SBE 53-BPR
Bottom Pressure Recorder

Bottom Pressure Recorder (BPR)
with RS-232 Interface

Serial Number: 5362517-0070

User Manual, Version 010

Sea-Bird Electronics, Inc.
13431 NE 20th Street
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SBE 53 BOTTOM PRESSURE RECORDER

TABLE OF CONTENTS

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Manual Generation Date: 10 February 2011

L I M I T E D L I A B I L I T Y S T A T E M E N T

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

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

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

DECLARATION OF CONFORMITY

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

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

Device Description: Various Data Acquisition Devices and Sensors

Model Numbers:

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

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

Applicable Harmonized Standards:

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

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

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

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

Authorized Signature:

Name: John Backes

Title of Signatory: Vice President

Date: 27 January 2010

Place: Bellevue, WA

WARNING !!

Do not submerge this instrument (S/N 5362517-0070) beyond the depth rating of the lowest rated component listed below!

Main Housing (Titanium)	7000 meters
Digiquartz (10000 Psia)	**6885 meters**

SYSTEM CONFIGURATION

11 February 2011

Model 53 BPR	**S/N 5362517-0070**
Firmware Version	**1.1E**
Baud Rate	**9600**
Pressure Sensor	**Digiquartz: 10000 psia, S/N 119383**
Memory	**32 Mbyte**
Housing	**7000 meter (Titanium)**
Conductivity Interface Installed	**Yes**
Conductivity Sensor	**None**

SBE 53 BPR
Bottom Pressure Recorder

Pressure, Temperature, and Optional Conductivity Recorder

Note:
New address (mid-January 2010; check website for exact date)
13431 NE 20th Street
Bellevue, WA 98005 USA

User's Manual

Sea-Bird Electronics, Inc.
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Manual Version #010, 12/14/09
Firmware Version 1.1e and later
SEASOFT for Waves Version 1.18b and later

Limited Liability Statement

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

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

Table of Contents

Section 1: Introduction

This section includes a Quick Start procedure, and photos of a standard SBE 53.

About this Manual

This manual is for use with the SBE 53 BPR Bottom Pressure Recorder. It is organized to guide the user from installation through operation, data collection, and processing. We have included detailed specifications, command descriptions, maintenance and calibration information, and helpful notes throughout the manual.

Sea-Bird welcomes suggestions for new features and enhancements of our products and/or documentation. Please contact us with any comments or suggestions (seabird@seabird.com or 425-643-9866). Our business hours are Monday through Friday, 0800 to 1700 Pacific Standard Time (1600 to 0100 Universal Time) in winter and 0800 to 1700 Pacific Daylight Time (1500 to 0000 Universal Time) the rest of the year.

Quick Start

Follow these steps to get a Quick Start using the SBE 53. The manual provides step-by-step details for performing each task.

Deployment:

1. Run Battery and Memory Endurance to determine sampling parameters (*Section 4*).

2. Install new batteries.

3. Connect SBE 53 to computer and run SeatermW (*Section 5*):
   A. Ensure all data has been uploaded, and then send **InitLogging** to make entire memory available for recording if desired.
   B. Set date and time (**SetTime**) and tide sampling parameters (**SetSampling**); enable conductivity if SBE 4M conductivity sensor is installed (**Conductivity=Y**); enable external thermistor if optional external thermistor installed (**ExternalTemperature=Y**).
   C. Check status (**DS**) and calibration coefficients (**DC**).
   D. Start logging (**Start**).

Recovery and Data Processing:

1. Connect SBE 53 to computer and run SeatermW. Stop logging (**Stop**), and upload data from SBE 53 memory (*Section 5*).

2. Run Convert Hex to convert uploaded data into tide and reference frequency files (*Section 6*).

3. Run Merge Barometric Pressure to remove barometric pressure from tide file (*Section 7*).

4. Run Plot Data to display the data (*Section 8*).

Unpacking SBE 53

Shown below is a typical SBE 53 shipment.

SBE 53

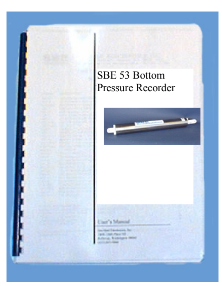
I/O cable

Pressure sensor
oil refill kit

Spare battery end cap
hardware and o-ring kit

Spare hardware kit

Jackscrew kit



SBE 53 manual

Software, and electronic copy of
user manual

Section 2: Description of SBE 53

This section describes the functions and features of the SBE 53, including specifications, dimensions, end cap connectors, power supply information, cable length limitations, data I/O protocols, and real-time setup.

System Description

The SBE 53 BPR measures full ocean depth water level with extremely high resolution, accuracy, and stability. The SBE 53 combines a uniquely precise and stable time base with low power frequency acquisition circuitry, Paroscientific Digiquartz® pressure transducer, non-volatile 32 MB FLASH memory, and a precision thermometer, to provide unprecedented bottom pressure recording capability. An optional conductivity sensor (SBE 4M) can be added to provide salinity data as well.

The SBE 53 integrates pressure measurements to obtain water levels (tides) unaffected by wave action. The interval between each water level measurement and the duration of the integration period are user-programmable. The interval is programmable over a range of 1 minute to 1 hour. The integration duration is programmable from 1 minute to the entire user-defined tide interval. The SBE 53 can continuously power the pressure transducer and reference frequency oscillator, eliminating turn-on transients and providing the highest quality data. Alternatively, the SBE 53 can be programmed to enter a power-down state between measurements to conserve battery power for very long deployments, with a user-specified *warm-up* period before each pressure measurement. Temperature data is recorded with each pressure integration. As an option, an SBE 4M conductivity sensor can be integrated for recording conductivity data with each tide measurement. Logging (recording) can be programmed to start and stop at specified times after the instrument is deployed. Data is always recorded in memory; in addition, real-time data can be output.

Large memory and low power requirements permit frequent water level recording. For example, with standard alkaline batteries, a 420-day deployment could include water level measurements every 30 minutes (integrating pressure for the entire 30 minutes); a 2-year deployment could be achieved if pressure integration is limited to 4 minutes for each water level measurement, with a 15-minute warm-up of the pressure sensor and reference frequency oscillator before each measurement. Alternatively, deployments approximately 3 times longer are possible with Electrochem DD lithium batteries. Binary upload of data in memory can be accomplished at up to 115,200 baud.

The SBE 53 is self-contained in a rugged, non-corroding, titanium housing for depths to 7000 meters. After recovery (and without opening the housing), the recorded data is transferred to a computer via an RS-232C data link for analysis, plotting, and permanent archiving. The battery compartment contains twelve standard alkaline D-cells (Duracell MN1300, LR20) and is sealed separately to minimize risk to the electronics.

The pressure sensor, a Paroscientific Digiquartz pressure sensor with a temperature-compensated quartz element, is available in 1300, 2000, 4000, and 6800 meter ranges (2000, 3000, 6000, and 10000 psia).

The pressure and internal temperature compensation (pressure temperature) signals (frequencies) from the transducer are integrated in parallel for the tide integration duration. The measurement times are set by a continuously powered, real-time clock with an accuracy of ± 5 seconds/month. Long-term drift of the counter's reference frequency is on the order of 1 ppm per year. To allow for correction of drift, an ovenized crystal oscillator is programmed to make a reference frequency measurement periodically.

Temperature is measured with an aged, super-stable thermistor embedded in the SBE 53 end cap. An AC excitation is applied to a hermetically sealed VISHAY reference resistor and the thermistor. A 24-bit A/D converter digitizes the reference resistor and thermistor outputs.

The standard SBE 53 includes:

- Titanium housing for depths to 7000 meters (22,900 ft)
- 1300, 2000, 4000, or 6800 meter (2000, 3000, 6000, or 10000 psia) Paroscientific Digiquartz temperature-compensated pressure sensor
- Accurate temperature sensor – aged thermistor embedded in end cap
- Frequency input channel and bulkhead connector for optional SBE 4M conductivity sensor
- 32 MB FLASH memory
- 12 alkaline D-cell batteries (Duracell MN1300, LR20); battery compartment is separated from electronics by a moisture-proof seal
- Impulse glass-reinforced epoxy bulkhead connectors

SBE 53 options include:

- SBE 4M conductivity sensor, interfaced via bulkhead connector and clamped to SBE 53 housing. SBE 4M comes equipped with expendable AF24173 Anti-Foulant Devices.
- High accuracy external temperature sensor (0.002 °C accuracy, 0.0001 °C resolution) in place of standard internal thermistor (0.01 °C accuracy, 0.001 °C resolution)
- Wet-pluggable (MCBH) bulkhead connectors in place of standard connectors
- Lithium batteries (six DD drop-in batteries with buttons) for longer deployments (lithium batteries **not** supplied by Sea-Bird). Note that one lithium DD battery is shorter than two alkaline D batteries, so a different battery cover plate is required if using the lithiums (cover plate available from Sea-Bird).

Notes:

- Help files provide detailed information on SEASOFT for Waves.
- **SEASOFT for Waves data processing modules cannot process real-time data from the SBE 53.**
- Sea-Bird supplies the current version of our software when you purchase an instrument. As software revisions occur, we post the revised software on our FTP site. See our website (www.seabird.com) for the latest software version number, a description of the software changes, and instructions for downloading the software from the FTP site.

Future upgrades and enhancements to the SBE 53 firmware can be easily installed in the field through a computer serial port and the data I/O bulkhead connector on the SBE 53, without the need to return the SBE 53 to Sea-Bird.

The SBE 53 is supplied with a modular Windows 95/98/NT/2000/XP software package, SEASOFT for Waves. The software provides pre-deployment planning, communication with the SBE 53 for setup and uploading of data, conversion of the uploaded data, removal of barometric pressure from tide data, and data plotting.

Specifications

> **Note:**
> The pressure sensor is mounted on the titanium connector end cap, with the pressure conveyed from the pressure port to the sensor via an oil-filled tube. The pressure reading is position sensitive as a result of the oil pressure head.

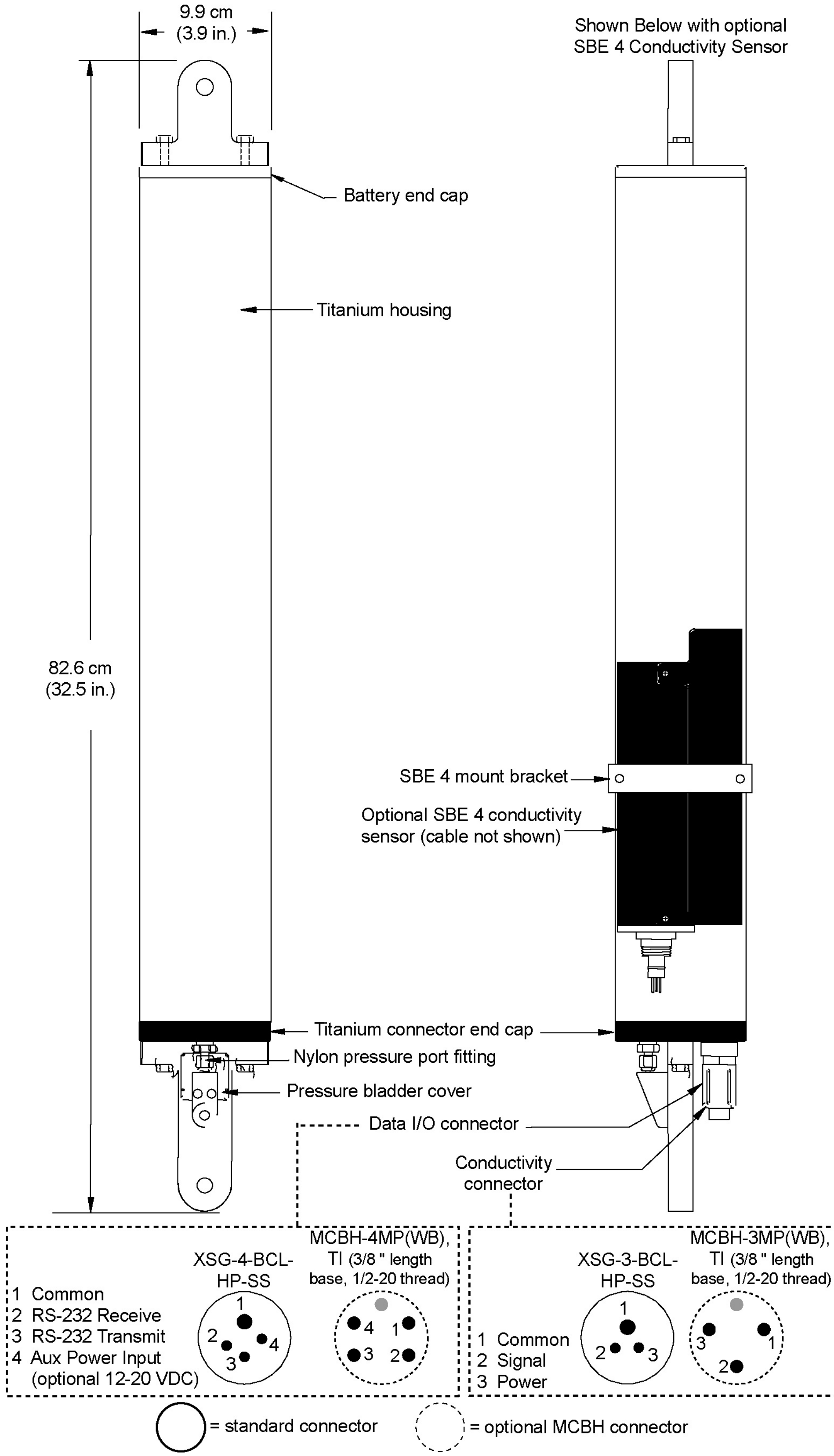
Pressure	
Range	0 to 1300, 2000, 4000, or 6800 m (2000, 3000, 6000, or 10,000 psia)
Accuracy *	0.01% of full scale
Repeatability	0.005% of full scale
Hysteresis	0.005% of full scale
Calibration	0 psia to full scale pressure
Resolution	0.045 ppm (0.3 mm for 10,000 psia range, 1-minute integration, continuously powered)
Standard Temperature (internal thermistor)	
Range	-5 to +35 °C
Accuracy	0.01 °C
Resolution	0.001 °C
Calibration	+1 to +32 °C (measurements outside this range may be at slightly reduced accuracy due to extrapolation errors)
Optional High Accuracy Temperature (external thermistor)	
Range	-5 to +35 °C
Accuracy	0.002 °C
Resolution	0.0001 °C
Calibration	+1 to +32 °C (measurements outside this range may be at slightly reduced accuracy due to extrapolation errors)
Conductivity (optional SBE 4M conductivity sensor)	
Range	0.0 to 7 S/m
Accuracy	±0.0003 S/m/month (typical); ±0.001 S/m/month (guaranteed; not applicable in areas of high bio-fouling or contamination or if Application Note 2D procedures are not followed)
Resolution	0.00002 S/m
Calibration	2.6 to 6 S/m plus zero conductivity (air)
Clocks	
Clocks	***Counter Time Base*** (for pressure and pressure temperature): Quartz TCXO ± 3 ppm per year aging (± 1 ppm per year typical), ± 0.1 ppm (0 - 20 °C) ***Ovenized Crystal Oscillator*** (for reference frequency drift correction): Warm-up re-stabilization: less than ± 1 x 10^{-7} Stability vs. temperature: ± 0.1 ppm (-20 °C to +70 °C) Aging: less than 1 x 10^{-7} per year, less than 1 x 10^{-6} /10 years ***Real-Time Clock*** (for time stamp and sample timing): Quartz TCXO watch-crystal type 32,768 Hz; accuracy ± 2 ppm (5 seconds/month). Battery-backed for minimum of 2-year operation, without main batteries installed. ***Conductivity Time Base***: Quartz TCXO ± 1 ppm per year aging; ± 15 ppm (-20 to +70 °C)

* Digiquartz residual temperature sensitivity is measured at Sea-Bird, and the Digiquartz calibration coefficients are adjusted so that the residual temperature sensitivity is less than 1 ppm over the range of 0 – 20 °C (0.05 ppm/°C; 0.0005 psia for a 10,000 psia range sensor).

Note:
See *Section 4: Pre-Deployment Planning – Plan Deployment and Battery and Memory Endurance*.

Other Specifications	
Memory	32 MB Flash RAM
Data Storage	If conductivity not enabled: Bytes/day = 17 (T + R) If conductivity enabled: Bytes/day = 20 (T + R) (T = tide samples/day, R = reference frequency samples/day)
Power Requirement	***Quiescent (sleep, when not logging)***: 0.0005 watt ***Communications***: 0.10 watt ***Data Upload***: 0.17 watt ***Logging:*** **Digiquartz & Reference Frequency Oscillator** *Case 1: Continuously powered, tide duration = tide interval* Powered and Integrating 0.016 watt *General (per measurement) 0.31 watt-seconds = 0.31 joules *Case 2: Continuously powered, tide duration < tide interval* Powered and Integrating 0.016 watt Powered but not Integrating 0.012 watt *General (per measurement) 0.47 watt-seconds = 0.47 joules *Case 3: Not continuously powered, tide duration < tide interval* Powered and Integrating 0.016 watt Powered but not Integrating 0.012 watt Powered down 0.0005 watt *General (per measurement) 0.66 watt-seconds = 0.66 joules **Optional Conductivity** 0.23 watt-seconds = 0.23 joules **Reference Frequency** Total per measurement 250 watt-seconds = 250 joules Peak 1.5 watts **General (per measurement) includes taking temperature measurement as well as storing data, etc.*
Power Supply	***Standard:*** 12 alkaline D-cell batteries (Duracell MN1300, LR20): Typical capacity 756,000 joules. Sea-Bird recommends derating 15% for safety, and 5% per year for battery self-discharge. Consider derating further for cold water applications. ***Optional:*** 6 lithium DD-cell batteries (Electrochem BCX85-3B76-TC) with buttons (lithiums **not** supplied by Sea-Bird). Note that 1 lithium DD is shorter than 2 alkaline Ds, so different battery cover plate required (cover plate available from Sea-Bird). Typical capacity 2,332,800 joules. Sea-Bird recommends derating 15% for safety, and 3% per year for battery self-discharge. ***Optional:*** external power source: 12 - 24 VDC.
Housing Materials	7000-meter titanium housing and end cap
Weight (with alkaline batteries)	14.5 kg (32 lbs) in air, 8.6 kg (19 lbs) in water

Dimensions and End Cap Connectors



Power Supply

Notes:

- For battery endurance calculations, see *Section 4: Pre-Deployment Planning – Battery and Memory Endurance*.
- The cut-off voltage is 9.25 volts. If the voltage falls below that, the SBE 53 provides a warning message, and will not take measurements.

The main batteries for a standard SBE 53 are 12 D-cell alkaline batteries (Duracell MN 1300, LR20). The SBE 53 can also be powered by 6 DD-cell batteries with buttons (batteries **not** supplied by Sea-Bird).

The SBE 53 can be powered from an external 12-24 VDC source. The internal batteries are diode-OR'd with the external source, so power is drawn from whichever voltage source is higher.

On-board lithium batteries (non-hazardous units which are unrestricted for shipping purposes) are provided to back-up the buffer and the real-time clock in the event of main battery failure, exhaustion, or removal. The main batteries can be replaced without affecting either the real-time clock or the memory. If the main power supply falls below 9 VDC, the SBE 53 will draw power from the back-up lithium batteries.

External Power and Cable Length

Note:
See *Real-Time Setup* below for baud rate limitations on cable length if transmitting real-time data.

There are two issues to consider if powering the SBE 53 externally:

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

Each issue is discussed below.

Note:
Common wire resistances:

Gauge	Resistance (ohms/foot)
12	0.0016
14	0.0025
16	0.0040
18	0.0064
19	0.0081
20	0.0107
22	0.0162
24	0.0257
26	0.0410
28	0.0653

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

The limit to cable length is typically reached when the maximum current ***during communication*** times the power common wire resistance is more than 1 volt, because the difference in ground potential of the SBE 53 and ground controller prevents the SBE 53 from transmitting real-time data.

V_{limit} = 1 volt = IR_{limit}

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

where I = maximum current required by SBE 53 during communication.

From *Specifications*, upload power required is 0.17 watt. Use 12 V (minimum input voltage) to calculate:

I * V = watts

I = 0.17 watts / 12V = 0.0142 amps

Example 1 – For 20 gauge wire, what is maximum distance to transmit power if transmitting real-time data?
For upload current, $R_{limit} = V_{limit}$ / I = 1 volt / 0.0142 amps = 70.4 ohms. For 20 gauge wire, resistance is 0.0107 ohms/foot.
Maximum cable length = 70.4 ohms / 0.0107 ohms/foot = 6582 feet = 2006 m

Example 2 – Same as above, but there are 4 instruments powered from the same power supply.
For upload current, $R_{limit} = V_{limit}$ / I = 1 volt / (0.0142 amps * 4 instruments) = 17.6 ohms
Maximum cable length = 17.6 ohms / 0.0107 ohms/foot = 1645 feet = 502 m (to SBE 53 *furthest* from power source).

Supplying Enough Power to SBE 53

Another consideration in determining maximum cable length is supplying enough power at the power source so that sufficient voltage is available, after IR loss in the cable, to power the SBE 53 externally.

The maximum power draw is for the reference frequency measurement, 1.5 watts. Use 12 V (minimum input voltage) to calculate:

I * V = watts

I = 1.5 watts / 12V = 0.125 amps

Example 1 – For 20 gauge wire, what is maximum distance to transmit power to SBE 53 from a 12 VDC power supply?
SBE 53 external power specification is 12 – 24 VDC. Battery cut-off (point at which SBE 53 stops taking measurements) is 9.25 V. Therefore, a 2.75 V IR drop (12 V – 9.25 V) would still provide enough power to SBE 53.
V = IR   2.75V = 0.125 amps * (0.0107 ohms/foot * cable length)
Maximum cable length = 2056 ft = 626 m
Note that 626 meters < 2142 m (maximum distance if SBE 53 is transmitting real-time data), so IR drop in power is controlling factor for this example. Using a higher voltage power supply or a different wire gauge would increase allowable cable length.

Example 2 – Same as above, but there are 4 instruments powered from same power supply.
2.75V = 0.125 amps * 4 instruments * (0.0107 ohms/foot * cable length)
Maximum cable length = 514 ft = 156 m (to SBE 53 *furthest* from power source)

Data I/O

The SBE 53 receives setup instructions and outputs diagnostic information or previously recorded data via a three-wire RS-232 link. The SBE 53 is factory-configured for 9600 baud, 8 data bits, 1 stop bit, and no parity. The communications baud rate can be changed using **Baud=** (see *Section 5: SBE 53 Setup, Installation, and Data Upload – SeatermW*). Standard ASCII data upload from memory is done at the communications baud rate. Binary data upload from memory can be accomplished at rates of up to 115,200 baud, regardless of the setting for the communications baud rate.

Real-Time Setup

Notes:
- Set:
  - Baud rate with **Baud=**.
  - **TxTide=Y** for real-time tide data.
  See *Section 5: SBE 53 Setup, Installation, and Data Upload – SeatermW* for command details.
- If using external power, see *External Power and Cable Length* above for power limitations on cable length.

Baud Rate and Cable Length

The length of cable that the SBE 53 can drive is dependent on the baud rate. The allowable combinations are:

Maximum Cable Length (meters)	Maximum Baud Rate
1600	600
800	1200
400	2400
200	4800
100	9600
50	19200
25	38400
16.7	57600 *
13.3	115200 *

* 57600 and 115200 baud are available only for binary upload, and are not applicable to real-time data output.

Real-Time Data Acquisition

Real-time tide data can be saved by clicking Capture in SeatermW before you begin logging. The data displayed in SeatermW will be saved to the designated file. Process the data as desired. Note that this file **cannot be processed by SEASOFT for Waves, as it does not have the required headers and format for Sea-Bird's processing software**.

Section 3: Software Installation and Use

Notes:
- Help files provide detailed information on SEASOFT for Waves.
- **SEASOFT for Waves data processing modules cannot process real-time data from the SBE 53.**
- Sea-Bird supplies the current version of our software when you purchase an instrument. As software revisions occur, we post the revised software on our FTP site. See our website (www.seabird.com) for the latest software version number, a description of the software changes, and instructions for downloading the software from the FTP site.

This section describes the installation and use of SEASOFT for Waves.

The SBE 53 is supplied with a modular Windows 95/98/NT/2000/XP software package, **SEASOFT for Waves**. The software provides pre-deployment planning, communication with the SBE 53 for setup and uploading of data from the SBE 53, conversion of the uploaded data, removal of barometric pressure from tide data, and data plotting.

Software Installation

Sea-Bird recommends the following minimum system requirements for installing the software: Pentium 90 CPU, 64 Mbyte RAM, Windows 98 or later. Although SEASOFT for Waves was designed to work with a PC running Windows, extensive testing has not shown any compatibility problems when using the software with a PC running Vista.

If not already installed, install SEASOFT for Waves on your computer using the supplied software CD-ROM:

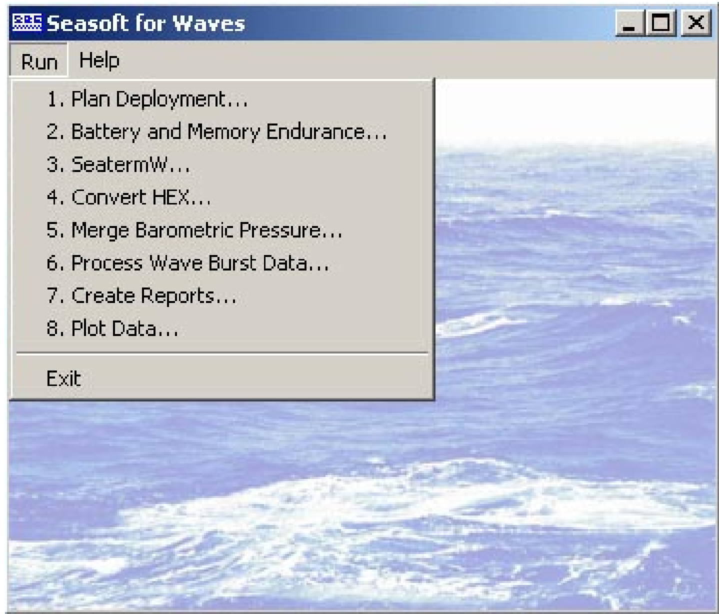
1. Insert the CD in your CD drive.

2. Install the software: Double click on **SeasoftWaves_V*_**.exe** (*_** is the software version). Follow the dialog box directions to install the software.

The default location for the software is
c:\Program Files\Sea-Bird\SeasoftWaves.

SEASOFT for Waves Use

Start SEASOFT for Waves by double clicking on SeasoftWavesLaunch.exe. The main screen looks like this:



The Run menu lists each program module:

Type	Module Name	Module Description
Pre-deployment planning See *Section 4*	**Plan Deployment**	Not applicable to SBE 53.
	Battery and Memory Endurance	Calculate nominal battery and memory endurance for user-specified sampling scheme.
Terminal program See *Section 5*	**SeatermW**	Send commands for status, data acquisition setup, diagnostics, and data upload.
Data conversion See *Section 6*	**Convert Hex**	Convert uploaded .hex data file into .tid tide file (with output data in engineering units) and .ref reference frequency file.
Tide data processing See *Section 7*	**Merge Barometric Pressure**	Remove barometric pressure from tide data in .tid file, output a .tid file.
Wave data processing	**Process Wave Burst Data**	Not applicable to SBE 53.
	Create Reports	Not applicable to SBE 53.
Data plotting See *Section 8*	**Plot Data**	Plot data from a .tid file; plots can be printed.

File Types

File extensions are used by SEASOFT for Waves to indicate the file type:

Extension	Description
.bmp	Bitmap graphics file created by Plot Data.
.bp	Barometric pressure data, used by Merge Barometric Pressure to remove barometric pressure from the tide data (.tid) file. This file, **not** supplied by Sea-Bird, is created by user, based on local barometric pressure data (such as that from a local weather station). See *Section 7: Tide Data Processing – Merge Barometric Pressure*.
.cap	Real-time data, queried data, and/or diagnostics captured using SeatermW.
.hex	Data uploaded from SBE 53 memory using SeatermW.
.ini	There are two .ini files used in SEASOFT for Waves: • SeasoftWaves.ini contains the location and file name of the last saved Program Setup (.psa) file and options settings for each module with a .psa file (Convert Hex, Merge Barometric Pressure, and Plot Data). • SeatermW.ini contains the last instrument type (SBE 26 or 26*plus*), COM port, and baud rate used in SeatermW for communicating with the instrument. Note: SBE 26*plus* communications settings are compatible with the SBE 53. The .ini files are saved to %USERPROFILE%\Local Settings\Apps\Sea-Bird (*Example* C:\Documents and Settings\dbresko\ Local Settings\Apps\Sea-Bird)
.jpg	JPEG graphics file created by Plot Data.
.psa	Program Setup file, used by Convert Hex, Merge Barometric Pressure, and Plot Data to store setup information (such as input and output file names and locations, and processing instructions). The user can save the .psa files to the desired locations. As a default, the .psa files are saved to %USERPROFILE%\Application Data\SeasoftWaves (*Example* C:\Documents and Settings\dbresko\ Application Data\Sea-Bird\SeasoftWaves).
.ref	Reference frequency file, created from uploaded .hex file by Convert Hex.
.tid	Tide measurements in engineering units, created from uploaded .hex file by Convert Hex. Also, file format for tide data that has had barometric pressure removed by Merge Barometric Pressure.
.wmf	Windows metafile graphics file created by Plot Data.

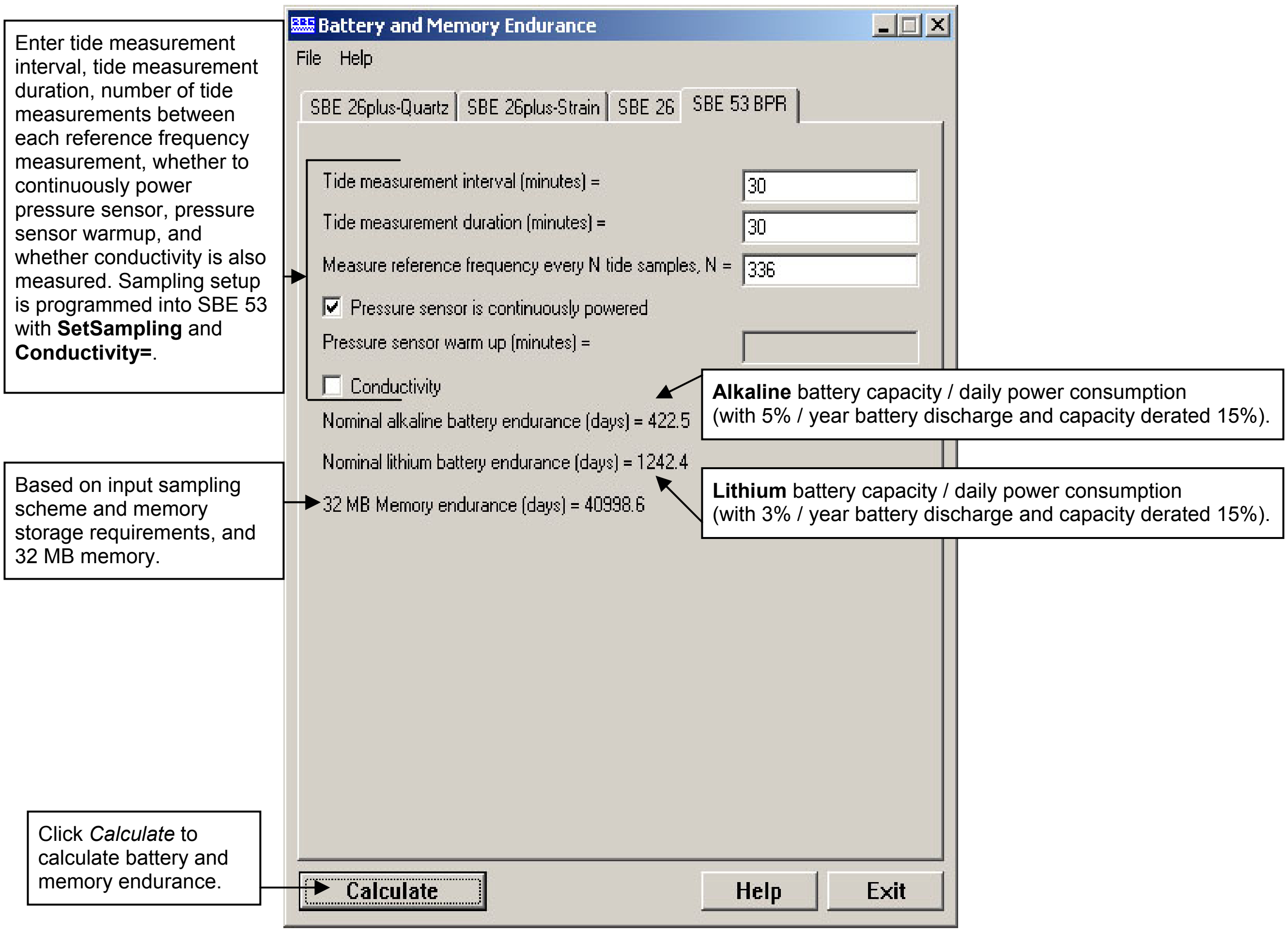
See *Appendix III: Data Formats* for details on the format of each file.

