SBE 19 SEACAT Profiler CTD

Conductivity, Temperature and Pressure Recorder

User's Manual

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

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SBE 19 SEACAT PROFILER

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1-1 INTRODUCTION

The SBE 19 SEACAT Profiler is designed to measure conductivity, temperature, and pressure in marine or fresh water environments to depths of 10,500 meters. The standard SEACAT operates in two modes. **Profiling mode** is designed for applications where vertical profiles of measured parameters are required; the sample rate can be varied from twice a second to once every 4 minutes in half-second increments. **Moored mode** provides time series measurements at sample rates of every 15 seconds to 8 hours, adjustable in 1-second increments.

Self-powered (9 D-size alkaline batteries provide 26 hours operation in profiling mode) and self-contained, the SEACAT features the proven Sea-Bird conductivity and temperature sensors and a precision semiconductor strain-gauge pressure transducer. The 1024K byte CMOS static RAM records 24 hours of conductivity, temperature, and pressure data while sampling at two scans per second (48, 96, or 192 hours with optional 2, 4, or 8 megabyte memories). External sensors may be powered and their frequency or voltage outputs acquired by the SEACAT. Setup, check-out, and data extraction are performed without opening the housing. Simultaneous real-time monitoring is possible using the SEACAT's three wire RS-232C interface.

The standard SEACAT has 1024K byte memory, 600-meter plastic housing, SBE 5M pump for pumped conductivity, a second bulkhead connector wired for 4 single-ended auxiliary A/D inputs, and alkaline batteries. Options include:

- aluminum or titanium housing for use to 3400, 6800, or 10500 meters
- 2, 4, or 8 megabyte memory
- internal optical isolation and cable driver for real-time telemetry over cables up to 7000 meters long
- 2 differential input A/D channels in place of the 4 single-ended channels
- sensors for dissolved oxygen, pH, fluorescence, light (PAR), light transmission, and turbidity
- SBE 5T pump for use with dissolved oxygen and/or pumped fluorometer sensor

The SEACAT can be used with the SBE 32 Carousel Water Sampler and SBE 33 Carousel Deck Unit. The SBE 32 provides +15 VDC power to the SEACAT and has ample power available for auxiliary sensors not normally supported by battery-powered CTDs. CTD data from the SEACAT is converted into single-wire telemetry for transmission over long (10,000 meter) seacables. 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.

Also available for use with the SEACAT is the SBE 36 CTD Deck Unit and Power Data Interface Module (PDIM), which provide real-time power and data handling capabilities over single-conductor seacables using the same method employed in the SBE 32/SBE 33 Carousel Water Sampler. The PDIM, a small pressure housing that is mounted on or near the CTD, provides +15 VDC power to the SEACAT and interfaces two way RS-232 communications from the SEACAT to the telemetry used on the seacable.

Supplied with the SEACAT is a powerful software package, SEASOFT, which enables the user to communicate, retrieve data, and calculate and display temperature, conductivity and derived variables such as salinity and sound velocity. SEASOFT is designed to run on IBM XT/AT/386/486 or compatible computers. A separate software manual contains additional information on the setup and use of SEASOFT.

Note: **This manual details use of the DOS version of SEASOFT with the SBE 19. A Windows software package, SEASOFT-Win32, is also available**, and is compatible with the SBE 19. SEASOFT-Win32 includes:

- **SEATERM** – terminal program for easy communication and data retrieval.
- **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.

Help files provide detailed information on the software use. Separate software manuals are also available for SEASAVE and SBE Data Processing.

1-2 FUNCTIONAL DESCRIPTION

1-2.1 SENSORS

SEACAT embodies the sensor elements (Pyrex cell and pressure-protected thermistor) and Wein-bridge oscillator interface technique previously employed in Sea-Bird's modular SBE 3 and SBE 4 sensors, but differs in using multiplexing to allow a single oscillator to service both temperature and conductivity measurements.

The pressure sensor is either a Paine strain-gauge sensor or a Paroscientific Digiquartz pressure sensor.

1-2.2 SENSOR INTERFACE

Temperature or conductivity dependent variable frequencies generated by the Wein-bridge are acquired (digitized) using a hybrid period counting technique (AP Counter) like that used in the Sea-Bird SBE 9 CTD. The AP Counter determines integer and fractional cycles of the variable frequency during a fixed time interval of 0.125 seconds (this period, and therefore the count accuracy, is determined using a precision quartz TCXO). The resulting count is offset and scaled in preparation for storage in CMOS static RAM.

Drift associated with changes in ambient temperature or component aging is compensated in SEACAT by switching stable resistors (Vishay types) into the Wein-bridge oscillator once per minute. The resulting frequencies (representing the approximate upper and lower frequency limits of the oscillator) are measured and used to correct circuit drift. Consequently, the accuracy of SEACAT electronics is limited principally by the stability of the Vishay resistors and time-base quartz crystal.

The strain gauge pressure sensor is operated as a DC bridge. The amplified sensor output signal is acquired by a 12-bit plus sign A/D converter providing an effective resolution of 0.015%.

1-2.3 REAL-TIME CLOCK

To minimize battery current drain, a low power *watch* crystal is used as the real-time-clock frequency source. Initial error, ambient temperature-induced drift, and aging of the *watch* crystal is compensated by measuring its actual frequency against the TCXO each time SEACAT powers up. The measured discrepancy (if any) is used to arithmetically correct the low power clock.

Clock power is supplied by the main battery or the internal lithium back-up, depending on which voltage is higher. Even a *dead* main battery usually supplies the very small clock power drain (less than 60 microamperes), so the back-up cells last indefinitely.

1-2.4 MEMORY

Memory consists of eight low standby-power CMOS static 128K X 8 RAM chips. Each recorded CTD scan contains 6 bytes of data (standard units), and 4000 bytes are reserved for scratch-pad use, including storage of header information containing cast number (up to 150 casts), time/date, and beginning and ending sample number for the cast. SEACAT sample capacity may be predicted by use of the following relationships:

M = memory size 1,048,576 bytes (1024K memory)

Z = scratch-pad reserved area, approximately 4000 bytes

B = bytes per scan (6 in a standard system)

S = # scans recorded (samples) = (M - Z) / B

For the standard 1024K version, the memory can hold approximately 174,000 samples of C, T, and P.

Either the lithium back-up or the main battery (whichever has the higher voltage) keep the memory intact. The main battery may be replaced without disturbing the memory contents.

1-2.5 MAGNETIC REED SWITCH

A magnetic switch is mounted on the conductivity cell guard. When SEACAT is quiescent (the CPU is not active) and set to profiling mode, sliding the switch to the *On* position switches on power to the CPU. If the battery voltage is greater than 7.2 volts and there is room in memory for data, SEACAT writes a header containing real-time and cast number, and begins storing CTD data in memory. When the magnetic switch is pushed to the *Off* position, SEACAT quits logging data and enters its low power quiescent mode. Keep the magnetic switch off (towards the connector end cap) when the SEACAT is not logging CTD data, i.e., during storage, setup and diagnostic interrogation, or data extraction.

Operation of the magnetic switch while in moored mode has no effect.

1-2.6 DATA I/O

SEACAT receives setup instructions and outputs diagnostic information or previously recorded data via a 3-wire RS-232C link, and is factory-configured for 600 baud (1200 baud with optional Paroscientific pressure sensor), 7 data bits, 1 stop bit, and even parity. SEACAT RS-232 levels are directly compatible with standard serial interface cards (IBM Asynchronous Communications Adapter or equal). The communications baud rate can be changed to alternate values using the SBn command as documented in section 2-2.6.

1-2.7 BATTERIES

A standard SEACAT uses 9 D-cell alkaline batteries or rechargeable nickel cadmium batteries. If necessary, carbon-zinc or mercury cells can also be used, but **lithium D-cells with their higher terminal voltages must not be used.** On-board lithium batteries (non-hazardous units which are unrestricted for shipping purposes) are provided to backup the memory and the real-time clock in the event of main battery failure or exhaustion. An auxiliary power source (10 - 15 volts DC) may be connected to the main I/O bulkhead to permit testing and data retrieval without affecting battery capacity on those units that do not have the optional optical isolation installed. The main batteries may be replaced without affecting either the real-time clock or memory.

1-2.8 HOUSING AND MECHANICAL DESIGN

The SEACAT main housing is a cylindrical pressure vessel having an outside diameter of 99 mm (3.9 inches) and flat end caps. The sensor end cap is retained by a bolt-circle, while the battery end cap is threaded on.

Main seals are single piston O-rings grooved into the end caps. Aluminum-housed SEACATs are hard-coat anodized and designed for use to depths of 3400 or 6800 meters; titanium housings are used for up to 10,500 meters. The aluminum housings employ anodes for corrosion protection.

1-3 SPECIFICATIONS

Measurement Range:	Temperature	-5 to +35 ºC
	Conductivity	0 to 7 S/m (0 to 70 mmho/cm)
	Pressure	
	Strain Gauge Sensor	100, 150, 300, 500, 1000, 1500, 3000, 5000, 10000, or 15000 psia
	Digiquartz Sensor	100, 200, 300, 400, 1000, 2000, 3000, 6000, 10000, or 15000 psia
Accuracy:	Temperature	0.01 ºC
	Conductivity	0.001 S/m
	Pressure	
	Strain Gauge Sensor	0.25% of full scale range (100 - 1500 psia) 0.15% of full scale range (3000 - 15000 psia)
	Digiquartz Sensor	0.02% of full scale range
Resolution:	Temperature	0.001 ºC
	Conductivity	0.0001 S/m
	Pressure	
	Strain Gauge Sensor	0.015% of full scale range (100 - 15000 psia)
	Digiquartz Sensor	0.001%
Sensor Calibration:	Temperature	+1 to +32 ºC (measurements outside this range may be at slightly reduced accuracy due to extrapolation errors)
	Conductivity	0 to 7 S/m. Physical calibration over the range 1.4 - 6 S/m. Measurements outside this range may be at slightly reduced accuracy due to extrapolation errors.
	Pressure	0 to full scale in 20% steps

Counter time-base: Quartz TCXO, ± 2 ppm per year aging; ± 2 ppm vs. temperature (-5 to +30 ºC).

Memory: CMOS static RAM, 1024K or (optional) 2, 4, or 8 Mbyte; battery-backed for minimum 3 years data retention.

Real-time clock: Watch-crystal type 32,768 Hz; battery-backed for minimum of 1 year operation irrespective of condition of main battery. Corrected for drift and aging by comparison to SEACAT counter time-base.

Batteries: 9 alkaline D-cells provide 8 amp-hours at 20 ºC (5 amp-hours at 0 ºC) and 3 year data retention reserve.

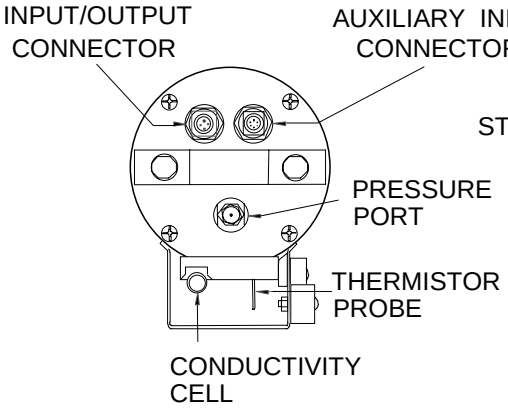
Materials:
600 meter Pressure Case, acetal copolymer (plastic)
3400 meter Pressure Case, 6061-T6 anodized aluminum
6800 meter Pressure Case, 7075-T6 anodized aluminum
7000 meter Pressure Case, 3AL-2.5V titanium
10500 meter Pressure Case, 6AL-4V titanium

2-1 CONFIGURATION OPTIONS

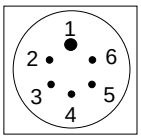
The SEACAT's standard configuration includes an externally mounted SBE 5M submersible pump, used to provide a constant flow rate through the conductivity cell. Optionally, if configured with a dissolved oxygen sensor, pumped fluorometer, or SEACAT T-C Duct, the more powerful SBE 5T pump is used. In either case, the pump is powered via a Y-cable connected to the 6-pin Data I/O bulkhead connector on the end cap. Two pins provide power for the pump; the remaining four pins are for communication and external power (Figure 1). The Y-cable has two branches: one connecting to the pump, and the other providing the connection to a computer with a 4-pin male connector (RMG-4-MP) (figure 2). If the SEACAT is configured without a pump, it is supplied with a 6-pin to 4-pin adapter cable to connect the Y-cable to the computer.

