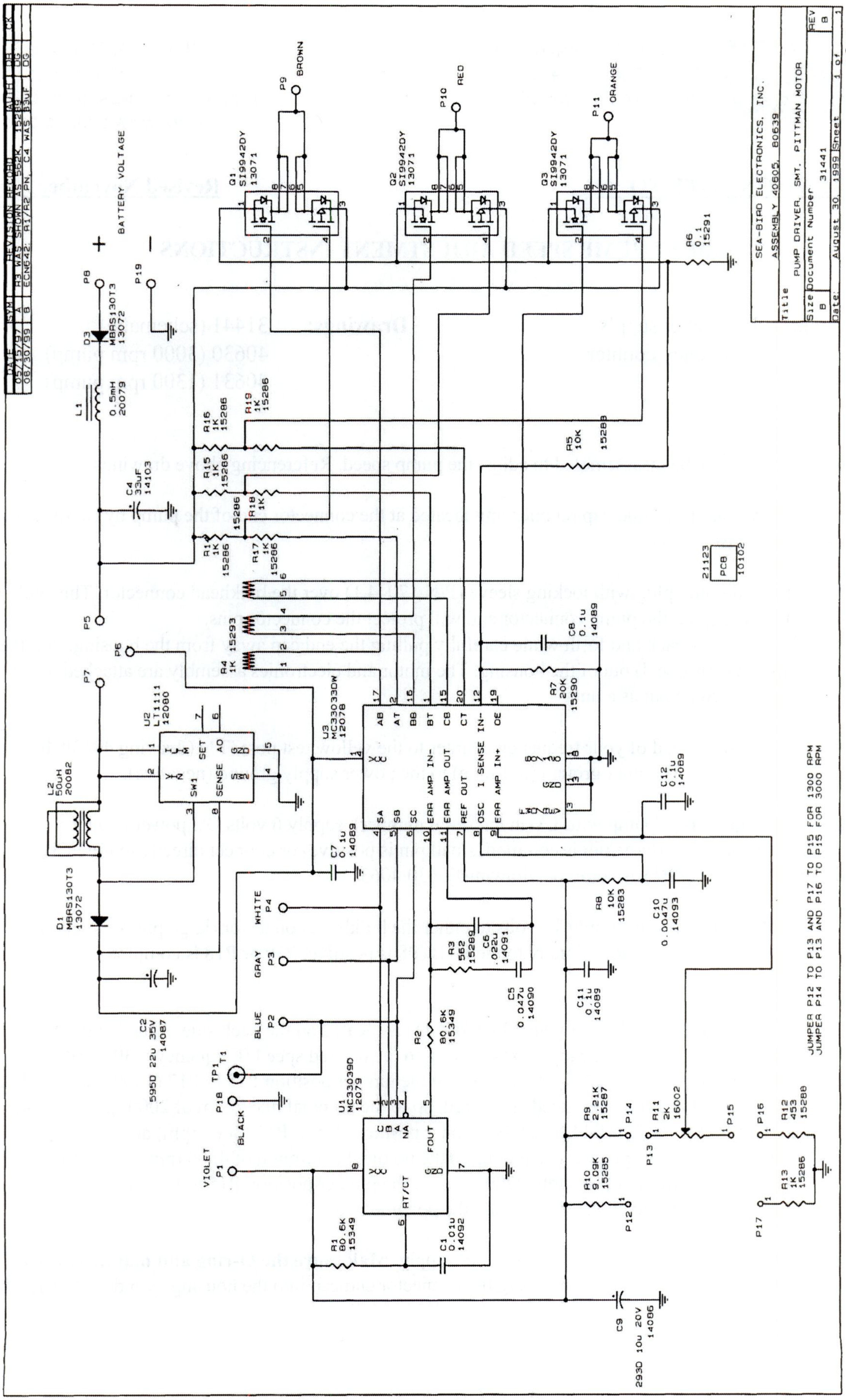
3. Connect the positive lead of your frequency counter to the yellow test post (T1) (drawing 40630/40631). Connect the frequency counter ground (negative) to the power supply ground (negative).

4a. **For low voltage pump** (pump with **LV** in the serial number), supply 6 volts DC power to either the bulkhead connector (large pin is common, small pin is positive) or connect directly to the PCB (P8 is positive, P19 or P18 is common, drawing 40630/40631).

4b. **For normal voltage pump**, supply 12 volts to either the bulkhead connector (large pin is common, small pin is positive) or connect directly to the PCB (P8 is positive, P19 or P18 is common, drawing 40630/40631).

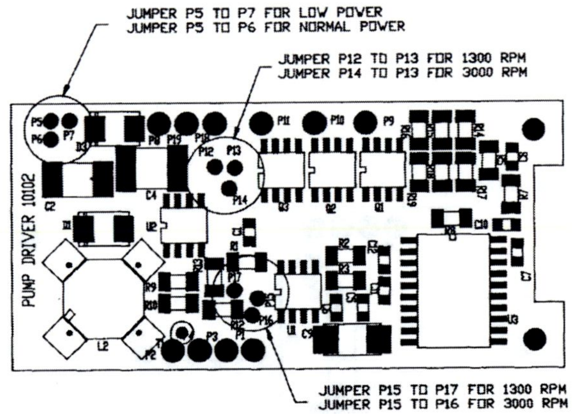
5. A 2K ohm potentiometer (R11, drawing 40630/40631) is located on the back side of the board. Adjust the potentiometer to obtain the frequency corresponding to the desired speed (Frequency * 30 = RPM). With the Pittman 18.2Ω motor (P/N 3711B113), set the jumper position P15 to P17 (1300 rpm) and P12 to P13 (1300 rpm), and adjust the speed as desired, up to the nominal maximum of 2000 rpm. With the Pittman 7.4Ω motor (P/N 3711B112), set the jumper position P15 to P16 (3000 rpm) and P14 to P13 (3000 rpm), and adjust the speed as desired, up to the nominal maximum of 4500 rpm. To adjust speed of the 7.4Ω motor below approximately 2200 rpm, set the jumper position P15 to P17 (1300 rpm) and P12 to P13 (1300 rpm), and adjust speed using the potentiometer.