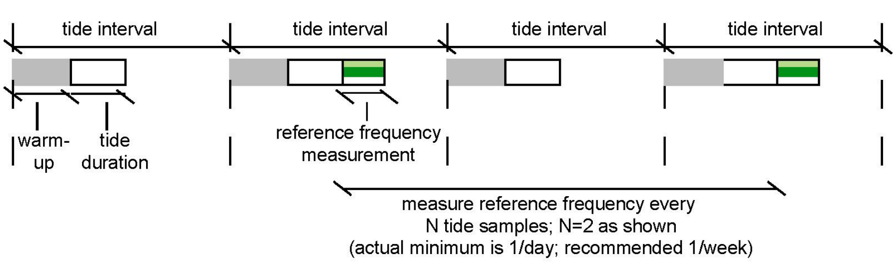
Section 4: Pre-Deployment Planning – Battery and Memory Endurance

Note:
See *Specifications* in *Section 2: Description of SBE 53* for power and memory specifications.

This section covers calculating battery and memory endurance for the desired sampling scheme, using the Battery and Memory Endurance module in SEASOFT for Waves. Power and memory endurance calculations for the SBE 53 are complex, and are dependent on the sampling scheme. Use Battery and Memory Endurance to calculate the endurance for a user-specified sampling scheme.

In SEASOFT for Waves' Run menu, select Battery and Memory Endurance. Click on the SBE 53 tab in the dialog box. The dialog box looks like this:





Notes:
- Drawing is schematic only, intended to define the sampling scheme terminology. See *Appendix II: Sample Timing* for timing details.
- See *Command Descriptions* in *Section 5: SBE 53 Setup, Installation, and Data Upload – SeatermW* for programming desired sampling scheme in SBE 53.
- Powering pressure continuously provides highest quality data. If not powering continuously, minimum warm-up is 5 minutes; Sea-Bird recommends 15 minutes or more.

Notes:
- See *Specifications* in *Section 2: Description of SBE 53* for power requirements and alkaline and lithium battery ratings.
- 1 watt-second = 1 joule

Discussions follow of the data and equations used in Battery and Memory Endurance; use this information to perform your own calculations if desired.

Battery Endurance

Examples: SBE 53 with standard alkaline batteries, no conductivity sensor. Measure tides at 30 minute intervals (48 measurements/day). Take 1 reference frequency measurement per week (1 after every 336 tide measurements [= 48 * 7]).

Reference frequency measurement (calculating pro-rated power per day for measurement once per week)
= 250 watt-sec/week * 1 week / 7 days = **36 joules/day**

Alkaline battery capacity and derating:
Alkaline battery capacity = 756,000 joules * 0.85 (derate for safety) = 642,600 joules
Derating 5% per year for battery self-discharge: 0.05 * 642,600 joules / 365 days per year = **88 joules/day**

(Note: If conductivity sensor included, add 0.23 joules/measurement * 48/day =**11 joules /day** to power requirement.)

Example 1 (Case 1 in *Specifications*): 30-minute (1800 sec) duration; power pressure sensor and reference frequency oscillator continuously while sampling. (Note: this is same sampling scheme as shown in Battery and Memory Endurance dialog box above.)

Digiquartz & reference frequency oscillator power =
[(0.016 watt * 1800 sec) + 0.31 watt-sec] * 48/day = **1397 joules/day**

Adding reference frequency and battery derating: **Total power/day** = 1397 + 36 + 88 = **1521 joules/day**

Battery endurance = 642,600 joules/ 1521 joules/day = **422 days = 1.2 years**

Example 2 (Case 2 in *Specifications*): 3-minute (180 sec) duration; power pressure sensor and reference frequency oscillator continuously while sampling.

Digiquartz & reference frequency oscillator power =
[(0.016 watt * 180 sec) + (0.012 watt * 1620 sec) + 0.47 watt-sec] * 48/day = **1094 joules/day**

Adding reference frequency and battery derating: **Total power/day** = 1094 + 36 + 88 = **1218 joules/day**

Battery endurance = 642,600 joules/ 1218 joules/day = **528 days = 1.4 years**

Example 3 (Case 3 in *Specifications*): 3-minute (180 sec) duration; power down pressure sensor and reference frequency oscillator after each measurement; provide a 15-minute (900 sec) warm-up for each measurement.

Digiquartz & reference frequency oscillator power =
[(0.016 watt * 180 sec) + (0.012 watt * 900 sec) + (0.0005 watt * 720 sec) + 0.66 watt-sec] * 48/day = **706 joules/day**

Adding reference frequency and battery derating: **Total power/day** = 706 + 36 + 88 = **830 joules/day**

Battery endurance = 642,600 joules/ 830 joules/day = **774 days = 2.1 years**
However, Sea-Bird recommends that alkaline batteries should not be expected to last longer than 2 years in the field. Battery and Memory Endurance provides a warning that deployments longer than 2 years are not recommended with alkaline batteries.

As a check, compare each of these examples with the output of Battery and Memory Endurance; the program shows the same results.

Memory Endurance

Note:
The current version of the SBE 53 ignores the storing of the reference frequency measurements when calculating memory endurance for the status (**DS**) command output. This has a very small effect on memory endurance, and will be corrected in the next firmware revision.

The SBE 53 comes standard with a 32 MB memory. Memory used for storing logged data is:

If conductivity not enabled: Bytes/day = 17 (T + R)
If conductivity enabled: Bytes/day = 20 (T + R)

where
T = number of tide samples/day
R = number of reference frequency measurements/day

Examples: SBE 53 with conductivity sensor.

Example 1 - Measure tides every 30 minutes (2/hour * 24 hours = 48 measurements/day).
Measure reference frequency every 336 tide intervals (1 measurement/week).
T = 48, R = 1/7 = 0.14286
Bytes/day = 20 (T + R) = 20 (48 + 0.14286) = 962.9 bytes/day
Memory capacity ≈ 32 MB * 1024 * 1024 = 33,554,432 bytes
Memory endurance ≈ 33,554,432 / 962.9= 34847 days = 95 years !!!

Example 2 - Measure tides every 1 minute (maximum sampling rate) (60/hour * 24 hours = 1440 measurements/day). Reference frequency measurement is disabled because tide duration < 10 minutes.
T = 1440, R = 0
Bytes/day = 20 (T + R) = 20 (1440 + 0) = 28800 bytes/day
Memory capacity ≈ 32 MB * 1024 * 1024 = 33,554,432 bytes
Memory endurance ≈ 33,554,432 / 28800 = 1165 days = 3.2 years

As a check, compare with the output of Battery and Memory Endurance; the program shows the same results. As you can see from these examples, memory capacity is not a limiting factor in deployment length.

Section 5: SBE 53 Setup, Installation, and Data Upload - SeatermW

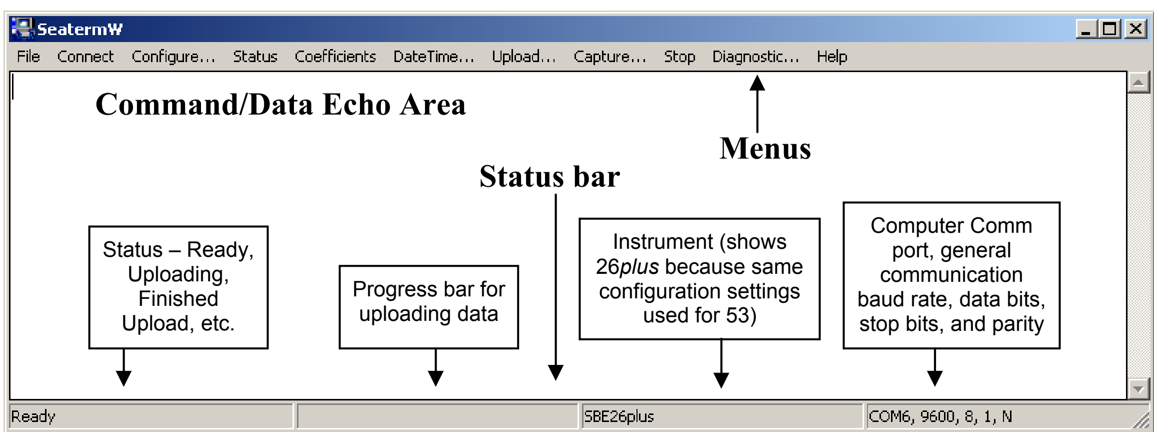
This section covers:

- Programming the SBE 53 for deployment using SeatermW
- Command descriptions
- Installing and deploying the SBE 53
- Uploading data from the SBE 53 memory using SeatermW

Programming for Deployment - SeatermW

1. Connect the SBE 53 to the computer using the 4-pin data I/O cable:
   A. By hand, unscrew the locking sleeve from the SBE 53 I/O (4-pin) connector. If you must use a wrench or pliers, be careful not to loosen the I/O connector instead of the locking sleeve.
   B. Remove the dummy plug from the SBE 53 I/O connector by pulling the plug firmly away from the connector.
   C. **Standard Connector** - Install the Sea-Bird I/O cable connector, aligning the raised bump on the side of the connector with the large pin (pin 1 - ground) on the SBE 53. **OR**
   MCBH Connector – Install the cable, aligning the pins.
   D. Connect the I/O cable connector to your computer's serial port.

2. In SEASOFT for Waves Run menu, select SeatermW.
   The main screen looks like this:



Note:
Once the system is configured and connected (Steps 3 and 4 below), to update the Status bar, click Status. SeatermW sends the status command (**DS**), which displays in the Command/Data Echo Area, and updates the Status bar.

- Menus – Contains tasks and frequently executed instrument commands.
- Command/Data Echo Area – Echoes a command executed using a Menu, as well as the SBE 53 response. Additionally, a command can be manually typed in this area, from the available commands for the SBE 53. The SBE 53 must be *awake* for it to respond to a command (use Connect to wake up the SBE 53).
- Status bar – Provides status information.

Note:
You must be *connected* to the instrument (Connect) when using Status, Coefficients, Upload, Stop, or Diagnostic.

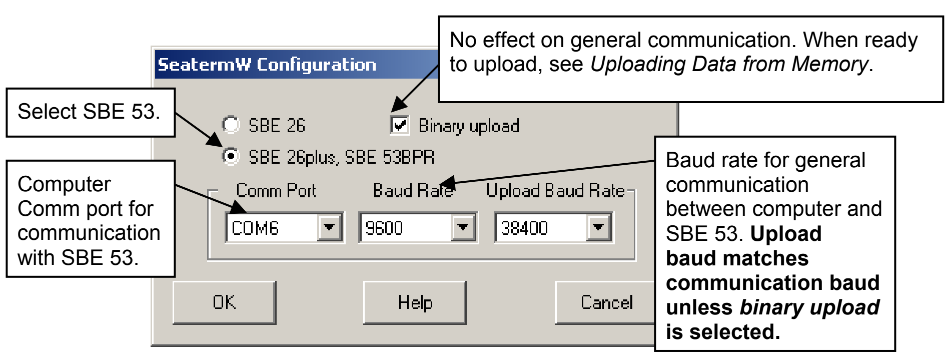
Following is a description of the menus:

Menu	Description	Equivalent Command*
File	Exit SeatermW.	-
Connect	Re-establish communications with SBE 53. Computer responds with S> prompt. SBE 53 *goes to sleep* after 2 minutes without communication from computer have elapsed.	(press Enter key)
Configure	Establish communication parameters (instrument, Comm port, and baud rate).	**-**
Status	Display SBE 53 setup and status (logging, samples in memory, etc.).	**DS**
Coefficients	Display pressure, temperature, and optional conductivity sensor calibration coefficients.	**DC**
DateTime	Set SBE 53 date and time based on time in computer. See *Setting Time in SBE 53 to Synchronize Sampling of Multiple Instruments* for details.	**DateTime=x**
Upload	Upload data stored in memory, in format our data processing module (Convert Hex) can use. Uploaded data has .hex extension. Before using, verify SBE 53 has stopped logging (send **Stop** unless you had input and enabled a pre-programmed stop time before beginning logging).	Upload with **DD** or **DBbaud,b,e** (use Upload if you will be processing data with SEASOFT for Waves' Convert Hex module)
Capture	Capture SBE 53 responses on screen to file; to save real-time data or may be useful for diagnostics. File has .cap extension. Click Capture again to turn off capture. Capture status displays in Status bar.	-
Stop	Interrupt and end current activity, such as uploading data or running diagnostic test (such as **FR**, **VR**, **TT**, **TTR**). Note: This does not stop logging – use **Stop** command to stop logging.	(press Esc key several times)
Diagnostic	Perform diagnostic tests on SBE 53. Tests are non-destructive – they do not write over any existing settings.	**DS** (status); **DC** (calibration coefficients); **DD0,10** (upload and display tide samples 0 – 10); **FR** (display frequencies)

*See *Command Descriptions* in this section.

Note:
SeatermW's general communication baud rate must be the same as the SBE 53 baud rate (set with **Baud=**). Baud is factory-set to 9600, but can be changed by the user (see *Command Descriptions*). Other communication parameters – 8 data bits, 1 stop bit, and no parity – cannot be changed.

3. Click Configure. The dialog box looks like this:
   Verify/modify the parameters in the Configuration dialog box. Click OK.



4. Click Connect. The display looks like this:

```
SBE 53 BPR
S>
```

This shows that correct communications between the computer and SBE 53 has been established.
If the system does not respond with the S> prompt:
- Click Connect again.
- Verify the correct instrument, Comm port, and baud rate were entered in the Configuration dialog box.
- Check cabling between the computer and SBE 53.

Note:
The SBE 53 automatically enters quiescent (sleep) state after 2 minutes without receiving a command. This timeout algorithm conserves battery energy if the user does not send **QS** to put the SBE 53 to sleep.
If the system does not appear to respond, click Connect to reestablish communications.

5. Display SBE 53 setup information by clicking Status; SeatermW sends the **DS** command. The display looks like this:

```
SBE 53 BPR V 1.1e  SN 12345    05 Aug 2008  13:35:13
user info=test setup
quartz pressure sensor: serial number = 90319, range = 10000 psia
internal temperature sensor
conductivity = YES
iop =  6.0 ma  vmain = 15.3 V  vlith =  9.3 V
last sample: p = 21.9520, t = 21.0250, s = 34.3799

tide measurement: interval = 30 minutes, duration = 3 minutes, power pressure sensor continuously
measure reference frequency every 336 tide samples
logging start time =  do not use start time
logging stop time =  do not use stop time

tide samples/day = 48.000
memory endurance = 34952.5 days
nominal battery endurance = 523 days alkaline, 1521 days lithium
total recorded tide measurements = 0
total recorded reference frequency measurements = 0
tide measurements since last start = 0
transmit real-time tide data = YES

status = stopped by user
logging = NO, send start command to begin logging
```

6. Send the desired commands to set up the SBE 53 (see *Command Descriptions* below). Verify the setup by clicking Status again.

Notes:
- See *Appendix II: Sample Timing* for a detailed description of when tide measurements are made and stored in memory.
- When transmitting real-time tide data, each tide measurement record displays **after** the tide duration is complete. For example, if the tide duration is 10 minutes, the first tide data displays 10 minutes after logging starts.

7. Test the setup by typing **Start** and pressing the Enter key to begin logging.

   If the **DS** response shows `logging start time = do not use start time` (***use start time?*** in **SetSampling** prompt is ***No***), the SBE 53 responds:
   `logging will start in 10 seconds`

   If the **DS** response shows `transmit real-time tide data = YES` (real-time tide data was enabled with **TxTide=Y**), each time the SBE 53 completes a tide measurement, the display looks like this:
   ```
   Tide: start time = 26 Jan 2006 13:40:01, pr =14.2135,
   pc = 14.2135, pt = 21.352, t = 21.0250, c = 4.81952,
   s = 34.3799
   ```
   where:
   - start time = start of tide measurement.
   - pr = stored raw pressure, converted to psia.
   - pc = corrected pressure (not stored) converted to psia, with correction based on most recent measured reference frequency.
   - pt = stored pressure temperature, converted to °C.
   - t = stored temperature, converted to °C.
   - c = stored conductivity, converted to S/m, and
     s = calculated salinity (not stored) in psu.
     Conductivity and salinity display only if **DS** response shows `conductivity = YES` (conductivity acquisition was enabled with **Conductivity=Y**).

8. End the test by typing **Stop** and pressing the Enter key to stop logging. You may need to press the Esc key before entering **Stop** to get the SBE 53 to stop if it is in the middle of sampling. Verify that logging has stopped by clicking Status and checking that the last line of the **DS** response shows `logging = no`.

9. (if ready for deployment)
   A. Type **InitLogging** and press the Enter key to make the entire memory available for recording. If **InitLogging** is not sent, data will be stored after the last recorded sample.
   B. To begin logging now: Type **Start** and press the Enter key.
      The SBE 53 should display:
      `logging will start in 10 seconds.`
   C. To begin logging at a delayed start date and time:
      - Type **SetStartTime**, press the Enter key, and respond to the prompts to establish a delayed start date and time.
      - Type **SetSampling** and press the Enter key, and answer yes to the ***use start time?*** prompt to enable logging at the delayed start date and time.
      - Type **Start** and press the Enter key. The SBE 53 should display:
      `logging will start at . . ..`

10. (if not ready for deployment) Type **QS** and press the Enter key to command the SBE 53 to go to sleep (quiescent state).

Command Descriptions

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

General Command Notes

- Input commands in upper or lower case letters and register commands by pressing the Enter key.
- The SBE 53 sends `? CMD` if an invalid command is entered.
- If the SBE 53 does not return an `S>` prompt after executing a command, press the Enter key to get the `S>` prompt.
- If a new command is not received within 2 minutes after completion of a command, the SBE 53 returns to quiescent (sleep) state and the display indicates `time out`.
- If in quiescent state, re-establish communications by clicking Connect or pressing the Enter key to get an `S>` prompt.
- The SBE 53 cannot have samples with different tide sample scan lengths (more or fewer data fields per sample) in memory. If the scan length is changed, the SBE 53 must initialize logging. Initializing logging sets the tide sample number and reference frequency sample number to 0, so the entire memory is available for recording data with the new scan length. **Initializing logging should only be performed after all previous data has been uploaded**. **Conductivity=**, which enables/disables acquisition and storing of optional conductivity data, changes the scan length. Therefore, **Conductivity=** prompts the user for verification before executing, to prevent accidental overwriting of existing data.

Note:
Interrupting a tide measurement by pressing the Esc key or clicking Stop will affect the quality of your data. For high quality data, Sea-Bird recommends setting sampling parameters with enough time between measurements to allow querying the SBE 53 during logging without interrupting measurements.

- The SBE 53 responds only to **DS**, **DC**, **QS**, **SL**, **SLO**, and **Stop** while making a tide measurement. If you query the SBE 53 while it is logging (for example, to send **DS** to check on logging progress), it does not interrupt logging.
- The SBE 53 responds only to **DS**, **DC**, **QS**, and **Stop** while *waiting to start logging* (***use start time?*** prompt in **SetSampling** command is ***Yes***, and **Start** was sent, but sampling has not started yet).
  To send any other commands:
  1. Send **Stop**.
  2. Send the desired commands to modify the setup.
  3. Send **Start** again.
- Click Upload to upload data that will be processed by SEASOFT for Waves. Manually entering a data upload command does not produce data with the required header information for SEASOFT for Waves.
- If the SBE 53 is uploading data and you want to stop it, press the Esc key or click Stop. Press the Enter key to get the `S>` prompt.

Entries made with the commands are permanently stored in the SBE 53 and remain in effect until you change them.

- The only exception occurs if the electronics are removed from the housing and the two PCBs are separated or the lithium jumper (JP7) is removed (see *Appendix IV: Electronics Disassembly/Reassembly*). Before beginning disassembly, upload all data in memory. Upon reassembly, reset the date and time (**SetTime**) and initialize logging (**InitLogging**).

Commands

Status Command

Note:
You can wake up the SBE 53 during a tide measurement and display status (press Enter key to get S>, then click Status) without interrupting logging.

DS

Display operating status and setup parameters. Equivalent to Status menu.

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

- Firmware version, serial number, date and time [**SetTime** or **DateTime=**]
- User-input description [**UserInfo=**]
- Pressure sensor type (quartz), serial number, and full scale range
- Enable high-accuracy external thermistor [**ExternalTemperature=**]?
- Enable conductivity sensor [**Conductivity=**]?
- Main operating current, main and back-up lithium battery voltages
- Last measured raw (uncorrected) pressure (psia) and temperature (ºC); calculated salinity (only if conductivity enabled, psu)
- Sampling setup [**SetSampling**]:
  - Interval between tide samples, tide sample duration, and pressure sensor power parameter (powered continuously, or warm-up time if not powered continuously)
  - Interval between reference frequency measurements;
  - Start time for logging (if enabled);
  - Stop time for logging (if enabled)
- Calculated number of tide samples/day [based on **SetSampling**]
- Calculated memory endurance [based on **SetSampling**]
- Calculated battery endurance [based on **SetSampling**]
- Number of tide measurements in memory
- Number of reference frequency measurements in memory
- Number of tide measurements since last start of logging
- Transmit real-time tide data [**TxTide=**]?
- Logging status is one of following:
  - `never started`
  - `waiting to start at . . .`
  - `logging started`
  - `stop: out of memory`
  - `stop: low battery`
  - `stop time reached`
  - `stopped by user`
  - `unknown`
- Logging is one of following:
  - `NO, send start command to begin logging` (if **Start** has not been sent)
  - `YES` (if **Start** has been sent and SBE 53 is currently logging)
  - `YES, waiting to start` (if **Start** has been sent but SBE 53 is programmed to start logging at a future date/time)

Notes:
- **Memory** endurance is based on ***total*** memory capacity, taking into account the setup (measurement interval and duration), but not considering the measurements already in memory.
- **Battery** endurance is based on ***original***, nominal battery capacity, taking into account the setup (measurement interval, duration, etc). It is not based on a measurement of remaining battery voltage or the number of measurements already taken. If calculated alkaline battery endurance is greater than 730 days, status response shows `deployments longer than 2 years are not recommended with alkaline batteries.`

Memory and battery endurance output with **DS** matches that calculated in Battery and Memory Endurance. See *Section 4: Pre-Deployment Planning – Battery and Memory Endurance*.

Note:
After sending **Start**, logging status should be one of the following if the SBE 53 is operating correctly:
- `logging started` – if ***use start time*** in **SetSampling** prompt is ***No*** (SBE 53 started logging 10 seconds after receipt of **Start**).
- `waiting to start at . .` - if ***use start time*** in **SetSampling** prompt is ***Yes*** (SBE 53 waits to start logging at time set with **SetStartTime**).

Status Command (*continued*)

Example: (user input in bold; parameter used to change value in parentheses).

```
S>DS
SBE 53 BPR V 1.1e   SN 12345    28 Aug 2008  13:35:13                      [SetTime or DateTime=]
user info=test setup                                                       [UserInfo=]
quartz pressure sensor: serial number = 90319, range = 10000 psia
internal temperature sensor                                                [ExternalTemperature=]
conductivity = YES                                                         [Conductivity=]
iop =  6.0 ma  vmain = 15.3 V  vlith =  9.3 V
last sample: p = 21.9520, t = 21.0250, s = 34.3799

tide measurement: interval = 30 minutes, duration = 3 minutes, warmup = 15 minutes   [SetSampling]
measure reference frequency every 336 tide samples                         [SetSampling]
logging start time =  29 Aug 2008  00:00:00                                [SetSampling and SetStartTime]
logging stop time =  30 Aug 2008  00:00:00                                 [SetSampling and SetStartTime]

tide samples/day = 48.000                                                  [based on SetSampling]
memory endurance = 34952.5 days                                            [based on SetSampling]
nominal battery endurance = 765 days alkaline, 2166 days lithium           [based on SetSampling]
total recorded tide measurements = 0
total recorded reference frequency measurements = 0
tide measurements since last start = 0
transmit real-time tide data = YES                                         [TxTide=]

status = stopped by user   (see Notes)
logging = NO, send start command to begin logging
```

Notes:

1. You must send **Start** to start logging at programmed logging start time. After you send **Start**, status line should show:
   `status = waiting to start at 29 Aug 2008  00:00:00`
2. If set up to continuously power pressure sensor and reference frequency oscillator during logging, tide measurement line looks like this:
   `tide measurement: interval = 30 minutes, duration = 3 minutes, power pressure sensor continuously`

General Setup Commands

SetTime

Set real-time clock date and time.
SBE 53 prompts for desired date and time.

Example: Set current date and time to 31 August 2008 12:35:00 (user input in bold).

```
S>SETTIME
set current time:
month (1 - 12) = 8
day (1 - 31) = 31
year (4 digits) = 2008
hour (0 - 23) = 12
minute (0 - 59) = 35
second (0 - 59) = 0
```

DateTime=x

x= real-time clock date and time (mmddyyyyhhmmss). Command is sent automatically when using SeatermW's DateTime menu. DateTime menu provides greater accuracy in setting time than can be achieved with **SetTime**; this may be important if you want to synchronize sampling among multiple instruments. See *Setting Time in SBE 53 to Synchronize Sampling of Multiple Instruments* below.

General Setup Commands (*continued*)

Note:
The SBE 53 baud rate for general communication (set with **Baud=**) must be the same as SeatermW's baud rate (set in the Configure menu).

Baud=x

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

ExternalTemperature=x

x=Y: SBE 53 has optional high-accuracy external thermistor.

x=N: SBE 53 has standard internal thermistor. Default.

Note:
When **Conductivity=** is sent, the SBE 53 must initialize logging, setting tide sample number to 0, so the entire memory is available for recording data with the new scan length. **This should only be done after all previous data has been uploaded.** Therefore, the SBE 53 requires verification when **Conductivity=** is sent; the SBE 53 responds: `this command will change the scan length and initialize FLASH memory. Proceed Y/N?`
Press Y and the Enter key to proceed.

Conductivity=x

x=Y: Enable conductivity logging (use if SBE 53 includes optional SBE 4M conductivity sensor).

x=N: Disable conductivity logging.

UserInfo=x

x= user-defined string that displays in status (**DS**) reply. Can be up to 59 characters, including spaces; SBE 53 drops any characters after 59. No carriage returns are allowed. Allows user to include information describing deployment, conditions, etc. as permanent part of data set, because **DS** reply is included in uploaded .hex file when Upload in SeatermW is used to upload data (see *Uploading Data from Memory*).

Note:
SEASOFT for Waves data processing modules cannot process real-time tide data from the SBE 53.

TxTide=x

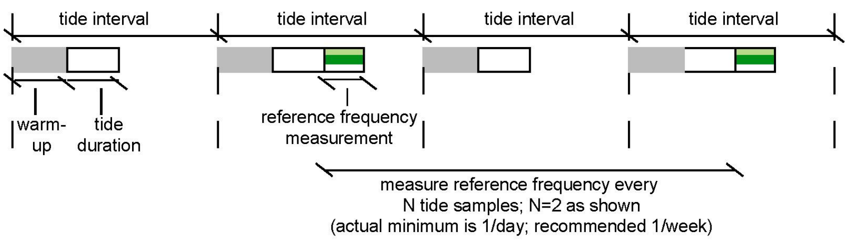
x=Y: Transmit real-time tide data while logging. Does not affect storing data to memory. SBE 53 transmits tide measurement start time, raw pressure (psia), corrected pressure (psia), pressure temperature (°C), and temperature (°C). If **Conductivity=Y**, it also transmits conductivity (S/m) and salinity (psu).

x=N: Do not transmit real-time tide data.

QS

Quit session and place SBE 53 in quiescent (sleep) state. Main power is turned off. Memory retention is not affected.

Note:
Drawing is schematic only, intended to define the sampling scheme terminology. See *Appendix II: Sample Timing* for timing details.



Notes:

- An alternate form for this command is **SetSample**; both have the same function.
- See *Appendix II: Sample Timing* for a detailed description of when tide measurements and reference frequency measurements are made.
- If (warmup + tide duration) > 59 minutes, SBE 53 sets tide interval to 60 minutes, tide duration to 44 minutes, and warmup to 15 minutes.
- The SBE 53 will not take any reference frequency measurements if **both** of the following conditions apply:
  (tide interval – tide duration) < 10 minutes **and** tide duration < 10 minutes,
- See *Making Corrections Using Reference Frequency Data* in *Appendix III: Data Formats* for the use of the reference frequency data in a pressure correction algorithm.

Tide Setup Command

SetSampling

Set sampling parameters. SBE 53 displays present value and asks for new value for each parameter. Type in desired value and press Enter key. To accept present value without change, press Enter key. SBE 53 prompts as follows:

Continuously power pressure sensor (y/n) = n, new value =

If **Y**, SBE 53 continuously powers pressure sensor and reference frequency oscillator (recommended for highest quality data). If **N**, SBE 53 powers down between measurements, reducing power consumption.

The following prompt appears only if you enter N above.

pressure sensor warmup (integer minutes) = 15, new value =

Warm-up time before pressure measurement, if pressure sensor and reference frequency oscillator not continuously powered. Minimum value 5 minutes; user-input outside range is set to minimum or maximum (see note) allowable value, as appropriate. Sea-Bird recommends 15 minutes or more for warm-up.

tide interval (integer minutes) = 30, new value =

Time from start of tide measurement to start of next tide measurement. Range 1 - 60 minutes; user-input outside range is set to minimum or maximum allowable value, as appropriate.

tide measurement duration (integer minutes) = 1, new value =

Length of tide measurement (SBE 53 integrates over this time, counting signal continuously and computing average pressure). Range 1 - 60 minutes. If tide duration > (tide interval – 10 sec), tide duration is set to tide interval, and SBE 53 samples tides continuously.

Measure reference frequency every N tide samples: N = 20, new value =

SBE 53 takes reference frequency measurement after every N tide samples, and uses this to establish pressure sensor drift. Sea-Bird recommends reference frequency measurement approximately 1/week; allowable values for N vary, depending on tide interval, and correspond to measuring reference frequency no more than 1/day to no less than 1/month.

Tide Setup Command (*continued*)

use start time (y/n) = n, new value =
If **Y**, SBE 53 responds to **Start** by starting logging at date and time set with **SetStartTime**.
If **N**, SBE 53 starts logging 10 seconds after **Start** is sent.

use stop time (y/n) = n, new value =
If **Y**, SBE 53 stops logging at date and time set with **SetStopTime**.
If **N**, SBE 53 continues logging until **Stop** is sent.

Use **DS** to verify that SBE 53 is set up to sample as desired.

Example (user input in bold): Set up SBE 53 to take 2-minute tide measurement (tide measurement duration = 2) every 60 minutes (tide interval = 60), to take 1 reference frequency measurement per day (once every 24 tide measurements), and to power the pressure sensor for a 15-minute warm-up before each measurement. Set up SBE 53 to start and stop sampling on command, rather than at pre-set start and stop times. Then send **DS** to verify setup.

```
S>SETSAMPLING
continuously power pressure sensor (y/n) = n, new value = n
pressure sensor warmup (integer minutes) = 10, new value = 15
tide interval (integer minutes) = 1, new value = 60
tide measurement duration (integer minutes) = 1, new value = 2
measure reference frequency every N tide samples: N = 20, new value = 24
use start time (y/n) = y, new value = n
use stop time (y/n) = n, new value = n
S>DS
SBE 53 BPR V 1.1e  SN 12345    26 Aug 2008 13:21:13
user info=test setup
quartz pressure sensor: serial number = 90319, range = 10000 psia
internal temperature sensor
conductivity = YES
iop =  6.0 ma  vmain = 15.3 V  vlith =  9.3 V
last sample: p = 21.9520, t = 21.0250, s = 34.3799

tide measurement: interval = 60 minutes, duration = 2 minutes, warmup = 15 minutes
measure reference frequency every 24 tide samples
logging start time =  do not use start time
logging stop time =  do not use stop time

tide samples/day = 24.00
memory endurance = 67108.9 days
nominal battery endurance = 931 days alkaline, 2591 days lithium
total recorded tide measurements = 0
total recorded reference frequency measurements = 0
tide measurements since last start = 0
transmit real-time tide data = YES

status = stopped by user
logging = NO, send start command to begin logging
```

Initialize Logging (Reset Memory) Commands

Note:
Do not initialize logging until all data has been uploaded. InitLogging does not delete data; it resets the data pointer. **If you accidentally initialize logging before uploading**, recover data as follows:

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

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

InitLogging — Initialize logging - after all previous data has been uploaded, initialize logging before starting to sample again to make entire memory available for recording. **InitLogging** sets tide sample number and reference frequency sample number to 0 internally. If not set to 0, data will be stored after last recorded sample. **Do not send InitLogging until all existing data has been uploaded.**

The following two commands are typically used only if you accidentally initialize logging before uploading the data in memory.

TideCount=x — **x**= sample number for first tide measurement when sampling begins. Use **TideCount=** to recover data if you accidentally initialize logging before uploading, and will be doing an ASCII upload.

***ByteCount=x** — **x**= byte number for first byte when sampling begins. Use ***ByteCount=** to recover data if you accidentally initialize logging before uploading, and will be doing a binary upload.

Logging Commands

To start logging, send **Start**:
- If ***Use start time?*** in **SetSampling** prompt is ***No***, logging starts approximately 10 seconds after receipt of **Start**.
- If ***Use start time?*** in **SetSampling** prompt is ***Yes***, logging starts at the delayed time set with **SetStartTime**.

The first time logging starts after receipt of initialize logging (**InitLogging**), data recording starts at the beginning of memory and any previously recorded data is written over.

To stop logging:
- Send **Stop**, or
- Before starting logging, set a delayed stop time with **SetStopTime**, and set ***Use stop time?*** in **SetSampling** prompt to ***Yes***.

Each time the SBE 53 is commanded to start logging again, recording continues, with new data stored after previously recorded data.