The SEACAT can be configured with a wide range of auxiliary sensors. A second 6-pin bulkhead connector on the end cap serves as the input port for the auxiliary sensor signal voltages and provides power to the sensors (Figure 1).

Figure 1 Connector Configurations



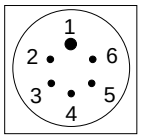
STANDARD SINGLE ENDED INPUTS



(AG-306-HP)

PIN	SIGNAL
(1)	COMMON
(2)	VOLTAGE 0
(3)	VOLTAGE 3
(4)	VOLTAGE 1
(5)	VOLTAGE 2
(6)	AUX POWER OUT

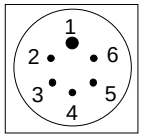
DATA I/O CONNECTOR



(AG-306-HP)

PIN	SIGNAL
(1)	COMMON
(2)	DATA RECEIVE
(3)	DATA TRANSMIT
(4)	PUMP POWER COMMON
(5)	PUMP POWER +
(6)	AUX POWER IN

OPTIONAL DIFFERENTIAL INPUTS



(AG-306-HP)

PIN	SIGNAL
(1)	COMMON
(2)	VOLTAGE 0 SIGNAL
(3)	VOLTAGE 0 COMMON
(4)	VOLTAGE 1 SIGNAL
(5)	VOLTAGE 1 COMMON
(6)	AUX POWER OUT

The SEACAT is configured with the SBE 5 pump to insure a reliable flow of water through the conductivity cell and optional dissolved oxygen sensor, regardless of descent rate. Figure 2 shows the plumbing arrangement of a SEACAT equipped with a pump. Sections 2-2.6 and 3-1.2 contain additional information on configuration and operation of the pump.

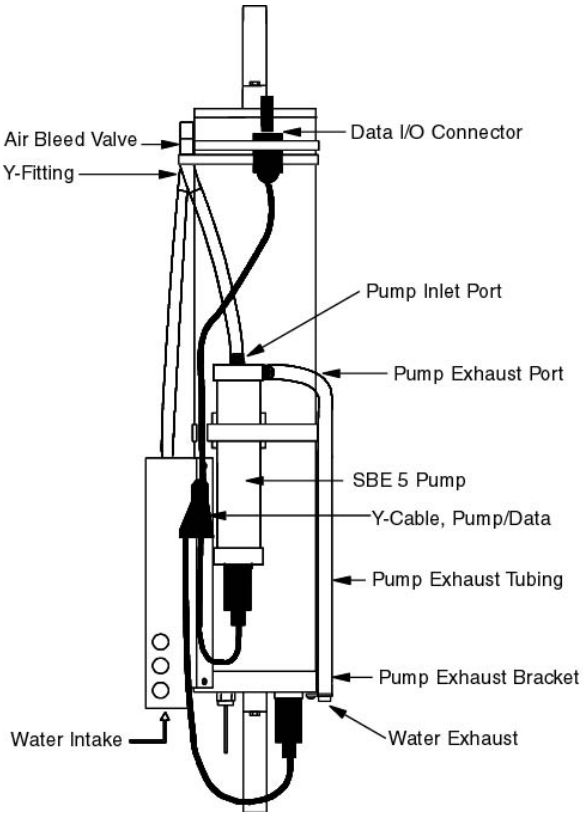


Figure 2. SBE 19 with SBE 5 Pump

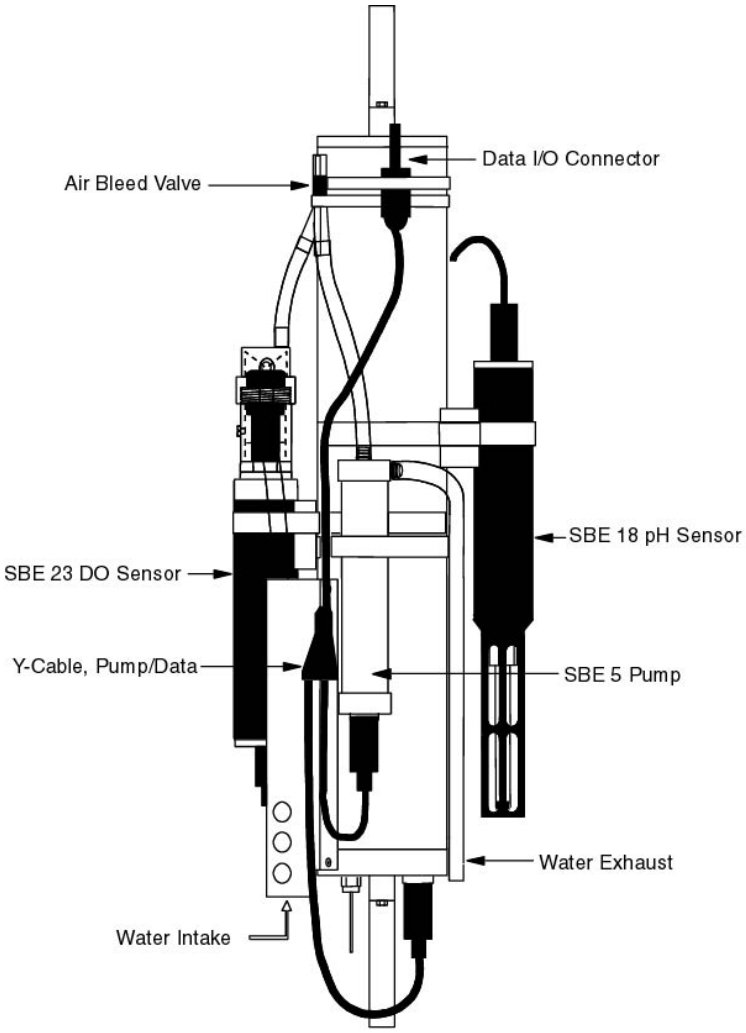


Figure 3. SBE 19 with SBE 5 Pump, and Optional Dissolved Oxygen and pH Sensors

Figure 3 shows the SEACAT configured with a pump and SBE 23 dissolved oxygen and SBE 18 pH sensors. Application note 29 contains additional information on configuration of the SEACAT with optional sensors.

2-2 SEACAT COMMUNICATION FUNDAMENTALS

SEACAT is factory configured for: 600 baud (1200 baud with optional Paroscientific pressure sensor), 7 Data Bits, 1 Stop Bit, Even Parity. SEACAT outputs - and expects to receive - industry standard RS-232 levels. If **TERM19** is used to communicate with the SEACAT, use the F2 key to set these parameters (see Section 2-5). Note: If desired, **use SEATERM instead of TERM19 (DOS) software to setup and upload data from the SEACAT**. See the SEATERM Help files for details. SEATERM is part of our SEASOFT Windows software suite.

Remove the dummy plug from SEACAT's I/O bulkhead connector or from the I/O connector on the pump Y-cable by unscrewing the locking sleeve and pulling the plug firmly away from the connector. Install the Sea-Bird cable connector, aligning the raised bump on the side of the connector with the large pin on the SEACAT connector. The other end of the I/O cable has a DB-25S for connection to your computer's serial port.

To begin communicating with SEACAT, keep the magnetic switch off. Mate the 4-pin test cable to the computer's serial port. If you are using Sea-Bird SEASOFT software, the serial port must be an IBM Asynchronous Communications Adapter, or equal. Run TERM19 and establish communications with the SEACAT. SEACAT is now in command mode and may be queried for various responses as described in the following sections of this manual.

About two minutes of keyboard inactivity causes SEACAT to time out and go into quiescent state. To regain control, press the Enter or carriage return key (CR) several times until the **S>** is displayed again. After completing a session with SEACAT, enter **qs(CR)**. This makes SEACAT enter the quiescent state immediately.

If the board-mounted internal lithium battery has been removed, disconnected, or exhausted, set the date and time with the ST command, set the pump parameters with the SP command, and enable the acquisition of external voltages with the SV command if auxiliary sensors are installed.

2-2.1 COMMAND FORMAT

Commands may be entered in upper or lower case letters. Responses made by SEACAT are indicated in bold type. SEACAT sends # whenever an invalid command is entered.

The following table describes the keyboard symbols used in this manual:

Symbol	Description	ASCII	HEX	Key Sequence
(CR)	Carriage Return	CR	0D	Return
NULL	Null character	NULL	00	Home Key
^	Control Key	--	--	Ctrl
^C	Escape Function	ETX	03	Ctrl + C or
^C	Escape Function	ESC	1B	Esc

When running TERM19, the Esc Key must be used to perform the Escape Function.

* Commands followed by an asterisk (*) alter SEACAT memory and prompt the user twice before executing (* is not part of the command). To execute the command, enter Y in response to **message Y/N**, and then hold down the Ctrl key and enter Y in response to **are you sure ^Y/N**. Any other responses abort the command.

[] Braces indicate optional parameters of the command. Items enclosed in braces need not be entered.

2-2.2 EDITING

The following keys are used to edit entries to SEACAT.

Description	ASCII	HEX
Carriage return: enters the command or line	CR	0D
Backspace: deletes the previous character	BS	08
Kill line: Ctrl X	CAN	18
Kill line: Escape	ESC	1B
Kill line: Ctrl C	ETX	03

2-2.3 COMMAND SUMMARY

Type	Command	Description
Diagnostics	J	Measure standby current
	TE	Extended memory test
	TM	Memory test
	VR	Display voltages
	FR	Display frequencies
Status	DS	Display current status
Setup	CN	Set conductivity channel to narrow range (fresh water)
	CS	Set conductivity channel to standard range (salt water)
	IR	Initialize RAM
	LW	Set time to pause after each line (0 is the default)
	MM	Set mode to moored
	MP	Set mode to profiling
	PN	Disable pump control logic
	QS	Quit session, enter quiescent state
	SB	Change default baud rate for communications and real-time data
	SP	Enable and set pump control parameters
	SR	Set sampling rate (profiling mode)
	SI	Set sample interval (moored mode)
	ST	Set date and time
	SV	Set the number of external voltages to sample
	VD	Set time to delay before measuring voltages in moored mode
Logging	IL	Initialize logging
	GL	Start logging, overwrite existing data
	QL	Quit logging in moored mode
	RL	Resume logging, do not overwrite data
	HOME KEY or Ctrl-Z halt logging in profiling mode	
Data Retrieval	DC	Dump data by cast
	DD	Dump data by scans
	DH	Display headers

2-2.4 DIAGNOSTICS

J(CR) Measure Standby current.

TE(CR)*^C Extended memory test. **WARNING, ALL DATA IN SEACAT WILL BE DESTROYED!** An incrementing pattern is written into all locations of each RAM. Data in the RAM is then compared to the pattern. Each pass the pattern is incremented by one. Each pass takes approximately 20 seconds and the test concludes after 10 passes. For each pass SEACAT sends the following message:

pass x
ram 0, OK
ram 1, OK
ram 2, OK
etc.

At the test conclusion or when an Escape Function character is received, SEACAT displays:
ram test passed with no errors.
NOTE: TE command not available in SEACAT firmware version 4.0b or greater.