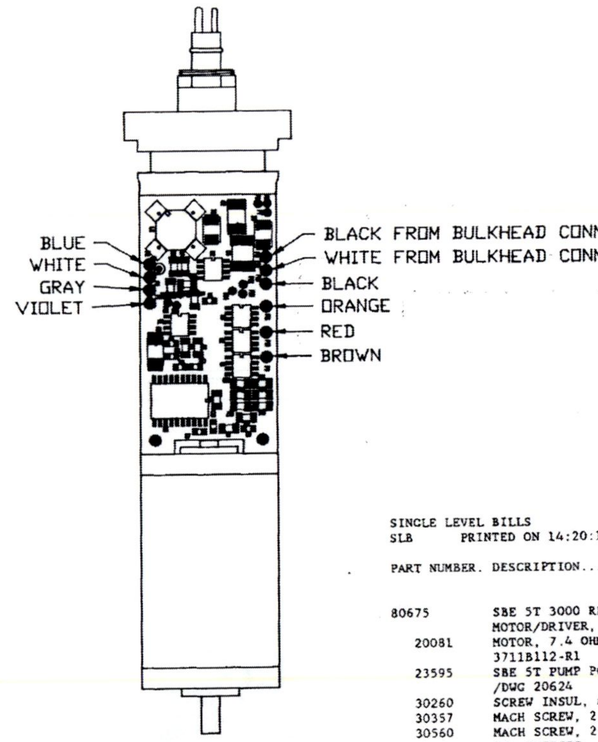
6. Disconnect the frequency counter and the power supply. **Make sure the O-ring and mating surfaces are clean.** Lightly lubricate before inserting the connector end cap into the housing cylinder. Replace the pump end cap retainer.

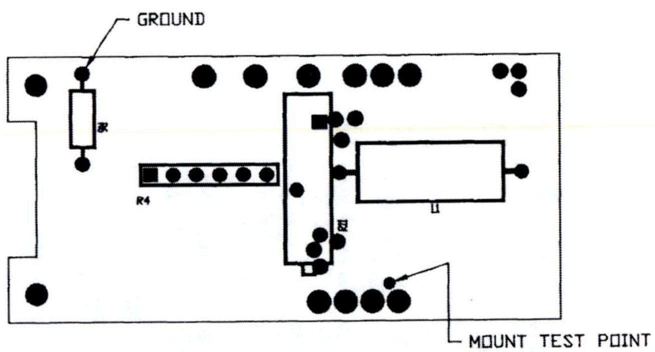


SEA-BIRD ELECTRONICS, INC.
ASSEMBLY 40605, 80639
Title PUMP DRIVER, SMT, PITTMAN MOTOR
Size B
Document Number 31441
REV B
Date August 30, 1999
BATTERY VOLTAGE
JUMPER P12 TO P13 AND P17 TO P15 FOR 1300 RPM
JUMPER P14 TO P13 AND P16 TO P15 FOR 3000 RPM

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
7/6/94	A	See HISTORY	P.G.	BW	







SINGLE LEVEL BILLS PAGE 1
SLB PRINTED ON 14:20:10 06 JUL 1994

PART NUMBER.	DESCRIPTION..................	QPA.....	ITM NBR	REF DESIG...........	DRAWING..... NUMBER
80675	SBE 5T 3000 RPM PUMP MOTOR/DRIVER, /DWG 40630				40630
20081	MOTOR, 7.4 OHM, PITTMAN 3711B112-R1	1.0000			
23595	SBE 5T PUMP PCB MOUNT BLOCK, /DWG 20624	1.0000			20624
30260	SCREW INSUL, # 2 X 1/8, IN-2/2	2.0000			
30357	MACH SCREW, 2-56 X 1/4 PH, SS	2.0000			
30560	MACH SCREW, 2-56 X 9/16 FH, SS, PHILIPS	2.0000			
80639	PUMP DRIVER, SMT, /DWG 40605	1.0000			40605 31441

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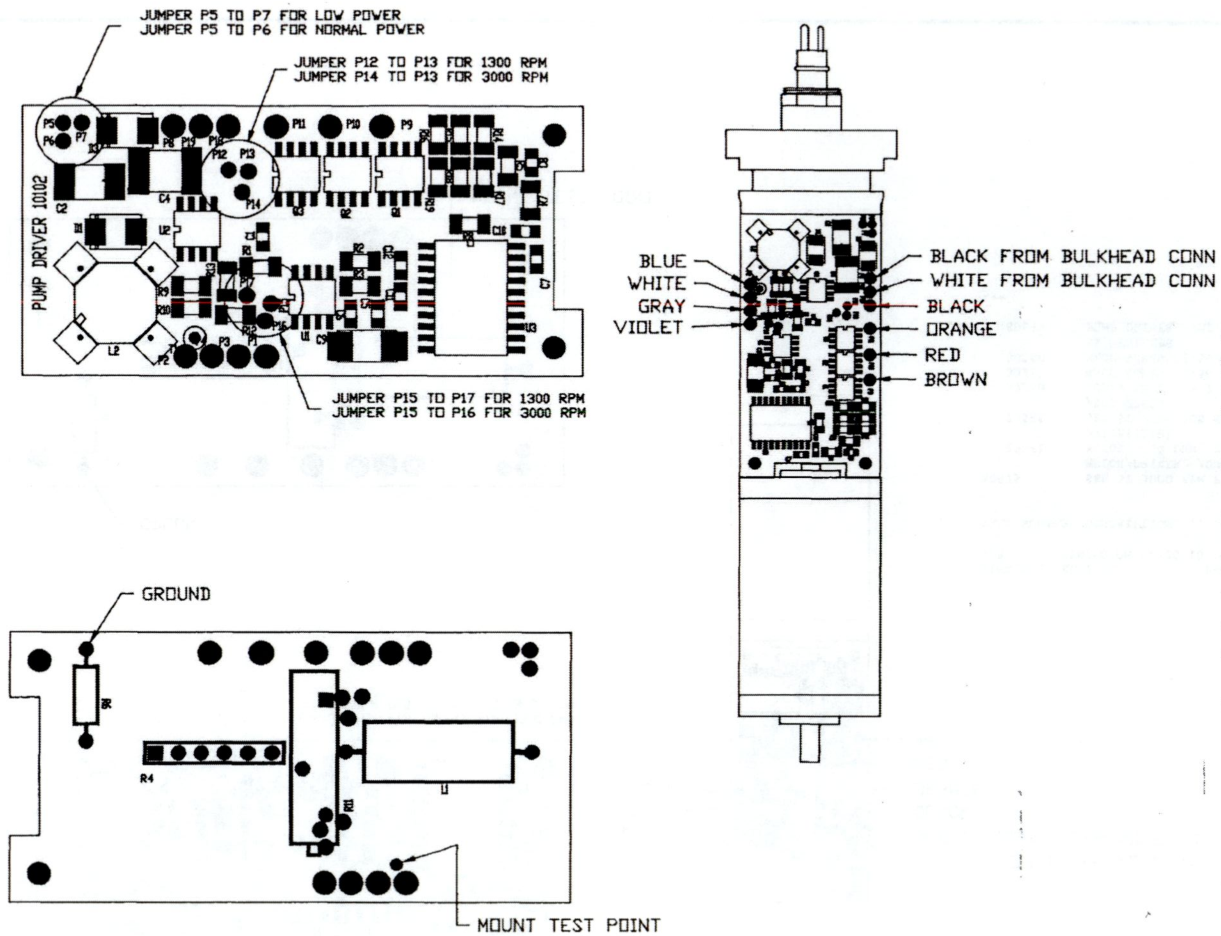
TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N 80675,31441	SCALE	DRAWN BY DJM / APPROVED BY
DECIMAL	TITLE SBE 5T 3000 RPM PUMP		
ANGULAR	DATE 2/11/93	DRAWING NUMBER 40630	REV A