Notes:
- You can wake up the SBE 53 during a tide measurement and display status (press Enter key to get S>, then click Status) without interrupting logging.
- You may need to send **Stop** several times to get the SBE 53 to respond.
- You must stop logging before uploading data.
- If ***Use start time?*** in the **SetSampling** prompt is ***Yes***, and **SetStartTime** is less than 10 seconds in the future when **Start** is sent, the SBE 53 ignores the programmed start time and starts logging in 10 seconds.
- If ***Use stop time?*** in the **SetSampling** prompt is ***Yes***, and **SetStopTime** is less than 1 hour after logging begins, the SBE 53 ignores the programmed stop time and continues logging until **Stop** is sent.
- See *Setting Time in SBE 53 to Synchronize Sampling of Multiple Instruments* below to set multiple instruments to start logging at the same time.

Start	If ***Use start time?*** in **SetSampling** prompt is ***No***: Start logging now (in approximately 10 seconds). **OR** If ***Use start time?*** in **SetSampling** prompt is ***Yes***: Wait to start logging at time set with **SetStartTime**.
Stop	Stop logging.
SetStartTime	Set date and time to start logging. SBE 53 prompts you to enter desired date and time. Upon receipt of **Start**, SBE 53 waits to starts logging at this date and time if ***Use start time?*** in **SetSampling** prompt is ***Yes***.
SetStopTime	Set date and time to stop logging. SBE 53 prompts you to enter desired date and time. SBE 53 stops logging at this date and time if ***Use stop time?*** in **SetSampling** prompt is ***Yes***.

Logging Commands (*continued*)

Example 1: Start and stop logging on command (user input in bold).

```
S>SETSAMPLING
 . . . (Respond to prompts, changing tide sampling setup as desired.)
use start time (y/n) = y, new value = n
use stop time (y/n) = y, new value = n
S>START
Logging will start in 10 seconds
```

(If **TxTide=Y**, tide data displays on screen. See *Programming for Deployment - SeatermW* for a description of screen display while logging.)

(To stop logging, press Enter key several times to get S> prompt.)

```
S>STOP
```

Example 2: Program SBE 53 to start logging on 20 August 200812:35:00 and stop logging on 21 August 2008 12:35:00 (user input in bold).

```
S>SETSAMPLING
 . . . (Respond to prompts, changing tide sampling setup as desired.)
use start time (y/n) = n, new value = y
use stop time (y/n) = n, new value = y
S>SETSTARTTIME
Set time to start logging:
Month (1-12) = 8
Day (1 - 31) = 20
Year (4 digits) = 2008
Hour (0 - 23) = 12
Minute (0 - 59) = 35
Second (0 - 59) = 0
S>SETSTOPTIME
Set time to stop logging:
Month (1-12) = 8
Day (1 - 31) = 21
Year (4 digits) = 2008
Hour (0 - 23) = 12
Minute (0 - 59) = 35
Second (0 - 59) = 0
S>START
Logging will start at 20 July 2006 12:35:00
Logging will stop at 20 July 2006 12:35:00
```

(When logging starts: If **TxTide=Y**, tide data displays on screen. See *Programming for Deployment - SeatermW* for a description of screen display while logging.)

(Logging stops at time set with **SetStopTime**.)

Send Last Sample Commands

Notes:
- See *General Command Notes* above for issues relating to sending commands while the SBE 53 is making a tide measurement.
- See *Making Corrections Using Reference Frequency Data* in *Appendix III: Data Formats* for pressure correction algorithm.

These commands cause the SBE 53 to transmit data from the last tide measurement in memory:
- pr = stored raw pressure, converted to psia.
- pc = corrected pressure (not stored) converted to psia, with correction based on most recent measured reference frequency.
- t = stored temperature, converted to °C.
- s = calculated salinity (computed from stored temperature and conductivity) in psu. Displays only if **DS** response shows `conductivity = YES` (conductivity acquisition was enabled with **Conductivity=Y**).
- date/time stored in memory with the data.

These commands are functional only while the SBE 53 is logging (after **Start** has been sent to start logging now or at a future date/time).
- If **Start** has not been sent, the SBE 53 responds with `? CMD`.
- If **Start** has been sent, but there is not yet a completed tide measurement in memory, the SBE 53 responds with:
  `pr = -99.0000, pc = -99.0000, t = -99.0000, s = -99.0000`

SL — Send data from last tide measurement and remain ready for another command (command mode).

SLO — Send data from last tide measurement and exit command mode. Equivalent to sending **SL** and then **QS**.

Example: (user input in bold).
```
S>SL
pr = 14.5266, pc= 14.5266, t = 22.7003, s = 29.05335, 06 Jul 2006 08:30:00
```

Data Upload Commands

Notes:
- **Use SeatermW's Upload menu to upload data in ASCII or binary to a .hex file that will be processed by SEASOFT for Waves' Convert Hex module** (see *Uploading Data from Memory* below). Manually entering **DD** or **DBbaud,b,e** does not produce data with the required header information for processing by SEASOFT for Waves. These commands are included here for reference for users who are writing their own software.
- To save manually uploaded data to a file, click Capture before entering the upload command.
- When SeatermW's Upload menu is used for binary upload, SeatermW automatically tests that the selected upload baud rate is compatible with your computer, sends **ByteCount**, and sends **DBbaud,b,e** as many times as needed to upload all the data in memory in blocks of 500,000 bytes.

Stop logging before uploading data from memory.

ASCII Upload:

DD — Upload all data **in ASCII** at baud rate set for general communication with **Baud=**.

Binary Upload:

Binary upload, useful for large data sets, is inherently faster than ASCII upload, because each byte is transmitted as one character instead of two. Additionally, the SBE 53 supports binary upload at rates up to 115,200 baud, compared to ASCII upload at rates up to 38,400. SeatermW uploads the data in binary and then converts to ASCII, **resulting in a .hex file with the same format as from an ASCII upload.**

DBbaud,b,e — Upload data **in binary** at **baud** rate (1200, 2400, 4800, 9600, 19200, 28800, 38400, 57600, or 115200) from byte **b** to **e**. First byte number is 0. SBE 53 can upload data in blocks of up to 500,000 bytes at one time. **Sending this command manually does not provide useful information.**

ByteCount — Display total number of bytes in memory.

Diagnostic Commands

Notes:
- Pressure output using **TS** or **TSR** is not very accurate, because SBE 53 turns on power to the pressure sensor immediately before taking the measurement (pressure sensor requires warm-up for accurate results).
- Conductivity and salinity are output only if conductivity is enabled (**Conductivity=Y**).

Data from these tests is not stored in FLASH memory.

TS Take 1 sample of pressure, pressure temperature, temperature, and optional conductivity, and output **converted** data (raw pressure psia, pressure temperature °C, temperature °C, conductivity S/m, salinity psu, date and time).

TSR Take 1 sample of pressure, pressure temperature, temperature, and optional conductivity, and output **raw** data (raw pressure frequency Hz, pressure temperature frequency Hz , temperature A/D counts, and conductivity frequency Hz).

TT Sample temperature, and output **converted** data (°C). SBE 53 runs continuously during test, drawing current. Press Esc key or click Stop to stop test.

TTR Sample temperature, and output **raw** data (A/D counts). SBE 53 runs continuously during test, drawing current. Press Esc key or click Stop to stop test.

FR Sample conductivity, and output **raw** data (frequency Hz). Displays only if conductivity enabled with **Conductivity=Y**. SBE 53 runs continuously during test, drawing current. Press Esc key or click Stop to stop test.

Diagnostic Commands (*continued*)

VR

Measure and display power:

Column	Output
1	Main battery voltage / 11.18
2	Back-up lithium voltage / 4.8187
3	Operating current (mA) / 20.04
4	Ground voltage

SBE 53 runs continuously during test, drawing current. Press Esc key or click Stop to stop test.

***FlashInit**

Map bad blocks and erase FLASH memory (2048 blocks), **destroying all data.** SBE 53 requires you to enter ***FlashInit** twice, to provide verification before it proceeds. All data bits are set to 1. Tide sample number is set to 0. **Test takes approximately 1 hour, and cannot be interrupted once it has started.**

Send ***FlashInit** (after uploading all data) if there are FLASH Read errors in Status (**DS**) response. If not encountering errors, use of command is optional,
as SBE 53 writes over previously recorded information when **InitLogging** is used before beginning sampling. However, knowledge of initial memory contents (i.e., all 1's) can be a useful cross-check when data is retrieved.

***FlashGood**

Display number of good blocks in FLASH memory (should be 2008 to 2048 blocks, with each block 16K bytes).
If number of good blocks not in this range, consult factory.

Notes:
- Dates shown are when calibrations were performed. Calibration coefficients are initially factory-set and should agree with Calibration Certificates shipped with SBE 53.
- See individual commands below to modify calibration coefficients.
- Calibration coefficients are applied to the raw data to output real-time and queried (**SL**, **SLO**, and some testing commands) data in engineering units.
- Pressure, temperature, and conductivity are stored in memory as raw data, before application of the calibration coefficients, and the data is uploaded from memory to a .hex file as raw data. The .hex file also contains the **DC** command and response. Convert Hex uses the calibration coefficients in the **DC** response to convert the raw data to engineering units. Pressure slope, and ***an additional pressure offset***, are entered in Convert Hex's Coefficient Configuration dialog box to make small post-deployment corrections for pressure sensor drift. Note that the pressure offset entered in Convert Hex is *in addition to* the offset shown in the **DC** response.

See *Section 6: Conversion into Tide and Reference Frequency Files – Convert Hex*; also see *Sensor Calibration* in *Section 9: Routine Maintenance and Calibration*.

Calibration Coefficients Commands

DC Display calibration coefficients.

Example: (user input in bold).

```
S>DC
Pressure coefficients:  15-apr-2007
  U0 = 5.818158e+00
  Y1 = -3.912547e+03
  Y2 = -1.192010e+04
  Y3 = 0.000000e+00
  C1 = -6.273148e+03
  C2 = 1.688132e+02
  C3 = 1.655105e+04
  D1 = 7.040300e-02
  D2 = 0.000000e+00
  T1 = 2.992117e+01
  T2 = 6.588880e-01
  T3 = 4.158092e+01
  T4 = 1.073818e+02
  Offset = 0.000000e+00                                    (psia)
  FRA0 = 4.915200000e+06
  FRA1 = 2.313499176e-01
  FRA2 = 2.313499176e-01
  FRA3 = 1.590508907e-09
  FRA4 = -4.979895771e-14
  FRA5 = 7.918649300e-19
  FRA6 = -5.031461328e-24
Temperature coefficients:  05-nov-2007
  TA0 = -1.653843e-05
  TA1 = 2.800270e-04
  TA2 = -2.759926e-06
  TA3 = 1.646110e-07
Conductivity coefficients:  05-nov-2007          (only if Conductivity=Y)
  CG = -8.000000e+00
  CH = 1.483257e+00
  CI = -1.931111e-04
  CJ = 9.170722e-05
  CTCOR = 3.250000e-06
  CPCOR = -9.570000e-08
  CSLOPE = 1.000000e+00
```

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

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

Pressure

PCalDate=S	**S**=calibration date.
PU0=F	**F**=U0.
PY1=F	**F**=Y1.
PY2=F	**F**=Y2.
PY3=F	**F**=Y3.
PC1=F	**F**=C1.
PC2=F	**F**=C2.
PC3=F	**F**=C3.
PD1=F	**F**=D1.
PD2=F	**F**=D2.
PT1=F	**F**=T1.
PT2=F	**F**=T2.
PT3=F	**F**=T3.
PT4=F	**F**=T4.
POffset=F	**F**=pressure offset (psia).
FRA0=F	**F**=reference frequency A0.
FRA1=F	**F**=reference frequency A1.
FRA2=F	**F**=reference frequency A2.
FRA3=F	**F**=reference frequency A3.

Temperature

TCalDate=S	**S**=calibration date.
TA0=F	**F**=A0.
TA1=F	**F**=A1.
TA2=F	**F**=A2.
TA3=F	**F**=A3.

Conductivity

CCalDate=S	**S**=calibration date.
CG=F	**F**=G.
CH=F	**F**=H.
CI=F	**F**=I.
CJ=F	**F**=J.
CTCor=F	**F**=TCOR.
CPCor=F	**F**=PCOR.
CSlope=F	**F**=Slope correction.

Setting Time in SBE 53 to Synchronize Sampling of Multiple Instruments

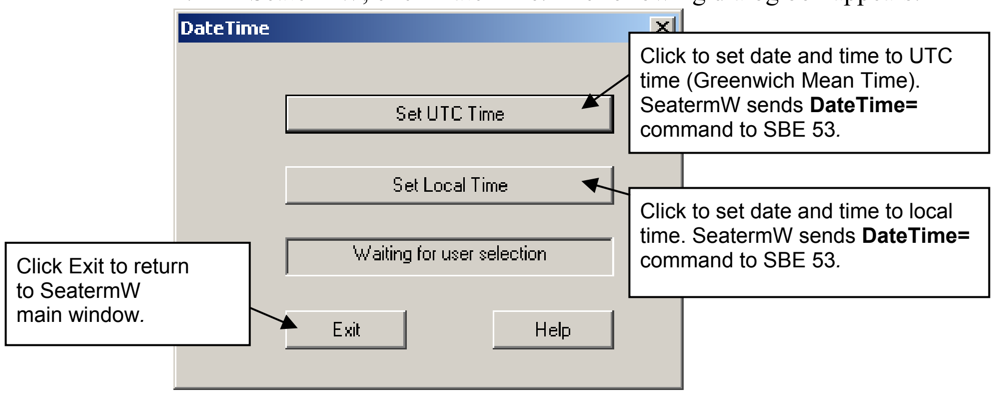
Note:
Software to provide accurate time on your computer is not supplied by Sea-Bird.

If you are running software on your computer that provides the computer with an accurate real-time stamp, the DateTime menu in SeatermW allows you to set the date and time in the SBE 53 to an accuracy of ± 25 msec of the time provided by the timekeeping software. This may be useful if you plan to deploy several instruments, and want to coordinate sampling so that each SBE 53 measures tides and waves on exactly the same schedule. Coordinating sampling can be accomplished by:

- Setting the time in each instrument accurately, using the DateTime menu,
- Setting up each instrument to sample at the same intervals and durations, and
- Setting up each instrument to start sampling at a delayed date and time – using the same start date and time for each instrument.

Set accurate time and coordinate sampling as follows:

1. In SeatermW, click DateTime. The following dialog box appears:



   Click the desired time setting (UTC or local time). SeatermW sends the **DateTime=** command to the SBE 53, using the computer date and time. Click Exit.

2. If desired, set up the SBE 53 to start logging at some time in the future, allowing you to coordinate sampling to begin in multiple instruments at the same time:
   - Send the **SetStartTime** command to the SBE 53. The SBE 53 prompts you to enter the desired start date and time.
   - Send the **SetSampling** command. Set up the desired sampling scheme, and enter Y in response to the ***Use start time?*** prompt.

Installing and Deploying SBE 53

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

1. Install a cable (if transmitting real-time tide data) or dummy plug for the data I/O connector on the SBE 53 end cap:
   A. Lightly lubricate the inside of the cable connector/plug with silicone grease (DC-4 or equivalent).
   B. **Standard Connector** - Install the connector/plug, aligning the raised bump on the side of the plug with the large pin (pin 1 – ground) on the SBE 53. Remove any trapped air by *burping* or gently squeezing the plug near the top and moving your fingers toward the end cap.
   OR
   MCBH Connector – Install the connector/plug, aligning the pins.
   C. Place the locking sleeve over the connector/plug. Tighten the locking sleeve finger tight only. **Do not overtighten the locking sleeve and do not use a wrench or pliers**.

2. If not using the SBE 4M conductivity sensor, install a dummy plug and locking sleeve on the SBE 53 3-pin bulkhead connector.
   Use the technique described in Step 1 for lubricating and burping a standard connector.

Note:
Acquisition of conductivity data must be enabled by sending **Conductivity=Y** in SeatermW when programming the SBE 53 for deployment.

3. (Optional) Install the SBE 4M conductivity sensor:
   A. Mount the SBE 4M to the SBE 53 with the supplied mounting bracket, positioning the SBE 4M connector towards the conductivity connector on the SBE 53.
   B. Connect the SBE 4M to the SBE 53 with the supplied cable, using the technique described in Step 1 for lubricating and burping a standard connector, and then installing the locking sleeve.
   C. Remove the Tygon tubing that was looped end-to-end around the SBE 4M conductivity cell to keep the cell clean while stored.
   D. See *Application Note 70: Installing Anti-Foulant Device Mount Kit on SBE 4, 16, 19, and 21 Conductivity Cells* and *Appendix V: AF24173 Anti-Foulant Device*.

Recovering SBE 53

WARNING!
If the SBE 53 stops working while underwater, or shows other signs of flooding or damage, carefully secure it away from people until you have determined that abnormal internal pressure does not exist or has been relieved. Pressure housings may flood under pressure due to dirty or damaged o-rings, or other failed seals. When a sealed pressure housing floods at great depths and is subsequently raised to the surface, water may be trapped at the pressure at which it entered the housing, presenting a danger if the housing is opened before relieving the internal pressure. Instances of such flooding are rare. However, a housing that floods at 5000 meters depth holds an internal pressure of more than 7000 psia, and has the potential to eject the end cap with lethal force. A housing that floods at 50 meters holds an internal pressure of more then 85 psia; this force could still cause injury.
If you suspect the SBE 53 is flooded, point it in a safe direction away from people, and loosen the 3 screws on the connector end cap about ½ turn. If there is internal pressure, the end cap will *follow* the screws out, and the screws will not become easier to turn. In this event, loosen 1 bulkhead connector very slowly, at least 1 turn. This opens an o-ring seal under the connector. Look for signs of internal pressure (hissing or water leak). If internal pressure is detected, let it bleed off slowly past the connector o-ring. Then, you can safely remove the end cap.

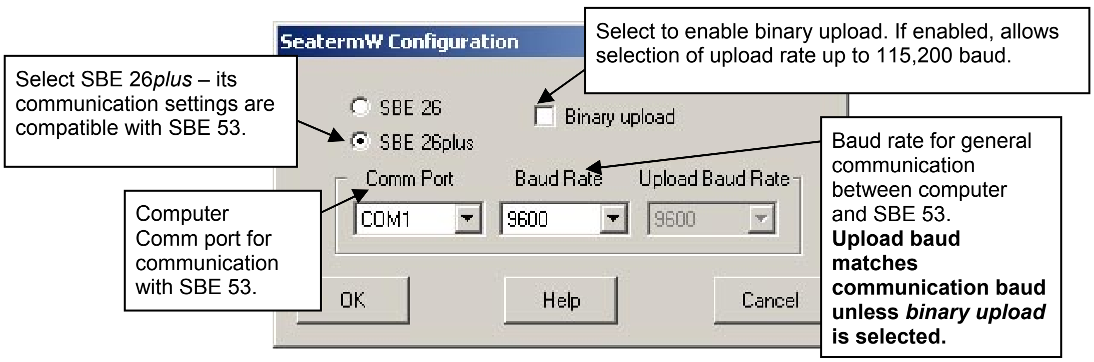
Rinse the SBE 53 with fresh water. See *Section 9: Routine Maintenance and Calibration* for (optional) conductivity cell cleaning and storage.

Uploading Data from Memory

The SBE 53 can upload data in ASCII at baud rates up to 38,400, or in binary at baud rates up to 115,200. Binary upload at 115,200 is approximately **six times faster** than ASCII upload at 38,400, because each byte is one character in binary but two characters in ASCII. Binary upload of the full memory (32 MB) at 115,200 baud requires approximately 3.5 hours. If binary upload is selected, SeatermW uploads the data in binary and then converts the data to ASCII, resulting in a .hex data file that is identical to one uploaded in ASCII.

1. In SEASOFT for Waves' Run menu, select SeatermW.
   SeatermW appears.

2. Click Configure. The Configuration dialog box appears. Verify/modify the instrument, Comm port, and baud rate, and whether to upload in binary (if *binary upload* is selected) or in ASCII. Click OK.



3. Click Connect. The `S>` displays. This shows that correct communications between the computer and SBE 53 has been established.
   If the system does not respond with the `S>` prompt:
   - Click Connect again.
   - Verify the correct instrument, Comm port, and baud rate were selected.
   - Check cabling between the computer and SBE 53.

4. If the SBE 53 is still logging, command it to stop logging by typing **Stop** and pressing the Enter key. You may need to press the Esc key before entering **Stop** to get the SBE 53 to stop if it is in the middle of sampling.

5. Display SBE 53 status information by clicking Status. The status response should indicate `logging = no`.

Note:
The SBE 53 communicates at 9600 baud (factory-set default), 8 data bits, 1 stop bit, and no parity, as documented on the instrument Configuration Sheet. Baud rate can be changed with **Baud=**; other parameters cannot be modified.

6. Click Upload to upload stored data in a form that SEASOFT for Waves' data processing modules can use. SeatermW responds as follows:

   A. SeatermW sends the status (**DS**) command, displays the response, and writes the command and response to the upload file, with each line preceded by *. **DS** provides information regarding the number of samples in memory, tide interval, etc.

   B. SeatermW sends the calibration coefficients (**DC**) command, displays the response, and writes the command and response to the upload file, with each line preceded by *. **DC** provides information regarding the sensor calibration coefficients.

   C. In the Save As dialog box, enter the desired upload file name and click OK. The upload file has a .hex extension.

   D. **ASCII Upload** (if binary upload was not selected in Step 2) – SeatermW sends the data upload command (**DD**). SeatermW writes the data to the upload file. The Status bar at the bottom of the SeatermW window displays the progress of the upload, indicating the number of uploaded lines of data.

   E. **Binary Upload** (if binary upload was selected in Step 2) –
   SeatermW tests that the selected binary upload baud rate is supported by your computer. If it is not, the upload is aborted.
   SeatermW sends **ByteCount** to determine how many bytes of data are in memory, because only 500,000 bytes can be uploaded in one block.
   SeatermW sends the data upload command (**DBbaud,b,e**), as many times as needed to upload all the data in memory in blocks of 500,000 bytes.
   SeatermW converts the binary data back to ASCII, and writes the data to the upload file. The Status bar at the bottom of the SeatermW window displays the progress of the upload, indicating the number of uploaded lines of data.

Note:
Although SeatermW sends **DBbaud,b,e** to upload data in binary, the uploaded .hex file shows the **DD** command, so the file looks exactly the same, regardless of whether ASCII or binary upload was used.

7. Type **QS** and press the Enter key to put the SBE 53 in quiescent (sleep) state until ready to redeploy.

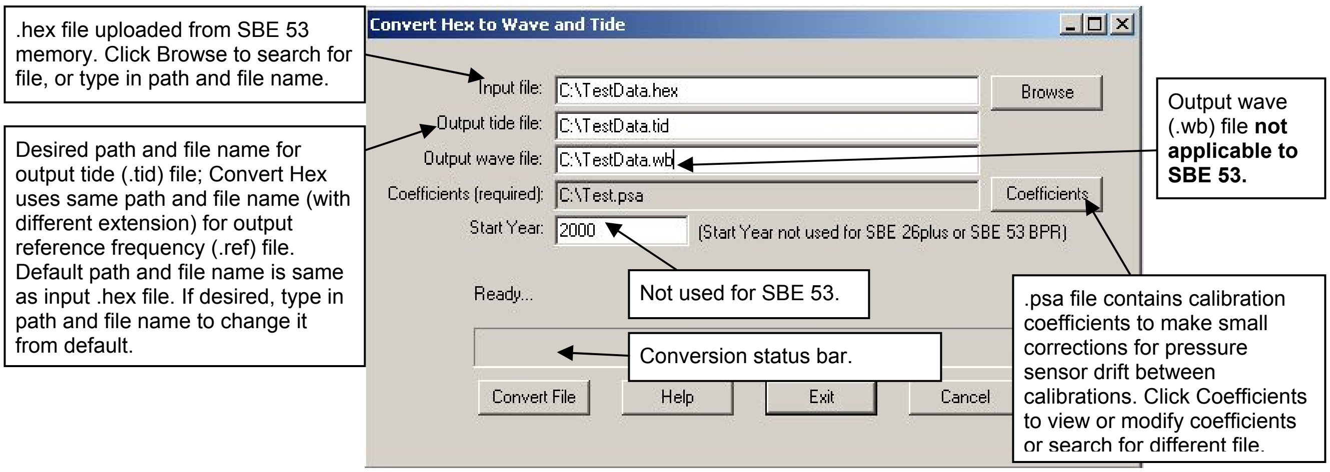
8. Ensure all data has been uploaded by processing the data. See *Section 6: Conversion into Tide and Reference Frequency Files – Convert Hex*.

Section 6: Conversion into Tide and Reference Frequency Files – Convert Hex

Notes:
- The first time you run Convert Hex, the Coefficients dialog box (Step 2 below) appears first.
- If you run Convert Hex from the command line with the –t command line option, Convert Hex adds diagnostic information to the output .tid file. See *Tide Data Format* in *Appendix III: Data Formats*.

Convert Hex converts uploaded hex (.hex) data into a tide (.tid) file with data in ASCII engineering units, and a reference frequency (.ref) file. Convert Hex must be run before further processing by SEASOFT for Waves.

1. In SEASOFT for Waves' Run menu, select Convert Hex. The dialog box looks like this:



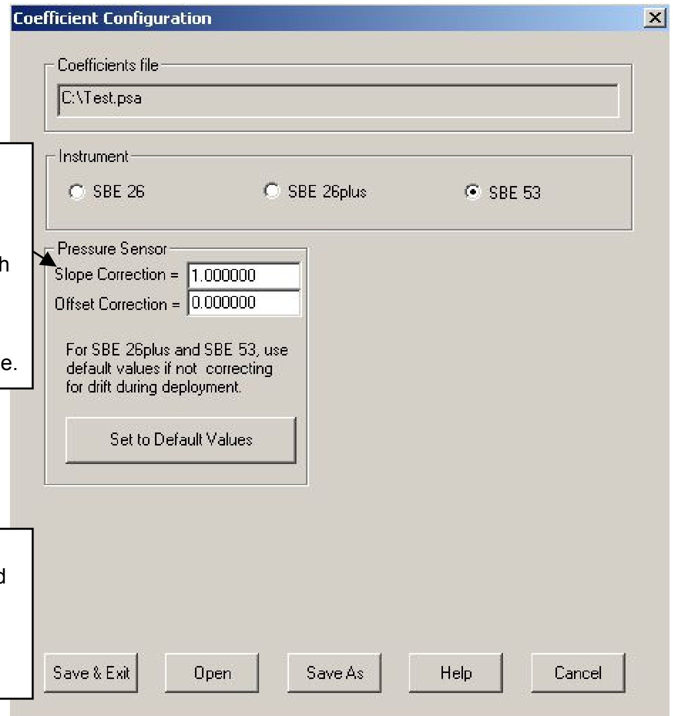
Enter information in the dialog box. Click Coefficients to enter / verify calibration coefficients for converting hex data to engineering units.

Note:
SeasoftWaves.ini contains the location and file name of the last saved .psa file for each module. SeasoftWaves.ini is stored in %USERPROFILE%\Local Settings\Apps\Sea-Bird
(*Example* C:\Documents and Settings\dbresko\Local Settings\Apps\Sea-Bird)

2. The Coefficients dialog box looks like this:

Slope and offset (psia) used to make small corrections for pressure sensor drift between calibrations. Other P coefficients are programmed into SBE 53 at Sea-Bird; they can be viewed with **DC**, and modified with calibration coefficient commands, in SeatermW. Note that offset entered here is *in addition to* offset shown in **DC** response.

Save & Exit to save updated .psa file and return to Convert Hex to Wave and Tide dialog box.
Open to select a different .psa file.
Save As to save updated .psa file settings to a different .psa file.



Make desired changes. Click OK to return to Convert Hex to Wave and Tide dialog box.

3. Click *Convert File* to process the data. The Status bar at the bottom of the dialog box shows the progress of the calculations; when completed, the Status bar shows *Finished conversion*.

Section 7: Tide Data Processing –
Merge Barometric Pressure

Note:
The barometric pressure (.bp) file is **not** supplied by Sea-Bird. It is created by the user, based on local barometric pressure data (such as that from a local weather station). See *Input Barometric Pressure File Format* below for the required data format.

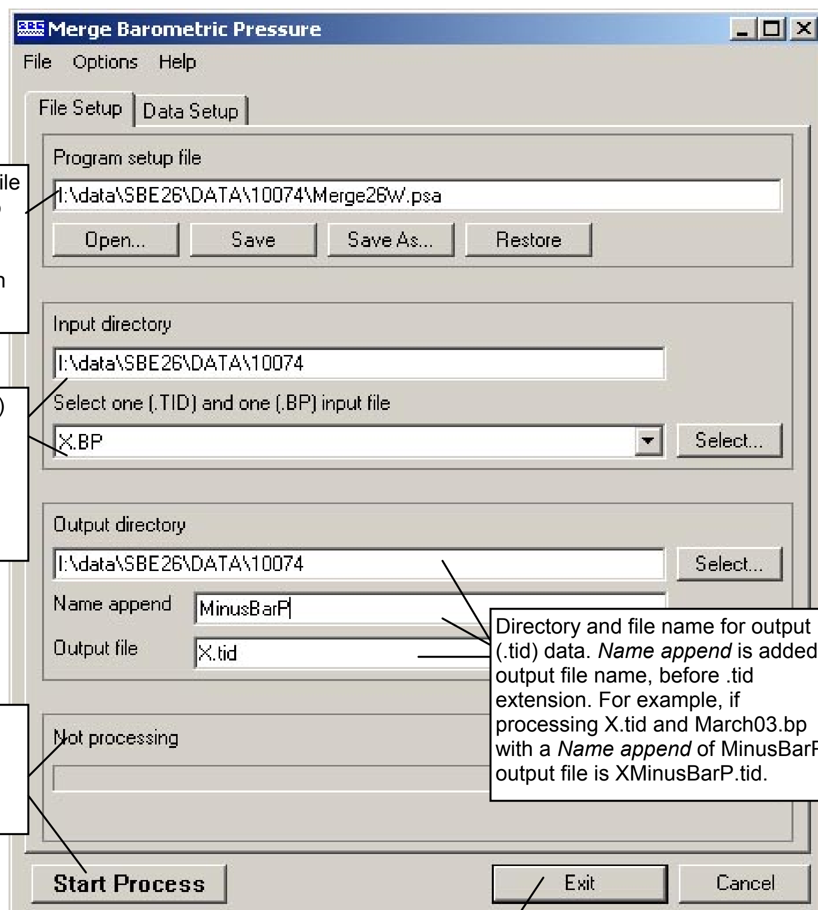
Merge Barometric Pressure reads in a tide (.tid) file (created with Convert Hex) and a barometric pressure (.bp) file, and subtracts barometric pressure from the tide data. The time in the files does not need to be aligned – Merge Barometric Pressure uses linear interpolation to align the data in time before subtracting barometric pressure. Merge Barometric Pressure can also convert tide pressure to water depth in meters, using average density and gravity.

Both the input tide data and output adjusted file have a .tid extension. However, Merge Barometric Pressure will not process a .tid file that it has already processed, preventing a user from erroneously removing barometric pressure multiple times from the tide data.

Remove barometric pressure as follows:

Note:
SeasoftWaves.ini contains the location and file name of the last saved .psa file for each module. SeasoftWaves.ini is stored in %USERPROFILE%\Local Settings\Apps\Sea-Bird (*Example* C:\Documents and Settings\dbresko\Local Settings\Apps\Sea-Bird)

1. In SEASOFT for Waves' Run menu, select Merge Barometric Pressure. The File Setup tab looks like this:



File to store all information input in File Setup and Data Setup tabs. **Open** to select a different .psa file, **Save** or **Save As** to save current settings, or **Restore** to reset all settings to match last saved version.

Directory and file names for tide (.tid) data and barometric pressure (.bp) data. Note that both .tid and .bp files must be in same directory, but they can have different names. **Select** to pick different files.

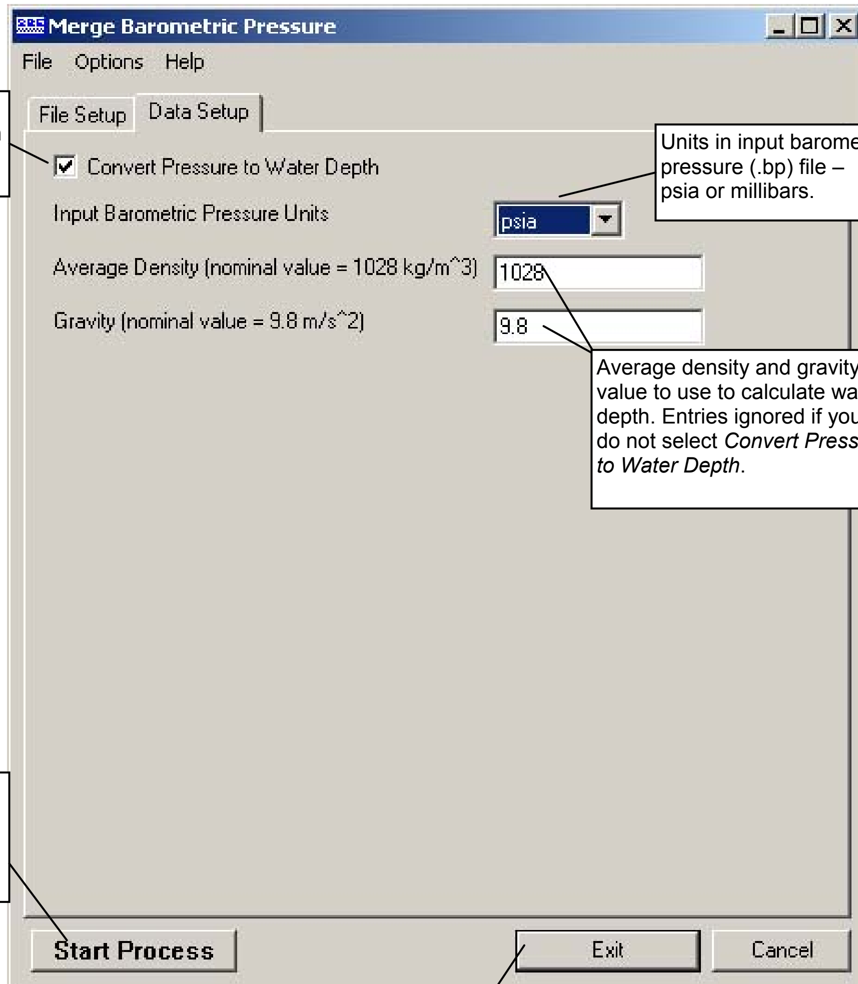
Directory and file name for output (.tid) data. *Name append* is added to output file name, before .tid extension. For example, if processing X.tid and March03.bp with a *Name append* of MinusBarP, output file is XMinusBarP.tid.