TM(CR)*^C Memory test. **WARNING, ALL DATA IN SEACAT WILL BE DESTROYED!** Same as extended memory test except that the test concludes after pass 0 is completed. **NOTE**: TM command not available in SEACAT firmware version 4.0b or greater.

VR(CR)^C Display voltages. The first column is the main battery voltage divided by 8.514. The second column is a voltage that represents the temperature in the pressure sensor The third column is the pressure sensor voltage. 0, 2, or 4 columns are added after the last column depending on how many external voltages are sampled.

CAUTION: After execution of VR, SEACAT runs continuously until the Escape Function is implemented. Unless an external power source is being used, the normal 170 mA current is drawn from the battery during this time.

Example: VR(CR) SEACAT sends:

0.982 0.745 4.716

FR(CR)^C Display corrected and uncorrected frequencies.

CAUTION: After execution of FR, SEACAT runs continuously until the Escape Function is implemented. Unless an external power source is being used, the normal 170 mA current is drawn from the battery during this time.

Example: FR(CR) SEACAT sends:

aaaaa.aaa bbbbb.bbb ccccc.ccc ddddd.ddd eeeee.eee fffff.fff

aaaaa.aaa	is the 400 ohm reference resistor frequency
bbbbb.bbb	is the 5000 ohm reference resistor frequency
ccccc.ccc	is the frequency generated by the temperature sensor
ddddd.ddd	is the frequency generated by the conductivity cell
eeeee.eee	is the corrected temperature frequency
fffff.fff	is the corrected conductivity frequency

2-2.5 STATUS

DS(CR) Display operating status: software version, serial number and current time; pressure sensor type, serial number, range and temperature compensation value for strain gauge sensors; real-time clock frequency, operating current (milliamps), main battery voltage, lithium battery voltage; operating mode, number of stored casts; sample rate; number of stored samples, number of samples free in memory, and number of milliseconds to wait after sending a carriage return line feed (provides extra time for slow computers); battery cut-off voltage; number of external voltages that are being sampled; and whether data is being logged or not (moored mode)

Example: DS(CR) SEACAT sends:

SEACAT PROFILER V3.1B SN 936 02/10/94 13:33:06.439
strain gauge pressure sensor: S/N = 12345, range = 1000 psia, tc = 240
clk = 32767.766 iop = 172 vmain = 8.1 vlith = 5.7
mode = PROFILE ncasts = 0
sample rate = 1 scan every 0.5 seconds
samples = 0 free = 174126 lwait = 0 msec
battery cutoff = 7.2 volts
number of voltages sampled = 0
logdata = NO

If the pump is installed and pump control is enabled via the SP command, the pump control parameters display.

SEACAT PROFILER V3.1B SN 936 02/10/94 13:33:23.989
strain gauge pressure sensor: S/N = 12345, range = 1000 psia, tc = 240
clk = 32767.766 iop = 172 vmain = 8.1 vlith = 5.8
mode = PROFILE ncasts = 0
sample rate = 1 scan every 0.5 seconds
minimum raw conductivity frequency for pump turn on = 3206 hertz
pump delay = 40 seconds
samples = 0 free = 174126 lwait = 0 msec
battery cutoff = 7.2 volts
number of voltages sampled = 0
logdata = NO

In moored mode, the voltage sample delay is displayed.

SEACAT PROFILER V3.1B SN 936 02/10/94 13:33:39.549
strain gauge pressure sensor: S/N = 12345, range = 1000 psia, tc = 240
clk = 32767.766 iop = 172 vmain = 8.2 vlith = 5.6
mode = MOORED
sample interval = 30 seconds
delay before measuring voltages = 4 seconds
samples = 0 free = 174126 lwait = 0 msec
battery cutoff = 7.2 volts
number of voltages sampled = 0
logdata = NO

If narrow range conductivity has been selected, this is displayed in the header.

SEACAT PROFILER V3.1B SN 936 02/10/94 13:33:23.989
strain gauge pressure sensor: S/N = 12345, range = 1000 psia, tc = 240
Narrow Range Conductivity
clk = 32767.766 iop = 172 vmain = 8.1 vlith = 5.8
mode = PROFILE ncasts = 0
sample rate = 1 scan every 0.5 seconds
minimum raw conductivity frequency for pump turn on = 2000 hertz
pump delay = 40 seconds
samples = 0 free = 174126 lwait = 0 msec
battery cutoff = 7.2 volts
number of voltages sampled = 0
logdata = NO

2-2.6 SETUP

SEACAT functions both as a profiling instrument and a moored or time series instrument. The differences between these two modes involve how the data are stored and whether the SEACAT runs continuously or powers off between samples.

In profiling mode the instrument runs continuously, drawing the full operating current from the main battery supply. The unit samples at two samples per second. If the sample rate is set to a slower value, the unit continues to sample at two samples a second but only stores data at the specified rate. The longest period between samples is 4 minutes. Temperature and conductivity data are stored as uncorrected frequencies. The necessary reference frequencies to convert the data to corrected frequencies are stored every 120 samples. See Section 2-3 on data formats for additional information.

Commands that only affect profiling mode are:

PN	Disable pump control logic
SP	Set pump control parameters
SR	Set sampling rate
DC	Dump data by casts (see Section 2-2.9)

In moored mode the SEACAT powers down between samples. The fastest sample rate is once every 15 seconds. The default time that SEACAT provides power to external sensors before sampling them is 4.0 seconds. This can be increased to a maximum of 32,000 seconds with the VD command for instruments such as the Sea Tech fluorometer that need a longer time to come to a stable value. Dissolved oxygen sensors require from 2 to 3 minutes to polarize after application of power to the sensor. Set the voltage delay to a minimum of 120 seconds and the sample interval to a minimum of 150 seconds if an oxygen sensor is installed. The pump is powered for the entire time power is applied to the auxiliary sensors. The increased power for the pump limits the number of samples that can be taken to between 350 and 400 when the voltage delay is set to 120 seconds for an oxygen sensor. Temperature and conductivity data are stored as corrected frequencies.

Commands that only affect moored mode are:

SI Set sample interval
VD Set time to delay before measuring voltages in moored mode

All SEACATs are built with the ability to record external voltages. If the SEACAT was ordered without auxiliary sensors, the number of voltages was set to zero to conserve memory usage. The SV command is used to enable acquisition of voltages if auxiliary sensors are added at a later date. Corresponding changes to the software configuration files also must be made for the SEASOFT software to recognize this change.

CN(CR) Set conductivity channel to narrow range (fresh water 0 - 0.6 S/m)
If narrow range is set, the line *Narrow Range Conductivity* displays in the status.

CS(CR) Set conductivity channel to standard range (salt water 0 - 6.5 S/m)

IR(CR)*^C Initialize RAM (memory): **WARNING, ALL DATA WILL BE DESTROYED!** All data bits are set to 0. Sample number, header number, and data pointers are set to 0. Allow 1.5 minutes to reset the entire memory. Memory initialization is optional, as SEACAT writes over previously recorded information when the gl command (see below) is used. However, knowledge of the initial memory contents (i.e., all zeros) can be a useful cross check when data is retrieved.

LWN(CR) Set wait interval of N milliseconds after each line of data; normally N = 0; increase for slower computers. Nmax = 65535.

MM(CR) Set mode to moored.

MP(CR) Set mode to profiling.

PN(CR) Disable pump control logic.

QS(CR) Quit session. Puts SEACAT in quiescent mode (50 microamps). Use this command and then wait 3 seconds before turning on the magnetic switch when in profiling mode.

SBn(CR) Change baud rate used by the SEACAT during normal communications.

Upon initial power up or reset, the SEACAT defaults to communicating at 600 baud. SB allows the user to change to one of the baud rates listed below. When SB is given, the SEACAT immediately changes its baud rate and all subsequent communications are at the new baud. The baud rate is retained by the SEACAT until power is removed from the circuit boards (by disassembly or by using the reset switch on the battery bulkhead) or until a new SB command is entered. The new baud rate is retained while the SEACAT is in quiescent mode between samples. This setting does not affect the baud controlled by the DD and DC commands for uploading data from the SEACAT.

The possible values are:

n = 1 600 baud
n = 2 1200 baud
n = 3 9600 baud
n = 6 4800 baud (firmware version 3.1d and above in 3.0 series; not applicable to 4.0 series)

Example: SB3 set baud rate to 9600

SP(CR) For the pump to prime properly at the surface, the pump and Tygon tubing must fill with water before the pump is turned on. This command sets pump turn-on parameters. SEACAT prompts:

minimum raw conductivity frequency for pump turn on = xxxx new value =
Enter a new value to change the value or press carriage return to accept the current value. The configuration sheet lists the uncorrected (raw) frequency output at 0 conductivity. For most salt water and estuarine applications, enter the 0 conductivity frequency + 500 Hz (factory default) as the minimum frequency. For fresh water, 5 Hz above the 0 conductivity frequency is typically used.

pump delay time (seconds) = xxx, new value =
Enter a new value to change the value or press carriage return to accept the current value. A value of 30 to 45 seconds typically gives ample time for the Tygon tubing and pump to fill with water after the SEACAT has been submerged.

The pump starts after the delay time, and after the conductivity cell's frequency output is greater than the minimum raw conductivity frequency. The pump stops as soon as the raw conductivity frequency drops below the minimum.

See Data Format (Section 2-3) for details on computing raw conductivity frequency from HEX data.

SR(CR) Set sample rate as prompted for profiling mode.

Example: SR(CR) SEACAT prompts:

number of 0.5 sec intervals between samples = 1
the sample rate is 1 scan every 0.5 seconds

The maximum number of intervals between samples is 480 (4 minutes between samples).

SI(CR) Set sample interval as prompted for moored mode.

Example: SI(CR) SEACAT prompts:

number of seconds between samples = 60
sample interval = 60 seconds

The minimum sample interval is 15 seconds, the maximum is 32000 seconds.

ST(CR) Set date and time as prompted

Example: ST(CR)
date (MMDDYY) = 042387(CR)
time (HHMMSS) = 191026(CR)

The date is set to April 23, 1987. The time is set to 19:10:26.

SVN(CR) Set the number of external voltages to sample as prompted.

Example: SV2(CR) sets the number of voltages to acquire to 2.

The possible values are 0, 2, or 4 voltages.

Enter a new value that reflects the number of external voltages that are to be recorded through the 6-pin auxiliary connector on the end cap. If the number of voltages is changed, a corresponding change must be made in the software configuration files for the SEASOFT software to recognize the change.

VDN(CR) Set the time to delay before measuring external voltages in moored mode.

Example: VD11(CR) adds 11 seconds to the default value of 4.0 seconds.

The default and minimum value is 4.0 seconds. The maximum value is 32000 seconds. N is entered in seconds. If a Sea Tech Fluorometer is installed, set N to 11 (delay of 15 seconds). If an oxygen sensor is installed, set N to a minimum of 116 (delay of 120 seconds).

2-2.7 LOGGING

In profiling mode, data logging can be initiated by turning on the magnetic switch while the SEACAT is in the quiescent state or by using the GL or RL commands when the CPU is active and the magnetic switch is on. Turning on the magnetic switch while the CPU is active will not start logging. If the switch is left on when the unit is put in the quiescent state (either by using the QS command or by timing out), the unit starts logging when the next attempt to establish communications is made. Logging commences approximately 5 seconds after the movement of the switch or the receipt of the GL or RL command. The first time the switch is turned on after receipt of the IL command, the data recording starts at the beginning of memory and any previously recorded data is written over, whether the memory has been initialized or not. When the switch is subsequently turned off, recording stops. Each time the switch is turned on again, recording continues with new data stored after the previously recorded data and a new header written to indicate the time, date, incremented cast number, and sample numbers contained in the cast. The maximum number of casts that can be taken is 150.