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
7/6/94	A	SEE HISTORY	P.G.	BAF	

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SLB       PRINTED ON 14:20:10  06 JUL 1994

PART NUMBER. DESCRIPTION.................. QPA.....

80676        SBE 5T 1300 RPM, NORM POWER
             MOTOR, /DWG 40631
   20080     MOTOR, PUMP, 18 OHM PITTMAN          1.0000
             3711B113-R1
   23595     SBE 5T PUMP PCB MOUNT BLOCK,         1.0000
             /DWG 20624
   30260     SCREW INSUL, # 2 X 1/8, IN-2/2       2.0000
   30357     MACH SCREW, 2-56 X 1/4 PH, SS        2.0000
   30560     MACH SCREW, 2-56 X 9/16 FH,          2.0000
             SS, PHILIPS
   80639     PUMP DRIVER, SMT, /DWG 40605         1.0000

***

SLB       PRINTED ON 14:20:10  06 JUL 1994

PART NUMBER. DESCRIPTION.................. QPA.....

80681        SBE 5T 1300 RPM LO-VOLT
             MOT/DRVR /DWG 40631
   20080     MOTOR, PUMP, 18 OHM PITTMAN          1.0000
             3711B113-R1
   23595     SBE 5T PUMP PCB MOUNT BLOCK,         1.0000
             /DWG 20624
   30260     SCREW INSUL, # 2 X 1/8, IN-2/2       2.0000
   30357     MACH SCREW, 2-56 X 1/4 PH, SS        2.0000
   30560     MACH SCREW, 2-56 X 9/16 FH,          2.0000
             SS, PHILIPS
   80639     PUMP DRIVER, SMT, /DWG 40605         1.0000

***
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TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N ~~80681~~, 80676' 3/4"	SCALE	DRAWN BY DJM / APPROVED BY
DECIMAL	TITLE SBE 5T 1300 RPM PUMP		
ANGULAR	DATE 2/11/93	DRAWING NUMBER 40631	REV A

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APPLICATION NOTE NO. 42 **Revised September 2001**

ITS-90 TEMPERATURE SCALE

Beginning January 1995, Sea-Bird temperature calibration certificates list a new set of coefficients labeled *g*, *h*, *i*, *j*, and *F0*. These coefficients correspond to ITS90 (T90) temperatures and should be entered by those researchers working with SEASOFT-DOS Versions 4.208 and higher (and all versions of SEASOFT-Win32). For the convenience of users who prefer to use older SEASOFT versions, the new certificates also list *a*, *b*, *c*, *d*, and *F0* coefficients corresponding to IPTS68 (T68) temperatures as required by SEASOFT-DOS versions older than 4.208.

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

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

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

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

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

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

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APPLICATION NOTE NO. 57 **Revised May 2003**

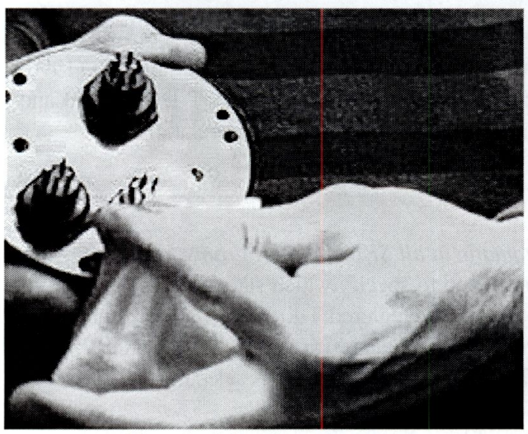
I/O Connector Care and Installation

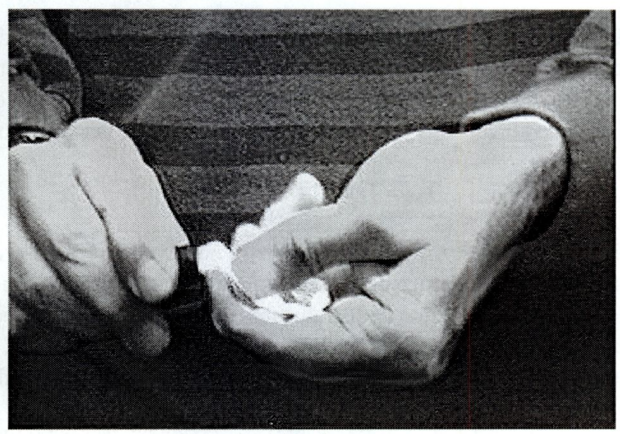
This Application Note describes the proper care and installation of standard I/O connectors for Sea-Bird CTD instruments. Once properly installed, the connections require minimal care. Unless access to the bulkhead is required, the connections can be left in place indefinitely.