Click **Start Process** to begin processing data. Status field shows *Processing complete* when done.

Return to SEASOFT for Waves window.
- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - This button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

Make the desired selections.

2. Click on the Data Setup tab. The Data Setup tab looks like this:



If selected, output .tid file contains water depth *in place of* pressure.

Units in input barometric pressure (.bp) file – psia or millibars.

Average density and gravity value to use to calculate water depth. Entries ignored if you do not select *Convert Pressure to Water Depth*.

Click **Start Process** to begin processing data. Status field on File Setup tab shows *Processing complete* when done.

Return to SEASOFT for Waves window.

- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - This button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

Make the desired selections and click *Start Process* to process the data.

Note:
Merge Barometric Pressure adds descriptive headings to the pressure (or depth), temperature, and optional conductivity and salinity columns. The presence of headings in the .tid file indicates that it has been processed by Merge Barometric Pressure. See *Appendix III: Data Formats*.

Input Barometric Pressure File Format

Note:
The barometric pressure (.bp) file is **not** supplied by Sea-Bird. It is created by the user, based on local barometric pressure data (such as that from a local weather station).

The required format for the input barometric pressure (.bp) file is:

MM/DD/YY HH:MM:SS P
MM/DD/YY HH:MM:SS P

where

MM = month	DD = day	YY = year
HH = hour	MM = minute	SS = second

P = barometric pressure in psia or millibars
(1 standard atmosphere = 14.7 psia or 1013.5 millibars)

Example .bp File:
```
07/01/94  00:00:00  1015.5
07/01/94  01:00:00  1016.4
07/01/94  02:00:00  1017.3
```

Merge Barometric Pressure Algorithm

The linear interpolation algorithm is:

$p_{bp} = p0 + [(t - t0) * (p1 - p0) / (t1 - t0)]$
corrected pressure = $p - p_{bp}$

where

t = time of tide sample in .tid file
p = pressure in .tid file at time t
t0 = latest time in .bp file that is less than or equal to t
p0 = barometric pressure at time t0
t1 = earliest time in .bp file that is greater than or equal to t
p1 = barometric pressure at time t1
p_{bp} = interpolated barometric pressure

Depth is calculated as:

depth = corrected pressure / (average density * gravity)

See Appendix *VI: Pressure-to-Depth Conversion*.

Section 8: Data Plotting – Plot Data

Plot Data displays and plots data from files with a .tid file extension:

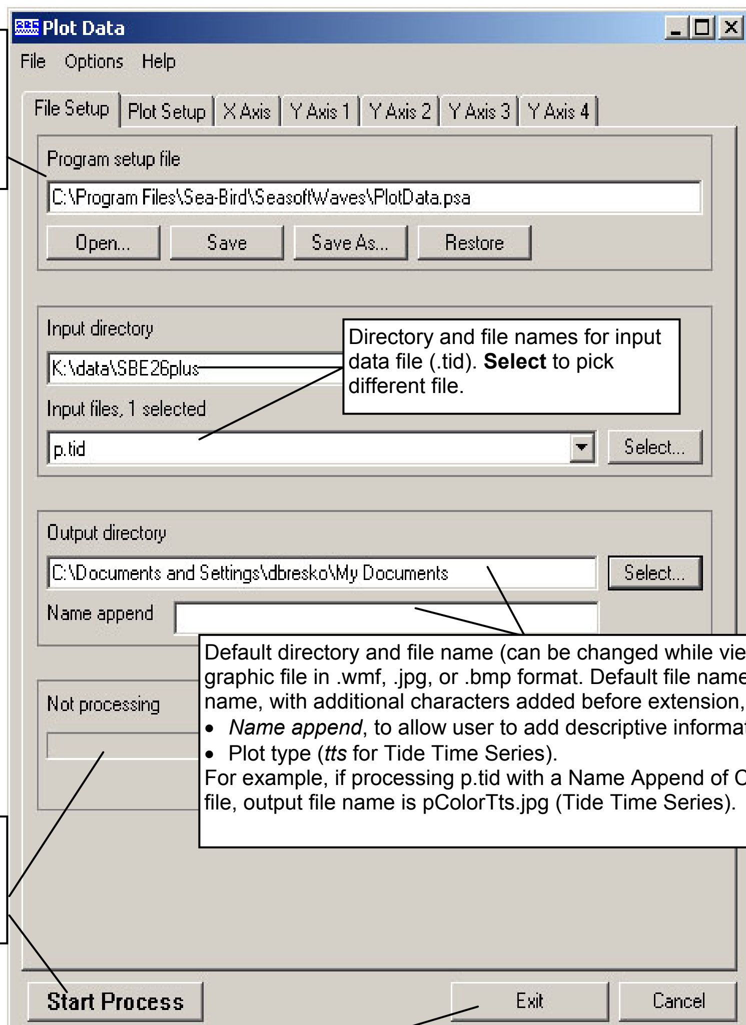
- Plots up to five variables on one plot, with one X axis and up to four Y axes.
- Zooms in on plot features.
- Sends plots to a printer, saves plots to the clipboard for insertion in another program (such as Microsoft Word), or saves plots as graphic files in bitmap, metafile, or JPEG format.

In SEASOFT for Waves' Run menu, select Plot Data. Each tab of the Plot Data dialog box is described below, as well as options for viewing, printing, and saving a plot.

Note:
SeasoftWaves.ini contains the location and file name of the last saved .psa file for each module. SeasoftWaves.ini is stored in %USERPROFILE%\Local Settings\Apps\Sea-Bird
(*Example* C:\Documents and Settings\dbresko\Local Settings\Apps\Sea-Bird)

File Setup Tab

The File Setup tab defines the Program Setup file, input data file(s), and output plot file name. The File Setup tab looks like this:



File to store all information input in File, Plot, and Axis tabs. **Open** to select a different .psa file, **Save** or **Save As** to save current settings, or **Restore** to reset all settings to match last saved version.

Directory and file names for input data file (.tid). **Select** to pick different file.

Default directory and file name (can be changed while viewing plot) for outputting graphic file in .wmf, .jpg, or .bmp format. Default file name is set to match input file name, with additional characters added before extension, in order listed below:

- *Name append*, to allow user to add descriptive information to file name.
- Plot type (*tts* for Tide Time Series).

For example, if processing p.tid with a Name Append of Color and outputting .jpg file, output file name is pColorTts.jpg (Tide Time Series).

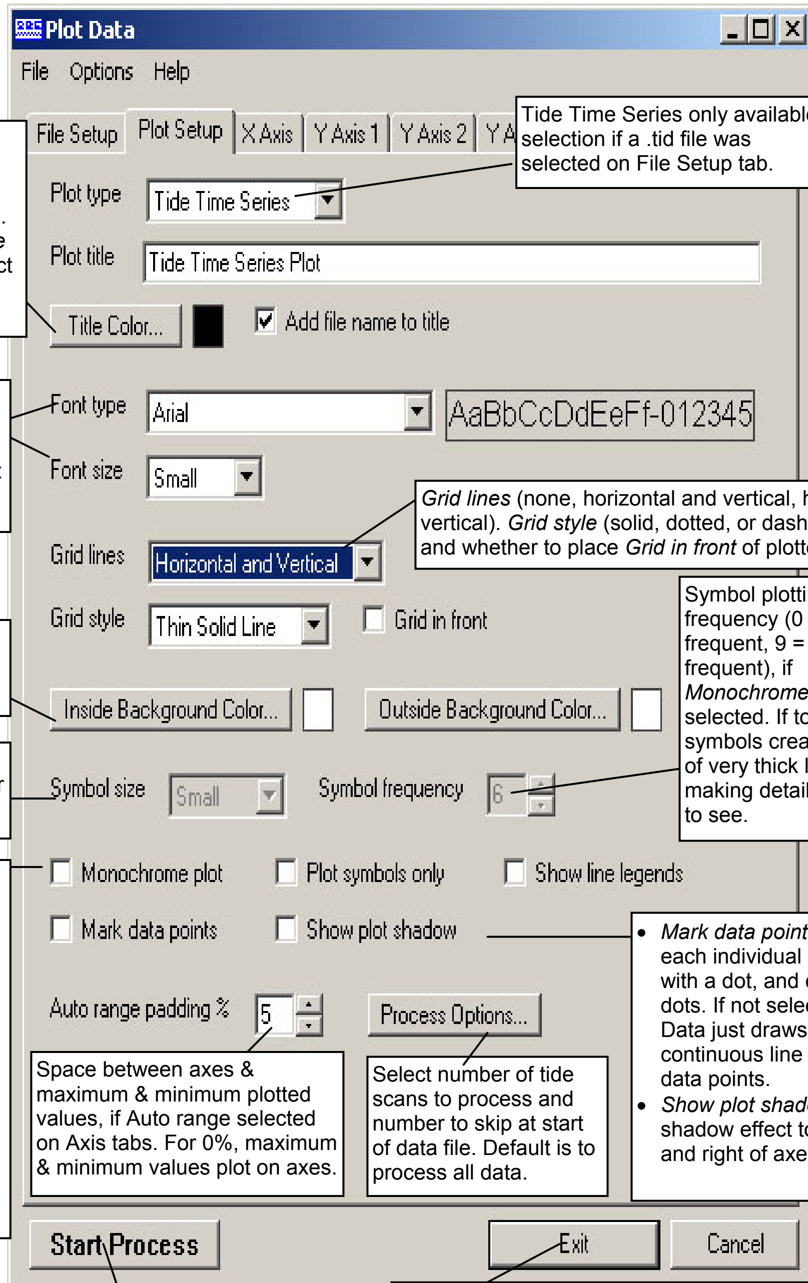
Click **Start Process** to begin processing data. Status field shows *Processing complete* when done.

Return to SEASOFT for Waves window.

- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - This button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

Plot Setup Tab

The Plot Setup tab defines the plot type, data to be included, and plot layout (title, color, font, grid lines, etc.). The Plot Setup tab looks like this:



- User input *Plot title*.
- User selected *Title color*.
- Select *Add file name to title* to add input data file name to user input title. For example, for a plot title *Tide Time Series* with input file *p.tid*, if you select *Add file name to title*, title is *Time Time Series, p.tid*.

Tide Time Series only available selection if a .tid file was selected on File Setup tab.

Plot *Font type* and *Font size* (small, medium, or large). Plot Data displays example of font type to right of selection. List of fonts depends on what fonts are installed on your computer.

Grid lines (none, horizontal and vertical, horizontal, vertical). *Grid style* (solid, dotted, or dashed line), and whether to place *Grid in front* of plotted data.

Inside Background Color defines color within axes. *Outside Background Color* defines color outside axes.

Symbol plotting frequency (0 = least frequent, 9 = most frequent), if *Monochrome plot* selected. If too frequent, symbols create illusion of very thick line, making details difficult to see.

Size (small, medium, large) of symbol for each variable, if *Monochrome plot* or *Plot symbols only* selected.

- *Monochrome plot*: Substitute black lines with symbols for colors (colors and symbols defined on Axis tabs). Allows you to set up axes with colors for viewing on screen, and then switch to black lines with symbols for black and white printing.
- *Plot symbols only*: Mark each individual data point with a symbol, and do not connect symbols with a line (symbols defined on Axis tabs).
- *Show line legends*: Show legends below plot title. Legend indicates line color or symbol, as applicable.

- *Mark data points*: Mark each individual data point with a dot, and connect dots. If not selected, Plot Data just draws a continuous line between data points.
- *Show plot shadow*: Create shadow effect to bottom and right of axes.

Space between axes & maximum & minimum plotted values, if Auto range selected on Axis tabs. For 0%, maximum & minimum values plot on axes.

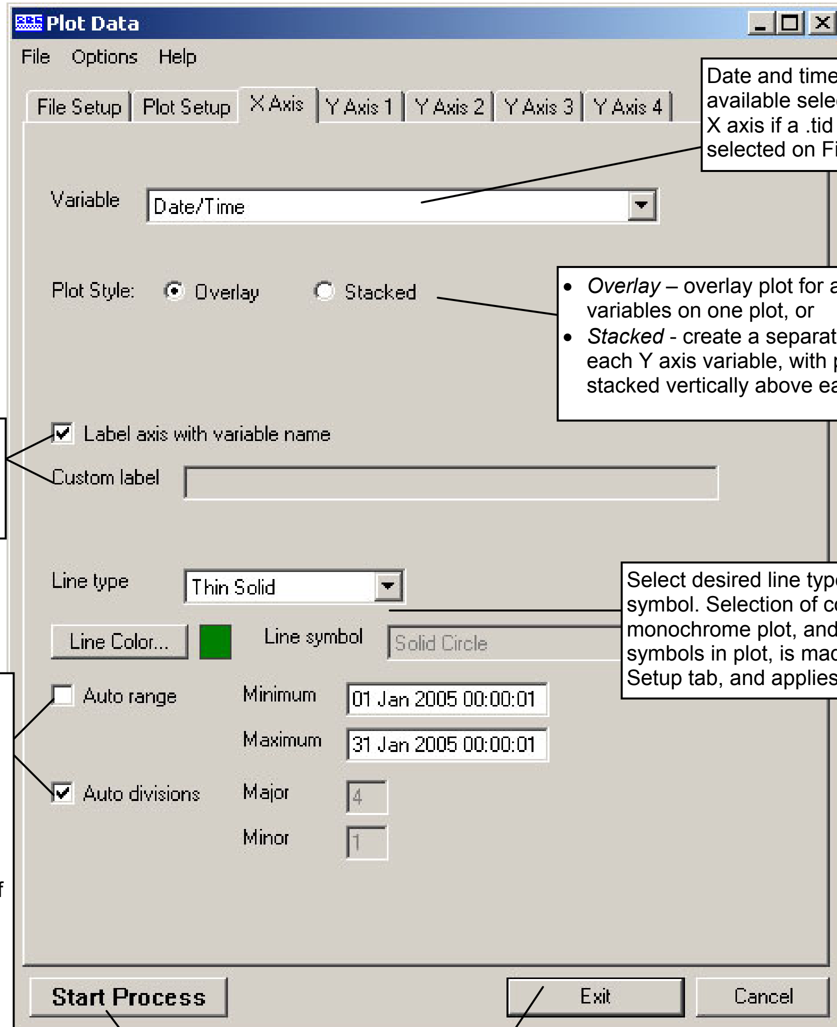
Select number of tide scans to process and number to skip at start of data file. Default is to process all data.

Click **Start Process** to begin processing data. Status field shows *Processing complete* when done.

Return to SEASOFT for Waves window.
- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - This button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

X Axis Tab

Click on the X Axis tab. The X Axis tab defines the plot style as well as the X axis variable, scale, and line type.
The X Axis tab looks like this for Tide Time Series:



Date and time only available selection for X axis if a .tid file was selected on File Setup tab

- *Overlay* – overlay plot for all Y axis variables on one plot, or
- *Stacked* - create a separate plot for each Y axis variable, with plots stacked vertically above each other.

Select to label axis with variable name as listed in drop down Variable list, or enter a Custom label for axis.

Select desired line type, color, and symbol. Selection of color or monochrome plot, and inclusion of symbols in plot, is made on Plot Setup tab, and applies to all axes.

- *Auto range* - Plot Data selects axis Minimum and Maximum values, number of Major divisions on axis, and number of Minor divisions between Major divisions.
- *Auto divisions* - Plot Data selects number of major divisions on axis, and number of minor divisions between major divisions. User selects axis Minimum and Maximum values.

Any values that fall outside user-selected Minimum to Maximum range will plot at minimum or maximum, as applicable.

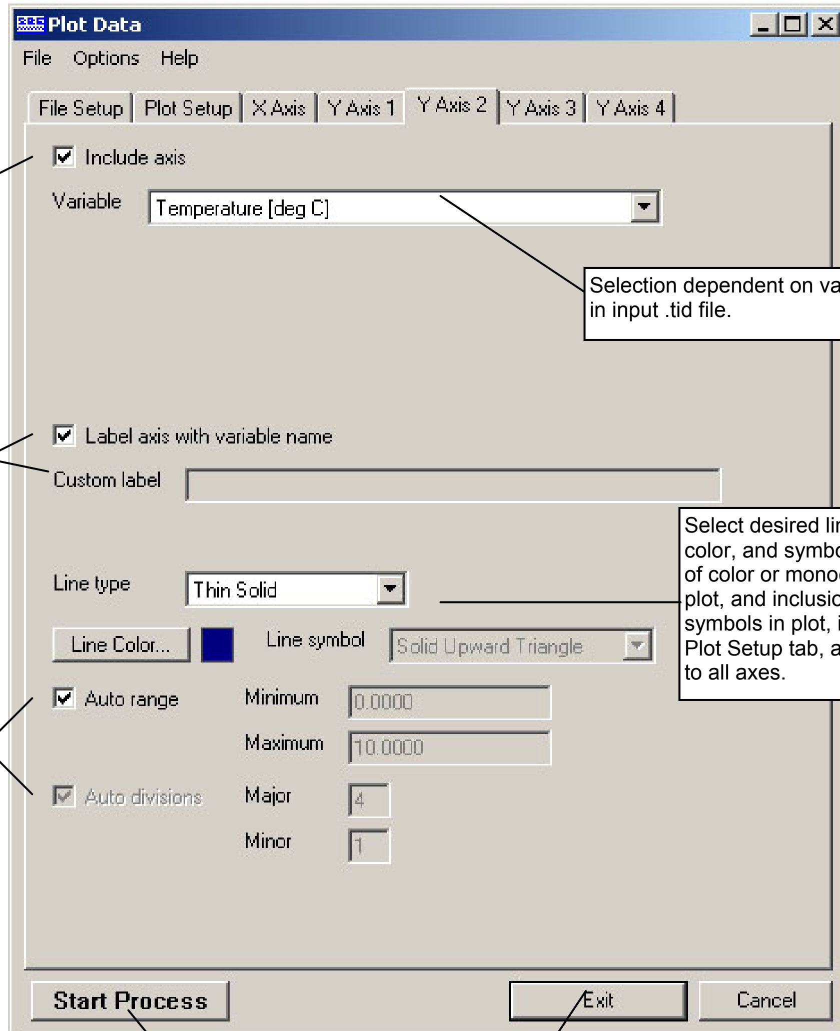
Click **Start Process** to begin processing data. Status field shows *Processing complete* when done.

Return to SEASOFT for Waves window.

- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - This button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

Y Axis Tab

The Y Axis tabs define the Y axis variables, scales, and line types.



Include this axis in plot. Plot Data can plot 1 X and up to 4 Y axes. At least 1X and 1 Y variable is required, so this selection is available only on Y Axis 2, 3, and 4.
Note: If you deselect an axis, all axes numbered *above* that axis are automatically deselected.

Selection dependent on variables in input .tid file.

Select to label axis with variable name as listed in drop down Variable list, or enter a Custom label for axis.

Select desired line type, color, and symbol. Selection of color or monochrome plot, and inclusion of symbols in plot, is made on Plot Setup tab, and applies to all axes.

- *Auto range* - Plot Data selects axis Minimum and Maximum values, number of Major divisions on axis, and number of Minor divisions between Major divisions.
- *Auto divisions* - Plot Data selects number of major divisions on axis, and number of minor divisions between major divisions. User selects axis Minimum and Maximum values.

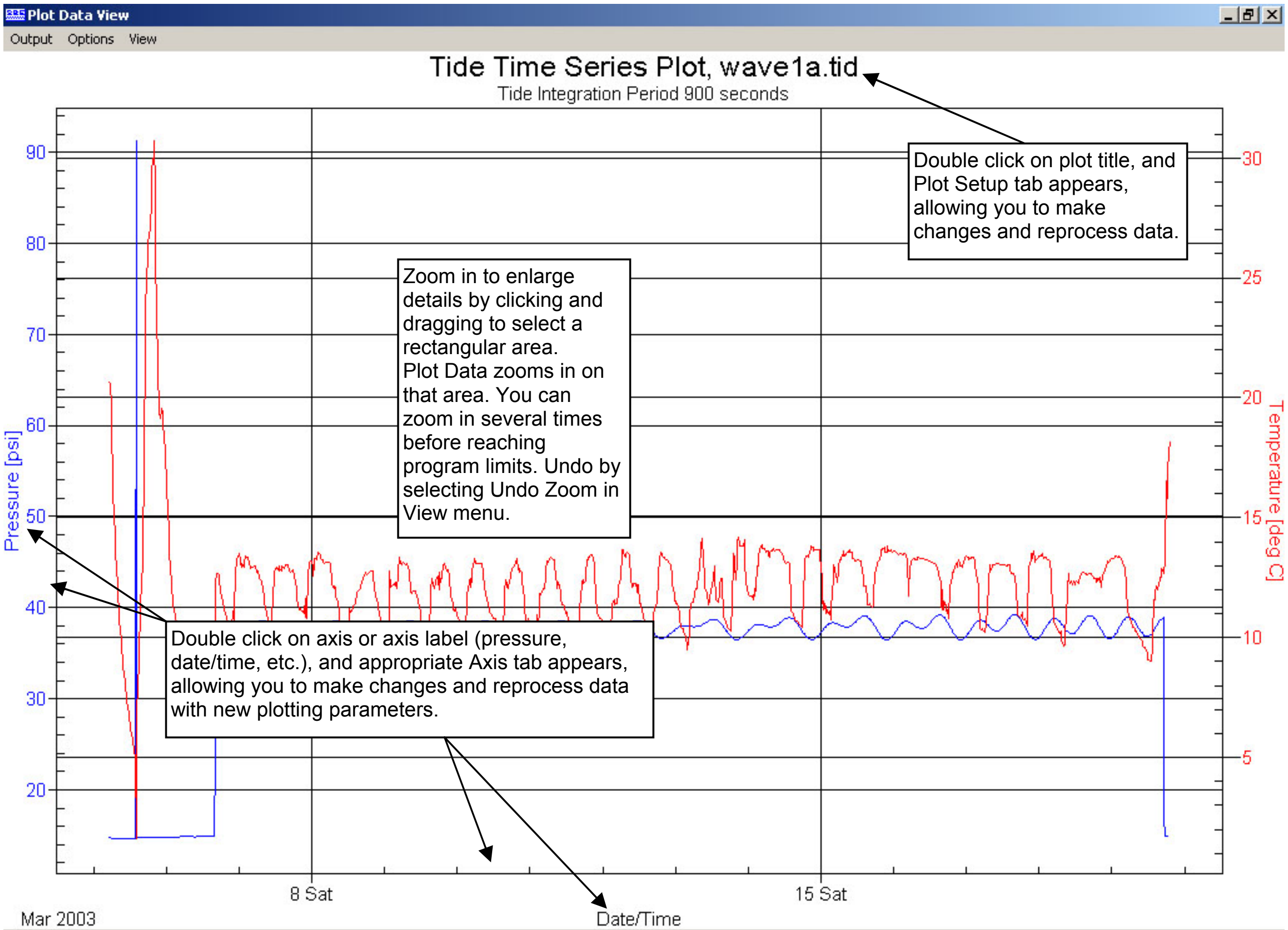
Any values that fall outside user-selected Minimum to Maximum range plot at minimum or maximum, as applicable.

Click **Start Process** to begin processing data. Status field shows *Processing complete* when done.

Return to SEASOFT for Waves window.

- If *Confirm Program Setup Change* was selected in Options menu - If you made changes and did not Save or Save As, program asks if you want to save changes.
- If *Confirm Program Setup Change* was not selected in Options menu - This button says **Save & Exit**. If you do not want to save changes, use Cancel button to exit.

Viewing and Outputting Plots



The Plot Data View window's menus are described below:

Output – Output the plot to printer, clipboard, or a file.

- *Print* – Print the single plot that is displayed on screen. In the dialog box, select printer, orientation, color, etc.; these selections override selections you made in Plot Data and in the Plot Data View **Options** menu.
- *File* – Output to file the single plot that is displayed on screen, in the selected format (.wmf, .jpg, or .bmp). In the dialog box, select the desired directory and output file name; these selections override selections you made in Plot Data and in the Plot Data View **Options** menu.
- *Clipboard* – Output to the clipboard the single plot that is displayed on screen, in the selected format (.wmf, .jpg, or .bmp). The selected format overrides the selection you made in the Plot Data View **Options** menu.
- *Print Range* – Not applicable to SBE 53 data.
- *File Range* – Not applicable to SBE 53 data.

Note:
To change the default printer in Windows XP: Click Start / Printers and Faxes. A list of printers installed on your system appears, with a check mark next to the default printer. Right click on the desired printer, and select Set as Default Printer.

Options – Sets up defaults for *how* the plot is output to the printer, file, or clipboard.

- *Print* –
  - Orientation – landscape, portrait, or (printer) driver default. If driver default is selected, orientation is determined by the default for the printer you select in Output / Print (if printing a single plot) or the system default printer (if printing multiple plots using Output / Print Range).
  - Print full page – If selected, scale plot to fit 8 ½ x 11 inch page. If not selected, Size determined by -
    Plot Data View Dimensions – plot dimensions as shown on screen.
    Values Entered Below – Units, Width, and Height entered here.
- *File* –
  - Data format – Metafile (.wmf), Jpeg (.jpg), or Bitmap (.bmp).
  - Size determined by -
    Plot Data View Dimensions – plot dimensions as shown on screen.
    Values Entered Below – Units, Width, and Height entered here.
- *Clipboard* –
  - Data format – Metafile (.wmf), Jpeg (.jpg), or Bitmap (.bmp).
  - Size determined by -
    Plot Data View Dimensions – plot dimensions as shown on screen.
    Values Entered Below – Units, Width, and Height entered here.

View – Sets up viewing options.

- *First Burst*, *Last Burst*, *Next Burst*, *Prior Burst*, *Go to Burst* – Not applicable to SBE 53 data.
- *Undo Zoom* –Return the plot to the original ranges specified on the Axis tabs. *Undo Zoom* is grayed out unless you have zoomed in (by clicking and dragging to select a rectangular area) to enlarge details.
- *Set Zoomed Ranges* – Substitute the current zoomed ranges of the plot for the Minimum and Maximum plot ranges on the Axis tabs. This allows you to save the ranges of the zoomed view, so you can go to exactly the same view the next time you run Plot Data. *Set Zoomed Ranges* is grayed out unless you have zoomed in (by clicking and dragging to select a rectangular area) to enlarge details.

Section 9: Routine Maintenance and Calibration

This section reviews corrosion precautions, connector mating and maintenance, battery replacement, pressure sensor maintenance, optional conductivity cell storage and cleaning, and sensor calibration. The accuracy of the SBE 53 is sustained by the care and calibration of the sensors and by establishing proper handling practices.

Corrosion Precautions

Rinse the SBE 53 with fresh water after use and prior to storage.

All exposed metal is titanium. No corrosion precautions are required, but avoid direct electrical connection of the titanium to dissimilar metal hardware.

The optional SBE 4M conductivity cell has a titanium housing. No corrosion precautions are required, but avoid direct electrical connection of the titanium to dissimilar metal hardware.

Connector Mating and Maintenance

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

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

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

When remating:

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

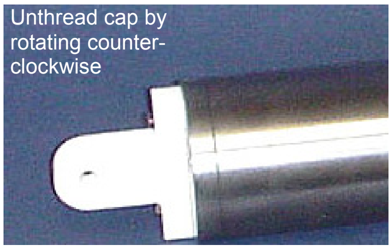
2. **Standard Connector** - Install the plug/cable connector, aligning the raised bump on the side of the plug/cable connector with the large pin (pin 1 - ground) on the SBE 53. Remove any trapped air by *burping* or gently squeezing the plug/connector near the top and moving your fingers toward the end cap. **OR**
   MCBH Connector – Install the plug/cable connector, aligning the pins.

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

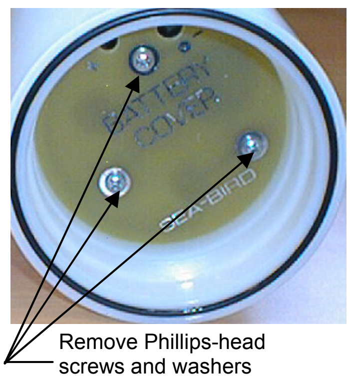
Verify that a cable or dummy plug is installed for each connector on the system before deployment.

Battery Replacement

Alkaline D-cell
(MN1300, LR20)



Note: photo shows instrument with plastic housing; detail for SBE 53 (which has titanium housing) is similar



Remove Phillips-head screws and washers

Note: Alkaline and lithium batteries require different cover plates, because 1 lithium DD cell is shorter than 2 alkaline D cells.

For **lithium DD** cells   For **alkaline D** cells

The SBE 53 uses 12 alkaline D-cells (Duracell MN1300, LR20) or 6 lithium DD-cells (Electrochem BCX85-3B76-TC), dropped into the battery compartment.

Leave the batteries in place when storing the SBE 53 to prevent depletion of the back-up lithium batteries by the real-time clock. Even *exhausted* main batteries power the clock (less than 25 microamperes) almost indefinitely. If the SBE 53 is to be stored for long periods, **replace the batteries yearly to prevent battery leakage** (which could damage the SBE 53).

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

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

3. Turn the SBE 53 over and remove the batteries.

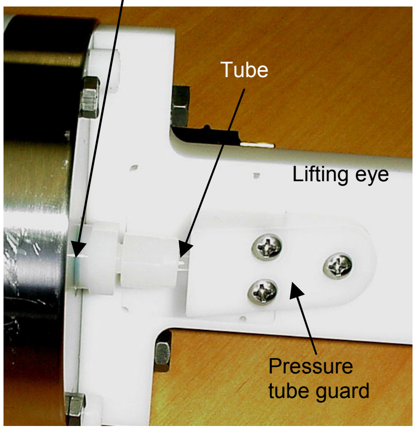
4. Install the new batteries, with the + terminals against the flat battery contacts and the - terminals against the spring contacts.

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

6. Check the battery voltage at BAT + and BAT - on the battery cover plate. For standard alkaline batteries, it should be approximately 18 volts. For lithium DD cell batteries, it should be approximately 21 volts.

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

Pressure Sensor Maintenance



Connector End Cap

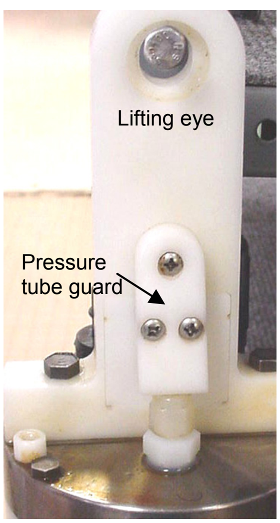
The pressure fitting – which includes a pressure port fitting, external tube, and polyurethane bladder bag – is filled with silicone oil at the factory. The oil transmits hydrostatic pressure via internal, capillary tubing to the pressure sensor inside the instrument, and prevents corrosion that might occur if the sensor diaphragm was exposed to water. The bladder bag is vacuum back-filled.

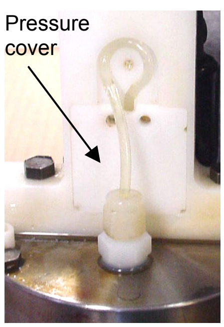
The bladder bag can develop tears and leaks over time. If the fitting has been damaged, or investigation due to poor data shows that the bag has torn, replace the fitting and bag and refill the oil. **Sea-Bird highly recommends that you send the SBE 53 back to the factory for this repair, as it is difficult to completely remove all air from the system in the field, resulting in potential pressure errors.** However, if you must do the repair to meet a deployment schedule, contact Sea-Bird to purchase the needed parts.

Parts required:

Part Number	Description	Quantity
30551	Pressure port bladder bag	2 *
50025	Pressure sensor oil refill kit (provided with SBE 53 shipment) **	1
50029	Nylon capillary assembly	2 *
30002	Swagelock, nylon, NY-200-1-OR	2 *
30521	Syringe, 60 cc, DURR #899069, MFG #309663 (18 gage needle ground)	1

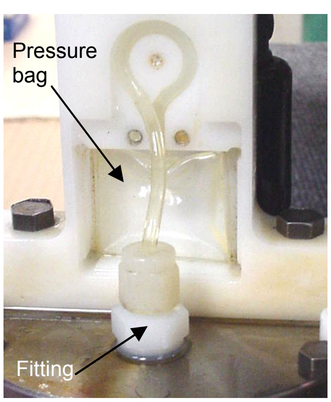
* Only 1 is required, but we recommend that you purchase a spare in case you have difficulty with the procedure.
** If you have a bell jar, use it to de-gas the oil in the oil refill kit.