In moored mode, logging is initiated by using the GL or RL commands. Leave the switch in the off position, but it has no effect on logging. If the switch is turned on while the SEACAT is in the quiescent state and in moored mode, the CPU enters the active state but logging will not begin. If no communications are established, the unit times out and enters quiescent state after 3 minutes.

In both profiling and moored mode, data is transmitted real-time at 600 baud (1200 baud if the optional Paroscientific Digiquartz pressure sensor is installed), or at the baud rate specified with the SB command.

If memory is filled to capacity, data logging and the transmission of real-time data continues, but excess data is not saved in memory.

IL(CR)* Initialize logging. Use this command to reset data pointers and the cast number **after existing data has been removed from SEACAT** and prior to recording new data.

GL(CR)* Go log. Start logging data. For this command to work in profiling mode, the magnetic switch must be on. The first scan is set to 0 so any previously recorded data is written over, whether the memory has been initialized or not. This command is useful for laboratory testing of SEACAT when in profiling mode.

QL(CR) Quit logging data in moored mode. When logging data in moored mode, SEACAT responds only to the DS, QS and QL commands. The QL command is given when communications have been established with SEACAT and the **S>** prompt is present.

RL(CR)* Resume logging data. Same as gl command except that the sample number is not reset. Previously recorded data is not overwritten. In profiling mode, a new cast is started. In moored mode, data is stored after the last previously stored sample.

2-2.8 STOP LOGGING

In profiling mode, turn off the magnetic switch. Logging may also be terminated in profiling mode by sending a NULL character (CONTROL Z or HOME KEY in TERM19) to SEACAT.

In moored mode, logging is terminated by establishing communications with the SEACAT and sending the QL command.

2-2.9 DATA RETRIEVAL

In TERM19 data retrieval is determined by the set up of the configuration file. TERM19 communicates with the SEACAT using the following commands. The SEACAT is capable of transmitting stored data at the following baud rates:

B = 1	600 baud	B = 2	1200 baud
B = 3	9600 baud	B = 4	19,200 baud
B = 5	38,400 baud		

B is the number used below to specify to SEACAT what baud rate to use to dump data.

DC[Bn](CR) Display raw data from cast n at the baud rate determined by B. If n is omitted, data from cast 0 displayed. If B is omitted the default baud rate is used. The first line consists of *Y* (valid cast number) or *N* (invalid cast number). Subsequent lines have the format described in section 2-3. This command is valid for profiling mode only.

Example: DC11(CR) SEACAT sends at 600 baud

Y Valid cast number
aaaaaaaaaaaa scan 0 data, cast # 1
bbbbbbbbbbbb scan 1 data, cast # 1
.
.
nnnnnnnnnnnn scan n data, cast # 1, where n+1 is the total number of scans of data stored in cast # 1

DD[B[n1],n2](CR)^C Raw data is displayed in HEX at the baud rate specified by B. If B, n1 and n2 are omitted all logged data is displayed at the default baud rate. Entering n1,n2 displays samples n1 through n2. The data format is described in section 2-3. This command is valid for both moored and profiling modes.

Example: DD(CR) SEACAT sends:

aaaaaaaaaaaa scan 0 data
bbbbbbbbbbbb scan 1 data
.
.
nnnnnnnnnnnn scan n data, where n+1 is the total number of scans of data stored in SEACAT

DH[[n1],n2](CR)^C Display headers. If n1 and n2 are omitted all headers are displayed. Entering n1 and n2 displays headers n1 through n2. If n1 equals n2 then only that one header is displayed.

A new header is written when data logging is started or resumed in profiling mode. In moored mode a new header is written when data logging is initiated and every 1000 samples thereafter.

Example: DH(CR) SEACAT sends (moored mode):

cast N MM/DD HH:MM:SS samples X to Y sample interval = NNN seconds stop = ZZZ

N	cast number
MM/DD HH:MM:SS	month, day, hour, minute and second read from real-time clock when this cast was initiated.
X	first sample in this cast
Y	last sample in this cast
NNN	is the sample interval
ZZZ	is the reason logging was halted

Possible values for ZZZ are:	
batfail	battery voltage too low
switch off	magnetic switch turned off
recv cmd	received NULL or CNTL Z character, or QL command
timeout	error condition
unknown	error condition
??????	error condition

In profiling mode the sample rate is shown as the number or scans every NNN seconds.

Sample: DH(CR) (in profiling mode)

cast 0 11/05 08:01:15 samples 0 to 3540 sample rate = 1 scan every 0.5 seconds stop = recv cmd
cast 1 11/05 12:30:33 samples 3541 to 8795 sample rate=1 scan every 0.5 seconds stop=recv cmd
cast 2 11/05 15:45:11 samples 8795 to 10816 sample rate=1 scan every 0.5 seconds stop=switch off

2-3 DATA FORMAT

Data storage format in SEACAT varies depending on whether the instrument is in moored or profiling mode.

Data is retrieved from SEACAT and stored on the computer system in hexadecimal format using TERM19.
Note: If desired, **use SEATERM instead of TERM19 (DOS) software to setup and upload data from the SEACAT**. See the SEATERM Help files for details. SEATERM is part of our SEASOFT Windows software suite.

2-3.1 PROFILING MODE

Temperature and conductivity data are stored as uncorrected (raw) frequencies. The reference data that is used to convert to corrected frequencies is stored in the 5th and 6th scans. Subsequently, after every 120 scans
two data scans are replaced by the two reference scans.

2-3.1.1 PAINE STRAIN GAUGE PRESSURE

Twelve ASCII HEX characters representing six bytes are transmitted per CTD scan. If two external voltages are sampled, 9 bytes are transmitted. If four external voltages are sampled, 12 bytes are transmitted. A carriage return and line feed follows the data from the last CTD scan.

The data format for CTD scans is:

aaaabbbbpppp

aaaa	four HEX characters representing 2 bytes of temperature data
bbbb	four HEX characters representing 2 bytes of conductivity data
pppp	four HEX characters representing 2 bytes of pressure data

The data format for CTD plus two external voltages is:

aaaabbbbuuuvvvpppp

aaaa	four HEX characters representing 2 bytes of temperature data
bbbb	four HEX characters representing 2 bytes of conductivity data
uuu	three HEX characters representing 12 bits of voltage data (V0)
vvv	three HEX characters representing 12 bits of voltage data (V1)
pppp	four HEX characters representing 2 bytes of pressure data

The data format for CTD plus four external voltages is:

aaaabbbbuuuvvvxxxyyypppp

aaaa	four HEX characters representing 2 bytes of temperature data
bbbb	four HEX characters representing 2 bytes of conductivity data
vvv	three HEX characters representing 12 bits of voltage data (V0)
www	three HEX characters representing 12 bits of voltage data (V1)
xxx	three HEX characters representing 12 bits of voltage data (V2)
yyy	three HEX characters representing 12 bits of voltage data (V3)
pppp	four HEX characters representing 2 bytes of pressure data

Temperature:

1. T = decimal equivalent of aaaa
2. Raw temperature frequency = T / 17 + 1950

Standard Conductivity:

1. C = decimal equivalent of bbbb
2. Raw conductivity frequency = sqrt (C * 2900 + 6250000)

Narrow Range Conductivity:

1. C = decimal equivalent of bbbb
2. Raw conductivity frequency = sqrt (C * 303 + 6250000)

Voltage:

1. V = decimal equivalent of uuu, vvv, xxx, or yyy
2. Volts = V / 819;

Pressure:

1. P = decimal equivalent of bits 0 through 13 of pppp. Bit 14 is the sign bit. If bit 14 is 0, the number is positive; if it is 1, the number is negative.
2. Pressure number = P;

If the most significant bit of pppp is a 1, then the CTD scan contains reference resistor frequency information.

The data format for references is:

xxrrrrrrpppp
if xx = 05 then the scan contains high frequency reference data and the conductivity range is Standard
if xx = 08 then the scan contains high frequency reference data and the conductivity range is Narrow Range
if xx = FF then the scan contains low frequency reference data
pppp is pressure data as described above
rrrrrr is the reference data

If external voltages are recorded, they appear between rrrrrr and pppp as described above.
High frequency reference frequency is the decimal equivalent of rrrrrr / 256.
Low frequency reference frequency is the decimal equivalent of rrrrrr / 256.
The references are read and stored every 120 samples.

Example:

scan 117 = 69CC43220EA4
scan 118 = 052A34398EA5
scan 119 = FF0B45808EA4
scan 120 = 69CE431E0EA5
scan 117 (CTD):

aaaa = 69CC, T = 27084, temperature frequency = 3543.177
bbbb = 4322, C = 17186, conductivity frequency = 7489.286
pppp = 0EA4, P = 3748, pressure number = 3748

scan 118 (High frequency reference)
xx = 05
rrrrrr = 2A3439, Refhi = 10804.225
pppp = 8EA5, P = 3749, pressure number = 3749

scan 119 (Low frequency reference)
xx = FF
rrrrrr = 0B4580, Reflow = 2885.500
pppp = 8EA4, P = 3748, pressure number = 3748

scan 120 (CTD):
aaaa = 69CE, T = 27086, temperature frequency = 3543.177
bbbb = 431E, C = 17182, conductivity frequency = 7488.511
pppp = 0EA5, P = 3749, pressure number = 3749

The reference data is used to compute the corrected temperature and conductivity frequencies.

The algorithm for computing the corrected frequencies is:

fraw = raw frequency (input to correction algorithm)
fcor = corrected frequency (algorithm output)
fhisq = Refhi * Refhi
flowsq = Reflow * Reflow

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

where:

a = (fhisq - flowsq) / X3
b = flowsq - (a / X2)

using the following constants:

KK = 2.4018669e-11
X1 = 9.6036247e-9
X2 = 1.1949587e-7
X3 = (X2 - X1) / (X2 * X1)
PC = 1 / (1e6 * KK)

Use the corrected values for temperature frequency and conductivity to convert to temperature and conductivity according to the sensor calibration certificates.

2-3.1.2 PAROSCIENTIFIC DIGIQUARTZ PRESSURE SENSOR

18 ASCII HEX characters representing 9 bytes are stored per CTD scan. A carriage return line feed follows the data from the last CTD scan.

The data format for CTD scans is:

aaaabbbbpppppppcccc
aaaa = four HEX characters representing 2 bytes of temperature data
bbbb = four HEX characters representing 2 bytes of conductivity data
pppppp = six HEX characters representing 3 bytes of Digiquartz pressure data
cccc = four HEX characters representing 2 bytes of pressure temperature data

The SEACAT has the capability to record up to four external voltages. If enabled, the voltage data appears between the pressure and the pressure temperature data.

The data format for temperature, conductivity, and external voltages is the same as for the strain gauge pressure sensor.

Pressure (Digiquartz):

1. P = decimal equivalent of pppppp
2. Pressure frequency = P / 256.0

Pressure Temperature:

1. C = decimal equivalent of cccc
2. Pressure Temperature Voltage = C / 819.0
3. Pressure Temperature = (Voltage + 9.7917) * 23.6967 - 273.15 (degrees Centigrade)

EXAMPLE

aaaabbbbpppppppuuuvvvcccc = 69CC43228D1B8003005908AA
aaaa = 69CC, T = 27084, Temperature Frequency = 3525.474
bbbb = 4322, C = 17186, Conductivity Frequency = 6506.970
pppppp = 8D1B80, P = 9247616, Pressure frequency = 36123.5
uuu = 030, V0 = 48, Voltage 0 = 0.059
vvv = 059, V1 = 89, Voltage 1 = 0.109
cccc = 08AA, C = 2218, Pressure Temperature = 23.0

2-3.2 MOORED MODE

Moored mode temperature and conductivity data are stored as corrected frequencies. The reference information is not stored with the data. Otherwise, the data format is the same as profiling mode except for the conversion of temperature and standard range conductivity from hexadecimal numbers to decimal frequencies.