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

Connector Cleaning and Installation

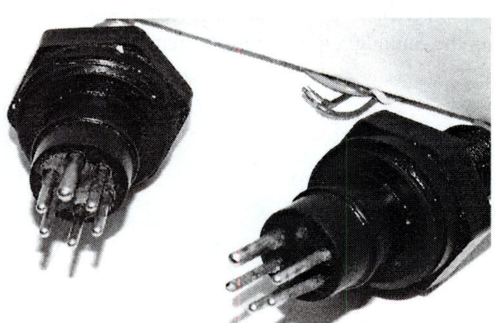
1. Carefully clean the bulkhead connector and the inside of the mating inline (cable end) connector with a Kimwipe. Remove all grease, hair, dirt, and other contamination.


Clean bulkhead connector

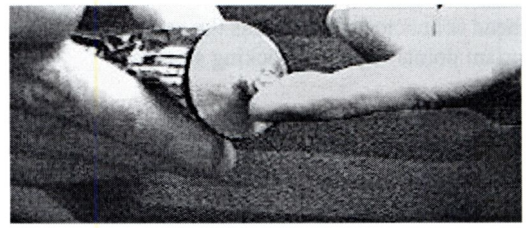

Clean inside of connector

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

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

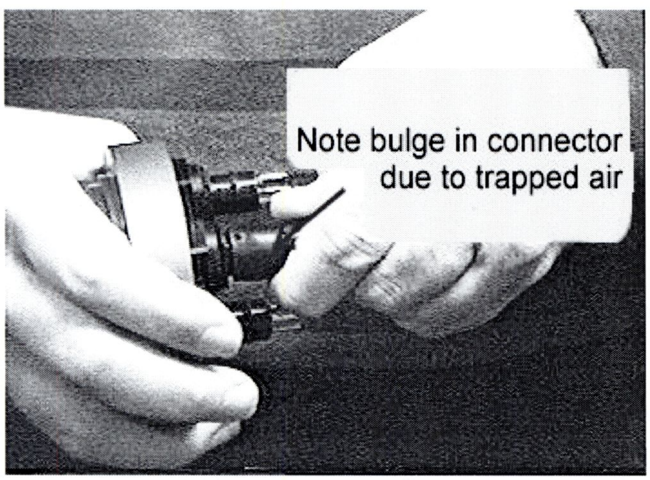

Corroded pins on bulkhead connectors - Connector on right has a missing pin

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.

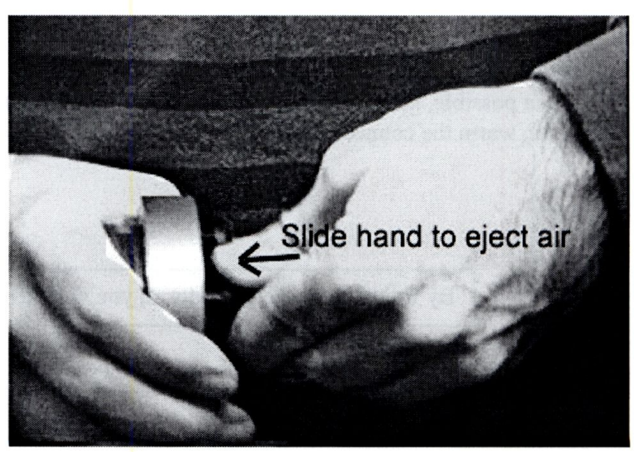


5. Mate the inline connector to the bulkhead, being careful to align the pins with the sockets. Do not twist the inline connector on the bulkhead connector. Twisting can lead to bent pins, which will soon break.

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.



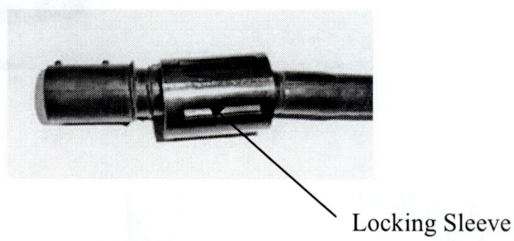
Locking Sleeve Installation

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!

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APPLICATION NOTE NO. 67 — October 2001

Editing Sea-Bird .hex Data Files

After acquiring real-time .hex data or uploading .hex data from CTD memory, users sometimes want to edit the header to add or change explanatory notes about the cast. Some text editing programs modify the file in ways that are not visible to the user (such as adding or removing carriage returns and line feeds), but that corrupt the format and prevent further processing by SEASOFT (both DOS and Windows versions). **This Application Note provides details on one way to edit a .hex data file with a text editor while retaining the required format.** The procedure described below has been found to work correctly on computers running Win 98, Win 2000, and Win NT. If the editing is not performed using this technique, SEASOFT may reject the data file and give you an error message.

1. Make a back-up copy of your .hex data file before you begin.

2. Run **WordPad**.

3. In the File menu, select Open. The Open dialog box appears. For *Files of type*, select *All Documents (*.*)*. Browse to the desired .hex data file and click Open.

4. Edit the file as desired, **inserting any new header lines after the System Upload Time line**. Note that all header lines must begin with an asterisk (*), and *END* indicates the end of the header. An example is shown below, with the added lines in bold:

```
* Sea-Bird SBE 21 Data File:
* FileName = C:\Odis\SAT2-ODIS\oct14-19\oc15_99.hex
* Software Version Seasave Win32 v1.10
* Temperature SN = 2366
* Conductivity SN = 2366
* System UpLoad Time = Oct 15 1999  10:57:19
* Testing adding header lines
* Must start with an asterisk
* Can be placed anywhere between System Upload Time and END of header
* NMEA Latitude = 30 59.70 N
* NMEA Longitude = 081 37.93 W
* NMEA UTC (Time) = Oct 15 1999  10:57:19
* Store Lat/Lon Data = Append to Every Scan and Append to .NAV File When <Ctrl F7> is Pressed
** Ship:     Sea-Bird
** Cruise:    Sea-Bird Header Test
** Station:
** Latitude:
** Longitude:
*END*
```

5. In the File menu, select Save (**not** Save As). If you are running Windows 2000, the following message displays:

   You are about to save the document in a Text-Only format, which will remove all formatting. Are you sure you want to do this?

   Ignore the message and click *Yes*.

6. In the File menu, select Exit.

NOTE: This Application Note **does not apply to .dat data files**. Sea-Bird is not aware of a technique for editing a .dat file that will not corrupt the file.