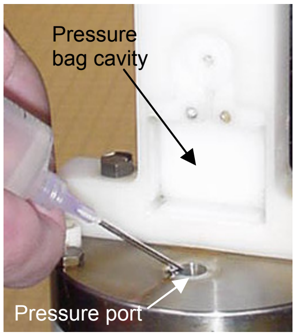
1. Securely mount the SBE 53 vertically (connector end cap up).

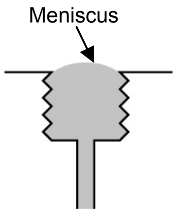
2. Remove the 3 Phillips-head screws attaching the pressure tube guard to the lifting eye. Remove the pressure tube guard and the pressure cover that is under it.



3. Remove the fitting from the end cap with a 9/16 inch wrench. Discard the fitting, tubing, and pressure bag.

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

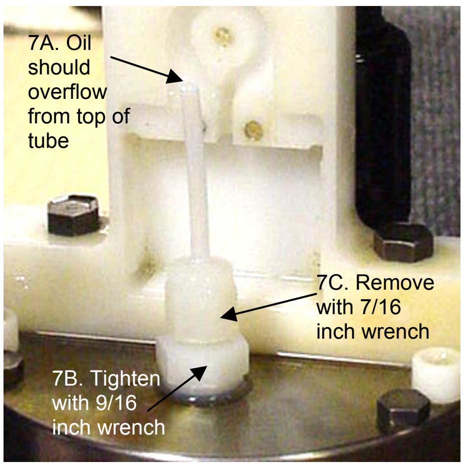




4. Clean the pressure bag cavity in the lift eye and the removed pressure tube guard and pressure cover, removing all residue/grit. Ensure that the holes in each corner of the pressure bag cavity in the lift eye are free of obstructions.

5. Clean the sensor end cap, being careful to remove any residue/grit near the pressure port.

6. From the 50025 pressure sensor oil refill kit, fill the small syringe with the supplied oil. Fill the pressure port, forming a meniscus on the surface of the end cap. Keep the SBE 53 in the vertical position for at least 30 minutes before proceeding, to allow any bubbles in the internal plumbing to rise to the surface. Add oil from the small syringe as necessary to maintain the meniscus.

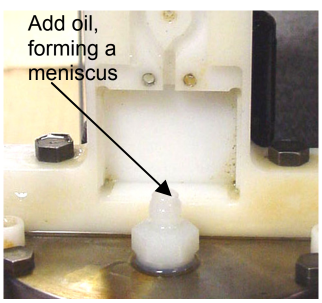


7. Install the supplied capillary fitting (50029) in the pressure port.

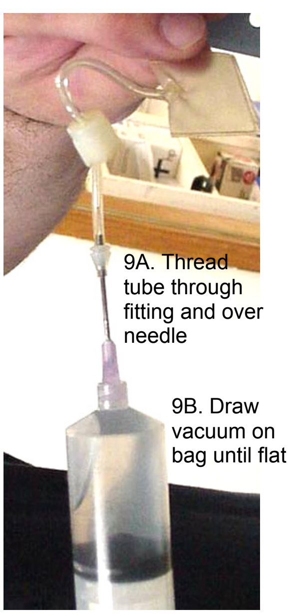
   A. As the fitting is installed, oil should rise the length of the tube and overflow. Wipe up the excess oil with a paper towel.

   B. Gently tighten the lower portion of the fitting with a 9/16 inch wrench - **DO NOT OVERTIGHTEN**.

   C. Remove the upper portion of the capillary fitting and tube using a 7/16 inch wrench. Store it for possible use another time.



8. Using the small syringe, add oil to the lower portion of the fitting, forming a meniscus.

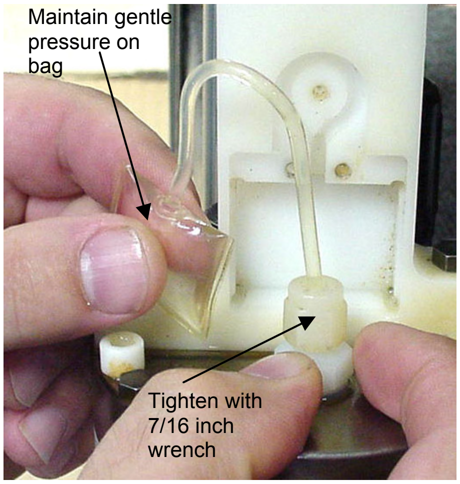


9. Fill the large syringe (30521) ¼ full with oil.

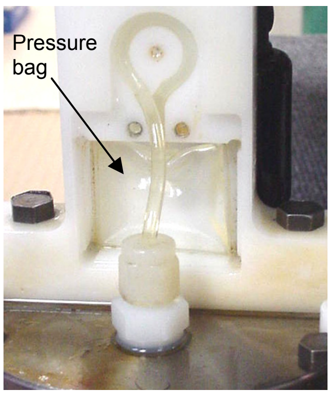
   A. Thread the tube from the pressure bag (30551) through the Swagelock fitting (30002), and install the pressure bag tube over the needle.

   B. Pull the plunger back on the syringe, drawing a vacuum on the pressure bag until it is completely flat. Maintain the vacuum on the bag.

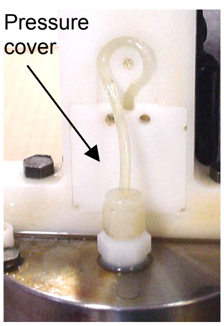
   C. Hold the syringe vertically with the bag down and slowly release the plunger, allowing the vacuum to be released. The bag should slowly fill with oil. There is enough oil in the bag when the bag looks like a *small pillow*. It is very important that there are no air bubbles in the pressure bag; you may have to perform this step several times to ensure that there are no bubbles.

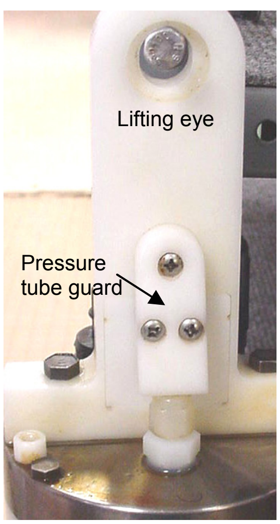


10. After the bag is filled, gently remove the tube from the needle, keeping the bag at or below the level of the end of the tube to prevent air from entering the bag. Maintaining gentle pressure on the bag to keep the oil at the end of the tube and prevent air from entering the bag, insert the end of the tube into the lower portion of the fitting on the end cap and screw the Swagelok fitting down, using a 7/16 inch wrench. Oil should overflow from the fitting, preventing air from entering the bag; the overflow should stop when the fitting is tightened. When completed, the bag should be approximately ½ full of oil and contain no air.



11. Install the pressure bag in the pressure bag cavity. Place the tubing in the indent, going counter-clockwise from the bag to the fitting.





12. Reinstall the pressure cover, pressure tube guard, and 3 Phillips-head screws, being careful not to pinch the tubing or the bag.

13. Log data on the SBE 53, and download the data. Compare the pressure readings to a local barometer. A pinched or overfilled bag will give pressure readings that are higher that the correct values.

Conductivity Cell Maintenance

CAUTIONS:

- **Do not put a brush or any object inside the conductivity cell to dry it or clean it.** Touching and bending the electrodes can change the calibration. Large bends and movement of the electrodes can damage the cell.
- **Do not store the SBE 4M with water in the conductivity cell.** Freezing temperatures (for example, in Arctic environments or during air shipment) can break the cell if it is full of water.

The SBE 53's optional conductivity cell (SBE 4M) is shipped dry to prevent freezing in shipping. **Refer to *Application Note 2D: Instructions for Care and Cleaning of Conductivity Cells* for conductivity cell cleaning procedures and cleaning materials.**

- The Active Use (after each cast) section of the application note is not applicable to the SBE 4M, which is intended for use as a moored instrument.

Sensor Calibration

Note:
After recalibration of the pressure, temperature, and/or optional conductivity sensor, Sea-Bird enters the new calibration coefficients in the SBE 53 EEPROM, and ships the instrument back to the user with Calibration Certificates showing the new coefficients.

Sea-Bird sensors are calibrated by subjecting them to known physical conditions and measuring the sensor responses. Coefficients are then computed, which may be used with appropriate algorithms to obtain engineering units. The pressure, temperature, and optional conductivity sensors on the SBE 53 are supplied fully calibrated, with coefficients printed on their respective Calibration Certificates (in manual).

We recommend that the SBE 53 be returned to Sea-Bird for calibration.

Pressure Sensor Calibration

Note:
Although the pressure sensor manufacturer can re-calibrate the pressure sensor by duplicating the original procedures, the sensor must be removed from the SBE 53, the cost is relatively high, and lead times can be considerable.

The pressure sensor is capable of meeting the SBE 53 error specification with some allowance for aging and ambient-temperature induced drift.

The pressure sensor coefficients are entered into the SBE 53 EEPROM with the calibration coefficient commands. The coefficients can be viewed using **DC** in SeatermW. Values for slope (default = 1.0) and offset (default = 0.0) can be entered in Convert Hex's Coefficient Configuration dialog box to make small post-deployment corrections for sensor drift. Note that the offset entered in Convert Hex is *in addition to* the offset entered in the SBE 53 EEPROM. Techniques are provided below for making small corrections using the slope and offset terms by comparing SBE 53 pressure output to:

- Readings from a barometer
- Readings from a dead-weight pressure generator – provides more accurate results, but requires equipment that may not be readily available

Before using either of these procedures, allow the SBE 53 to equilibrate (with power on) in a reasonably constant temperature environment for at least 5 hours before starting. Pressure sensors exhibit a transient change in their output in response to changes in their environmental temperature. Sea-Bird instruments are constructed to minimize this by thermally decoupling the sensor from the body of the instrument. However, there is still some residual effect; allowing the SBE 53 to equilibrate before starting will provide the most accurate calibration correction.

Calculating Offset using a Barometer

1. Place the SBE 53 in the orientation it will have when deployed.
2. In SeatermW, connect to the SBE 53.
3. Send **FR** to display the pressure and pressure sensor temperature compensation frequencies. Click Stop to end the test. Compute pressure in psia from the frequencies with the formula shown on the calibration sheet.
4. Compare the SBE 53 output to the reading from a good barometer. Calculate *Offset* = barometer reading – SBE 53 reading.
5. Enter the calculated offset (positive or negative) in Convert Hex's Coefficients Configuration dialog box.

Offset Correction Example
Pressure measured by barometer is 1010.50 mbar. Pressure calculated from SBE 53 pressure frequency is 14.06 psia.
Convert barometer reading to psia using relationship: mbar * 0.01 dbar/mbar * 1 psia / 0.689476 dbar = psia
Barometer reading = 1010.50 mbar * 0.01 / 0.689476 = 14.66 psia *Offset* = 14.66 – 14.06 = +0.60 psia
Enter offset in Convert Hex's Coefficient Configuration dialog box.

Calculating Slope and Offset using a Dead-Weight Pressure Generator

Tests show that room-temperature-derived *slope* and *offset* corrections to the initial quartz calibration can account for long-term drift to within less than 0.01% of the sensor's full scale range. To perform this correction:

1. Use a suitable dead-weight pressure generator to subject the sensor to increments of known pressures. The end cap's 5/16-24 straight thread permits mechanical connection to a pressure source. Use a fitting that has an o-ring face seal, such as Swagelok-200-1-OR. See *Application Note 12-1: Pressure Port Oil Refill Procedure & Nylon Capillary Fitting Replacement*.
2. In SeatermW, connect to the SBE 53.
3. Send **FR** to display the pressure and pressure sensor temperature compensation frequencies. Click Stop to end the test. Compute pressure in psia from the frequencies with the formula shown on the calibration sheet.
4. Enter the calculated slope and offset (positive or negative) in Convert Hex's Coefficient Configuration dialog box.

Pressure Slope and Offset Correction Example

A 2000 psia sensor has drifted and its responses are low, as shown below:

Actual Pressure (psia)	**Indicated Pressure (psia)**
0	-2.533
400	397.3
800	797.2
1200	1197
1600	1597
2000	1996

Linear regression (best straight-line fit) *pcorrected = (pindicated * slope) + offset* yields *slope* = +1.000603 and *offset* = +2.405. Enter these correction coefficients, originally set to 1.0 and 0.0 respectively, in Convert Hex's Coefficient Configuration dialog box.

Temperature Sensor Calibration

Note:
Temperature sensor calibration coefficients in Convert Hex's Coefficient Configuration dialog box are ignored (software will be updated in future to eliminate these entries from dialog box).

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

The temperature sensor coefficients are entered into the SBE 53 EEPROM with the calibration coefficient commands. The coefficients can be viewed using **DC** in SeatermW.

Conductivity Sensor Calibration

The optional SBE 4M 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 conductivity sensor calibration certificate shows the following coefficients: g, h, i, j, Cpcor, and Ctcor. View and/or modify these coefficients in Convert Hex's Coefficient Configuration dialog box and in the SBE 53 EEPROM.

- Cpcor makes a correction for the highly consistent change in dimensions of the conductivity cell under pressure. The default is the compressibility coefficient for borosilicate glass (-9.57×10^{-8}). Some sensors fabricated between 1992 and 1995 (serial numbers between 1100 and 1500) exhibit a compression that is slightly less than pure borosilicate glass. For these sensors, the (hermetic) epoxy jacket on the glass cell is unintentionally strong, creating a composite pressure effect of borosilicate and epoxy. For sensors tested to date, this composite pressure coefficient ranges from -9.57×10^{-8} to -6.90×10^{-8}, with the latter value producing a correction to deep ocean salinity of 0.0057 PSU in 5000 dbars pressure (approximately 0.001 PSU per 1000 dbars). Before modifying Cpcor, confirm that the sensor behaves differently from pure borosilicate glass. Sea-Bird can test your cell and calculate Cpcor. Alternatively, test the cell by comparing computed salinity to the salinity of water samples from a range of depths, calculated using an AutoSal.

Note:
See Application Note 31 for computation of slope correction coefficient from pre- and post-cruise calibrations supplied by Sea-Bird or from salinity bottle samples taken at sea during profiling.

Enter the value for slope (default = 1.0) in the SBE 53 EEPROM to make small corrections for conductivity sensor drift between calibrations:

Corrected conductivity = (slope * computed conductivity)
where
slope = true conductivity span / instrument conductivity span

Conductivity Slope and Offset Correction Example
At true conductivity = 3.5 S/m, instrument reading = 3.49965 S/m
Calculating the slope:
Slope = 3.5 / 3.49965 = + 1.000100010001000100010001

The primary mechanism for calibration drift in conductivity sensors is the fouling of the cell by chemical or biological deposits. Fouling changes the cell geometry, resulting in a shift in cell constant (slope of the calibration curve), typically resulting in lower conductivity readings over time. Offset error (error at 0 S/m) is usually due to electronics drift, and is typically less than ± 0.0001 S/m per year. Because offsets greater than ± 0.0002 S/m are a symptom of sensor malfunction, Sea-Bird recommends that drift corrections be made by assuming no offset error, unless there is strong evidence to the contrary or a special need.

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

Section 10: Troubleshooting

This section reviews common problems in operating the SBE 53, and provides the most common causes and solutions.

Problem 1: Unable to Communicate with SBE 53

The `S>` prompt indicates that communications between the SBE 53 and computer have been established. Before proceeding with troubleshooting, attempt to establish communications again by clicking Connect in SeatermW or hitting the Enter key several times.

Cause/Solution 1: The I/O cable connection may be loose. Check the cabling between the SBE 53 and computer for a loose connection.

Cause/Solution 2: The instrument, Comm port, and/or baud rate may not have been entered correctly in SeatermW. Click Configure and verify the settings. **Note that you need to select the SBE 26*plus* in SeatermW to communicate with the SBE 53;** the SBE 26*plus* and SBE 53 have the same communication settings.

Cause/Solution 3: The I/O cable may not be the correct one. The I/O cable supplied with the SBE 53 permits connection to the DB-9P input connector on a standard RS-232 interface.

- SBE 53 Pin 1 (large pin on standard connector) goes to DB-9 pin 5 (ground)
- SBE 53 pin 2 (counter-clockwise from pin 1) goes to DB-9 pin 3
- SBE 53 pin 3 (opposite pin 1) goes to DB-9 pin 2

Cause/Solution 4: In rare cases, the program that controls the SBE 53 microprocessor can be corrupted by a severe static shock or other problem. This program can be initialized by using the reset switch. Proceed as follows to initialize:

1. **As a precaution, upload all data before proceeding**.
2. Open the battery end cap and remove the batteries (see *Replacing Batteries* in *Section 9: Routine Maintenance and Calibration* for details).
3. There is a toggle reset switch on the battery compartment bulkhead, which is visible after the batteries are removed. The switch is used to disconnect the internal back-up lithium batteries from the electronics. Set the switch to the reset position for at least 5 minutes.
4. Reinstall or replace the batteries, and close the battery end cap.
5. Establish communications with the SBE 53 (see *Section 5: SBE 53 Setup, Installation, and Data Upload - SeatermW* for details). Send the status command (**DS**) to verify that the setup is unaffected.

Note:
Using the reset switch does not affect the SBE 53 memory - data in memory and user-programmable parameter values are unaffected.

Problem 2: Nonsense or Unreasonable *Uploaded* Data

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

Cause/Solution 1: An uploaded data file with unreasonable values for pressure, temperature, or optional conductivity may be caused by incorrect calibration coefficients in either of the following places:

- In the instrument EEPROM - pressure, temperature, and conductivity sensor coefficients. View the coefficients by sending **DC** in SeatermW. If necessary, modify calibration coefficient(s) by sending the appropriate coefficient command(s) (see *Command Descriptions* in *Section 5: SBE 53 Setup, Installation and Data Upload – SeatermW*).
- In the instrument .psa file used by Convert Hex – pressure sensor slope and offset (this offset is in addition to the offset programmed in the instrument EEPROM). View/modify the coefficients by clicking the Coefficients button in Convert Hex's dialog box.

Verify that the calibration coefficients match the instrument Calibration Certificates.

Problem 3: Nonsense or Unreasonable *Real-Time* or *Queried* Data

Note:
If real-time or queried **pressure** values are unreasonable, note that a pressure slope and offset can be entered in Convert Hex's Coefficient Configuration dialog box to make small post-deployment corrections for pressure sensor drift on the uploaded data.

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

Cause/Solution 1: Real-time or queried data with unreasonable values for pressure, temperature, or optional conductivity and salinity may be caused by incorrect pressure, temperature, and conductivity calibration coefficients in the instrument EEPROM. View the coefficients by sending **DC** in SeatermW; verify that the calibration coefficients match the instrument Calibration Certificates. If necessary, modify calibration coefficient(s) by sending the appropriate coefficient command(s) (see *Command Descriptions* in *Section 5: SBE 53 Setup, Installation and Data Upload – SeatermW*).

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Glossary

Battery and Memory Endurance – SEASOFT for Waves module for calculating power endurance and memory endurance for a user-specified sampling scheme.

Convert Hex – SEASOFT for Waves module for converting uploaded .hex file into tide (.tid) and reference frequency (.ref) files.

Fouling – Biological growth in the conductivity cell during deployment.

Merge Barometric Pressure – SEASOFT for Waves module for removing barometric pressure from tide data.

PCB – Printed Circuit Board.

Plot Data – SEASOFT for Waves module for plotting tide data.

SEASOFT for Waves - DOS – Modular DOS program for use with the SBE 26. **SEASOFT for Waves –DOS is not compatible with the SBE 53.**

SEASOFT for Waves – Modular Win 95/98/NT/2000/XP program for pre-deployment planning, communication with the SBE 53 for setup, uploading of data from the SBE 53, separation of uploaded data into separate wave and tide files, removal of barometric pressure from tide data, statistical analysis, and data plotting. Modules applicable to SBE 53 include Battery and Memory Endurance, SeatermW, Convert Hex, Merge Barometric Pressure, and Plot Data.

SeatermW – SEASOFT for Waves module for communication with the SBE 53 for setup and uploading of data from the SBE 53.

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

TCXO – Temperature Compensated Crystal Oscillator.

Triton X-100 – Reagent grade non-ionic surfactant (detergent), used for cleaning the conductivity cell. Triton can be ordered from Sea-Bird, but should also be available locally from chemical supply or laboratory products companies. Triton is manufactured by Mallinckrodt Baker (see www.mallbaker.com/changecountry.asp?back=/Default.asp for local distributors).

Appendix I: Command Summary

> **Note:**
> See *Command Descriptions* in *Section 5: SBE 53 Setup, Installation, and Data Upload - SeatermW* for detailed information and examples.

CATEGORY	COMMAND	DESCRIPTION
Status	**DS**	Display status and setup parameters.
Setup	**SetTime**	Set real-time clock date and time.
	DateTime=x	**x**= real-time clock date and time. See *Setting Time in SBE 53 to Synchronize Sampling of Multiple Instruments* in *Section 5*.
	Baud=x	**x**= baud rate for general communication (600, 1200, 2400, 4800, 9600, 19200, or 38400). Default 9600.
	External Temperature=	**x=Y**: Optional external thermistor. **x=N**: Standard internal thermistor. Default.
	Conductivity=x	**x=Y**: Enable conductivity logging (if optional conductivity sensor included). **x=N**: Do not.
	UserInfo=x	**x**= user-defined string (displays in **DS** reply).
	TxTide=x	**x=Y**: Transmit real-time tide data. **x=N**: Do not.
	QS	Enter quiescent (sleep) state. Main power turned off, memory retention unaffected.
Tide Setup	**SetSampling** (or **SetSample**)	Set sampling parameters: • Continuously power pressure sensor? If no, pressure sensor warm-up (minimum 5 minutes, recommended 15 minutes). • Tide interval (1 – 60 minutes). • Tide duration (1 – 60 minutes). • Reference frequency interval (corresponding to no more than 1/day and no less than 1/month) • At receipt of **Start**, start logging at **SetStartTime** or immediately? • Stop logging at **SetStopTime** or wait for user to send **Stop**?
Initialize Logging (Reset Memory)	**InitLogging**	**After all data uploaded**, send this before starting to sample to make entire memory available for recording. If not sent, data stored after last sample.
	TideCount=x	**x=** tide sample number for first tide measurement when sampling begins. Use to recover data if you accidentally initialize logging before **ASCII** uploading.
	***ByteCount=x**	**x=** byte number for first byte when sampling begins. Use to recover data if you accidentally initialize logging before **binary** uploading.
Logging	**Start**	Start logging now (if ***use start time?*** in **SetSampling** prompt is ***No***), *or* Start waiting to start logging (if ***use start time?*** in **SetSampling** is ***Yes***).
	Stop	Stop logging now.
	SetStartTime	Set date and time to start logging. At receipt of **Start**, SBE 53 starts logging at this date and time if ***Use start time?*** in **SetSampling** is ***Yes***.
	SetStopTime	Set date and time to stop logging. SBE 53 stops logging at this date and time if ***Use stop time?*** in **SetSampling** is ***Yes***.
Send Last Sample	**SL**	Send data from last tide measurement and do not go to sleep (do not enter quiescent state).
	SLO	Send data from last tide measurement and go to sleep (enter quiescent state).
Data Upload	**DD**	Upload data **in ASCII** at baud set for general communication with **Baud=**.
	DBbaud,b,e	Upload data **in binary** at **baud** (1200, 2400, 4800, 9600, 19200, 28800, 38400, 57600, or 115200) from byte **b** to **e**. First byte is 0. Can upload up to 500,000 bytes at one time.
	ByteCount	Display total number of bytes in memory.

> **Note:**
> Use the Upload menu to upload data that will be processed by SEASOFT for Waves. Manually entering a data upload command does not produce data in the required format for processing by SEASOFT for Waves.

CATEGORY	COMMAND	DESCRIPTION
Diagnostic (data from these tests not stored in FLASH memory)	**TS**	Take 1 sample of pressure, pressure temperature, temperature, and conductivity, and output **converted** data.
	TSR	Take 1 sample of pressure, pressure temperature, temperature, and conductivity, and output **raw** data.
	TT	Sample temperature, and output **converted** data. SBE 53 runs continuously, drawing current. Press Esc key or click Stop to stop test.
	TTR	Sample temperature, and output **raw** data. SBE 53 runs continuously, drawing current. Press Esc key or click Stop to stop test.
	FR	Measure and output conductivity frequency. SBE 53 runs continuously, drawing current. Press Esc key or click Stop to stop test.
	VR	Measure and output: • main battery voltage / 11.18 • back-up lithium battery voltage / 4.8187 • operating current (mA) / 20.04 • ground voltage SBE 53 runs continuously, drawing current. Press Esc key or click Stop to stop test.
	***FlashInit**	Map bad blocks and erase FLASH memory, **destroying all data**.
	***FlashGood**	Display number of good blocks in FLASH memory.
Calibration Coefficients (F=floating point number; S=string with no spaces) Dates shown are when calibrations were performed. Coefficients are initially factory-set and should agree with Calibration Certificates shipped with SBE 53.	**DC**	Display sensor calibration coefficients.
	PCalDate=S	**S**=pressure calibration date.
	PU0=F	**F**=pressure U0.
	PY1=F	**F**=pressure Y1.
	PY2=F	**F**=pressure Y2.
	PY3=F	**F**=pressure Y3.
	PC1=F	**F**=pressure C1.
	PC2=F	**F**=pressure C2.
	PC3=F	**F**=pressure C3.
	PD1=F	**F**=pressure D1.
	PD2=F	**F**=pressure D2.
	PT1=F	**F**=pressure T1.
	PT2=F	**F**=pressure T2.
	PT3=F	**F**=pressure T3.
	PT4=F	**F**=pressure T4.
	POffset=F	**F**=pressure offset (psia).
	FRA0=F	**F**=reference frequency A0.
	FRA1=F	**F**=reference frequency A1.
	FRA2=F	**F**=reference frequency A2.
	FRA3=F	**F**=reference frequency A3.
	TCalDate=S	**S**=temperature calibration date.
	TA0=F	**F**=temperature A0.
	TA1=F	**F**=temperature A1.
	TA2=F	**F**=temperature A2.
	TA3=F	**F**=temperature A3.
	CCalDate=S	**S**=conductivity calibration date.
	CG=F	**F**=conductivity G.
	CH=F	**F**=conductivity H.
	CI=F	**F**=conductivity I.
	CJ=F	**F**=conductivity J.
	CTCor=F	**F**=conductivity TCOR.
	CPCor=F	**F**=conductivity PCOR.
	CSlope=F	**F**=conductivity slope correction.

Appendix II: Sample Timing

Notes

- When **Start** is sent:
  - If ***Use start time?*** in the **SetSampling** prompt is ***No***, the SBE 53 starts logging 10 seconds after receipt of **Start**.
  - If ***Use start time?*** in the **SetSampling** prompt is ***Yes***, the SBE 53 starts logging at **SetStartTime**.

- If ***Use start time?*** in the **SetSampling** prompt is ***Yes***, and **SetStartTime** is less than 10 seconds in the future when **Start** is sent, the SBE 53 ignores the programmed start time and starts logging in 10 seconds.

- If ***Use stop time?*** in the **SetSampling** prompt is ***Yes***, and **SetStopTime** is less than 1 hour after logging begins, the SBE 53 ignores the programmed stop time and continues logging until **Stop** is sent.

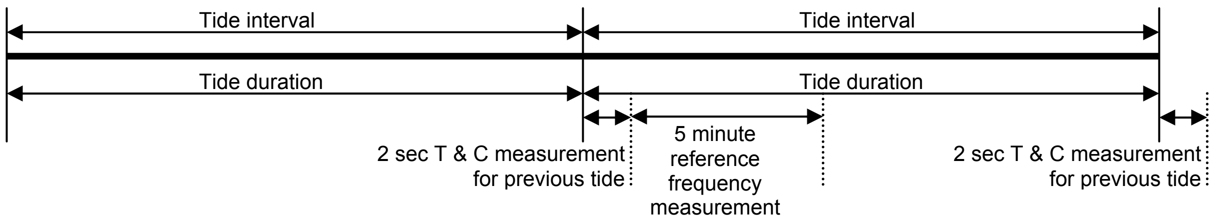
- The SBE 53 integrates the pressure sensor output over the entire tide duration, calculating and storing an average pressure for that time period. The SBE 53 measures the temperature and optional conductivity (T and C) associated with the tide *after* the tide duration. The time stamp (the time reported with the tide pressure, temperature, and conductivity data) is the time at the **beginning** of the tide duration.

- The SBE 53 requires 5 minutes for each reference frequency measurement. The measurement timing is dependent on whether the pressure sensor and reference frequency oscillator are continuously powered:
  - **Continuously powered -**
    - If (tide interval – tide duration) $\geq$ 10 minutes, reference frequency measurement is done **after** the applicable tide measurement.
    - If (tide interval – tide duration) < 10 minutes **and** tide duration $\geq$ 10 minutes, reference frequency measurement is done **during** the applicable tide measurement.
    - If (tide interval – tide duration) < 10 minutes **and** tide duration < 10 minutes, reference frequency measurement is **disabled**.
  - **Not continuously powered (user-programmable warmup time) -**
    - If (tide interval – tide duration - warmup) $\geq$ 10 minutes, reference frequency measurement is done **after** the applicable tide measurement.
    - If (tide interval – tide duration - warmup) < 10 minutes **and** tide duration $\geq$ 10 minutes, reference frequency measurement is done **during** the applicable tide measurement.
    - If (tide interval – tide duration - warmup) < 10 minutes **and** tide duration < 10 minutes **and** warmup $\geq$ 10 minutes, reference frequency measurement is done **during** the applicable reference frequency measurement.
    - If (tide interval – tide duration - warmup) < 10 minutes **and** tide duration < 10 minutes **and** warmup < 10 minutes, reference frequency measurement is **disabled**.

Sample Timing Schematics

Pressure Sensor and Reference Frequency Oscillator Continuously Powered

- If tide duration > (tide interval – 10 sec), tide duration is set to tide interval and the SBE 53 samples tides continuously.
  When tide interval = tide duration, if tide duration $\geq$ 10 minutes, reference frequency measurement is done during the applicable tide measurement; if tide duration < 10 minutes, reference frequency measurement is disabled.

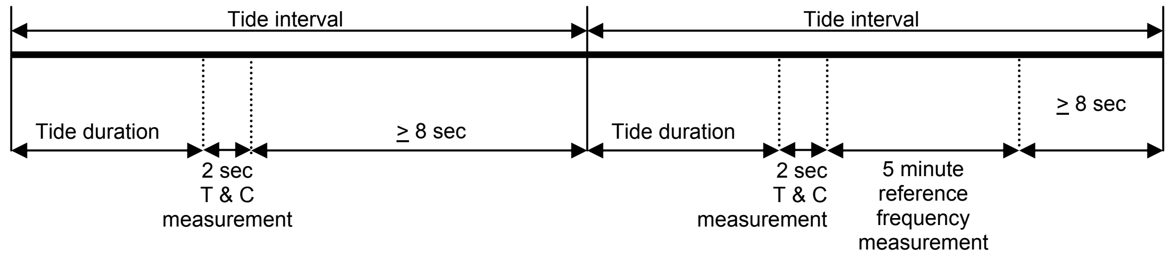


Example 1: Tide interval = tide duration = 15 minutes.
Measure reference frequency every 96 tide measurements (1/day).
Set **SetStartTime** to 12:00:00.
Checking setup: Tide duration = 15 minutes $\geq$ 10 minutes, so reference frequency measurement is not disabled.

Day & Time	Time Stamp for Tide #	Begin P for Tide #	End P for Tide #	Begin T & C for Tide #	End T & C for Tide #	Begin Reference Frequency Measurement #	End Reference Frequency Measurement #
Day 1 12:00:00	#1	#1	-	-	-	-	-
Day 1 12:15:00	#2	#2	#1	#1	-	-	-
Day 1 12:15:02	-	-	-	-	#1	-	-
Day 1 12:30:00	#3	#3	#2	#2	-	-	-
Day 1 12:30:02	-	-	-	-	#2	-	-
Etc.							
Day 2 12:00:00	#97	#97	#96	#96	-	-	-
Day 2 12:00:02	-	-	-	-	#96	#1	-
Day 2 12:05:02	-	-	-	-	-	-	#1
Day 2 12:15:00	#98	#98	#97	#97	-	-	-
Day 2 12:15:02	-	-	-	-	#97	-	-
Day 2 12:30:00	#99	#99	#98	#98	-	-	-
Day 2 12:30:02	-	-	-	-	#98	-	-
Etc.							

- If tide duration < (tide interval – 10 sec), SBE 53 does not sample tides continuously. There are two cases for timing of the reference frequency.

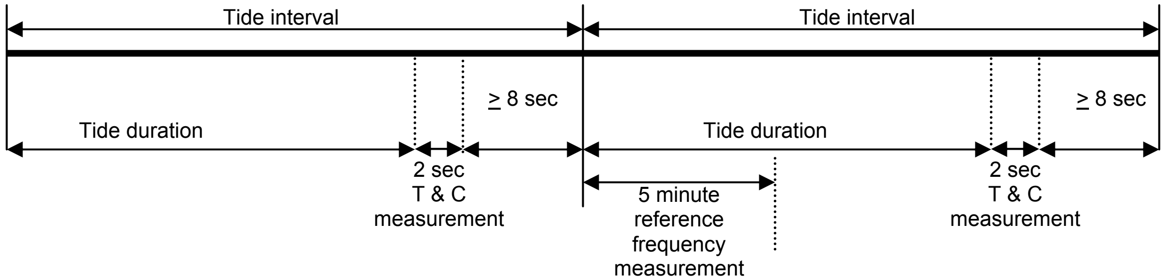
  Case A: If (tide interval – tide duration) ≥ 10 minutes, reference frequency measurement is done **after** the applicable tide measurement.