The correct scaling for moored mode temperature and standard range conductivity are:

Temperature:

1. T = decimal equivalent of aaaa
2. Temperature frequency = T / 19 + 2100

Standard Conductivity:

1. C = decimal equivalent of bbbb
2. Conductivity frequency = sqrt(C * 2100 + 6250000)

Narrow Range Conductivity:

1. C = decimal equivalent of bbbb
2. Raw conductivity frequency = sqrt(C * 303 + 6250000)

Use these values for temperature frequency and conductivity frequency to convert to temperature and conductivity according to the sensor calibration certificates.

The conversion of pressure and voltages are the same as profiling mode.

2-4 SEASOFT SOFTWARE CONFIGURATION FILES

TERM19 is used to communicate with and retrieve data from SEACAT. TERM19 creates the file TERM19.CFG to store its setup parameters, so they do not have to be reentered every time. The file TERM19.CFG, with typical setup parameters for using your SEACAT (assuming installation on C: drive) is included on the SEASOFT disks that accompanied your SEACAT.

The program SEACON creates or modifies a file SEASOFT.CON, which is used by SEASOFT modules to obtain calibration coefficients and instrument configuration information. For new instruments this information was entered at the factory, and a copy of this file was included on the software disks that accompanied your SEACAT. If the instrument is recalibrated or the configuration is changed (such as adding external sensors), run SEACON to enter new calibration information or modify configuration settings.

Refer to the instrument *configuration page* and/or calibration certificates in this manual, and the SEASOFT software manual for additional information.

Note: If desired:

- **Use SEATERM instead of TERM19 (DOS) to setup and upload data from the SEACAT**.
- **Use the Configure menu in SEASAVE or SBE Data Processing instead of SEACON (DOS) to modify the instrument configuration file.**

SEATERM, SEASAVE, and SBE Data Processing are part of our SEASOFT Windows software suite. See the software Help files for details.

2-5 OPERATION USING TERM19

Note: If desired, **use SEATERM instead of TERM19 (DOS) to setup and upload data from the SEACAT**. See the SEATERM Help files for details. SEATERM is part of our SEASOFT Windows software suite.

TERM19 is a terminal emulation program designed to communicate with SEACAT: characters typed on the keyboard are sent to SEACAT and characters sent by SEACAT are displayed on the console. TERM19 expects to find the file TERM19.CFG in the current directory.

SEACAT automatically sends ^S and ^Q characters if the computer does not keep up with data it sends.

The main terminal screen is shown below:

```
┌──────────────────────────────────────────────────────────────────────────┐
│ SBE 19 Terminal Program  4.0            Thursday  January 16, 1992  4:50 pm │
├──────────────────────────────────────────────────────────────────────────┤
│ <F1> Help     <F2> Setup       <F3> Status     <F4> Headers    <F5> Capture  │
│ <F6> Wake Up  <F7> Baud Rate   <F8> Init Log   <F9> Upload     <F10> Exit    │
│                                                                          │
│                                                                          │
│                                                                          │
│<F1>Help  <Ctrl-C>Halt Instr <Ctrl-F10 or Home>Stop Log Baud = 600  Capt = NO │
└──────────────────────────────────────────────────────────────────────────┘
```

Press F2 and select *Communication Set Up* to set the COMM port and baud rate. Exit the Set Up form (press Esc) and press F6 to establish communications with the instrument. To abort the attempt to establish communications press the Esc Key.

Once communications have been established, characters transmitted by the instrument display in the center portion of the main screen.

The active function keys are:

F1 Display help screens.

F2 Display the terminal set up form.

F3 Display instrument status.

F4 Display instrument headers.

F5 Capture instrument responses to a file (use F9 for data upload).

F6 Reestablish communications with the instrument. The instrument *goes to sleep* after 2 minutes without receiving any commands from the computer.

F7 Change the baud rate.

F8 Initialize logging. Reset the scan and cast pointers in the instrument to 0. Upload any data in the instrument before sending this command.

F9 Upload data from the instrument. The upload parameters are configured in the setup menu (F2).

F10 Exit to DOS.

Ctrl-C Sends Ctrl-C to the instrument to halt display voltages and display frequencies diagnostics.

Ctrl-F10 or Home Stop Logging (sends a Null character to the instrument).

On the bottom status line:

Baud = Displays current baud rate

Capt = Displays capture to file status. If YES, all replies from the instrument are being written to a file.

The function keys are used to control various features of the terminal program and to send commands to the instrument for data upload, initialization, and status information. If communications or instrument problems are encountered, refer to Section 2-2 for the diagnostic and data commands.

In particular, if the terminal program is not able to establish communications with the instrument by cycling through the baud rates and comm ports, set the baud rate (as documented on the configuration page) with the F7 key and verify the set up parameters accessed through the F2 key. Subsequent attempts at communicating with the instrument can be made by pressing the Enter key or via the F6 key.

2-5.1 TERMINAL SET UP FORM

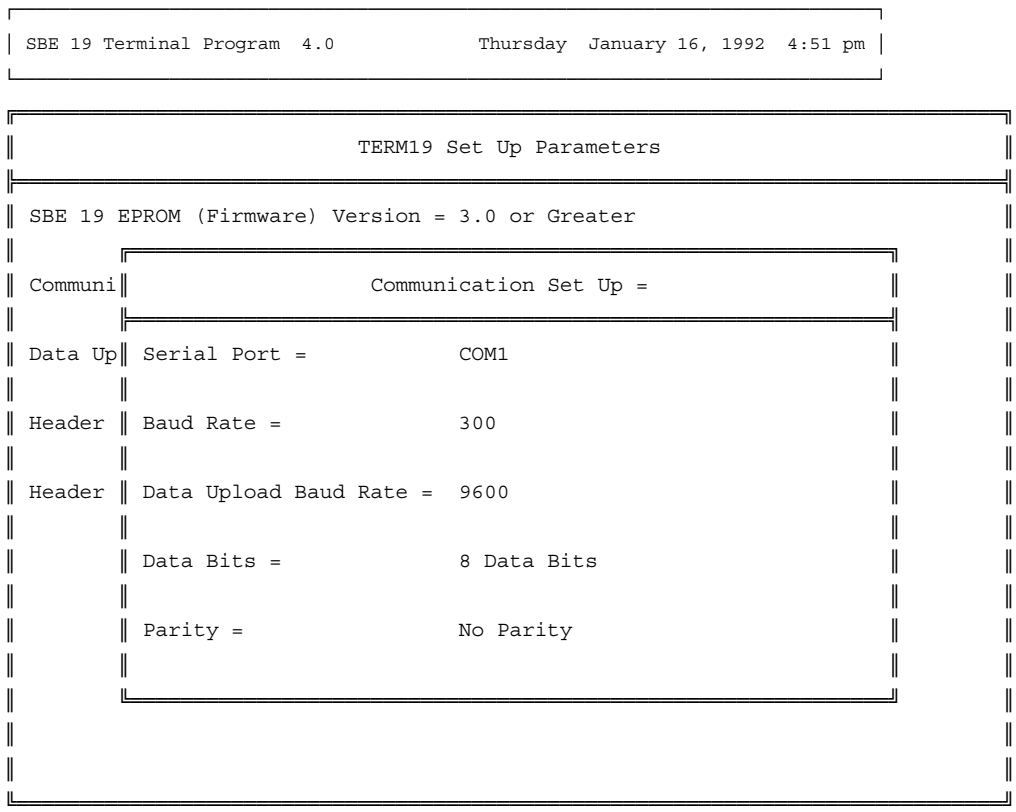
```
┌──────────────────────────────────────────────────────────────────────────┐
│ SBE 19 Terminal Program  4.0             Thursday  January 16, 1992  4:50 pm │
└──────────────────────────────────────────────────────────────────────────┘

╔══════════════════════════════════════════════════════════════════════════╗
║                          TERM19 Set Up Parameters                        ║
╠══════════════════════════════════════════════════════════════════════════╣
║ SBE 19 EPROM (Firmware) Version = 3.0 or Greater                         ║
║                                                                          ║
║ Communication Set Up =            <Press Enter To Modify>                ║
║                                                                          ║
║ Data Upload Set Up Parameters =   <Press Enter To Modify>                ║
║                                                                          ║
║ Header =                          Prompt for Header Information          ║
║                                                                          ║
║ Header Form =                     <Press Enter To Modify>                ║
║                                                                          ║
╚══════════════════════════════════════════════════════════════════════════╝

              <F1> Help;  <Esc> Exit;  <Enter> Modify the field
```

The EPROM Version is recorded on the configuration sheet of the manual and also displayed in the first line of the reply to the display status (F3) reply.

The Communication Set Up Form is:



Standard instruments are set to 7 data bits, even parity

Firmware Versions Less than 3.0:

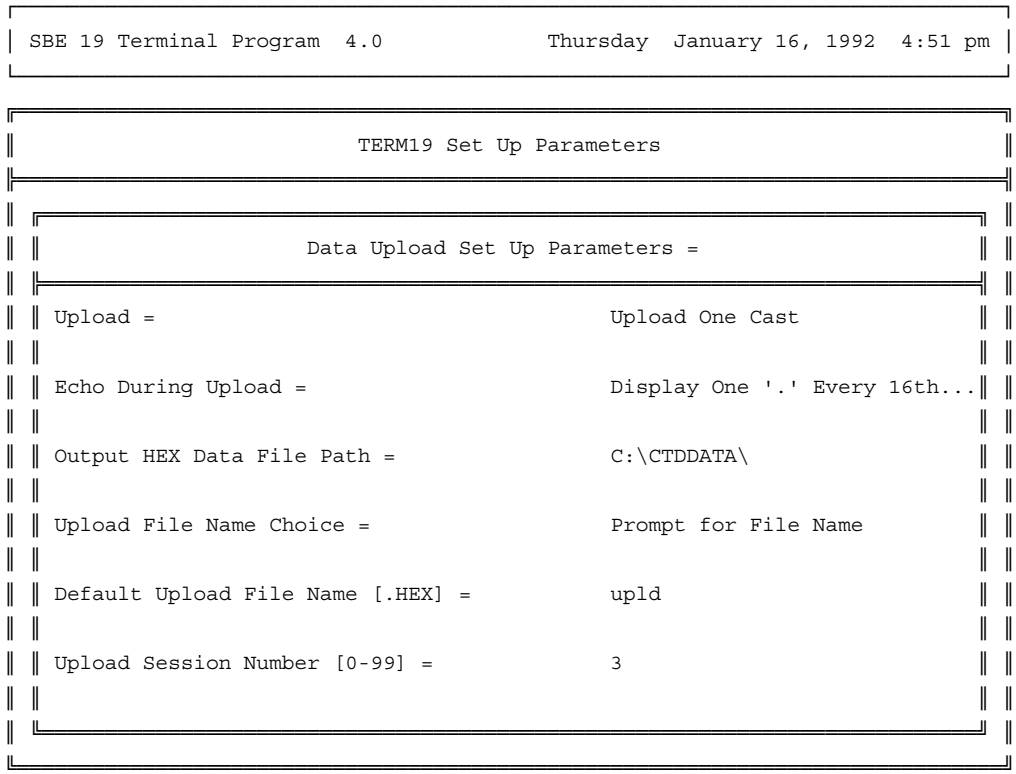
baud rate = 9600
upload baud rate = 9600

Firmware Versions 3.0 or greater:

baud rate = 600
upload baud rate is programmable to 600, 1200, 9600, 19200, or 38400

use slower upload baud rates with slow computers and long cables.
use 38400 baud with short cables and 386- or 486-based PCs.

2-5.2 DATA UPLOAD SETUP FORM



The Upload choices are:

Upload All Data Separated by Casts:
All data is uploaded. A separate file is written for each cast.