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APPLICATION NOTE NO. 68

Revised March 2004

Using USB Ports to Communicate with Sea-Bird Instruments

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

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

- **Keyspan** (www.keyspan.com) - High Speed USB Serial Adapter (part # USA-19QW) and USB 4-Port Serial Adapter (part # USA-49W)
- **Edgeport** (www.ionetworks.com) - Standard Serial Converter Edgeport/2 (part # 301-1000-02)
- **IOGEAR** (www.iogear.com) – USB 1.1 to Serial Converter Cable (model # GUC232A)

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

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APPLICATION NOTE NO. 69 **July 2002**

Conversion of Pressure to Depth

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

Sea-Bird uses the following algorithms for calculating depth:

Fresh Water Applications

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

$$\text{depth (meters)} = \text{pressure (decibars)} * 1.019716$$

Seawater Applications

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

The gravity variation with latitude and pressure is computed as:

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

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

Then, depth is calculated from pressure:

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

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

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APPLICATION NOTE NO. 71

September 2003

Desiccant Use and Regeneration (drying)

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

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

When to Replace Desiccant Bags

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

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

What do we mean by *expose the electronics*?

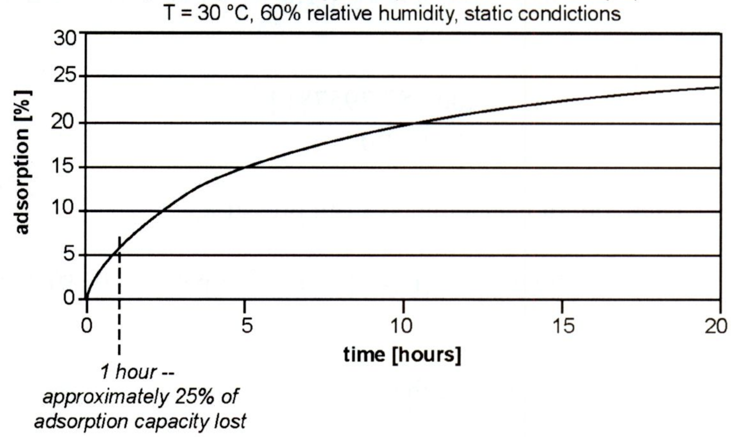
- For most battery-powered Sea-Bird instruments (such as SBE 16, 16*plus*, 16*plus*-IM, 17*plus*, 19, 19*plus*, 25, 37-SM, 37-SMP, 37-IM, 37-IMP, 44; PN 90208 Auto Fire Module [AFM]), there is a bulkhead between the battery and electronics compartments. Battery replacement does not affect desiccation of the electronics, as the batteries are removed without removing the electronics and no significant gas exchange is possible through the bulkhead. Therefore, opening the battery compartment to replace the batteries does not expose the electronics; you do not need to install a new desiccant bag in the electronics compartment each time you open the battery compartment. For these instruments, install a new desiccant bag if you open the electronics compartment to access the printed circuit boards.
- For the SBE 39 and 48, the electronics must be removed or exposed to access the battery. Therefore, install a new desiccant bag each time you open the housing to replace a battery.

Storage and Handling

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

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

Adsorption Rate for Sorb-It®
(from http://www.s-cpp.com/pdf/DesiccantPerfData.pdf)
T = 30 °C, 60% relative humidity, static condictions



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.

SÜD-CHEMIE
Creating Performance Technology

ISO 9002 CERTIFIED

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101 Christine Dr.
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Fax: (505) 864-9296

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

SECTION I -- PRODUCT IDENTIFICATION

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

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

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

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

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

SECTION III -- PHYSICAL DATA

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

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SECTION IV -- FIRE EXPLOSION DATA

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

Flash Point - Nonflammable.

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

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

SECTION V -- HEALTH HAZARD DATA

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

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

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

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

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

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

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

SECTION VI -- REACTIVITY DATA

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

SECTION VII --SPILL OR LEAK PROCEDURES

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

SECTION VIII -- SPECIAL PROTECTION INFORMATION

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

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

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

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

SECTION IX -- SPECIAL PRECAUTIONS

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

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

* No Information Available

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

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

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Application Note 56 **Revised September 2003**

Interfacing to RS-485 Sensors

A few Sea-Bird instruments use the RS-485 protocol for transmitting setup commands to the instrument and receiving data from the instrument. However, most personal computers (PCs) do not come with an RS-485 port. This Application Note covers interfacing our RS-485 instruments with a PC by the following methods:

- Connecting the instrument to an external RS-485/RS-232 Interface Converter that plugs into an existing RS-232 port on the PC.

  OR
- Installing an RS-485 interface card (and associated software) in the PC, and then connecting the instrument directly to the new RS-485 port in the PC.

External RS-485/RS-232 Interface Converter

RS-485/RS-232 Interface Converters are available commercially. These converters plug into the RS-232 port on the PC, and allow an RS-485 device to be connected through the converter. Sea-Bird tested a converter from one manufacturer with our instruments, and verified compatibility. The manufacturer and tested converter is:

Black Box (www.blackbox.com) –
IC520A-F with RS-232 DB-25 female connector and RS-485 terminal block connector

Other converters from this manufacturer, and converters from other manufacturers, **may** also be compatible with Sea-Bird instruments. We recommend testing other converters with the instrument before deployment, to verify that there is no problem.

Follow this procedure to use the IC520A-F Converter:

1. Connect the Converter to the PC:
   - If the PC has a 25-pin male RS-232 connector, plug the Converter directly into the PC connector.
   - If the PC has a 9-pin male RS-232 connector, plug the Converter into a 25-pin to 9-pin adapter (such as Black Box FA520A-R2 Adapter). Plug the 25-pin to 9-pin adapter into the PC.

2. On the Converter, measure the voltage between XMT+ and ground and between XMT- and ground. Connect whichever has the highest voltage to RS-485 'A' and the other to RS-485 'B'. The ground terminal can be left unconnected.

RS-485 Interface Card and Port in the PC

An RS-485 Interface Card installs in the PC, and allow an RS-485 device to be connected to the RS-485 port. These Interface Cards are available commercially. When using with a Sea-Bird instrument:

- **RS-485 Transmitter -**
  The Interface Card must be configured to automatically handle the RS-485 driver enable.

- **Two-Wire Interface -**
  TX+ and RX+ on the Interface Card must be connector together and to 'A' on the instrument.
  TX- and RX- on the Interface Card must be connected together and to 'B' on the instrument.
  Note: Some Interface Cards have a jumper to make the connections internally, while for other Cards the connections must be made in a jumper cable.