Example 2: Tide interval = 15 minutes; tide duration = 5 minutes.
Set **SetStartTime** to 12:00:00.
Measure reference frequency every 96 tide measurements (1/day).
Checking setup:
tide duration = 5 minutes = 300 sec < tide interval – 10 sec = 15 minutes – 10 sec = 890 sec.
tide interval – tide duration = 15 minutes – 5 minutes = 10 minutes ≥ 10 minutes, so reference frequency measurement is done after the applicable tide measurement.

Day & Time	Time Stamp for Tide #	Begin P for Tide #	End P for Tide #	Begin T & C for Tide #	End T & C for Tide #	Begin Reference Frequency Measurement #	End Reference Frequency Measurement #
Day 1 12:00:00	#1	#1	-	-	-	-	-
Day 1 12:05:00	-	-	#1	#1	-	-	-
Day 1 12:05:02	-	-	-	-	#1	-	-
Day 1 12:15:00	#2	#2	-	-	-	-	-
Day 1 12:20:00	-	-	#2	#2	-	-	-
Day 1 12:20:02	-	-	-	-	#2	-	-
Etc.							
Day 2 12:00:00	#97	#97	-	-	-	-	-
Day 2 12:05:00	-	-	#97	#97	-	-	-
Day 2 12:05:02	-	-	-	-	#97	#1	-
Day 2 12:10:02	-	-	-	-	-	-	#1
Day 2 12:15:00	#98	#98	-	-	-	-	-
Day 2 12:20:00	-	-	#98	#98	-	-	-
Day 2 12:20:02	-	-	-	-	#98	-	-
Etc.							

Case B: If (tide interval – tide duration) < 10 minutes **and** tide duration ≥ 10 minutes, reference frequency measurement is done **during** the applicable tide measurement; if tide duration < 10 minutes, reference frequency measurement is disabled.

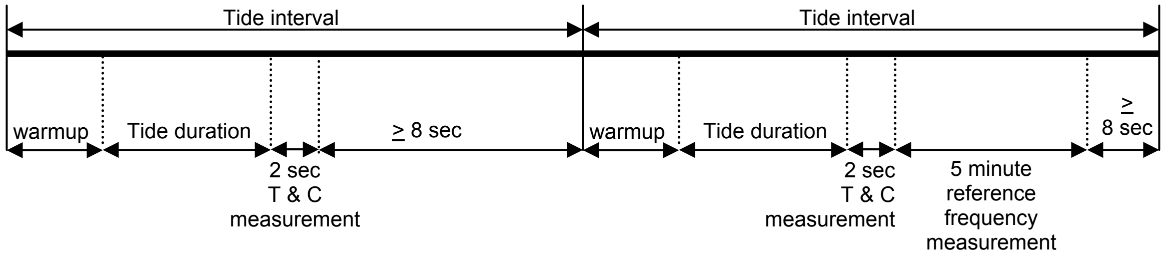


Example 3: Tide interval = 15 minutes; tide duration = 12 minutes.
Set **SetStartTime** to 12:00:00.
Measure reference frequency every 96 tide measurements (1/day).
Checking setup:
tide duration = 12 minutes = 720 sec < tide interval – 10 sec = 15 minutes – 10 sec = 890 sec.
tide interval – tide duration = 15 minutes – 12 minutes = 3 minutes < 10 minutes, so reference frequency measurement is done during the applicable tide measurement (tide duration = 12 minutes ≥ 10 minutes, so reference frequency measurement is not disabled).

Day & Time	Time Stamp for Tide #	Begin P for Tide #	End P for Tide #	Begin T & C for Tide #	End T & C for Tide #	Begin Reference Frequency Measurement #	End Reference Frequency Measurement #
Day 1 12:00:00	#1	#1	-	-	-	-	-
Day 1 12:12:00	-	-	#1	#1	-	-	-
Day 1 12:12:02	-	-	-	-	#1	-	-
Day 1 12:15:00	#2	#2	-	-	-	-	-
Day 1 12:27:00	-	-	#2	#2	-	-	-
Day 1 12:27:02	-	-	-	-	#2	-	-
Etc.							
Day 2 12:00:00	#97	#97	-	-	-	#1	-
Day 2 12:05:00	-	-	-	-	-	-	#1
Day 2 12:12:00	-	-	#97	#97	-	-	-
Day 2 12:12:02	-	-	-	-	#97	-	-
Day 2 12:15:00	#98	#98	-	-	-	-	-
Day 2 12:27:00	-	-	#98	#98	-	-	-
Day 2 12:27:02	-	-	-	-	#98	-	-
Etc.							

Pressure Sensor and Reference Frequency Oscillator *Not* Continuously Powered

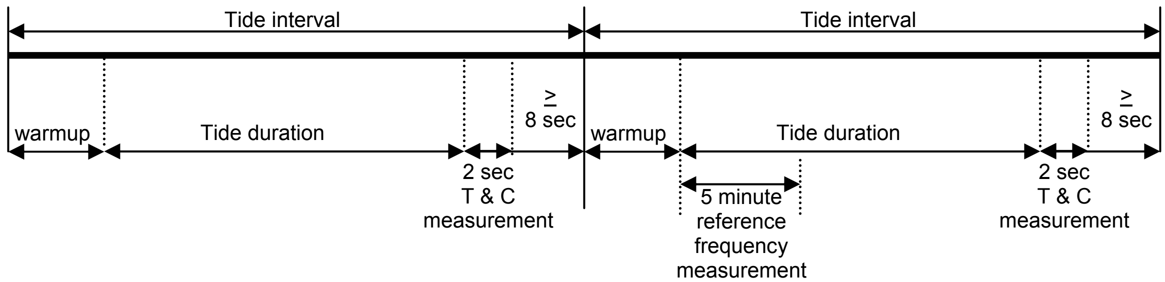
- If (tide interval – tide duration - warmup) ≥ 10 minutes, reference frequency measurement is done **after** the applicable tide measurement.



Example 1: Tide interval = 30 minutes; tide duration = 5 minutes; warmup = 15 minutes.
Set **SetStartTime** to 12:00:00.
Measure reference frequency every 48 tide measurements (1/day).
Checking setup:
tide interval – tide duration – warmup = 30 minutes – 5 minutes – 15 minutes = 10 minutes ≥ 10 minutes, so reference frequency measurement is done after the applicable tide measurement.

Day & Time	Begin Warmup for Tide #	Time Stamp for Tide #	Begin P for Tide #	End P for Tide #	Begin T & C for Tide #	End T & C for Tide #	Begin Reference Frequency Measurement #	End Reference Frequency Measurement #
Day 1 12:00:00	#1	-	-	-	-	-	-	-
Day 1 12:15:00	-	#1	#1	-	-	-	-	-
Day 1 12:20:00	-	-	-	#1	#1	-	-	-
Day 1 12:20:02	-	-	-	-	-	#1	-	-
Day 1 12:30:00	#2	-	-	-	-	-	-	-
Day 1 12:45:00	-	#2	#2	-	-	-	-	-
Day 1 12:50:00	-	-	-	#2	#2	-	-	-
Day 1 12:50:02	-	-	-	-	-	#2	-	-
Etc.								
Day 2 12:00:00	#49	-	-	-	-	-	-	-
Day 2 12:15:00	-	#49	#49	-	-	-	-	-
Day 2 12:20:00	-	-	-	#49	#49	-	-	-
Day 2 12:20:02	-	-	-	-	-	#49	#1	-
Day 2 12:25:02	-	-	-	-	-	-	-	#1
Day 2 12:30:00	#50	-	-	-	-	-	-	-
Day 2 12:45:00	-	#50	#50	-	-	-	-	-
Day 2 12:50:00	-	-	-	#50	#50	-	-	-
Day 2 12:50:02	-	-	-	-	-	#50	-	-
Etc.								

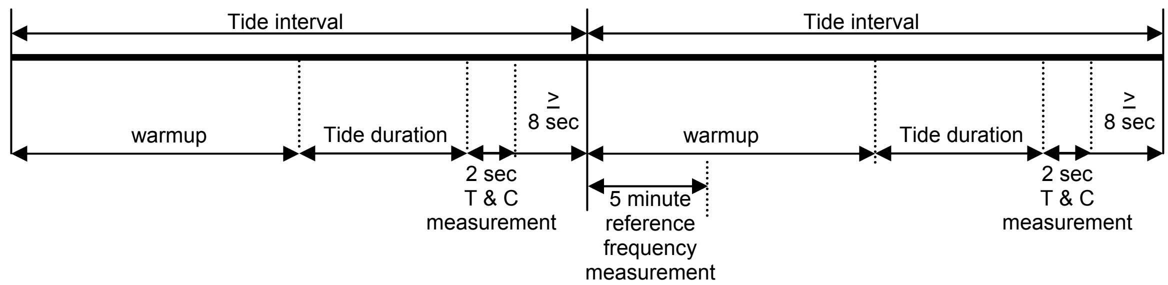
- If (tide interval – tide duration - warmup) < 10 minutes **and** tide duration ≥ 10 minutes, reference frequency measurement is done **during** the applicable tide measurement.



Example 2: Tide interval = 30 minutes; tide duration = 10 minutes; warmup = 15 minutes.
Set **SetStartTime** to 12:00:00.
Measure reference frequency every 48 tide measurements (1/day).
Checking setup:
tide interval – tide duration – warmup = 30 minutes – 10 minutes – 15 minutes = 5 minutes < 10 minutes, **and**
tide duration = 10 minutes ≥ 10 minutes, so reference frequency measurement is done during the applicable tide measurement.

Day & Time	Begin Warmup for Tide #	Time Stamp for Tide #	Begin P for Tide #	End P for Tide #	Begin T & C for Tide #	End T & C for Tide #	Begin Reference Frequency Measurement #	End Reference Frequency Measurement #
Day 1 12:00:00	#1	-	-	-	-	-	-	-
Day 1 12:15:00	-	#1	#1	-	-	-	-	-
Day 1 12:25:00	-	-	-	#1	#1	-	-	-
Day 1 12:25:02	-	-	-	-	-	#1	-	-
Day 1 12:30:00	#2	-	-	-	-	-	-	-
Day 1 12:45:00	-	#2	#2	-	-	-	-	-
Day 1 12:55:00	-	-	-	#2	#2	-	-	-
Day 1 12:55:02	-	-	-	-	-	#2	-	-
Etc.								
Day 2 12:00:00	#49	-	-	-	-	-	-	-
Day 2 12:15:00	-	#49	#49	-	-	-	#1	-
Day 2 12:20:00	-	-	-	-	-	-	-	#1
Day 2 12:25:00	-	-	-	#49	#49	-	-	-
Day 2 12:25:02	-	-	-	-	-	#49	-	-
Day 2 12:30:00	#50	-	-	-	-	-	-	-
Day 2 12:45:00	-	#50	#50	-	-	-	-	-
Day 2 12:55:00	-	-	-	#50	#50	-	-	-
Day 2 12:55:02	-	-	-	-	-	#50	-	-
Etc.								

- If (tide interval – tide duration - warmup) < 10 minutes **and** tide duration < 10 minutes **and** warmup ≥ 10 minutes, reference frequency measurement is done **during** the applicable warmup; if warmup < 10 minutes, reference frequency measurement is disabled.



Example 3: Tide interval = 30 minutes; tide duration = 8 minutes; warmup = 15 minutes.
Set **SetStartTime** to 12:00:00.
Measure reference frequency every 48 tide measurements (1/day).
Checking setup:
tide interval – tide duration – warmup = 30 minutes – 8 minutes – 15 minutes = 7 minutes < 10 minutes, **and**
tide duration = 8 minutes < 10 minutes, **and**
warmup = 15 minutes ≥ 10 minutes, so reference frequency measurement is done during the applicable warmup
(warmup = 15 minutes ≥ 10 minutes, so reference frequency measurement is not disabled).

Day & Time	Begin Warmup for Tide #	Time Stamp for Tide #	Begin P for Tide #	End P for Tide #	Begin T & C for Tide #	End T & C for Tide #	Begin Reference Frequency Measurement #	End Reference Frequency Measurement #
Day 1 12:00:00	#1	-	-	-	-	-	-	-
Day 1 12:15:00	-	#1	#1	-	-	-	-	-
Day 1 12:23:00	-	-	-	#1	#1	-	-	-
Day 1 12:23:02	-	-	-	-	-	#1	-	-
Day 1 12:30:00	#2	-	-	-	-	-	-	-
Day 1 12:45:00	-	#2	#2	-	-	-	-	-
Day 1 12:53:00	-	-	-	#2	#2	-	-	-
Day 1 12:53:02	-	-	-	-	-	#2	-	-
Etc.								
Day 2 12:00:00	#49	-	-	-	-	-	#1	-
Day 2 12:05:00	-	-	-	-	-	-	-	#1
Day 2 12:15:00	-	#49	#49	-	-	-	-	-
Day 2 12:23:00	-	-	-	#49	#49	-	-	-
Day 2 12:23:02	-	-	-	-	-	#49	-	-
Day 2 12:30:00	#50	-	-	-	-	-	-	-
Day 2 12:45:00	-	#50	#50	-	-	-	-	-
Day 2 12:53:00	-	-	-	#50	#50	-	-	-
Day 2 12:53:02	-	-	-	-	-	#50	-	-
Etc.								

Appendix III: Data Formats

This appendix provides detailed information on data format for each file type, except as noted.

Extension	Description
.cap	Capture file of queried data (response to **SL** or **SLO**), or capture file of real-time data from SBE 53 (output if **TxTide=Y**).
.hex	Hex data uploaded from SBE 53 memory using SeatermW.
.tid	Tide data, created from .hex file by Convert Hex. Also, file output by Merge Barometric Pressure, which removes barometric pressure from an input .tid file.
.ref	Reference frequency data, created from .hex file by Convert Hex. Can be used in post-processing to adjust .tid data for pressure sensor drift.
.bp	Barometric pressure data, used by Merge Barometric Pressure to remove barometric pressure from tide data (.tid) file. See *Section 7: Tide Data Processing – Merge Barometric Pressure* for .bp format.

Queried Data Format (.cap extension)

Note:
See *Making Corrections Using Reference Frequency Data* below for pressure correction algorithm.

Queried data is obtained by sending **SL** or **SLO** (command the SBE 53 to send the last sample from memory) while logging. Queried data is saved to a .cap file if you click Capture in SeatermW. Each time **SL** or **SLO** is sent, the display looks like this:

```
pr = 14.5266, pc= 14.5266, t = 22.7003, s = 29.05335,
06 Jul 2005 08:30:00
```

where:

- pr = stored raw pressure, converted to psia.
- pc = corrected pressure (not stored) converted to psia, with correction based on most recent measured reference frequency.
- t = stored temperature, converted to °C.
- s = calculated salinity (computed from stored temperature and conductivity) in psu. Displays only if **DS** response shows `conductivity = YES` (conductivity acquisition was enabled with **Conductivity=Y**).
- Date/time is the date/time stored in memory with the data.

Real-Time Data Format (.cap extension)

Notes:
- Each tide measurement record displays **after** the tide duration is complete. For example, if the tide duration is 10 minutes, the first tide data displays 10 minutes after logging starts.
- See *Making Corrections Using Reference Frequency Data* below for pressure correction algorithm.

Real-time data is output if the **DS** response shows `transmit real-time tide data = YES` (real-time tide data was enabled with **TxTide=Y**). Real-time output is saved to a .cap file if you click Capture in SeatermW.

Each time a tide measurement is completed, the display looks like this:

```
Tide: start time = 06 Jul 2005 13:40:01, pr =14.2135,
pc = 14.2135, pt = 21.352, t = 21.0250, c = 4.81952, s = 34.3799
```

where:

- start time = start of tide measurement.
- pr = stored raw pressure, converted to psia.
- pc = corrected pressure (not stored) converted to psia, with correction based on most recent measured reference frequency.
- pt = stored pressure temperature, converted to °C.
- t = stored temperature, converted to °C.
- c = stored conductivity, converted to S/m, and
  s = calculated salinity (not stored) in psu.
  Conductivity and salinity display only if **DS** response shows `conductivity = YES` (conductivity acquisition was enabled with **Conductivity=Y**).

Hex Data Format (.hex extension)

A .hex file contains hexadecimal data uploaded from SBE 53 memory using SeatermW's Upload.

The beginning of a sample .hex file **without conductivity** follows:

```
*Sea-Bird SBE 53 BPR Data File
*FileName = H:\sbe53\test-4.hex
*Software Version 1.11
*DS
*SBE 53 BPR V 1.1c  SN 12345    26 Jan 2008  15:17:26
*user info=test setup
*quartz pressure sensor: serial number = 90319, range = 10000 psia
*conductivity = NO
*iop = 10.1 ma  vmain = 14.8 V  vlith =  0.0 V
*last sample: p = 21.9520, t = 21.0250
*
*tide measurement: interval = 15.000 minutes, duration = 15 minutes,
power pressure sensor continuously
*measure reference frequency every 3 tide samples
*logging start time = do not use start time
*logging stop time = do not use stop time
*
*tide samples/day = 96.000
*memory endurance = 15420.2 days
*nominal battery endurance = 67 days alkaline, 207 days lithium
*total recorded tide measurements = 12
*total recorded reference frequency measurements = 4
*tide measurements since last start = 12
*transmit real-time tide data = YES
*
*status = stopped by user
*logging = NO, send start command to begin logging
*S>DC
*Pressure coefficients:  04-15-2003
*    U0 = 5.822311e+00
* . . .                                (more pressure sensor calibration coefficients)
*Temperature coefficients:  24-dec-04
*    TA0 = 2.542717e-04
*    TA1 = 2.511151e-04
*    TA2 = -1.767157e-06
*    TA3 = 1.562220e-07
*S>DD
63B4753A18ED1D4E07AE0641E409D6BAB1        (tide data)
63B4753518ED1D4D07AE09429C09D6BE35        (tide data)
63B4753B18ED1D4E07AE0942A609D6C1B9        (tide data)
FFFFFFFF004B004D04775041B809D6C548        (reference frequency scan)
63B4757A18ED1D5E07AE0741E909D6C53D        (tide data)
63B4754818ED1D5207AE0642CF09D6C8C1        (tide data)
63B4754818ED1D5207AE0642D909D6CC45        (tide data)
FFFFFFFF004B004D06F75B431309D6CFD4        (reference frequency scan)
. . .
```

> **Note:**
> If you uploaded data in binary, SeatermW sent **DBbaud,b,e** instead of **DD**. However, the uploaded .hex file ***always*** shows the **DD** command, so the file looks exactly the same, regardless of whether ASCII or binary upload was used.

The beginning of a sample .hex file **with conductivity** follows:

(beginning of file, with **DS** and **DC** response, same as above, except **DS** response shows *conductivity = YES*, calculated memory endurance and battery endurance in **DS** response is reduced, and **DC** response shows conductivity coefficients in addition to other coefficients)

```
*S>DD
63B4753A18ED1D4E07AE0641E40A415C09D6BAB1  (tide data)
63B4753518ED1D4D07AE09429C0A415409D6BE35  (tide data)
63B4753B18ED1D4E07AE0942A60A415809D6C1B9  (tide data)
FFFFFFFF004B004D04775041B80A415A09D6C548  (reference frequency scan)
63B4757A18ED1D5E07AE0741E90A415309D6C53D  (tide data)
63B4754818ED1D5207AE0642CF0A415209D6C8C1  (tide data)
63B4754818ED1D5207AE0642D90A415B09D6CC45  (tide data)
FFFFFFFF004B004D06F75B43130A415109D6CFD4  (reference frequency scan)
. . .
```

Looking at lines in the file(s):

- Beginning lines - ***** flags header. Header lines contain (in order):
  - Input file name
  - Software version used to upload the data
  - SBE 53 response to status (**DS**) command
  - SBE 53 response to calibration coefficients (**DC**) command

- Following lines - Data follows, with each line followed by a carriage return and line feed. Data (lines after the `*S>DD`) is described below.

Line	**SBE 53 *without* Conductivity** (all data is 17 bytes = 34 Hex characters)	**SBE 53 *with* Conductivity** (all data is 20 bytes = 40 Hex characters)
1	`63B4753A18ED1D4E07AE0641E409D6BAB1` – • First 4 bytes (`63B4753A`) - pressure number. • Next 4 bytes (`18ED1D4E`) - pressure temperature frequency number. • Next 3 bytes (`07AE06`) - temperature A/D counts. • Next 2 bytes (`41E4`) - reference frequency thermistor raw A/D counts. • Last 4 bytes (`09D6BAB1`) - start time of measurement (seconds since January 1, 2000).	`63B4753A18ED1D4E07AE0641E40A415C09D6BAB1` – • First 4 bytes (`63B4753A`) - pressure number. • Next 4 bytes (`18ED1D4E`) - pressure temperature frequency number. • Next 3 bytes (`07AE06`) - temperature A/D counts. • Next 2 bytes (`41E4`) - reference frequency thermistor raw A/D counts. • Next 3 bytes (`0A415C`) - conductivity number. • Last 4 bytes (`09D6BAB1`) - start time of measurement (seconds since January 1, 2000).
2	Same format as line 1	Same format as line 1
3	Same format as line 1	Same format as line 1
4	`FFFFFFFF004B004D04775041B809D6C548` – • First 4 bytes (`FFFFFFFF`) - flags this scan as reference frequency scan. Setup for this example was to measure reference frequency every 3 tide samples, so there are 3 tide records before reference frequency scan. • Next 4 bytes (`004B004D`) - integer part of reference frequency. • Next 3 bytes (`047750`) - fractional part of reference frequency. • Next 2 bytes (`41B8`) - reference frequency thermistor raw A/D counts. • Last 4 bytes (`09D6C548`) - start time of reference frequency scan measurement (seconds since January 1, 2000).	`FFFFFFFF004B004D04775041B80A415A09D6C548` – • First 4 bytes (`FFFFFFFF`) - flags this scan as reference frequency scan. Setup for this example was to measure reference frequency every 3 tide samples, so there are 3 tide records before reference frequency scan. • Next 4 bytes (`004B004D`) - integer part of reference frequency. • Next 3 bytes (`047750`) - fractional part of reference frequency. • Next 2 bytes (`41B8`) - reference frequency thermistor raw A/D counts. • Next 3 bytes (`0A415A`) - conductivity number. • Last 4 bytes (`09D6C548`) - start time of reference frequency scan measurement (seconds since January 1, 2000).

Convert Hex converts the hex data and creates two files:

- Output tide (.tid) file - pressure (psia), temperature (°C), (optional) conductivity (S/m) and salinity (psu), and date and time.
- Output reference frequency (.ref) file – reference frequency (Hz), reference frequency thermistor output (Hz), and date and time.

Data conversions are described below:

pressure frequency (Hz) = PF = pressure number / 50000
pressure temperature compensation frequency (Hz) = PTCF
= pressure temperature number / 12500

Pressure is computed as follows:

$U = [(1.0 / PTCF) * 1000000] - U0$
$C = C1 + (C2 * U) + (C3 * U^2)$
$D = D1 + D2$ but $D2 = 0$, so $D = D1$
$T0 = (T1 + T2 * U + T3 * U^2 + T4 * U^3) / 1{,}000{,}000$
$W = 1.0 - (T0 * T0 * PF * PF)$

pressure (psia)
= slope correction * [{C * W * (1.0 - D * W)} + POFFSET] + offset correction
where

- U0, C1, C2, C3, D1, T1, T2, T3, T4, and POFFSET are entered in the SBE 53 EEPROM at the factory using the calibration coefficient commands, and are read by Convert Hex from the uploaded .hex file header (in the **DC** command response).
- Slope and offset corrections are read from the Convert Hex calibration coefficients (.psa) file.

temperature (°C) = 1.0 / [TA0 + (r*{TA1 + r*(TA2 + r*TA3)})] – 273.15
where

- r = ln (temperature A/D counts).
- temperature A/D counts is converted from Hex to decimal.
- TA0, TA1, TA2, and TA3 are entered in the SBE 53 EEPROM at the factory using the calibration coefficient commands, and are read by Convert Hex from the uploaded .hex file header (in the **DC** response).

conductivity frequency (Hz) = conductivity number / 256
where

- Conductivity number is converted from Hex to decimal.

Conductivity frequency is converted to conductivity using the coefficients and equation found on the calibration certificate for the sensor. These coefficients are entered in the SBE 53 EEPROM at the factory using the calibration coefficient commands, and are read by Convert Hex from the uploaded .hex file header (in the **DC** response).

time = time number = number of seconds since January 1, 2000

- Time number is converted from Hex to decimal.

Tide Data Format (.tid extension)

A .tid file is created from the .hex file in Convert Hex. A sample tide data (.tid) file is shown below:

```
1   04/06/05 10:27:16   14.8125    22.102   3.55682    23.909
2   04/06/05 10:28:16   15.0086    14.818   3.48032    27.844
3   04/06/05 10:29:16   15.0836    11.242   3.07901    26.714
4   04/06/05 10:30:16   15.1536     8.951   3.07101    28.376
5   04/06/05 10:31:16   15.2267     7.225   3.06788    29.772
```

- Column 1 = Tide measurement number
- Columns 2 and 3 = Date and time of beginning of tide measurement
- Column 4 = Raw (uncorrected) pressure (psia)
- Column 5 = Water temperature (°C)
- Column 6 = Conductivity (S/m)
- Column 7 = Calculated salinity (PSU)

Notes:
- If conductivity logging is not enabled (**Conductivity=N**; status display shows `conductivity = NO`), the conductivity and salinity columns are not included in the .tid file.
- See *Making Corrections Using Reference Frequency Data* below for pressure correction algorithm.

If Merge Barometric Pressure has been run on the .tid file to remove the effect of barometric pressure, the output .tid file contains descriptive column headings. The presence of headings in the .tid file indicates that it has been processed by Merge Barometric Pressure. Additionally, Merge Barometric Pressure has the ability to replace the pressure in the fourth column with calculated water depth. See *Section 7: Tide Data Processing – Merge Barometric Pressure* for details, and for the required data format for the barometric pressure (.bp) file to input in Merge Barometric Pressure.

Format with -t Command Line Option

When Convert Hex is run with the –t command line option, Convert Hex adds diagnostic information to the .tid file. The .tid file output is:

- Column 1 = Tide measurement number
- Columns 2 and 3 = Date and time of beginning of tide measurement
- Column 4 = Pressure frequency (Hz)
- Column 5 = Pressure temperature frequency (Hz)
- Column 6 = Raw (uncorrected) pressure (psia)
- Column 7 = Water temperature (°C)
- Column 8 = Conductivity (S/m)
- Column 9 = Calculated salinity (PSU)
- Column 10 = Measured thermistor output from reference crystal oscillator (A/D counts)
- Column 11 = Reference crystal oscillator raw temperature (Hz)
- Column 12 = Last reference frequency from reference crystal oscillator (Hz)
- Column 13 = Pressure frequency computed using last measured reference frequency (Hz)
- Column 14 = Pressure temperature frequency computed using last measured reference frequency (Hz)
- Column 15 = Pressure computed using measured reference frequencies (psia)
- Column 16 = Raw (uncorrected) pressure - Pressure computed using measured reference frequencies (psia)

Reference Frequency Data Format (.ref extension)

A .ref file is created from the .hex file in Convert Hex. A sample reference frequency data (.ref) file is shown below:

```
1   04/02/2005 18:15:11 4915277.259918  17120
2   04/03/2005 18:15:11 4915277.292688  17330
3   04/04/2005 18:15:11 4915277.051838  16742
4   04/05/2005 18:15:11 4915276.899446  16532
5   04/06/2005 18:15:11 4915276.833906  16449
```

- Column 1 = Reference frequency measurement number
- Columns 2 and 3 = Date and time of beginning of reference frequency measurement
- Column 4 = Measured reference frequency from crystal oscillator (Hz)
- Column 5 = Measured thermistor output from crystal oscillator (A/D counts)

The reference frequency data can be used to correct the .tid data for long-term drift of the pressure sensor (expected to be on the order of 1 ppm per year). **Sea-Bird does not currently supply software to do this correction.**

Making Corrections Using Reference Frequency Data

You can use the reference frequency data in the pressure scans and in the reference frequency scans to correct uploaded data for pressure sensor frequency drift.

Reference frequency (Hz) **= Fm** = IRF + FRF / 10^6
where
- IRF = integer part of reference frequency **in reference frequency scan**
- FRF = fractional part of reference frequency **in reference frequency scan**

fc = FRA0 + (RFT * {FRA1 + RFT * [FRA2 + RFT * FRA3]})
where
- RFT = reference frequency thermistor raw A/D counts in **reference frequency scan**
- FRA0, FRA1, FRA2, and FRA3 are entered in the SBE 53EEPROM at the factory using the calibration coefficient commands

offset = fm – fc

fy = FRA0 + (RFTP * {FRA1 + RFTP * [FRA2 + RFTP * FRA3]})
where
- RFTP = reference frequency thermistor raw A/D counts in **pressure scan**
- FRA0, FRA1, FRA2, and FRA3 are entered in the SBE 53 EEPROM at the factory using the calibration coefficient commands

fCor = fy + offset
where
offset is a function of time (defined above)

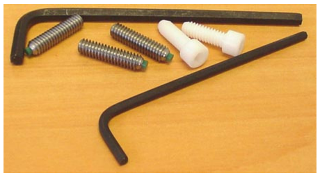
corrected pressure frequency = recorded pressure frequency * fCor / fy

corrected pressure temperature frequency
= recorded pressure temperature frequency * fCor / fy

Notes:
- When you output real-time data (**TxTide=Y**) or query the SBE 53 with **SL** or **SLO**, it outputs both data that has not been corrected for drift (pr) and data that has been corrected for drift (pc). The SBE 53 uses data from the most recent reference scan in the correction calculation.
- Data uploaded from memory (.hex file) and uploaded data converted to engineering units (.tid file) have not been corrected for drift.

Appendix IV: Electronics Disassembly/Reassembly

Jackscrew kit



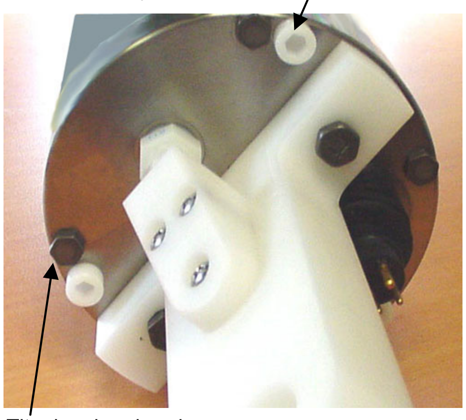
Sea-Bird provides a jackscrew kit with the SBE 53, to assist in removal of the connector end cap. The kit contains:

- 2 Allen wrenches
- 3 jackscrews
- 2 spare plastic socket hex-head screws

Disassembly

CAUTION:
Disconnect and dismount the optional SBE 4M conductivity cell from the SBE 53 before disassembly to avoid breaking the conductivity cell.

Plastic hex-head screw (typical, 3 places)



Titanium hex-head screw (typical, 4 places)

1. Establish communications with the SBE 53 (see *Section 5: SBE 53 Setup, Installation, and Data Upload - SeatermW* for details). **As a precaution, click Upload to upload any data in memory before beginning.**

2. Wipe the outside of the end cap and housing dry, being careful to remove any water at the seam between them.

3. Remove the four titanium hex-head screws securing the connector end cap to the housing.

4. Remove the three plastic hex-head screws from the end cap using the larger Allen wrench. Insert the three jackscrews in these three holes in the end cap. When you begin to feel resistance, use the smaller Allen wrench to continue turning the screws. Turn each screw 1/2 turn at a time. As you turn the jackscrews, the end cap will push away from the housing. When the end cap is loosened, pull it and the PCB assembly out of the housing.

5. Remove any water from the O-ring mating surfaces inside the housing with a lint-free cloth or tissue. Be careful to protect the O-rings from damage or contamination.

6. Disconnect the Molex connector connecting the PCB assembly to the battery compartment bulkhead.

7. Remove the jackscrews from the end cap.

Reassembly

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

1. Install a new desiccant bag each time you open the electronics chamber. If a new bag is not available, see *Application Note 71: Desiccant Use and Regeneration (drying)*.
2. If possible, dry gas backfill each time you open the housing. If you cannot, wait at least 24 hours before redeploying, to allow the desiccant to remove any moisture from the housing.

Note that opening the battery compartment does not affect desiccation of the electronics.

1. Remove any water from the O-ring and mating surfaces with a lint-free cloth or tissue. Inspect the O-ring and mating surfaces for dirt, nicks, and cuts. Clean or replace as necessary. Apply a light coat of O-ring lubricant (Parker Super O Lube) to O-ring and mating surfaces.
2. Reconnect the Molex connector to the PCB assembly. Verify the connector holds and pins are properly aligned.
3. Carefully fit the PCB assembly into the housing, aligning the holes in the end cap and housing.
4. Reinstall the 4 hex-head screws to secure the end cap to the housing.
5. Reinstall the 3 plastic hex head screws in the end cap.
6. Establish communications with the SBE 53 (see *Section 5: SBE 53 Setup, Installation, and Data Upload - SeatermW* for details). Reset the date and time (**SetTime**) and initialize logging (**InitLogging**) before redeploying. No other parameters should have been affected by electronics disassembly (send **DS** to verify).

Appendix V: 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.	EPA Registration No. 74489-1
1808 - 136th Place Northeast	EPA Establishment No. 74489-WA-1
Bellevue, WA 98005	

AF24173 Anti-Foulant Device

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

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

DANGER
See Precautionary Statements for additional information.