Upload Data By Cast Number Range:
The user is prompted for beginning and ending cast numbers. A separate file is written for each cast.

Upload One Cast:
The user is prompted for the cast number range. One file is written.

Upload All Data as One File:
The terminal program sends the *DD* (dump data) command rather than the *DC* dump cast command to the instrument. For diagnostic use only with SEACAT. One file is written.

Upload Data By Scan Number Range:
The terminal program prompts the user for beginning and ending scan number and then sends the *DD* (dump data) command to the instrument. For diagnostic use only. One file is written.

The Echo Choices are:

Echo Data During Upload:
The HEX data from the instrument is displayed on the screen as it is received

Display One '.' Every 16th scan during Upload:
Shortens the time required to upload the data.

Output HEX Data File Path =
Enter the path where you wish the uploaded HEX file to be written.

Upload File Name Choice:

If one cast is uploaded at a time, the upload file name can be up to 8 characters long. TERM19 adds a .HEX extension to the name.

If multiple casts are uploaded (*Upload All Data Separated by Casts* is selected in the set up form), the filename can be up to 6 characters long. TERM19 adds 2 characters signifying the cast number to the name and adds a .HEX extension to the name.

If the upload file name choice is *Use Default File Name*, the uploaded file name is:

NNNNXXYY.HEX where

NNNN is the default upload file name (one to four characters)
XX is the upload session number
YY is the cast number

Header:
Include Default Header in Upload File:
The default header form is included in the upload file. The user is not prompted to add any information.
Prompt For Header Information:
Each time a cast is uploaded the user is prompted to fill out the header form
Don't Include Header in Upload File:
Header information is not included in the upload file

Upload File Name Choice =

Use Default File Name:
The user is not prompted for the file name. The upload session number and cast number are added to the default file name to form the actual file name.

Prompt for File Name:
The user is prompted for the file name.

Default Upload File Name [.HEX] =

If the upload file name choice is *Use Default File Name*, this default file name is used along with the upload session number and the cast number to form the complete upload file. The maximum length for the default file name is 4 characters. The file name extension need not be entered.

Upload Session Number [0 - 99] =

The upload session number is incremented each time data is uploaded (F9). It is reset by setting this field to 0.

Header Form:

The header form is customized by editing this form. The entries are free form and 0 to 12 lines may be entered. If header = *Prompt for Header Information*, this form displays for the user to fill in. If header = *Include Default Header*, only this form is included in the upload file.

2-5.3 TERMINAL PROGRAM: FIELD OPERATION

Connect the instrument to the computer's serial port. Run TERM19 (the file TERM19.CFG created during setup should be in the current directory). Press F6 to establish communications with the SEACAT (...communications established... displays when this occurs and the S> shows on the screen, indicating that the SEACAT is ready to accept commands). If communications are not established, press F2 and select Communication Set Up. Verify that the serial port, baud rate, data bits, and parity are correct for your configuration.

To upload data, press F9. The prompts that you see are determined by the current setup read from TERM19.CFG. TERM19 automatically obtains status and header information from the SEACAT and then proceeds to transfer the data to the upload file(s). When the upload is complete, the screen displays the message *Data Upload is Complete, Press <ESC> to continue*. Press <ESC> to continue. If you wish to reset the memory pointers to initialize logging, press F8. In addition to resetting the pointers, TERM19 puts the SEACAT in quiescent mode and then returns to DOS.

2-6 DATA RECORDING AND READOUT: SAMPLE SESSIONS

These examples assume the software has been installed on the computer. Consult the SEASOFT manual for installation instructions.

Connect SEACAT to the serial port with the cable supplied.

Place new (or freshly charged) batteries in SEACAT.

2-6.1 SAMPLE SESSION - PROFILING MODE

Verify that the file SEASOFT.CON is correct for your system by running the SEACON program and examining the instrument configuration and calibration information with that contained in this manual.

2-6.1.1 RECORD DATA WITH SEACAT (COMPUTER INITIATED)

1. If the magnetic switch is on, turn it off.

2. Connect SEACAT test cable to SEACAT and the RS-232C port on an IBM PC/XT/AT or compatible. Type cd \profiler to change to the profiler subdirectory. Type term19.

3. Enter DS(CR) to display SEACAT status. A typical response would be:

SEACAT PROFILER V3.1B SN 936 02/10/94 13:33:06.439
strain gauge pressure sensor: S/N = 12345, range = 1000 psia, tc = 240
clk = 32767.766 iop = 172 vmain = 8.1 vlith = 5.7
mode = PROFILE ncasts = 0
sample rate = 1 scan every 0.5 seconds
samples = 0 free = 174126 lwait = 0 msec
battery cutoff = 7.2 volts
number of voltages sampled = 0
logdata = NO

4. Turn the magnetic switch on. Enter GL(CR) [go log command]. **Do not use this command if previously recorded data has not yet been removed from SEACAT.** Type y(CR) in response to the prompt **start logging Y/N ?**. Type ^y(CR) [CTRL Y] in response to the prompt **are you sure ^Y/N ?**. (Note that the GL command automatically initializes SEACAT; it is not necessary to send the IL command before sending the GL command.)

5. After a few seconds, data (in HEX) displays on the CRT at 2 scans per second. Wait a few minutes while *cast 0* data is recorded by SEACAT.

6. Press the HOME key to end *cast 0*. **S>** displays.

7. To record a second cast repeat steps 4 - 6, entering RL(CR) [resume logging] instead of gl(CR) in step 4.

2-6.1.2 RECORD DATA WITH SEACAT (MAGNETIC SWITCH INITIATED)

1. If the magnetic switch is turned on, turn it off.

2. Connect SEACAT test cable to SEACAT and the RS-232C port on an IBM PC/XT/AT or compatible. Type cd \profiler to change to the profiler subdirectory. Type term19.

3. Enter DS(CR) to display SEACAT status. A typical response would be:

SEACAT PROFILER V3.1B SN 936 02/10/94 13:33:06.439
strain gauge pressure sensor: S/N = 12345, range = 1000 psia, tc = 240
clk = 32767.766 iop = 172 vmain = 8.1 vlith = 5.7
mode = PROFILE ncasts = 1
sample rate = 1 scan every 0.5 seconds
samples = 505 free = 173616 lwait = 0 msec
battery cutoff = 7.2 volts
number of voltages sampled = 0
logdata = NO

4. Enter IL(CR) to *initialize logging*. Type y(CR) in response to the prompt **initialize logging Y/N ?**. Type ^y(CR) [CTRL Y] in response to the prompt **are you sure ^Y/N ?**. **Do not use this command if previously recorded data has not yet been removed from SEACAT**.

5. Enter DS(CR) to display SEACAT status. Check that ncasts = 0 and samples = 0.

6. Enter QS(CR) to *quit session* and put SEACAT in quiescent mode.

7. Wait 3 seconds, then turn on the magnetic switch to begin logging data. After a few seconds, data (in HEX) displays on the CRT at 2 scans per second. Wait a few minutes while *cast 0* data is recorded by SEACAT.

8. Turn off the magnetic switch and wait a few seconds. This terminates the recording of *cast 0*. Turn on the magnetic switch again to resume data logging. Turn off the magnetic switch after a few minutes to end recording of *cast 1*.

2-6.1.3 RETRIEVE DATA FROM SEACAT

Before attempting to retrieve data, record data in SEACAT by following the steps outlined in section 2-6.1.2 above. To retrieve the recorded data:

1. If the magnetic switch is turned on, turn it off.

2. Connect the SEACAT test cable to SEACAT and the RS-232C port on an IBM PC/XT/AT or compatible. Type cd \profiler to change to the profiler subdirectory. Type term19.

3. Enter DS(CR) to display SEACAT status. The following is typical:

SEACAT PROFILER V3.1B SN 936 02/10/94 13:33:06.439
strain gauge pressure sensor: S/N = 12345, range = 1000 psia, tc = 240
clk = 32767.766 iop = 172 vmain = 8.1 vlith = 5.7
mode = PROFILE ncasts = 2
sample rate = 1 scan every 0.5 seconds
samples = 1505 free = 172616 lwait = 0 msec
battery cutoff = 7.2 volts
number of voltages sampled = 0
logdata = NO

4. Enter DH(CR) to display headers.

cast 0 09/10 08:01:15 samples 0 to 924 sample rate = 1 scan every 0.5 seconds stop = recv cmd
cast 1 09/10 12:30:33 samples 925 to 1504 sample rate = 1 scan every 0.5 seconds stop = recv

5. Use the F2 key to verify the data upload parameters are set correctly.

6. Use the F9 key to upload the data into a hexadecimal file.
   In each file (one per cast), the DS and DH command responses as well as the hexadecimal data itself. Each line of the DS or DH responses has an asterisk in the first position.

7. Press F10 to return to DOS.

2-6.1.4 DISPLAY SEACAT DATA USING SEASOFT

The program SEASAVE is used to display the *raw* hexadecimal data output from SEACAT in engineering units, and compute derived variables. In the main screen of SEASAVE, select archived data to view recorded files, or select real-time data to log directly to a file. In the next SEASAVE screen, the type of display and other parameters are set before the data are actually presented. Refer to the SEASOFT manual for detailed information on the use of the SEASAVE program, as well as the other programs used to analyze, process, and plot SEACAT data.

3-1 INSTALLATION AND OPERATING INSTRUCTIONS

SEACATs are shipped with new alkaline batteries installed, unless rechargeable nickel cadmium batteries were ordered. **Charge rechargeable batteries before using the SEACAT for the first time** (see Application note 21 for charging and use instructions). As delivered, the SEACAT is in quiescent mode, drawing 50 microamperes or less. The initialization routines described below are performed at the factory and the real-time clock is running (set to Pacific Time).

To gain experience with SEACAT communications protocol, follow the Sample Set-up Sessions described in Section 2-6.

If a separate power supply is available for testing, connect the power supply to the 4-pin bulkhead connector (see Section 2-1 for hook-up instructions).

Power is drawn from the main batteries, the external power source, or the internal printed circuit-mounted lithium back-up cells (5.6 volts), depending on which voltage source is highest. **Avoid having the magnetic switch turned on when neither main battery nor external power sources are connected.**

If using a Sea-Bird junction box, connect the box to SEACAT using the 4-pin to MS cable provided. Connect the box to the computer serial port using the DB-25 cable. Connect AC mains power. Press the red power button to provide power to SEACAT. The junction box supplies about 15 volts, so SEACAT's batteries are not depleted when the junction box is in use.

3-1.1 BATTERY INSTALLATION

Unthread the battery compartment end cap (end cap without any connectors). Remove the three Phillips-head machine screws from the battery retainer plate immediately inside the pressure housing. Lift this plate clear. Batteries are installed with the + terminal against the flat battery contacts and the - terminal against the spring contacts. Slide the batteries into their respective slots. Align the retainer plate so that the flat and spring contacts are over the + and - battery contacts respectively, and re-install the plate. **The screws must be fully tightened, or battery power to the circuitry is intermittent**. Check for battery voltage (approximately 9 volts) at the screw heads marked BAT POS and BAT NEG. If the magnetic switch is turned off, the SEACAT enters quiescent mode. In this mode, the clock runs and memory is kept alive, but the power drain is only about 50 microamperes. Check the O-ring and mating surface and rethread the end cap.

3-1.2 PUMP OPERATION

Normally, the conductivity cell must be in water before the pump runs. After the cell enters the water, there is a delay before 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 contains 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 though the SEACAT 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 is lost.** If this happens, turn the switch off. Wait at least 5 seconds, then turn the switch on, submerge the SEACAT completely, and wait for the pump delay time before beginning the profile.