- **Terminal Program Compatibility -**
  If the Interface Card uses shared interrupts, SEATERM (our Windows terminal program) must be used to communicate with the instrument.
  If the Interface Card is configured as a standard COM port, either SEATERM or our DOS-based terminal programs may be used to communicate with the instrument.

Sea-Bird tested two Interface Cards from one manufacturer with our instruments, and verified compatibility. The manufacturer and tested cards are:

National Instruments (www.ni.com) -
AT-485/2
PCI-485/2

Other Cards from this manufacturer, and Cards from other manufacturers, **may** also be compatible with Sea-Bird instruments. We recommend testing other Cards with the instrument before deployment, to verify that there is no problem.

Follow this procedure to use the AT-485/2 or PCI-485/2 Interface Card:

1. Install the RS-485 driver software (provided with Interface Card) on your PC before installing the Interface Card.

2. Install the RS-485 Interface Card.

3. Configure the RS-485 Interface Card in your PC (directions are for a PC running Windows XP):
   A. Right click on My Computer and select Properties.
   B. In the System Properties dialog box, click on the Hardware tab. Click the Device Manager button.
   C. In the Device Manager window, double click on Ports. Double click on the desired RS-485 port.
   D. In the Communications Port Properties dialog box, click the Port Settings tab.
   Click the Advanced button.
   E. In the Advanced Settings dialog box, set Transceiver Mode to 2 wire TxRdy Auto.

4. Make a jumper cable (**do not use a standard adapter cable**) to connect the Interface Card to the instrument's I/O cable. Pin outs are shown for a Sea-Bird 9-pin (current production) or 25-pin (older production) I/O cable:

DB-9S (connect to PC)	**DB-9P** (connect to Sea-Bird I/O cable PN 801385)	**DB-25P** (connect to Sea-Bird I/O cable PN 801046)
pin 1 common	pin 5 common	pin 7 common
pin 4 TX+	pin 3 'A'	pin 2 'A'
pin 8 RX+	pin 3 'A'	pin 2 'A'
pin 5 TX-	pin 2 'B'	pin 3 'B'
pin 9 RX-	pin 2 'B'	pin 3 'B'

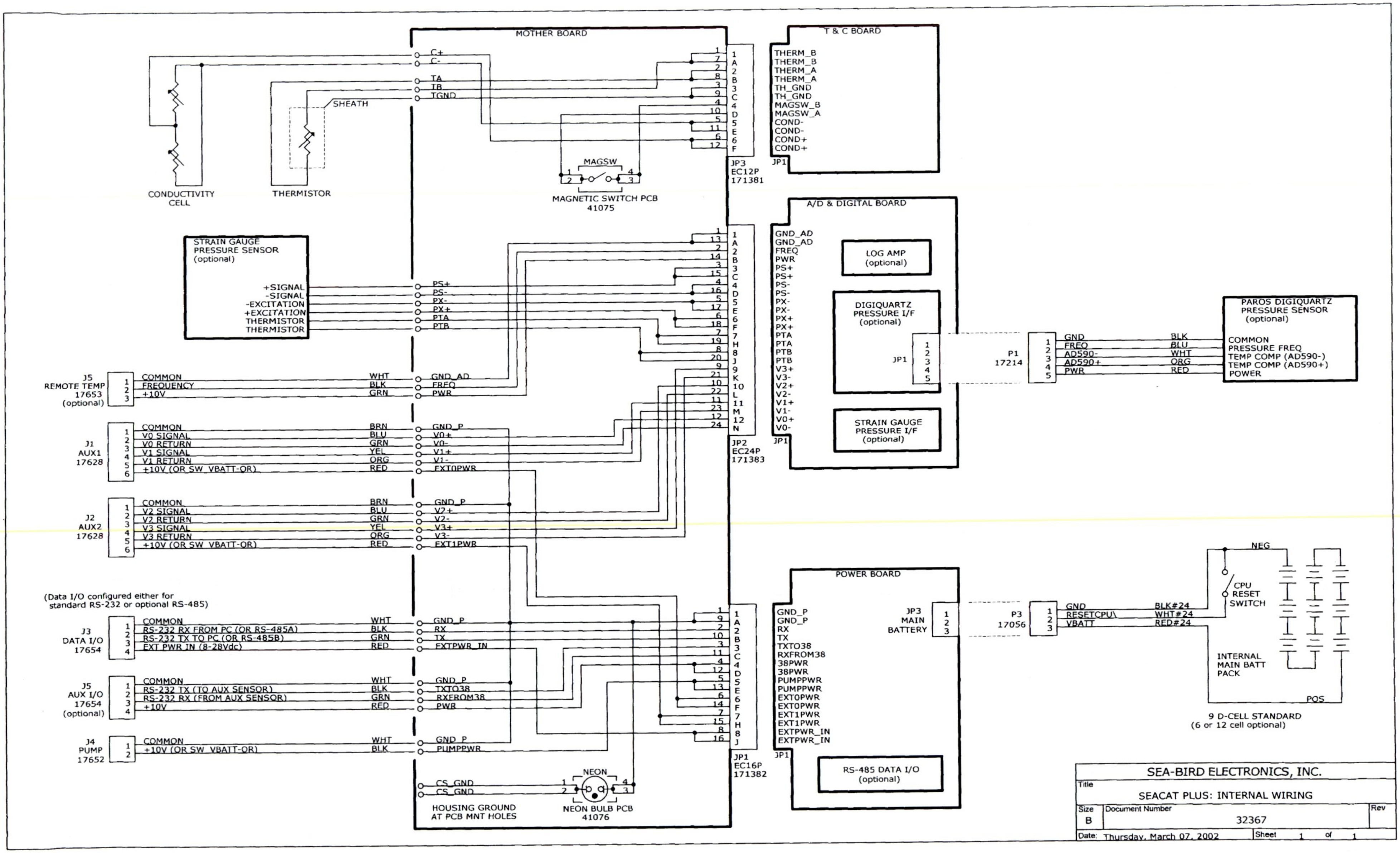
5. Run SEATERM (these Cards use shared interrupts, so the DOS terminal programs cannot be used):
   A. In SEATERM's Configure menu, select the desired instrument.
   B. In the Configuration Options dialog box, set Mode to RS-485 and set COMM Port to the appropriate RS-485 port.