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

Net Contents: Two anti-foulant devices

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

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

PRECAUTIONARY STATEMENTS

HAZARD TO HUMANS AND DOMESTIC ANIMALS

DANGER

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

PERSONAL PROTECTIVE EQUIPMENT

USER SAFETY RECOMMENDATIONS

Users should:

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

ENVIRONMENTAL HAZARDS

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

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

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

STORAGE AND DISPOSAL

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

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

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

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

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

Appendix VI: Pressure-to-Depth Conversion

Force is mass * acceleration, units are Newtons [N]:

$N = Kg\ m / sec^2$

Density (ρ) is mass / volume, units are [Kg / m^3]:

This is the *in situ* value, and is approximately 1025 Kg / m^3 at the surface.

Specific weight (W) is weight / volume, units are [N / m^3]:

$W = \rho * g$

where g = local gravity [m / sec^2]

Hydrostatic equation:

$p = p_{atm} + W * z$

p_{atm} = atmospheric pressure in Pascals [N / m^2]

p = total pressure in Pascals [N / m^2]

W is average density times gravity [N / m^3]

z = depth [m]

Conversions:

1 Pascal = 10^{-4} decibars

1 psi = 0.6894757 decibars

Example:

average density = 1025 kg / m^3

average gravity = 9.8 m / sec^2

pressure reading = 6000 decibars = 6×10^7 Pascals

atmospheric pressure = 14.7 psia = 1.013529×10^5 Pascals

$W = 1025 * 9.8 = 10045$ [N / m^3]

$6 \times 10^7 - 1.013529 \times 10^5 = 10045 * z$

$z = 5.989865 \times 10^7 / 10045 = 5963.031$ meters

Appendix VII: Replacement Parts

Part Number	Part	Application Description	Quantity in 53
22018	Alkaline D-cell batteries, Duracell MN1300 (LR20)	Power 53	12
41124B	Battery cover plate	Retains **alkaline** D-cell batteries	1
801575	Battery cover plate/spacer	Retains **lithium** DD-cell batteries with buttons	-
30346	Screw, 10-24 x 1" hex-head, titanium	Secures connector end cap to housing	4
50092	SBE 16/19 Jackscrew Kit	For removing connector end cap	1
60021	Spare battery end cap hardware and o-rings	O-rings and hardware, including: • 30145 Screw, 6-32 x 1/2" Phillips-head, stainless steel (secures battery cover plate to battery posts) • 30242 Washer, #6 flat, stainless steel (for screw 30145) • 30816 Parker 2-234E603-70 (battery end cap to housing piston seal) • 30090 Parker 2-153N674-70 (battery end cap to housing face seal)	-
50056	Spare parts kit	Assorted hardware and o-rings, including: • 30145 Screw, 6-32 x 1/2" Phillips-head, stainless steel (secures battery cover plate to battery posts) • 30242 Washer, #6 flat, stainless steel (for screw 30145) • 30447 Bolt ¼-20 x 1¼ Hex, titanium (secures lift eye to connector end cap and plastic bar to battery end cap) • 30816 Parker 2-234E603-70 (battery end cap to housing piston seal) • 30090 Parker 2-153N674-70 (battery end cap to housing face seal) • 30815 Parker 2-233E603-70 (connector end cap to housing radial piston seal)	-

Continued on next page

Continued from previous page

Part Number	Part	Application Description	Quantity in 53
17695	3-pin RMG-3FS to 3-pin RMG-3FS cable, 0.28 m (11 in.) long	From SBE 53 to optional conductivity sensor	1
171752	3-pin to MCIL-3FS (wet-pluggable connector) to 3-pin RMG-3FS cable, 0.28 m (11 in.) long	From SBE 53 to optional conductivity sensor	1
801225	4-pin RMG-4FS to DB-9S data I/O cable, 2.4 m (8 ft) long	From SBE 53 to computer	1
801374	4-pin MCIL-4FS (wet-pluggable connector) to DB-9S data I/O cable, 2.4 m (8 ft) long	From SBE 53 to computer	1
171888	25-pin DB-25S to 9-pin DB-9P cable adapter	For use with computer with DB-25 connector	-
17043	Locking sleeve	Locks I/O cable or dummy plug in place	2
171192	Locking sleeve (wet-pluggable connector)	Locks I/O cable or dummy plug in place	2
17045.1	3-pin RMG-3FS dummy plug with locking sleeve	For when optional conductivity sensor not used	1
171500.1	3-pin MCDC-3-F (wet-pluggable) dummy plug with locking sleeve	For when optional conductivity sensor not used	1
17046.1	4-pin RMG-4FS dummy plug with locking sleeve	For I/O connector during deployment	1
171398.1	4-pin MCDC-4-F (wet-pluggable) dummy plug with locking sleeve	For I/O connector during deployment	1
801542	AF24173 Anti-Foulant Device	For use with optional conductivity sensor – Bis(tributyltin) oxide device inserted into anti-foulant device cup in mount kit	1 (set of 2)
50315	Anti-foulant device mount kit	Mounts on ends of conductivity cell to hold AF24173 Anti-Foulant Devices	1
30411	Triton X-100	Octyl Phenol Ethoxylate – Reagent grade non-ionic cleaning solution for conductivity cell (supplied in 100% strength; dilute as directed)	1

Index

L

M

P

Q

R

S

T

U

BPR Bottom Pressure Recorder SBE 53

The SBE 53 BPR measures full ocean depth water level with extremely high resolution, accuracy, and stability. The BPR combines a uniquely precise and stable time base with low power frequency acquisition circuitry, Paroscientific Digiquartz® pressure transducer, non-volatile 32 MB FLASH memory, and a precision thermometer, to provide unprecedented bottom pressure recording capability. An optional conductivity sensor (SBE 4M) can be added to provide salinity data as well.

The BPR integrates pressure measurements to obtain water levels (tides) unaffected by wave action. The interval between each water level measurement and the duration of the integration period are user-programmable. The interval is programmable over a range of 1 minute to 1 hour. The integration duration is programmable from 1 minute to the entire tide interval. The BPR can continuously power the pressure transducer and reference frequency oscillator, eliminating turn-on transients and providing the highest quality data. Alternatively, the BPR can be programmed to enter a power-down state between measurements to conserve battery power for very long deployments, with a user-specified *warm-up* period before each pressure measurement. Temperature data is recorded with each pressure integration. Logging (recording) can be programmed to start and stop at specified times after the instrument is deployed.

The pressure signal and internal temperature compensation (pressure temperature) signal (frequencies) from the transducer are integrated in parallel for the tide integration duration. The measurement times are set by a continuously powered, real-time clock with an accuracy of ± 5 seconds/month. Long-term drift of the counter's reference frequency is on the order of 1 ppm per year. To allow for correction of drift, an ovenized crystal oscillator is programmed to periodically make a reference frequency measurement.

Large memory and low power requirements permit frequent water level recording. For example, with standard alkaline batteries, a 420-day deployment could include water level measurements every 30 minutes (integrating pressure for the entire 30 minutes); a 2-year deployment could be achieved if pressure integration is limited to 4 minutes for each water level measurement, with a 15-minute warm-up of the pressure sensor and reference frequency oscillator before each measurement. Alternatively, deployments approximately 3 times longer are possible with Electrochem DD lithium batteries. Binary upload of data in memory can be accomplished at up to 115,200 baud.

Firmware upgrades can be downloaded via the serial interface without opening the electronics compartment.

STANDARD CONFIGURATION

- Titanium housing for depths to 7000 meters (22,900 ft)
- 1300, 2000, 4000, or 6800 meter (2000, 3000, 6000, or 10000 psia) Paroscientific Digiquartz temperature-compensated pressure sensor
- Accurate temperature sensor – aged thermistor embedded in BPR end cap
- Frequency input channel and bulkhead connector for optional SBE 4M conductivity sensor
- 32 MB FLASH memory
- 12 alkaline D-cell batteries (Duracell MN1300, LR20); battery compartment is separated from electronics by a moisture-proof seal.
- Impulse glass-reinforced epoxy bulkhead connectors

OPTIONS

- SBE 4M Conductivity sensor, interfaced via bulkhead connector and clamped to BPR housing
- High accuracy external temperature sensor
- Wet-pluggable (MCBH) connectors in place of standard connectors

SOFTWARE

The BPR includes a comprehensive package of Windows programs for instrument setup and data retrieval, data conversion, and plotting.

BPR Bottom Pressure Recorder SBE 53

SPECIFICATIONS

Pressure
Range: 0 to 1300, 2000, 4000, or 6800 m (2000, 3000, 6000, or 10000 psia)
Accuracy *: 0.01% of full scale
Repeatability: 0.005% of full scale
Hysteresis: 0.005% of full scale
Calibration: 0 psia to full scale pressure
Resolution: 0.045 ppm (0.3 mm for 10,000 psia range, 1-minute integration, continuously powered)

* Digiquartz residual temperature sensitivity is measured at Sea-Bird, and Digiquartz calibration coefficients are adjusted so that residual temperature sensitivity is less than 1 ppm over 0 – 20 °C (0.05 ppm/°C; 0.0005 psia for a 10,000 psia range sensor).

Standard Temperature [°C]
Range: -5 to +35 Accuracy: 0.01
Resolution: 0.001 Calibration: +1 to +32 [1]

High Accuracy Temperature [°C] (optional)
Range: -5 to +35 Accuracy: 0.002
Resolution: 0.0001 Calibration: +1 to +32 [1]

Conductivity [S/m] (optional)
Range: 0 to 7 Accuracy: 0.001
Resolution: 0.00002
Calibration: 2.6 – 6 plus zero conductivity (air) [1]

[1]Measurements outside specified calibration ranges will be at slightly reduced accuracy due to extrapolation errors.

Clocks
Counter Time Base (for Digiquartz pressure & pressure temperature):
Quartz TCXO ± 3 ppm per year aging
(± 1 ppm/year typical), ± 0.1 ppm (0 - 20 °C)
Ovenized Crystal Oscillator (for reference frequency drift correction):
Warm-up re-stabilization: less than ± 1×10^{-7}
Stability vs. temperature: ± 0.1 ppm (-20 °C to +70 °C)
Aging: < 1×10^{-7} per year, less than 1×10^{-6} /10 years
Real-Time Clock (for time stamp and sample timing):
Quartz TCXO watch-crystal type 32,768 Hz;
accuracy ± 2 ppm (5 seconds/month).
Battery-backed for minimum 2-year operation, without main batteries installed.
Conductivity Time Base:
Quartz TCXO ± 1 ppm per year aging;
± 15 ppm (-20 to +70 °C).

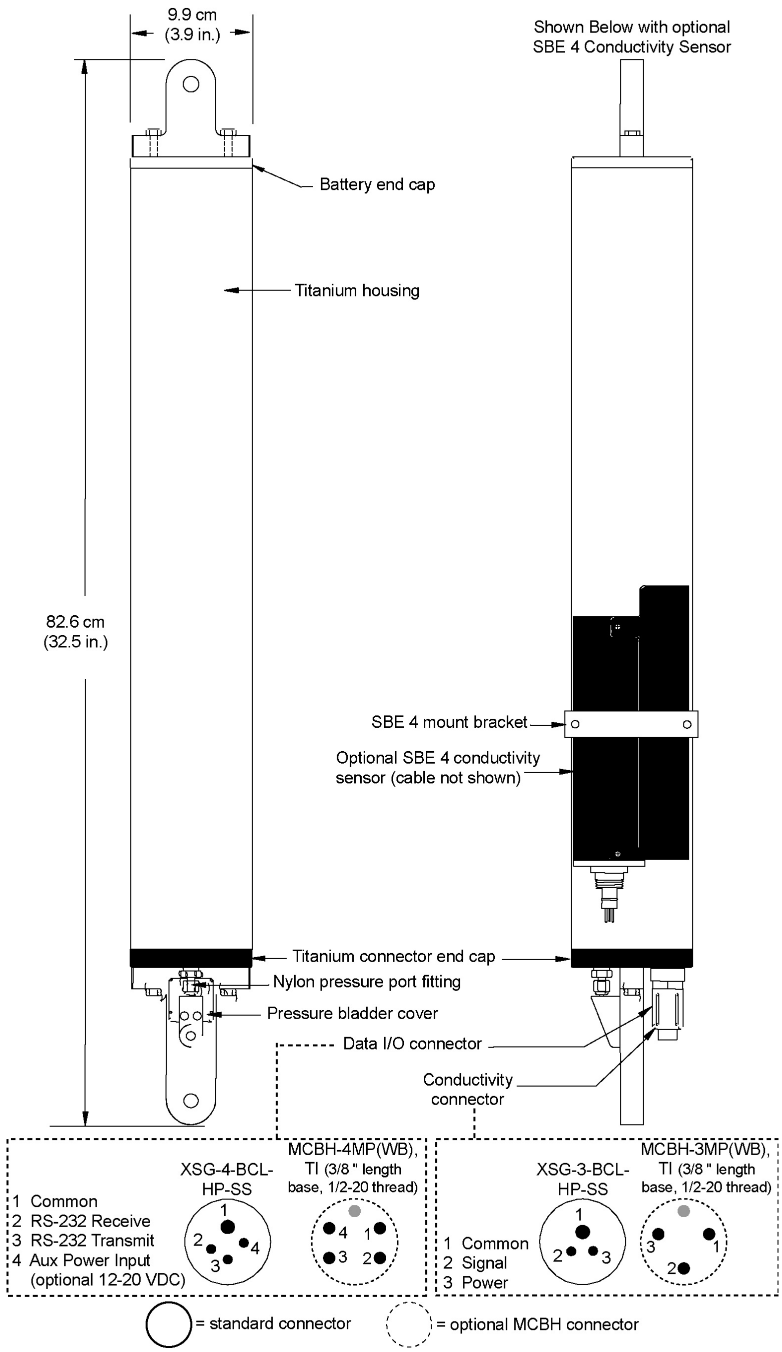
Memory: 32 MB Flash RAM.

Data Storage: 17 bytes/sample (no conductivity)
20 bytes/sample (with conductivity)

Power Supply: Internal: 12 alkaline D cells, Duracell MN 1300, LR20 (standard) **or**
6 lithium DD cells (Electrochem BCX85-3B76-TC)
External: 12 – 24 VDC nominal.

Housing: Titanium to 7000 m

Weight (with alkaline batteries):
14.5 kg (32 lbs) in air, 8.6 kg (19 lbs) in water



08/09

Sea-Bird Electronics, Inc.
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CALIBRATION SHEETS

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 0070

CALIBRATION DATE: 23-Jan-11

SBE 53 TEMPERATURE CALIBRATION DATA

ITS-90 COEFFICIENTS

a0 = 2.898154e-004

a1 = 2.423056e-004

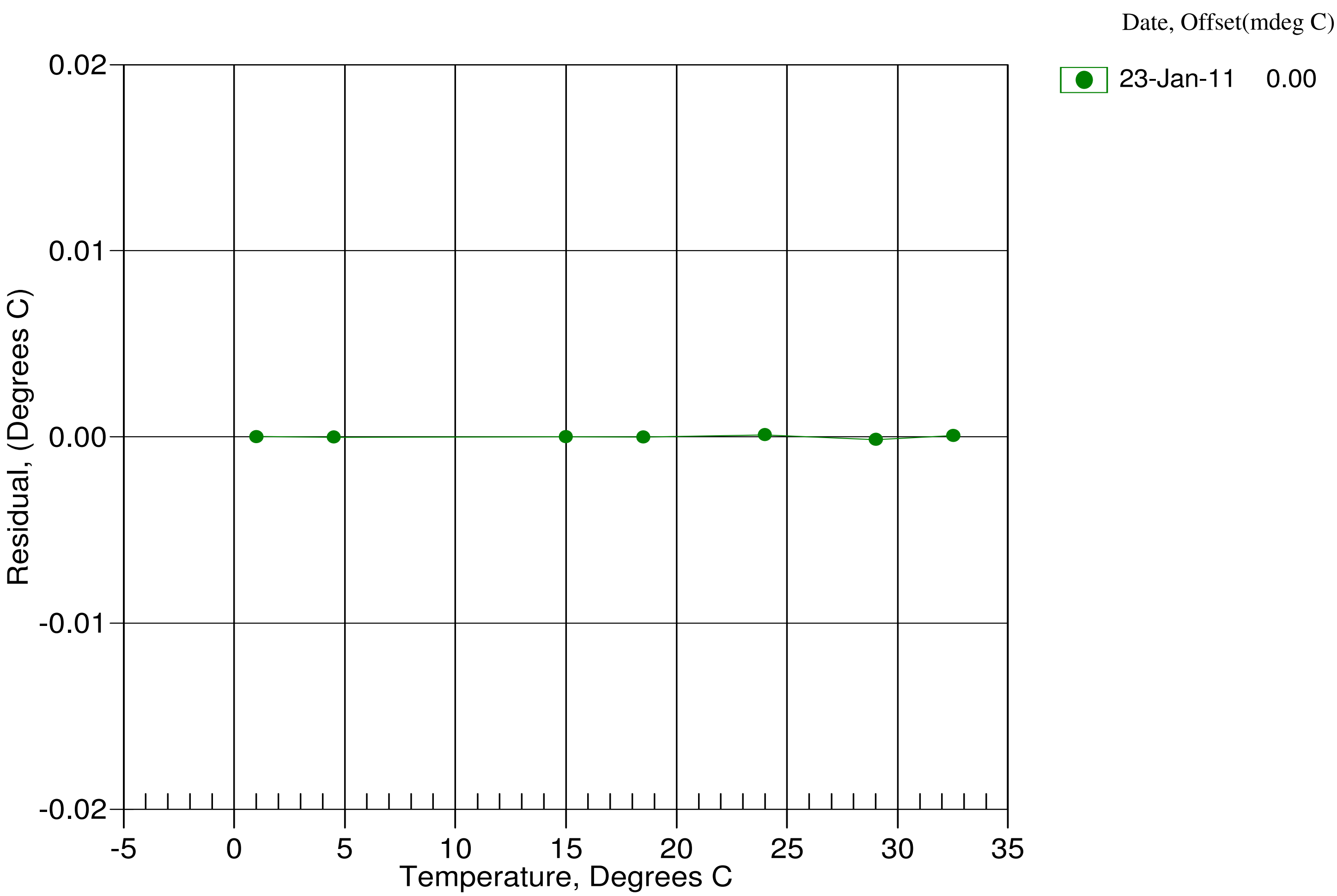
a2 = -1.036390e-006

a3 = 1.360302e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	593987.6	1.0000	0.0000
4.5000	505822.0	4.5000	-0.0000
15.0000	318383.8	15.0000	0.0000
18.5000	274519.4	18.5000	-0.0000
24.0000	218742.8	24.0001	0.0001
29.0000	179000.0	28.9998	-0.0002
32.5000	156063.7	32.5001	0.0001

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

Residual = instrument temperature - bath temperature



Sea-Bird Electronics, Inc. FAX: (425) 643-9954
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5362517-0070 10-Febuary-2011
Pressure Range: 10,000 psia
Pressure sensor Serial Number: 119383
Pressure sensor Type: Digiquartz

Pressure offset correction for SBE 53 Bottom Pressure Recorder

Pressure sensor output in the SBE 53 Bottom Pressure Recorder is sensitive to ambient pressure (including elevation and atmospheric pressure) and orientation of the instrument. As part of the test of this instrument, the output of the pressure sensor was measured in a vertical orientation with the sensor submerged **8cm** under water. This data was averaged and compared to the output of a precision barometer at an elevation of 43 feet above sea level with compensation for the depth of the instrument in water. The difference between these two measurements has been entered into instrument as an offset correction. The slope correction for the SBE 53 is nominally set to 1.0 for new instruments. The offset correction should be recalculated by the end-user in a manner appropriate for the intended use of the instrument.

ATMOSPHERIC CALIBRATION DATA

Orientation: Vertical
Pressure Sensor Range 10,000 psia

Reference Pressure (psia)	SBE 53 pressure (psia)	Difference (psia)
14.8977	14.9532	-0.0555

These coefficients are entered into the instrument by Sea-Bird Electronics.

OFFSET = -0.0555
SLOPE = 1

Vertical Orientation

Sea-Bird Electronics, Inc.
13431 NE 20th Street, Bellevue, Washington 98005 USA
Website: http://www.seabird.com

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Tel: (425) 643-9866
Email: seabird@seabird.com

Crystal Calibration: SBE 53 S/N 0070 Date 10-Feb-2011

Sea-Bird Electronics has performed a calibration on the Crystal Oscillator installed in SBE 53 S/N 0070. The calibration coefficients are listed below. These are entered into the instrument at the factory. They are provided here in case the equipment is reset for any reason and the coefficients are deleted. Type the coefficients as shown below:

```
FRA0= 3999897.72785
FRA1= 0.014358624
FRA2= -4.2346614e-007
FRA3= 2.6595965e-012
FRA4= 2.3006113e-016
FRA5= -6.6342432e-021
FRA6= 5.5110001e-026
```

CALIBRATION COEFFICIENTS

PAROSCIENTIFIC
PRESSURE TRANSDUCER
Corrected coefficients for SBE-53, SN 0070.

Serial No: **119383**
Original Cal Date: 8/16/2010
Corrected Cal Date: 2/10/2011

MODEL:	PRESSURE RANGE:	TEMP. RANGE:	PORT:
410K-134	0 to 10000 psia	0 to 125 deg C	oil filled

TEMPERATURE COEFFICIENTS

X = temperature period (µsec)

$U = X - U_0$

Temperature: (deg C)

$Temp = Y_1U + Y_2U^2 + Y_3U^3$

U0	5.823774	µsec
Y1	-3801.392	deg C/µsec
Y2	-9623.166	deg C/µsec^2
Y3	0	

PRESSURE COEFFICIENTS

T = pressure period (µsec)

$C = C_1 + C_2U + C_3U^2$

$D = D_1 + D_2U$

$T_0 = T_1 + T_2U + T_3U^2 + T_4U^3 + T_5U^4$

pressure: (psia)

$P = C(1 - (T_0^2/T^2))(1 - D(1 - (T_0^2/T^2)))$

C1	*-47871.986*	*psia*
C2	*-1.473409E+03*	*psia/µsec*
C3	1.628382E+05	psia/µsec^2
D1	0.035415	
D2	0	
T1	*29.95897*	*µsec*
T2	*6.705212E-01*	*µsec/µsec*
T3	6.295587E+01	µsec /µsec^2
T4	1.966443E+02	µsec /µsec^3
T5	0	

SBE

Digiquartz Pressure Calibration Coefficients

Corrected at Sea-Bird Electronics on **10-Feb-2011**

as per Paroscientific Calibration and SBE dP/dT tests.

(Changed coefficients are posted in italics.)

B

CALIBRATION COEFFICIENTS

PRESSURE TRANSDUCER

SERIAL NO : 119383

DATE : 08-16-2010

MODEL :	PRESSURE RANGE :	TEMP. RANGE :	PORT :
410K-134	0 to 10000 psia	0 to 125 deg C	

TEMPERATURE COEFFICIENTS

X = temperature period (µsec)

$U = X - U_0$

Temperature : (deg C)

$$Temp = Y_1U + Y_2U^2 + Y_3U^3$$

U_0	5.823774	µsec
Y_1	-3801.392	deg C/µsec
Y_2	-9623.166	deg C/µsec^2
Y_3	0	

PRESSURE COEFFICIENTS

T = pressure period (µsec)

$$C = C_1 + C_2U + C_3U^2$$

$$D = D_1 + D_2U$$

$$T_0 = T_1 + T_2U + T_3U^2 + T_4U^3 + T_5U^4$$

Pressure : (psia)

$$P = C\left(1 - \frac{T_0^2}{T^2}\right)\left(1 - D\left(1 - \frac{T_0^2}{T^2}\right)\right)$$

C_1	-47870.27	psia
C_2	-1503.874	psia/µsec
C_3	162838.2	psia/µsec^2

D_1	0.035415
D_2	0

T_1	29.95947	µsec
T_2	0.661673	µsec/µsec
T_3	62.95587	µsec/µsec^2
T_4	196.6443	µsec/µsec^3
T_5	0	

(08-16-2010)

HISTORY

PAROSCIENTIFIC, INC.
4500 148th AVENUE N.E.
REDMOND, WA. 98052

CUSTOMER : SEABIRD ELECTRONICS, INC.

PARO TEST 12

SALES ORDER : 27828

PREPARED BY : T.C.

CALIBRATION COEFFICIENTS

PRESSURE TRANSDUCER

SERIAL NO : 119383

DATE : 08-16-2010

MODEL :	PRESSURE RANGE :	TEMP. RANGE :	PORT :
410K-134	0 to 10000 psia	0 to 125 deg C	

PRESSURE COEFFICIENTS AT FIXED TEMPERATURE

(only valid at specified temperature)

T = pressure period (μsec)

Pressure equation : (psia)

$$P = C\left(1 - \frac{T_0^2}{T^2}\right)\left(1 - D\left(1 - \frac{T_0^2}{T^2}\right)\right)$$

Temperature: 21.0 C

C (psia)	-47856.72				
D	0.035415				
T_0 (μsec)	29.95771				

(08-16-2010)

PAROSCIENTIFIC, INC.
4500 148th AVENUE N.E.
REDMOND, WA. 98052

CUSTOMER : SEABIRD ELECTRONICS, INC.

PARO TEST 12

SALES ORDER : 27828 PREPARED BY : T.C.

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PRESSURE TEST CERTIFICATES

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

SBE Pressure Test Certificate

Test Date: **1/20/2011** Description **SBE-53 Bottom Pressure Recorder**

Job Number: **62517** Customer Name **MBARI**

SBE Sensor Information:

Model Number: **53BPR**
Serial Number: **0070**

Pressure Sensor Information:

Sensor Type: **DigiQuartz**
Sensor Serial Number: **119383**
Sensor Rating: **10000**

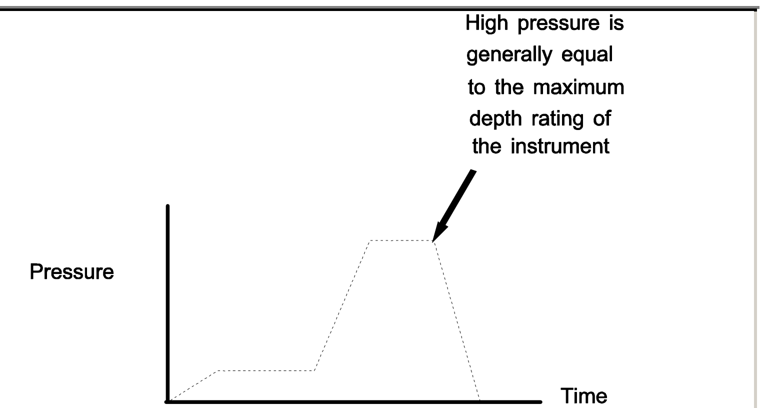
Pressure Test Protocol:

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

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

Passed Test: ☑

Tested By: nd



typical Test Profile

APPLICATION NOTES

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

ITS-90 TEMPERATURE SCALE

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

The international oceanographic research community continues to use IPTS-68 (T68) for computation of salinity and other seawater properties. Therefore, following the recommendations of Saunders (1990) and as supported by the Joint Panel on Oceanographic Tables and Standards (1991), our software and our instrument firmware (for instruments that can calculate and output salinity and other seawater properties directly) converts between T68 and T90 according to the linear relationship:

$$T_{68} = 1.00024 * T_{90}$$

The use of T68 for salinity and other seawater calculations is automatic in our software and in those instruments that directly output salinity and other seawater parameters.

Note: In our SEASOFT V2 suite of software programs, edit the CTD configuration (.con or .xmlcon) file to enter calibration coefficients using the Configure Inputs menu in Seasave V7 (real-time data acquisition software) or the Configure menu in SBE Data Processing (data processing software).

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

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

SEASOFT supports entry of either the T90 or the T68 coefficients for these instruments. When selecting temperature as a display/output variable, you must select which standard (T90 or T68) is to be used to compute temperature. SEASOFT recognizes whether you have entered T90 or T68 coefficients in the configuration (.con or .xmlcon) file, and performs the calculations accordingly, depending on which coefficients were used and which display variable type is selected.

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

SBE 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 26*plus*, 35, 35RT, 37 (all), 38, 39 and 39-IM, 45, 49, 51, 52-MP, 53, *and all higher numbered instruments*

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

- Instruments that can internally compute and then output salinity and other seawater parameters (for example, SBE 37-SI) - Use of T68 for salinity and other seawater calculations is automatic; the instrument internally performs the conversion between T90 and T68 according to the Saunders equation.
- Instruments supported in SEASOFT (for example, SBE 19*plus* V2) - Use of T68 for salinity and other seawater calculations is automatic; the software performs the conversion between T90 and T68 according to the Saunders equation. When selecting temperature as a display/output variable, you must select which standard (T90 or T68) is to be used to compute temperature.

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

Connector Care and Cable Installation

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

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

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

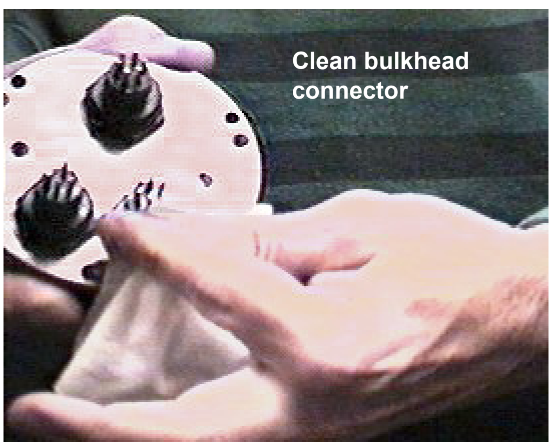
Connector Cleaning and Inspection, and Cable / Dummy Plug Installation

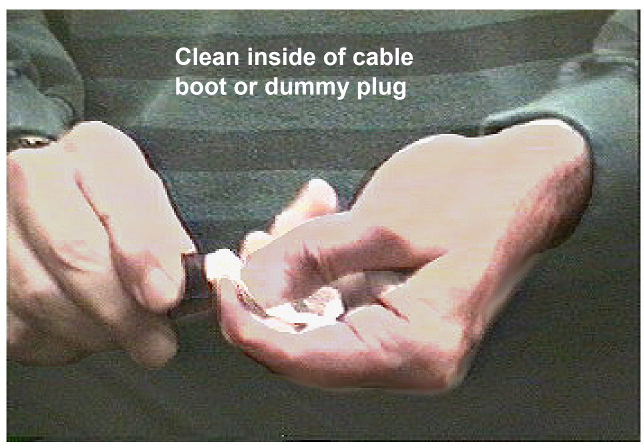
Clean and inspect connectors, cables, and dummy plugs:

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

Follow this procedure:

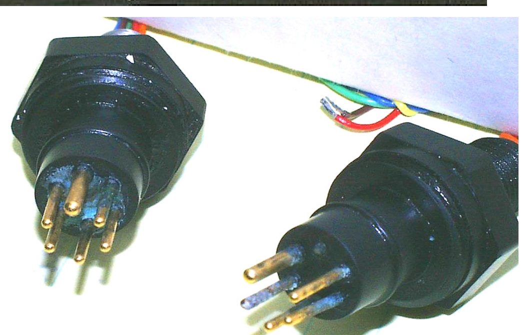
1. Carefully clean the bulkhead connector and the inside of the mating cable's boot or the dummy plug with a Kim wipe. Remove all grease, hair, dirt, and other contamination.





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

   Replace severely corroded or otherwise damaged connectors, cables, and dummy plugs - contact Sea-Bird for instructions and a Return Material Authorization (RMA) number.



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

3. Using a tube of 100% silicone grease (Dow DC-4 or equivalent), grease the bulkhead connector and the cable boot or dummy plug.

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

   A. Squeeze the silicone grease -- approximately half the size of a pea -- onto the end of your finger. Apply a light, even coating of grease to the molded ridge around the base of the bulkhead connector. The ridge looks like an O-ring molded into the bulkhead connector base and fits into the groove of the mating cable boot or dummy plug.

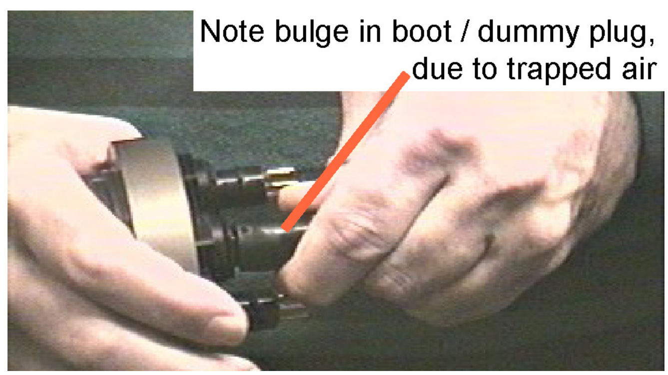
   B. Squeeze approximately half the size of a pea of the silicone grease onto the end of your finger. Apply a light, even coating of grease to the inside of the cable boot or dummy plug.

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

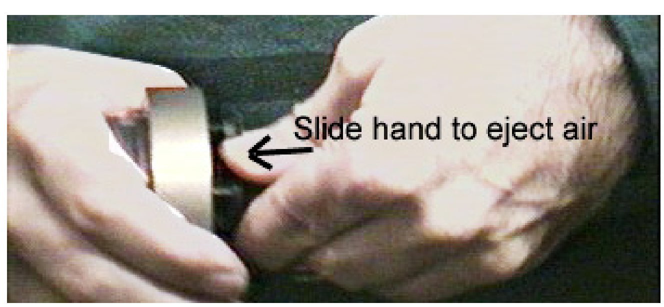
   Optional wet-pluggable MCBH connectors only: Align the non-conducting guide pin and the conducting pins with the mating sockets.