Pump turn-on occurs when two conditions programmed using the SP (set pump) command have been met: *raw frequency* from the conductivity interface circuit exceeds the minimum 0 conductivity frequency value entered, and the delay interval has elapsed.

For oceanic water in the 35 ppt range, enter the set point for the minimum 0 conductivity frequency as 3500 Hz, since actual in-water frequencies are always higher. For fresh/nearly fresh water, the set point frequency must be only slightly higher (e.g., 5 Hz) than the 0 conductivity *raw frequency* shown on the instrument configuration sheet. If the set point is too close to the 0 conductivity *raw frequency*, the pump may turn on when the SEACAT is in air as 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 delay time to control the pump. If so, set a frequency lower than the *0 conductivity raw frequency* value.

The second entry made via the SP command sets the time delay. The necessary delay can be judged by immersing the SEACAT (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 about 1.5 times longer. When actually using the SEACAT, *soak* the instrument just under the surface for at least the time required for pump turn on.

Entries made with the SP command are permanently stored in the SEACAT and remain in effect until you change them. The only exception is if the SEACAT is completely reset. This occurs only with disassembly of the electronics from the housing (along with disconnection of the battery connector to the electronics card set) or if the toggle switch at the bottom of the battery compartment (newer units only) is placed in the *reset* position.

3-1.3 DEPLOYMENT

Check that the anodes have not been eroded away, and that hardware and external fittings are secure. Refer to Section 2 for information on programming SEACAT for the desired operating routine, and confirm that memory capacity is sufficient. Make sure that the self-diagnostic battery voltage is proper. A screen dump (to a printer) of SEACAT's response to the DS command makes a useful record of the instrument's pre-deployment condition.

In general, take the following steps before putting the SEACAT in the water:

1. Turn the magnetic switch off (slide towards connector end cap).
2. Use the IL command to initialize the memory.
3. Use DS to check that time, date, vbatt are satisfactory and that ncasts = 0 and samples = 0.
4. Use QS to return SEACAT to quiescent conditions. **If this step is omitted**, and the magnetic switch is turned on before auto power-down (about 2 minutes later) **SEACAT will not sample data!**
5. **Put a light coating of silicon grease** on the dummy cover and install it on SEACAT's bulkhead connector I/O port.
6. Remove the Tygon tubing looped end-to-end around the conductivity cell.
7. Immediately prior to deployment, turn on the magnetic switch (slide towards the center of the case). The SEACAT is ready to go into the water.

3-1.4 OPTIMIZING DATA QUALITY

Experience has shown that a profiling speed of about 1 meter/second is usually satisfactory. However, the magnitude of ship motion, and the dynamic effect it has on data quality, has to be considered as operating conditions change. Slow profiling speeds (especially with an unpumped CTD) causes degraded 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 (up to as much as 2-3 meters/second) to reduce the dynamic errors (*spiking*) caused by the rapidly changing rate of descent/ascent of the CTD (yo-yo effect).

In common with other CTD equipment, the SEACAT is intended for obtaining downcast data, and will not generally give best quality results on the upcast. If you must have upcast data, invert the SEACAT so that the sensors are at the top - in which case the downcast data should be ignored. **It is very important that the instrument not be positioned in a way that causes the water that flows past its sensors to be thermally contaminated by other instruments, sample bottles, etc**. The sensors **respond** to the temperature and conductivity of the water in which they are immersed, and it is quite remarkable how much this can be influenced by other objects! SEACATs equipped with the submersible pump are able to get better data with slow descent rates than unpumped SEACATs. Since the pump creates and maintains a constant and optimum flow, the SEACAT can be lowered more slowly to give greater vertical resolution in the profile data, especially on lakes, protected bays, or other calm conditions. Adjust the minimum descent rate for pumped SEACATs according to the magnitude of ship motion (i.e., sea state). On a very calm lake, 10 cm/second is feasible if used with a constant winch speed.

When a pumped SEACAT 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 the water continues to flow through the sensors. However, the manner in which the SEACAT is mounted on the water sampler can have a dramatic effect on data quality. The optional SEACAT T-C Duct can be used to overcome dynamic errors induced by a poor mounting method or location (see Application Note 51).

Where the water temperature is markedly different from the temperature at which the SEACAT has been stored, better results are obtained if the SEACAT is allowed to equilibrate to the water temperature at the surface (soak) for a minute or two 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 is reduced. In cases where the difference between water temperature and SEACAT storage temperature are extreme, allow more *soak time*.

Spiking is sometimes seen in the derived values for salinity, density, or sound velocity and results largely from response time mismatching of the conductivity and temperature sensors, especially when the profiling descent rate is non-uniform. This is a problem in all CTD work, and the suppression of the effect (it is never eliminated) has been the goal of instrument manufacturers and ocean researchers for many years. The greatest immunity to spiking is found in premium CTD equipment such as the SBE 9, which uses very fast sensors (0.07 second), high speed (24 Hz) parallel signal acquisition, and an pumped-flow (constant time response) conductivity sensor. SEACAT's static accuracy is the same as that achieved by the SBE 9, but its dynamic responses - owing to its simpler, less costly, and more compact design - are not as ideal.

The amount of *spiking* with SEACAT depends on the temperature gradient encountered, and is much worse where 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*.

Where very heavy seas cause severe ship motion and result in periodic reversals of the instrument descent, it is possible to greatly improve the data set by removing those scans taken when the pressure signal is not increasing. Consult the SEASOFT manual for information on programs that can be used to correct data for the influences of ship motion and to minimize salinity spiking.

3-1.5 ANTI-FOULANT ATTACHMENTS

For moored applications where biological activity is anticipated, anti-foulant device attachments and expendable AF24173 Anti-Foulant Devices are available for each end of the conductivity cell. See Appendix I for handling details. Also see *Application Note 70: Installing Anti-Foulant Device Mount Kit on SBE 4, 16, 19, and 21 Conductivity Cells*.

3-1.6 RECOVERY

CAUTION!! IMPROPERLY SEALED PRESSURE HOUSINGS MAY FLOOD IN SUCH A WAY AS TO TRAP AND COMPRESS THE AIR INSIDE. IF THIS HAPPENS, A POTENTIALLY LIFE-THREATENING EXPLOSION CAN OCCUR WHEN THE INSTRUMENT IS BROUGHT TO THE SURFACE.

ACCORDINGLY, TREAT A MALFUNCTIONING INSTRUMENT WITH GREAT CAUTION UNTIL IT HAS BEEN DETERMINED THAT ABNORMAL INTERNAL PRESSURE DOES NOT EXIST, OR HAS BEEN RELIEVED.

IF THE SEACAT IS UNRESPONSIVE TO I/O COMMANDS OR SHOWS OTHER SIGNS OF FLOODING OR DAMAGE, LOOSEN EACH OF THE SENSOR END RETAINING HARDWARE 1/2 TURN. IF THERE IS INTERNAL PRESSURE, THE END CAP *FOLLOWS* THE SCREWS OUT, AND THE SCREWS WILL NOT BECOME EASIER TO TURN. IN THIS EVENT, LOOSEN THE I/O BULKHEAD CONNECTOR AT LEAST TWO TURNS TO RELIEVE ANY INTERNAL PRESSURE.

Rinse the conductivity sensor with fresh water, and replace the Tygon tubing.

Remove the dummy cover from the I/O port, and connect SEACAT to a computer serial port. If the main batteries are exhausted, they must be replaced before data can be read out.

TERM19 may be used to upload the recorded data. **Make a back-up copy of the data file, and store it in a safe place**! SEASOFT software may be used to tabulate and plot the archived data set. See the SEASOFT manual for details.
Note: If desired:

- **Use SEATERM instead of TERM19 (DOS) to upload data from the SEACAT**.
- **Use SEASAVE or SBE Data Processing to tabulate and plot the archived data.**

SEATERM, SEASAVE, and SBE Data Processing are part of our SEASOFT Windows software suite. See the software Help files for details.

Leave the main batteries in place when storing SEACAT to prevent depletion of the back-up lithium cells by the real-time clock. Even an *exhausted* main battery powers the clock (50 microamperes) almost indefinitely.

3-1.7 STORAGE

Rinse SEACAT with fresh water after use and prior to storage. See Application Note 2D for cleaning and storage recommendations. If SEACAT is to be stored for long periods, leave the batteries in place and change yearly.

4-1 COMMON PROBLEMS AND THEIR CURES

The most common problems involve improper setup of SEASOFT. Read the software manual for guidance. SEACATs are shipped with the software set up to match the configuration of your instrument, and have the calibration coefficients already entered. We recommend that you make back-up copies of the supplied disks.
Note: If desired:

- **Use SEATERM instead of TERM19 (DOS) to setup and upload data from the SEACAT**.
- **Use SEASAVE or SBE Data Processing to check the configuration file, and to tabulate and plot the archived data.**

SEATERM, SEASAVE, and SBE Data Processing are part of our SEASOFT Windows software suite. See the software Help files for details.

4-1.1 UNABLE TO COMMUNICATE WITH SEACAT

The I/O cable supplied with SEACAT permits connection to the DB-25P input connectors used on standard RS-232 interfaces. Pin 1 of the SEACAT I/O bulkhead (large pin) goes to DB-25 pin 7 (ground). SEACAT pin 2 (CCW from large pin) goes to DB-25 pin 2, and SEACAT pin 3 (opposite the large pin) goes to DB-25 pin 3.

If you cannot establish communication (**S>** is not displayed in response to multiple [CR]s), verify the setup parameters in TERM19. TERM19 permits choice of communications port 1 or 2 (must agree with your serial card configuration) and of the I/O baud rate which must be 600 baud, even parity, 1 stop bit for standard SEACATs (1200 baud for SEACATs with a Paroscientific Digiquartz pressure sensor). TERM19 writes a file called *TERM19.CFG* to the current directory. **This file must be copied to the directory from which TERM19 is being run before communications may be established.**

4-1.2 NO DATA RECORDED

SEACAT must be in quiescent mode before it responds to the magnetic switch and begin taking data. Quiescent mode is entered by entering QS[CR] when communicating with a computer or terminal, or waiting about
3 minutes after the last keyboard command. It is best to always use the QS command when ending a data readout, diagnostic, or set-up session with a computer or terminal.

Verify that the memory is not full (use the DS command; *free = 0* if memory is full). Once the memory is full, no further data is recorded. It is generally best to upload all previous data before beginning another deployment. Then use the IL command to reset memory. DS shows *samples = 0* and *free = 42958* (or *free = some other number*, depending on the SEACAT's memory capacity).

4-1.3 NONSENSE DATA

If an uploaded data file yields nonsense values (9999.99, for example), the problem is usually an incorrect value in the instrument configuration or firmware version as entered in SEACON. **See INSTRUMENT CONFIGURATION at the beginning of the manual for the correct configuration of your CTD system**.

If TERM19 fails to correctly upload the data, verify that the firmware version (see configuration page) and the data upload baud rate in the TERM19 setup (F2 key) are set correctly.

Unreasonable values for temperature, conductivity, etc. are usually the result of incorrect entries in the calibration coefficients section of SEACON. Check that the values entered agree with the calibration certificates supplied with your unit.

4-1.4 RESETTING THE SEACAT's INTERNAL MEMORY

In rare cases the memory resident program that controls the microprocessor in the SEACAT can be corrupted by a severe static shock or other problem. This program can be reloaded from the EPROM located in the SEACAT by removing all power from the internal circuitry. When the main batteries are removed or exhausted, the small lithium batteries located on the internal circuit cards keep memory alive. If the lithium battery power is removed from the circuitry, the SEACAT loses all memory. When power is reapplied, a fresh copy of the firmware is loaded into volatile memory from the EPROM.