DRAWINGS

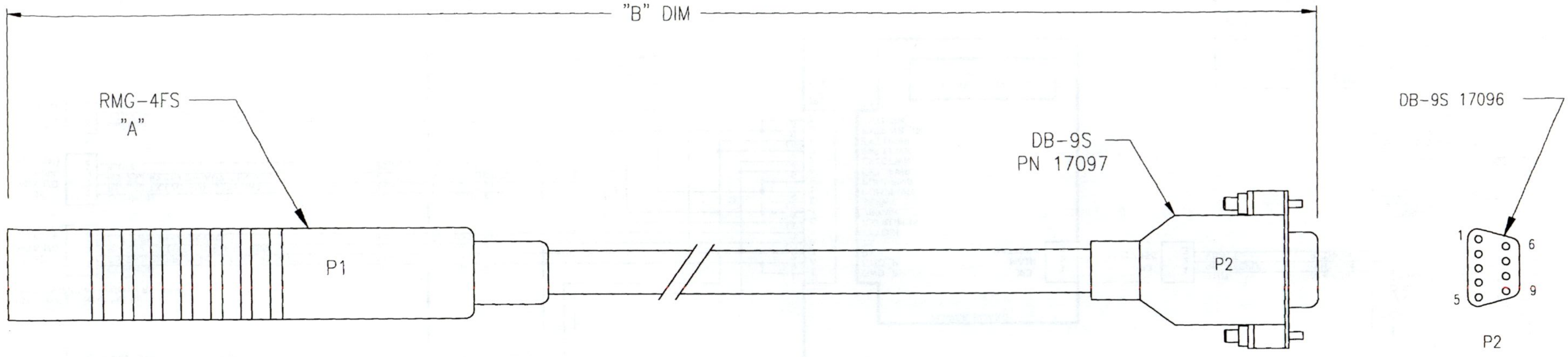
Dwg 32367 SEACAT Plus Internal Wiring, Impulse Connectors.......................... 1

Dwg 32421 Cable Assy, Data I/O, RMG-4FS to DB-9S, PN 801225.................... 2

Dwg 30565 Cable, RMG-2FS to RMG-2FS, Pump Interface, PN 17133.............. 3


MOTHER BOARD
T & C BOARD
THERM_B
THERM_B
THERM_A
THERM_A
TH_GND
TH_GND
MAGSW_B
MAGSW_A
COND-
COND-
COND+
COND+
JP3
EC12P
171381
C+
C-
TA
TB
TGND
SHEATH
CONDUCTIVITY CELL
THERMISTOR
MAGSW
MAGNETIC SWITCH PCB
41075
A/D & DIGITAL BOARD
GND_AD
GND_AD
FREQ
PWR
PS+
PS+
PS-
PS-
PX-
PX-
PX+
PX+
PTA
PTA
PTB
PTB
V3+
V3-
V2+
V2-
V1+
V1-
V0+
V0-
LOG AMP
(optional)
DIGIQUARTZ PRESSURE I/F
(optional)
JP1
STRAIN GAUGE PRESSURE I/F
(optional)
JP2
EC24P
171383
STRAIN GAUGE PRESSURE SENSOR
(optional)
+SIGNAL
-SIGNAL
-EXCITATION
+EXCITATION
THERMISTOR
THERMISTOR
PS+
PS-
PX-
PX+
PTA
PTB
P1
17214
GND
FREQ
AD590-
AD590+
PWR
BLK
BLU
WHT
ORG
RED
PAROS DIGIQUARTZ PRESSURE SENSOR
(optional)
COMMON
PRESSURE FREQ
TEMP COMP (AD590-)
TEMP COMP (AD590+)
POWER
J5
REMOTE TEMP
17653
(optional)
COMMON
FREQUENCY
+10V
WHT
BLK
GRN
GND_AD
FREQ
PWR
J1
AUX1
17628
COMMON
V0 SIGNAL
V0 RETURN
V1 SIGNAL
V1 RETURN
+10V (OR SW VBATT-OR)
BRN
BLU
GRN
YEL
ORG
RED
GND_P
V0+
V0-
V1+
V1-
EXT0PWR
J2
AUX2
17628
COMMON
V2 SIGNAL
V2 RETURN
V3 SIGNAL
V3 RETURN
+10V (OR SW VBATT-OR)
GND_P
V2+
V2-
V3+
V3-
EXT1PWR
(Data I/O configured either for standard RS-232 or optional RS-485)
J3
DATA I/O
17654
COMMON
RS-232 RX FROM PC (OR RS-485A)
RS-232 TX TO PC (OR RS-485B)
EXT PWR IN (8-28Vdc)
GND_P
RX
TX
EXTPWR_IN
J5
AUX I/O
17654
(optional)
COMMON
RS-232 TX (TO AUX SENSOR)
RS-232 RX (FROM AUX SENSOR)
+10V
GND_P
TXTO38
RXFROM38
PWR
J4
PUMP
17652
COMMON
+10V (OR SW VBATT-OR)
GND_P
PUMPPWR
CS_GND
CS_GND
HOUSING GROUND AT PCB MNT HOLES
NEON
NEON BULB PCB
41076
JP1
EC16P
171382
POWER BOARD
GND_P
GND_P
RX
TX
TXTO38
RXFROM38
38PWR
38PWR
PUMPPWR
PUMPPWR
EXT0PWR
EXT0PWR
EXT1PWR
EXT1PWR
EXTPWR_IN
EXTPWR_IN
JP3
MAIN
BATTERY
RS-485 DATA I/O
(optional)
P3
17056
GND
RESETCPU\
VBATT
BLK#24
WHT#24
RED#24
NEG
CPU RESET SWITCH
INTERNAL MAIN BATT PACK
POS
9 D-CELL STANDARD
(6 or 12 cell optional)
SEA-BIRD ELECTRONICS, INC.
Title
SEACAT PLUS: INTERNAL WIRING
Size
B
Document Number
32367
Rev
Date: Thursday, March 07, 2002
Sheet 1 of 1

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.