On the battery side of the bulkhead located in the SEACAT housing is a small two-position switch. This switch can be used to disconnect the internal lithium batteries from the electronics. Access to this switch is through the battery compartment. When the main batteries are removed, this switch is visible on the battery bulkhead. To reset the SEACAT, move the switch to the reset position and leave it there for 5 minutes to allow several capacitors to drain. Then move the switch back to the on position. Reinstall the main batteries and communicate with the SEACAT using TERM19.

NOTE: All contents of memory are lost when the SEACAT is reset. This includes data stored in memory and all variable parameters that are user configurable.

Use the ST command to reset the date and time, the SV command to enable the acquiring of external voltages, and the SP command to reset the pump start parameters.

5-1 ROUTINE MAINTENANCE AND CALIBRATION

5-1.1 CORROSION PRECAUTIONS

On aluminum-housed units, there is a large zinc anode screwed into the battery end cap, and a second on the conductivity cell guard is also used on plastic versions. Check these anodes from time to time to see that they are securely fastened, and have not been eaten away.

All the stainless steel screws that are exposed to salt water have been generously lubricated with NEVER SEEZ Blue Moly (available through marine hardware stores). After a deployment, it is wise to remove these screws and re-lubricate them with a similar compound. This compound is electrically conductive, so take care not to get it on circuit boards.

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

5-1.2 CONDUCTIVITY CELL STORAGE

Refer to Application Note 2D for conductivity cell cleaning and storage procedures and materials.

5-1.3 SENSOR CALIBRATION

Sea-Bird sensors are calibrated by subjecting them to known physical conditions, and measuring the sensor responses. Then coefficients are computed which may be used with appropriate algorithms to obtain engineering units. The conductivity and temperature sensors on SEACAT are supplied fully calibrated, with coefficients as printed on their respective Calibration Certificates.

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

If SEACAT is recalibrated, enter the new calibration coefficients in the instrument configuration file.

5-1.3.1 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. The effect is to change the cell geometry, resulting in a shift in cell constant. A second drift mechanism is associated with change in the quality of the platinized electrodes, and this effect is also induced by fouling. Accordingly, the most important determinant of long-term sensor accuracy is the state of cleanliness of the cell. We recommend that the conductivity sensors be calibrated before and after important deployments, but particularly when the cell has been exposed to contamination by oil slicks or biological material.

5-1.3.2 TEMPERATURE SENSOR CALIBRATION

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

5-1.3.3 PRESSURE SENSOR CALIBRATION

The strain-gauge pressure sensor is a semi-conductor type, which is capable of meeting SEACAT's 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 5/16-24 straight thread permits mechanical connection to the pressure source. The pressure port uses an oil-filled capillary to buffer the pressure sensor against rapid thermal variations (a source of short-term error) and to prevent galvanic reactions in aluminum housed units.

To recalibrate the pressure transducer, remove the nylon fitting (with short attached 1/8-inch OD plastic tube) from the lower end cap of the sensor housing. There is silicon oil in this fitting, so there will be some spillage. The end cap is tapped with a 5/16-24 straight thread to accept your pressure fitting. Use a fitting that has an O-ring face seal, such as Swagelok-200-1-OR.

After calibration, turn the instrument so the lower end cap is facing up, remove the fitting and fill the cavity with silicon oil (such as Dow Corning DC200 fluid, with 20 centistokes viscosity). Use a 2-inch long 21 gauge hypodermic needle (supplied, with syringe) inserted as far as it will go into the small hole at the bottom of the cavity. Then replace the nylon fitting. The oil in the cavity should fill the nylon fitting and 1/8-inch tube as the fitting is screwed in.

6-1 DESCRIPTION OF SEACAT CIRCUITRY

SEACAT circuitry is contained on three rectangular (approximately 75 X 250 mm) printed boards supporting analog, CPU, and memory functions. The CPU and memory boards are interconnected at several points by means of pin and socket SIP connectors to form a digital *module*. A single DIP interboard connector is used to carry the 26 lines between the analog board and the digital module.

6-1.1 BATTERY WIRING AND POWER SUPPLY

SEACAT's main battery is a series connection of D-cells that drop into the battery compartment as a cluster of three end-to-end stacks (three batteries each). 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 6-pin pc board connector (J6).

The Analog board contains two series-connected lithium cells (1/2 AA 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 SEACAT functions and serves to permit orderly shut-down in the event of failed or exhausted main batteries.

Whenever the main power switch is *on*, battery voltage is connected to a low-power regulator chip (Intersil 7663) used to supply 5 volts (+ 5C) to the real-time clock (RTC) and memory circuits. When a conductivity/temperature sample is to be taken, the RTC *wakes up* the CPU by switching on a power MOSFET to connect battery voltage to the main supply regulator (National Semiconductor LM 2950, + 5volts). The CPU checks that main battery voltage is adequate (minimum 5.9 volts) before proceeding with the measurement routine.

6-1.2 SENSOR MULTIPLEXING

The conductivity cell and thermistor are sequentially connected to a single Wein-bridge oscillator circuit by means of mercury-wetted relays driven by NPN saturated switches under control of the CPU. The relays retain their low (0.1 ohm) initial contact resistance within 0.005 ohms throughout a life-time of 200 X 10^6 operations minimum (over 3 years continuous operation of SEACAT). Every 120th scan substitutes two reference resistors to allow arithmetic cancellation of most of the electronic drift sources.

Relay coil power is derived directly from the unregulated battery line through emitter-follower Q7. The advantage is that the system regulator is not required to handle the (relatively large) and intermittent relay coil current.

6-1.3 WEIN-BRIDGE OSCILLATOR

The Wein-bridge oscillator (WBO) is configured as a controlled-gain amplifier using high-frequency bipolar transistors and low-valued load resistors to achieve minimum phase shift. An input FET provides high impedance to the WBO frequency-determining components (two fixed capacitors, a fixed resistor, and the unknown sensor resistance) while an emitter follower presents and a low driving impedance to the MOSFET gain control element.

The WBO output of 0.16 volts p-p (small enough to avoid significant self-heating in the SEACAT sensors) is amplified to supply the higher AC level (approximately 1.2 volts p-p) needed to activate the AGC detector.

6-1.4 SQUARING CIRCUITS AND AP COUNTER

The amplified WBO output is squared by CMOS inverters connected as Schmidt-triggers. While the squared WBO signal is selected by the CPU controlled MUX, the AP counter circuit (on the Memory board) is used to count its frequency. A 12-bit CMOS counter (4040) acquires the integer count during a 0.125 second interval, while a second 4040 counts the TCXO frequency (2.097 mHz) to yield a number representing the *fractional* cycle of the input frequency. The CPU uses the two counts to compute a single number representative of WBO frequency, at a resolution equal to 1/(0.125 X 2.097e6) or 1/262,000. This is comparable to the counter resolution obtained with other Sea-Bird CTD equipment.

6-1.5 A/D CONVERTER (INTERNAL DIAGNOSTICS)

A 12-bit plus sign A/D converter (National Semiconductor ADC1205) is used on the CPU board to obtain diagnostic information relating to SEACAT status and functionality. A pre-amplifier and buffer (Precision Monolithics OP220) are used to condition the internal signal levels selected by the MUX. Main supply current is determined by measuring the voltage across a 0.5 ohm resistor, while main unregulated and lithium back-up voltages are sensed using resistive dividers. To assure ability of the back-up lithium supply to power SEACAT functions, its voltage is measured under typical load. SEACAT quiescent current (RTC and memory only supported) is also measured by the A/D.

6-1.6 CPU AND DATA I/O

SEACAT's CPU is configured around an 80C85 CMOS 8-bit microprocessor (CPU board), with program storage in CMOS EPROM (27C256, Memory Board). Communication with SEACAT is via RS-232 interface to the XR88C681 UART (CPU Board), while level conversion is handled by a LT1081; this chip serves a double role in supplying a source of ± 12 v power used to drive the A/D converter's precision 5-volt reference (PMI REF02).

A time-out signal is generated which resets the CPU after 5 seconds of CPU inactivity. The time-out feature is intended to protect against inadvertent incapacitation resulting from some unforeseen software *loop*. The reset inhibit is detected on the CPU Board in response to periodically imbedded lines of code which cause a write instruction to location C1 HEX.

6-1.7 REAL-TIME CLOCK

RTC oscillator circuitry (Memory Board transistor oscillator, CMOS buffer/squaring) is on the Memory Board. A flip-flop converts the 3 v p-p squared oscillator output to the 5 volt level required for SEACAT's digital circuitry. The RTC oscillator frequency is counted during each data acquisition cycle using SEACAT's precision TCXO. The results are used to arithmetically correct the inter-sample interval and recorded time. The clock/calendar chip is on the CPU Board (National Semiconductor MM58167A). CPU Board uses tri-state buffers to protect the clock/calendar from inadvertent wake-alarm rewrite during power-up.

6-1.8 MEMORY

Eight low-power CMOS static RAM chips (Memory Board, Hitachi HM628128) are used for main data memory. Bank switching is used, and memory contents protected on power-up by tri-state latches.

7-1 DISASSEMBLY/REASSEMBLY INSTRUCTIONS

COMPLETE DISASSEMBLY WILL DESTROY ANY DATA PREVIOUSLY STORED IN SEACAT!

Great care must be taken during assembly and reassembly to avoid breaking the conductivity cell. The cell is robust and well protected when the instrument is intact, but becomes extremely vulnerable during the disassembly/reassembly procedure.

Remove the four machine screws retaining the sensor guard to the housing and set the guard aside. Remove the small screw holding the upper (opposite end cap) end of the conductivity cell to the housing. Now remove the four screws retaining the sensor end cap to the cylindrical housing. The end cap and attached electronics chassis may now be slid out of the pressure cylinder. The Molex connector toward the battery end of the analog electronics board (the board to which the yellow lithium batteries are mounted) must be unmated before the chassis/end cap assembly may be fully removed.

For reassembly, reverse the disassembly process, being careful that the mating surfaces are clean and the O-ring greased, undamaged, and properly positioned. Use a new desiccant package. Re-mate the Molex connector (be careful to line up the connector socket holes properly with respect to the mating header pins).

7-2 O-RING SIZES

O-RING SIZES (600, 3400, AND 6800 METER CASE SEACATS)

Battery end cap (piston) seal:	Parker 2-234E603-70
Battery end cap (face) seal:	Parker 2-153N674-70
Sensor end cap (piston) seal:	Parker 2-233E603-70
Sensor end cap (crush) seal	Parker 5-374E603-70
I/O bulkhead connector:	Parker 2-017N674-70
Conductivity cell penetrator:	Parker LS-001

O-RING SIZES (7000 AND 10500 METER CASE SEACATS)

Battery end cap (piston) seal:	Parker 2-234E603-70
Battery end cap (face) seal:	Parker 2-153N674-70
Sensor end cap (piston) seal:	Parker 2-233E603-70
Sensor end cap (crush) seal	Parker 5-374E603-70
I/O bulkhead connector:	Parker 2-017N674-70
Conductivity cell face seal:	Parker 2-110E603-70

Appendix I: AF24173 Anti-Foulant Device

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

AF24173 ANTI-FOULANT DEVICE

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

ACTIVE INGREDIENT:

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

DANGER

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

Net Contents: Two anti-foulant devices

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

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

AF24173 Anti-Foulant Device

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

ACTIVE INGREDIENT:

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

DANGER

See Precautionary Statements for additional information.

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

Net Contents: Two anti-foulant devices

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

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

PRECAUTIONARY STATEMENTS

HAZARD TO HUMANS AND DOMESTIC ANIMALS

DANGER

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

PERSONAL PROTECTIVE EQUIPMENT

USER SAFETY RECOMMENDATIONS

Users should:

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

ENVIRONMENTAL HAZARDS

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

PHYSICAL OR CHEMICAL HAZARDS

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

DIRECTIONS FOR USE

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

STORAGE AND DISPOSAL

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

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

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

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

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