ASSY P/N	"A" CABLE P/N	"B" DIM
801225	17741	8 FEET

ROCHESTER 3-N-5 OR EQUIV.
3 CONDUCTOR PIGTAIL

P1 RMG-4FS	COLOR	P2 DB-9S
PIN 1	WHITE	PIN 5
PIN 2	BLACK	PIN 3
PIN 3	RED	PIN 2

ESSEX ROYAL 18/4 OR EQUIV.
4 CONDUCTOR PIGTAIL

P1 RMG-4FS	COLOR	P2 DB-9S
PIN 1	WHITE	PIN 5
PIN 2	BLACK	PIN 3
PIN 3	GREEN	PIN 2
PIN 4	RED	N/C

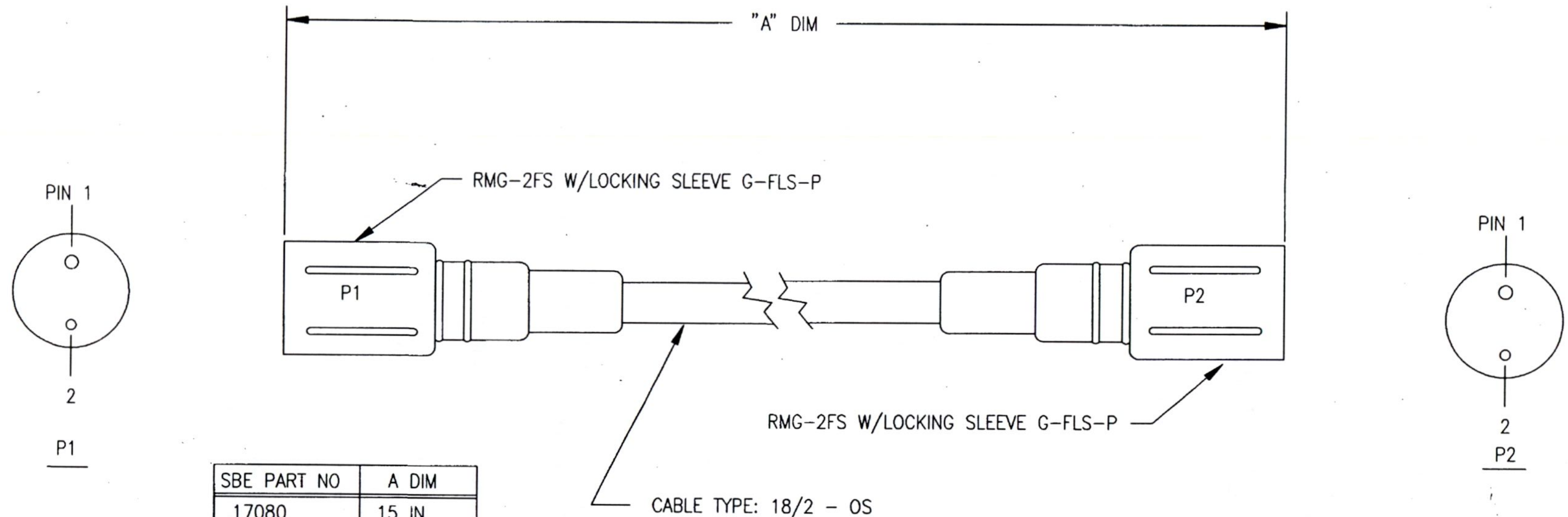
SEA-BIRD ELECTRONICS, INC

P/N	SCALE	DRAWN BY	APPROVED BY
SEE TABLE	-	PMc	

RMG-4FS TO DB-9S CABLE ASSEMBLY

DATE	DWG NO.	SHEET	REV
6/26/00	32421	1 of 1	-

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.



SBE PART NO	A DIM
17080	15 IN
17100	40 IN
17101	6 FT
17127	60 IN
17133	44 IN
17159	36 IN
17188	34 IN
17200	79 IN
17259	120 IN
17285	12 IN
17394	29 IN
17450	24 IN
17584	48 IN
171229	10 M
171249	130 CM

P1	P2
PIN 1	PIN 1
PIN 2	PIN 2

TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N SEE TABLE	SCALE N.T.S.	DRAWN BY CEG / APPROVED BY CB
DECIMAL	TITLE CABLE, 2 PIN / 2 PIN RMG-2FS W/LOCKING SLEEVE		
ANGULAR	DATE 9.21.98	DRAWING NUMBER 30565	REV

WARRANTY POLICY

2003

5-YEAR LIMITED WARRANTY (NEW PRODUCTS)

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

LIMITED WARRANTY ON SERVICE & REPAIRS

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

MODIFICATIONS / EXCEPTIONS / EXCLUSIONS

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

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

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

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

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

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

Warranty Administration Policy

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

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

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

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

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

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

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

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

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

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

Service Request Form

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

PLEASE:

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

RETURNED MATERIAL AUTHORIZATION (RMA) NUMBER

RMA Number: ______________________________

CONTACT INFORMATION

Your name: ______________________________

Institution/Organization/Company: ______________________________

Shipping/Delivery address for packages: ______________________________

____

____

Telephone: ____________________ Fax: ____________________

e-mail: ______________________________

SERVICE INFORMATION

Date Shipped: ______________________________

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

Quantity: ______________________________

Serial Numbers: ______________________________

____

____

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

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

[ ] **Perform Routine Services:**

____Calibration (includes basic diagnostic):

___Temperature ___Conductivity ___Pressure ___DO ___pH

(Please allow a minimum of 3 weeks after we receive the instrument(s) to complete calibration.)

____Full System Diagnostic and Check Out

____Other (specify): ______________________________

____

[ ] **System Upgrade or Conversion:**

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

____

____

[ ] **Diagnose and Repair Operational Faults:**

Please send a disk containing the raw data (.hex or .dat files) which shows the problems you describe. Also send the .con files you used to acquire or display the data.

Problem Description (continue on additional pages if needed; include instrument serial number if multiple instruments are part of shipment): ______________________________

____

____

____

____

PAYMENT/BILLING INFORMATION

Credit Card: Sea-Bird accepts payment by MasterCard, VISA, 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 EU and Chinese regulations, if Sea-Bird receives an instrument from the EU or China in a crate containing coniferous solid wood, we will return the instrument in a new crate made with mahogany and plywood. 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:

Overall Volume (cm3)	Example Instrument	Price (USD)
less than 52,000	37-SM MicroCAT	$45
52,000 to less than 65,000	SEACAT, no cage	$70
65,000 to 240,000	CTD in cage	$125
more than 240,000	--	consult factory

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