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

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



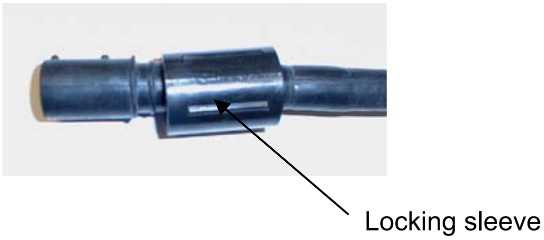
6. *Standard XSG/AG connectors only:* After the cable or dummy plug is mated, run your fingers along the cable boot or dummy plug toward the bulkhead connector, *milking* any trapped air out of the boot or plug. You should hear the air being ejected.
   CAUTION:
   Failure to eject the trapped air will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



Locking Sleeve Installation

After the cable boot or dummy plug is mated to the bulkhead connector, install the locking sleeve. The locking sleeve secures the cable or dummy plug to the bulkhead connector and prevents them it being inadvertently removed. Important points regarding locking sleeves:

- Tighten the locking sleeve by hand. **Do not** use a wrench or pliers to tighten the locking sleeve. Over-tightening will gall the threads, which can bind the locking sleeve to the bulkhead connector. Attempting to remove a tightly bound locking sleeve may instead result in the bulkhead connector actually unthreading from the end cap. A loose bulkhead connector will lead to a flooded instrument. **Pay particular attention when removing a locking sleeve to ensure the bulkhead connector is not loosened**.
- It is a common misconception that the locking sleeve provides watertight integrity. **It does not, and continued re-tightening of the locking sleeve will not *fix* a leaking connector**.
- As part of routine maintenance at the end of a day's casts, remove the locking sleeve, slide it up the cable, and rinse the connection (still mated) with fresh water. This will prevent premature cable failure.



Cold Weather Tips

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

Removing a *Frozen* Cable Boot or Dummy Plug:

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

Installing a Standard XSG/AG Cable or Dummy Plug:
When possible, install cables and dummy plugs in warm environments. If not, warm the cable boot or dummy plug sufficiently so it is flexible. A flexible cable boot or dummy plug will install properly.

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

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APPLICATION NOTE NO. 67 October 2001

Editing Sea-Bird .hex Data Files

After acquiring real-time .hex data or uploading .hex data from CTD memory, users sometimes want to edit the header to add or change explanatory notes about the cast. Some text editing programs modify the file in ways that are not visible to the user (such as adding or removing carriage returns and line feeds), but that corrupt the format and prevent further processing by SEASOFT (both DOS and Windows versions). **This Application Note provides details on one way to edit a .hex data file with a text editor while retaining the required format.** The procedure described below has been found to work correctly on computers running Win 98, Win 2000, and Win NT. If the editing is not performed using this technique, SEASOFT may reject the data file and give you an error message.

1. Make a back-up copy of your .hex data file before you begin.

2. Run **WordPad**.

3. In the File menu, select Open. The Open dialog box appears. For *Files of type*, select *All Documents (*.*)*. Browse to the desired .hex data file and click Open.

4. Edit the file as desired, **inserting any new header lines after the System Upload Time line**. Note that all header lines must begin with an asterisk (*), and *END* indicates the end of the header. An example is shown below, with the added lines in bold:

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

5. In the File menu, select Save (**not** Save As). If you are running Windows 2000, the following message displays:
   You are about to save the document in a Text-Only format, which will remove all formatting. Are you sure you want to do this?
   Ignore the message and click *Yes*.

6. In the File menu, select Exit.

NOTE: This Application Note **does not apply to .dat data files**. Sea-Bird is not aware of a technique for editing a .dat file that will not corrupt the file.

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APPLICATION NOTE NO. 68

Revised June 2009

Using USB Ports to Communicate with Sea-Bird Instruments

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

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

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

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

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

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

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

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

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

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APPLICATION NOTE NO. 69 **July 2002**

Conversion of Pressure to Depth

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

Sea-Bird uses the following algorithms for calculating depth:

Fresh Water Applications

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

depth (meters) = pressure (decibars) * 1.019716

Seawater Applications

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

The gravity variation with latitude and pressure is computed as:

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

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

Then, depth is calculated from pressure:

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

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

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APPLICATION NOTE NO. 71 — Revised March 2008

Desiccant Use and Regeneration (drying)

This application note applies to all Sea-Bird instruments intended for underwater use. The application note covers:
- When to replace desiccant
- Storage and handling of desiccant
- Regeneration (drying) of desiccant
- Material Safety Data Sheet (MSDS) for desiccant

When to Replace Desiccant Bags

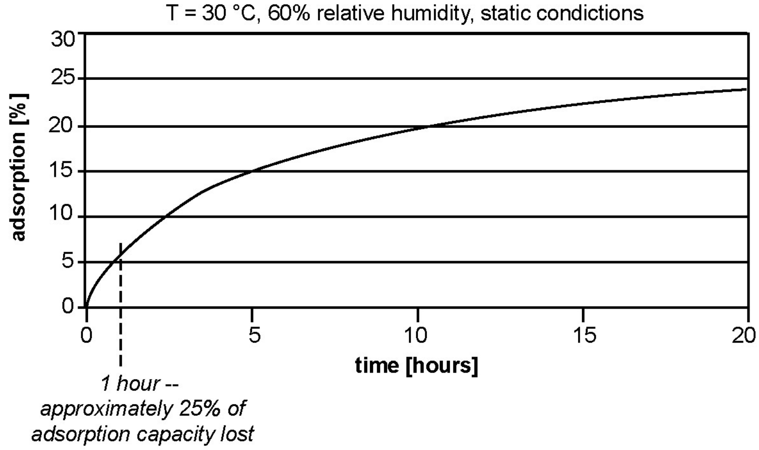
Before delivery of the instrument, a desiccant package is placed in the housing, and the electronics chamber is filled with dry Argon. These measures help prevent condensation. To ensure proper functioning:
1. Install a new desiccant bag each time you open the housing and expose the electronics.
2. If possible, dry gas backfill each time you open the housing and expose the electronics. If you cannot, wait at least 24 hours before redeploying, to allow the desiccant to remove any moisture from the chamber.

What do we mean by *expose the electronics*?
- For most battery-powered Sea-Bird instruments (such as SBE 16, 16*plus*, 16*plus* V2, 16*plus*-IM, 16*plus*-IM V2, 17*plus*, 19, 19*plus*, 19*plus* V2, 25, 26, 26*plus*, 37-SM, 37-SMP, 37-IM, 37-IMP, 44, 53, 54, 55, Auto Fire Module [AFM]), there is a bulkhead between the battery and electronics compartments. Battery replacement does not affect desiccation of the electronics, as the batteries are removed without removing the electronics and no significant gas exchange is possible through the bulkhead. Therefore, opening the battery compartment to replace the batteries does not expose the electronics; you do not need to install a new desiccant bag in the electronics compartment each time you open the battery compartment. For these instruments, install a new desiccant bag if you open the electronics compartment to access the printed circuit boards.
- For the SBE 39, 39-IM, and 48, the electronics must be removed or exposed to access the battery. Therefore, install a new desiccant bag each time you open the housing to replace a battery.

Storage and Handling

Testing by Süd-Chemie (desiccant's manufacturer) at 60% relative humidity and 30 °C shows that approximately 25% of the desiccant's adsorbing capacity is used up after only 1 hour of exposure to a constantly replenished supply of moisture in the air. In other words, if you take a bag out of a container and leave it out on a workbench for 1 hour, one-fourth of its capacity is gone before you ever install it in the instrument. Therefore:
- Keep desiccant bags in a tightly sealed, impermeable container until you are ready to use them. Open the container, remove a bag, and quickly close the container again.
- Once you remove the bag(s) from the sealed container, rapidly install the bag(s) in the instrument housing and close the housing. **Do not use the desiccant bag(s) if exposed to air for more than a total of 30 minutes.**

Adsorption Rate for Sorb-It®
(from http://www.s-cpp.com/pdf/DesiccantPerfData.pdf)
T = 30 °C, 60% relative humidity, static condictions



Regeneration (drying) of Desiccant

Replacement desiccant bags are available from Sea-Bird:

- PN 60039 is a metal can containing 25 1-gram desiccant bags and 1 humidity indicator card. The 1-gram bags are used in our smaller diameter housings, such as the SBE 3 (*plus*, F, and S), 4 (M and C), 5T and 5P, 37 (-SI, -SIP, -SM, -SMP, -IM, and –IMP), 38, 39, 39-IM, 43, 44, 45, 48, 49, and 50.
- PN 31180 is a 1/3-ounce desiccant bag, used in our SBE 16*plus*, 16*plus* V2, 16*plus*-IM, 16*plus*-IM V2, 19*plus*, 19*plus* V2, 21, and 52-MP.
- PN 30051 is a 1-ounce desiccant bag. The 1-ounce bags are used in our larger diameter housings, such as the SBE 9*plus*, 16, 17*plus*, 19, 25, 26, 26*plus*, 32, 53 BPR, 54, 55, AFM, and PDIM.

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

MIL-D-3464 Desiccant Regeneration Procedure

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

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

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

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

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

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

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

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SECTION I -- PRODUCT IDENTIFICATION

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

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

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

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

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

SECTION III -- PHYSICAL DATA

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

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SECTION IV -- FIRE EXPLOSION DATA

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

Flash Point - Nonflammable.

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

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

SECTION V -- HEALTH HAZARD DATA

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

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

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

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

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

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

SECTION VI -- REACTIVITY DATA

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

SECTION VII --SPILL OR LEAK PROCEDURES

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

SECTION VIII -- SPECIAL PROTECTION INFORMATION

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

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

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

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

SECTION IX -- SPECIAL PRECAUTIONS

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

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* No Information Available

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

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

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

Using Instruments with Pressure Sensors at Elevations Above Sea Level

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

Background

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

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

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

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

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

- SBE **9*plus*** CTD and SBE **25** SEALOGGER CTD
- SBE **16*plus*** and **16*plus* V2 (RS-232 versions)** SEACAT C-T (pressure optional) Recorder, SBE **19*plus*** and **19*plus*** **V2** SEACAT Profiler CTD, and SBE **49** FastCAT CTD Sensor
- SBE **16*plus*** and **16*plus* V2 (RS-485 versions)** SEACAT C-T (pressure optional) Recorder, and SBE **16*plus*-IM** and **16*plus*-IM V2** SEACAT C-T (pressure optional) Recorder
- SBE **37** MicroCAT (all IDO models and all other models with firmware version ≥ 3.0)
- SBE **37** MicroCAT (all models with firmware version < 3.0, except IDO models)
- SBE **50** Digital Oceanographic Pressure Sensor
- SBE **52-MP** Moored Profiler CTD and DO Sensor
- SBE **39-IM** Temperature (pressure optional) Recorder
- SBE **39** Temperature (pressure optional) Recorder
- SBE **26*plus*** SEAGAUGE Wave and Tide Recorder and SBE **53** BPR Bottom Pressure Recorder

SBE 9*plus* and 25

Sea-Bird real-time data acquisition software (Seasave) and post-processing software (SBE Data Processing) use calibration coefficients programmed in a configuration (.con or .xmlcon) file to convert raw data from these instruments to engineering units.

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

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

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

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

Follow this procedure to correct the pressure:
1. With the instrument in the air, place it in the orientation it will have when deployed.
2. In Seasave, in the .con or .xmlcon file, set the pressure offset to 0.0.
3. Acquire data in Seasave, and display the pressure sensor output in decibars.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the .con or .xmlcon file.
6. Also enter the calculated offset in the instrument (using the **POffset=** command in the terminal program*).
   *Note: SBE 16*plus* V2 and 19*plus* V2 use SeatermV2 terminal program; the other instruments use SEATERM.

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

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

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

Follow this procedure to correct the pressure:
1. With the instrument in the air, place it in the orientation it will have when deployed.
2. In the terminal program*, set the pressure offset to 0.0 (**#iiPOffset=0**) and set the output format to converted data in decimal form (**#iiOutputFormat=3**).
   *Note: 16*plus* V2 and 16*plus*-IM V2 use SeatermV2; the other instruments use SEATERM.
3. Acquire data using the **#iiTP** command.
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the instrument (using the **#iiPOffset=** command).
6. Also enter the calculated offset in the .con or .xmlcon file, using SBE Data Processing.

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

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

The SBE 37 is able to directly output data that is already converted to engineering units (pressure in decibars), using calibration coefficients that are programmed into the instrument. If using SeatermV2 (version 1.1 and later) to upload data, SeatermV2 creates a configuration (.xmlcon) file along with a .hex data file. Sea-Bird post-processing software (SBE Data Processing) uses the calibration coefficients in the .xmlcon file to convert raw data to engineering units.

Follow this procedure to correct the pressure:
1. With the SBE 37 in the air, place it in the orientation it will have when deployed.
2. In the SeatermV2 terminal program, set the pressure offset to 0.0 and pressure sensor output to decibars. *
3. Acquire data. *
4. Calculate *offset* = (0 – instrument reading).
5. Enter the calculated offset in the SBE 37 in SeatermV2. *
6. If you have already uploaded data, also enter the calculated offset in the .xmlcon file, using SBE Data Processing.

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

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

Instrument	Pressure Offset Command	Output Format Command	Command to Acquire Data **
MicroCATs with Inductive Modem (IM) or RS-485 telemetry	**#iiPOffset=**	**#iiOutputFormat=1**	**#iiTSn:100** (measures and outputs data 100 times)
MicroCATs with RS-232 telemetry	**POffset=**	**OutputFormat=1**	**TSn:100** (measures and outputs data 100 times)

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

SBE 37 (all models with firmware version < 3.0, *except* IDO [Integrated Dissolved Oxygen] models)

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

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

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

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

Instrument	Pressure Offset Command	Output Format Command	Command to Acquire Data
MicroCATs with Inductive Modem (IM) or RS-485 telemetry	**#iiPOffset=**	**#iiFormat=1**	**#iiTP** (measures and outputs pressure 30 times)
MicroCATs with RS-232 telemetry	**POffset=**	**Format=1**	**TP** (measures and outputs pressure 100 times)

SBE 50

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

Follow this procedure to correct the pressure:

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

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

SBE 52-MP

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

Follow this procedure to correct the pressure:

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

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

SBE 39-IM

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

Follow this procedure to correct the pressure:

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

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

SBE 39

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

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

Range (m or db) *	Range (psi) = Range (db) / 0.689476	0.1 * Range (psi)	Atmospheric Pressure (psi) at elevation at which error occurs = [14.7 – 0.1 * Range (psi)]	Approximate Corresponding Elevation (m)
20	29	2.9	11.8	1800
100	145	14.5	0.2	No where on Earth!
350	507	50.7	-	-
1000	1450	145	-	-
2000	2900	290	-	-
3500	5076	507	-	-
7000	10152	1015	-	-

* Notes:

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

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

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

> *Example 1*: You want to deploy the SBE 39 with a 20 m pressure sensor in a mountain lake at 1400 meters (4590 feet). This is lower than 1800 meters shown in the table, so you do not need to adjust the sensor range. After the data is recorded and uploaded, perform post-processing to adjust for the pressure offset.
>
> *Example 2*: You want to deploy the SBE 39 with a 20 m pressure sensor in a mountain lake at 2000 meters (6560 feet). This is higher than 1800 meters shown in the table, so you need to adjust the sensor range. In SEATERM, set **PRange=100** to allow use of the SBE 39 at this elevation. After the data is recorded and uploaded, perform post-processing to adjust for the pressure offset.

SBE 26*plus* and 53

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

Application Note Revision History

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

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

Deployment of Moored Instruments

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

- SBE 16*plus*, 16*plus*-IM, 16*plus* V2, and 16*plus*-IM V2 SEACAT Conductivity and Temperature Recorder
- SBE 19*plus* and 19*plus* V2 SEACAT Profiler CTD (in moored mode)
- SBE 26*plus* SEAGAUGE Wave and Tide Recorder
- SBE 37 (-IM, -IMP, -SM, -SMP, -SI, -SIP) MicroCAT Conductivity and Temperature Recorder
- SBE 37 (-IMP-IDO, -SMP-IDO, -SIP-IDO) MicroCAT Conductivity, Temperature, and Dissolved Oxygen Recorder
- SBE 39 and 39-IM Temperature Recorder
- SBE 53 BPR Bottom Pressure Recorder

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

- Instrument communication interface - RS-232, RS-485, or inductive modem
- Deployment interface for RS-232 or RS-485 - with I/O cable for real-time data or dummy plug for self-contained operation
- Sampling initiation - using delayed start commands to set a date and time for sampling to automatically begin or starting sampling just before deploying the instrument
- Sensors included in your instrument –
  - Pressure is optional in the SBE 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 37 (all), 39, and 39-IM.
  - Conductivity is optional in the SBE 26*plus* and 53, and is not provided in the SBE 39 and 39-IM.
  - Optional auxiliary sensors can be integrated with the SBE 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, and 19*plus* V2.

Deployment Summary

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

Preparation for Deployment

Task	Completed ?
If applicable, upload existing data in memory. Perform preliminary processing / analysis of data to ensure you have uploaded all data, that data was not corrupted in upload process, and that (if uploading converted data) instrument EEPROM was programmed with correct calibration coefficients. If there is a problem with data, you can try to upload again now. Once you record over data in next deployment, opportunity to correct any upload problem is gone.	
Initialize memory to make entire memory available for recording. If memory is not initialized, data will be stored after last recorded sample.	
Calculate battery endurance to ensure sufficient power for intended sampling scheme. See instrument manual for example calculations.	
Calculate memory endurance to ensure sufficient memory for intended sampling scheme. See instrument manual for example calculations.	
Install fresh batteries. Even if you think there is adequate battery capacity left for another deployment, cost of fresh batteries is small price to pay to ensure successful deployment.	
Establish setup / operating parameters. 1. Click Capture in terminal program and enter file name to record instrument setup, so you have complete record of communication with instrument. 2. Set current date and time. 3. Establish setup / operating parameters. 4. If desired, set date and time for sampling to automatically begin. 5. Send *Status* command (**DS** or **#iiDS**) to verify and provide record of setup. ** 6. Send *Calibration Coefficients* command (**DC**, **#iiDC**, **DCal**, or **#iiDCal**) to verify and provide record of calibration coefficients. **	
Get conductivity sensor ready for deployment: Remove protective plugs that were placed in Anti-Foulant Device caps **or** remove Tygon tubing that was looped end-to-end around conductivity cell to prevent dust / dirt from entering cell. *Note*: Deploying instrument with protective plugs or looped Tygon tubing in place will prevent instrument from measuring conductivity during deployment, and may destroy cell.	
Install fresh AF24173 Anti-Foulant Devices for conductivity sensor. Rate of anti-foul use varies greatly, depending on location and time of year. If you think there is adequate capability remaining, and previous deployment(s) in this location and at this time of year back up that assumption, you may not choose to replace Anti-Foulant Devices for every deployment. However, as for batteries, cost of fresh Anti-Foulant Devices is small price to pay to ensure successful deployment.	
For instrument with external pump (16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2), verify that system plumbing is correctly installed. See instrument manual for configuration.	
Start sampling (if you did not set up instrument with a delayed start command), or verify that sampling has begun (if you set up instrument with a delayed start command). 1. Click Capture in terminal program and enter file name to record instrument setup, so you have a complete record of communication with instrument. 2. If you did not set up instrument with a delayed start command, send command to start sampling. 3. Send *Status* command (**DS** or **#iiDS**) to verify and provide record that instrument is sampling. ** 4. Send *Send Last* command (**SL** or **#iiSL**) to look at most recent sample and verify that output looks reasonable (i.e., ambient temperature, zero conductivity, atmospheric pressure). ** 5. If instrument has pressure sensor, record atmospheric pressure with barometer. You can use this information during data processing to check and correct for pressure sensor drift, by comparing to instrument's pressure reading in air (from Step 4). Note: For instrument with pump (external **or** integral), avoid running pump *dry* for extended period of time.	
If cable connectors or dummy plugs were unmated, reinstall cables or dummy plugs as described in *Application Note 57: Connector Care and Cable Installation*. Failure to correctly install cables may result in connector leaking, causing data errors as well as damage to bulkhead connector.	
Install mounting hardware on instrument. Verify that hardware is secure.	

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

Recovery

Immediately upon recovery

Task	Completed?
Rinse instrument with fresh water.	
Remove locking sleeve on dummy plug or cable, slide it up cable (if applicable), and rinse connection (still mated) with fresh water.	
For instrument with pump (external or integral), stop sampling. Connect to instrument in terminal program and send command to stop sampling (**Stop** or **#iiStop**). Stop sampling as soon as possible upon recovery to avoid running pump *dry* for an extended period of time (for *some* instruments, pump turns off automatically when conductivity frequency is below programmed minimum value). **	
If instrument has pressure sensor, record atmospheric pressure with barometer. You can use this information during data processing to check and correct for pressure sensor drift, by comparing to instrument's pressure reading in air.	
Gently rinse conductivity cell with clean de-ionized water, drain, and gently blow through cell to remove larger water droplets. • If cell is not rinsed between uses, salt crystals may form on platinized electrode surfaces. When instrument is used next, sensor accuracy may be temporarily affected until these crystals dissolve. • Note that **vigorous flushing is not recommended** if you will be sending instrument to Sea-Bird for post-deployment calibration to establish drift during deployment. • For instruments with integral pump or integral pump and dissolved oxygen sensor (37-SMP, -SMP-IDO, -SIP, -SIP-IDO, -IMP, -IMP-IDO): Rinse all internal plumbing in addition to conductivity cell. If not rinsed between uses, salt crystals may form on pump impeller and/or on oxygen sensor membrane.	
For instrument with external pump (16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2): Remove Tygon tubing from pump head's hose barbs, and rinse inside of pump head, pouring fresh water through a hose barb. If pump head is not rinsed between uses, salt crystals may form on impeller. Over time, this may *freeze* impeller in place, preventing pump from working.	
Install protective plugs in Anti-Foulant Device caps or loop Tygon tubing end-to-end around conductivity cell for *long term* storage. This will prevent dust / dirt from entering conductivity cell. *Note*: For short term storage of all instruments *except* IDO MicroCATs, see *Application Note 2D: Instructions for Care and Cleaning of Conductivity Cells*. For IDO MicroCATs, see *Application Note 64: SBE 43 Dissolved Oxygen Sensor*.	
Upload data in memory. 1. Connect to instrument in terminal program. 2. If you have not already done so, send command to stop sampling (**Stop** or **#iiStop**). ** 3. Click Upload in terminal program to upload data in memory. 4. Perform preliminary processing / data analysis to ensure you have uploaded all data, data was not corrupted in upload process, and (if uploading converted data) instrument EEPROM was programmed with correct calibration coefficients. If there is a problem with data, you can try to upload again now. Once you record over data in next deployment, opportunity to correct any upload problem is gone.	

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

Later

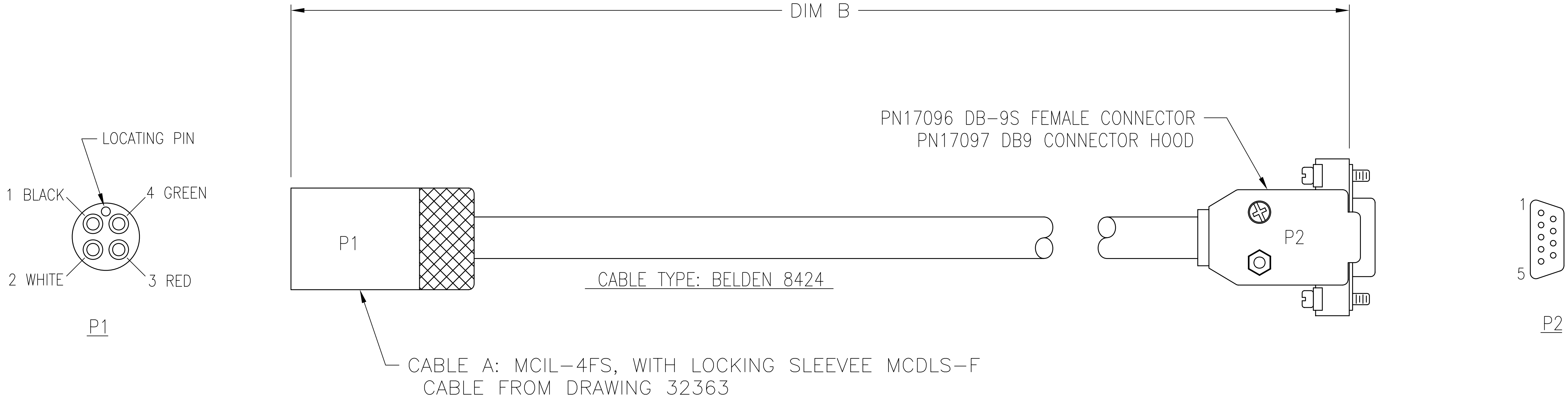
Task	Completed?
Clean conductivity cell, as needed: • Do not clean cell if you will be sending instrument to Sea-Bird for post-deployment calibration to establish drift during deployment. • Clean cell if you will not be performing a post-deployment calibration to establish drift. See cleaning instructions in instrument manual. For all instruments *except* IDO MicroCATs, see *Application Note 2D: Instructions for Care and Cleaning of Conductivity Cells*. For IDO MicroCATs, see *Application Note 64: SBE 43 Dissolved Oxygen Sensor*.	
For instrument with external pump (16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19*plus*, 19*plus* V2): Clean pump as described in *Application Note 75: Maintenance of SBE 5T and 5M Pumps*.	
(Annually) Inspect and (if applicable) rinse pressure port. See instructions in instrument manual.	
Send instrument to Sea-Bird for calibrations / regular inspection and maintenance. We typically recommend that instrument be recalibrated once a year, but possibly less often if used only occasionally. Return instrument to Sea-Bird for recalibration. Between lab calibrations, take field salinity samples to document conductivity cell drift. ***Notes:*** 1. We cannot place instrument in our calibration bath if heavily covered with biological material or painted with anti-foul paint. Remove as much material as possible before shipping to Sea-Bird; if we need to clean instrument before calibrating it, we will charge you for cleaning. To remove barnacles, plug ends of conductivity cell to prevent cleaning solution from getting into cell, then soak instrument in white vinegar *for a few minutes*. To remove anti-foul paint, use Heavy Duty Scotch-Brite pad or similar material. 2. If using lithium batteries, do not ship batteries installed in instrument. See http://www.seabird.com/customer_support/LithiumBatteriesRev2005.htm for shipping details.	

Application Note Revision History

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

DRAWINGS

DATE	REV	REVISION RECORD	AUTH.	DR.	CK.

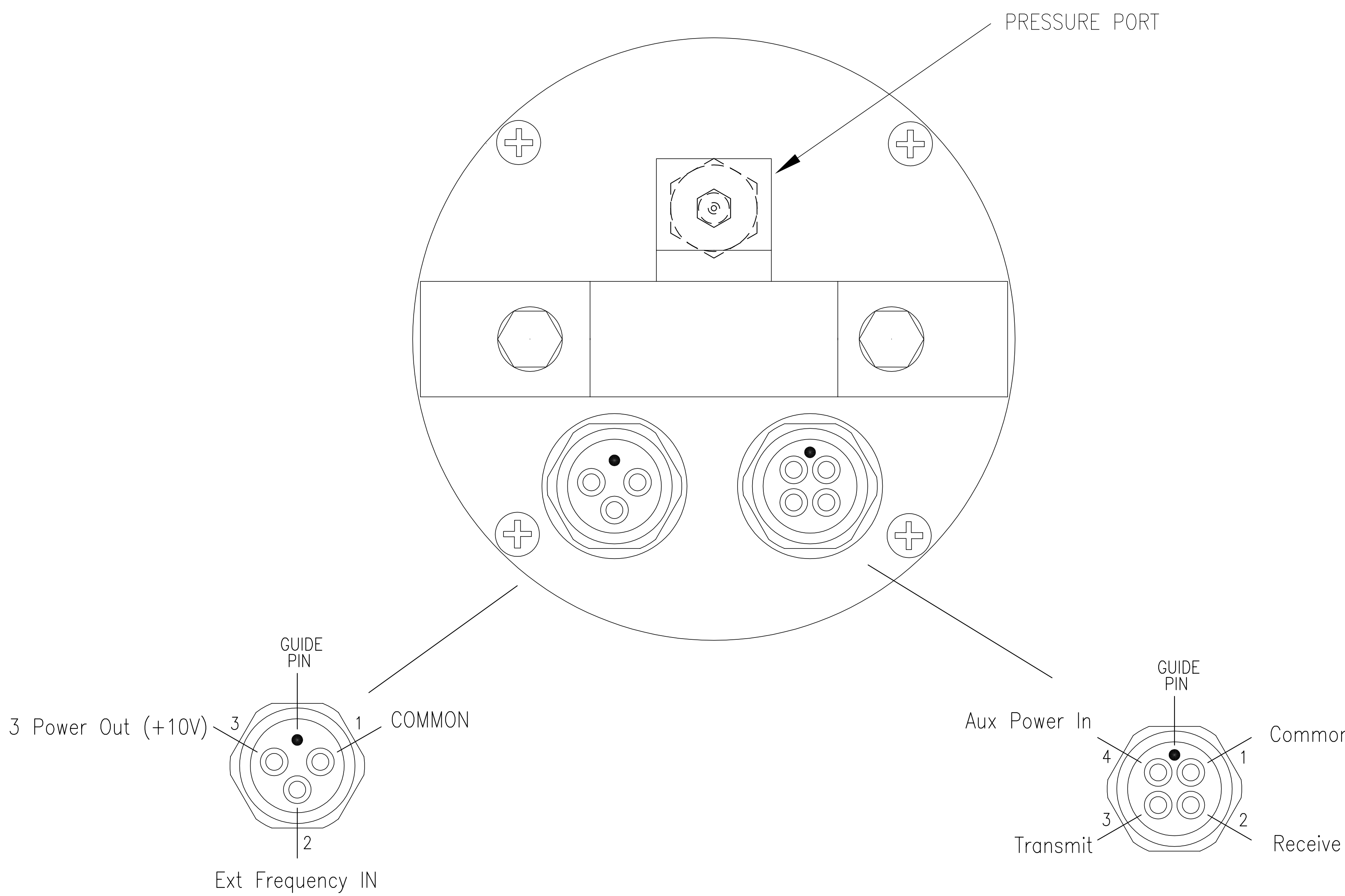


COLOR	P1 MCIL-4FS	P2 DB-9S
BLACK	PIN 1	PIN 5
WHITE	PIN 2	PIN 3
RED	PIN 3	PIN 2
	PIN 4	--

SBE PN	CABLE 'A' PN	DIM B	
801374	171368	8 FT	2.4 M
801444	171689	20 FT	6 M
801664	172190	33 FT	10 M
801700	172277	197 FT	60 M
801785	172397	75 FT	23 M
801887	172548	10 FT	3 M

TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N SEE TABLE	SCALE NTS	DRAWN BY KLP APPROVED BY
DECIMAL	TITLE CABLE ASSY: MCIL-4FS TO DB-9S		
ANGULAR	DATE 9.12.02	DRAWING NUMBER 32715	REV

DATE	REV	REVISION RECORD	AUTH.	DR.	CK.
1.27.04	A	REMOVED A NOTE	CB	KLP	

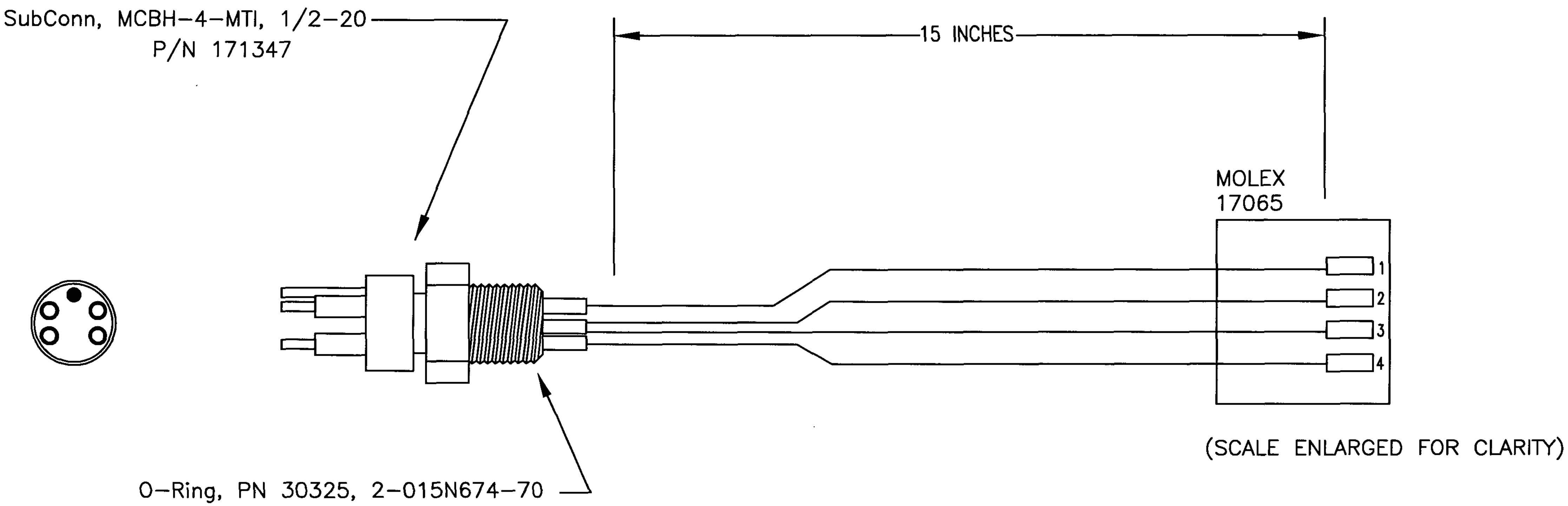


NOTES:

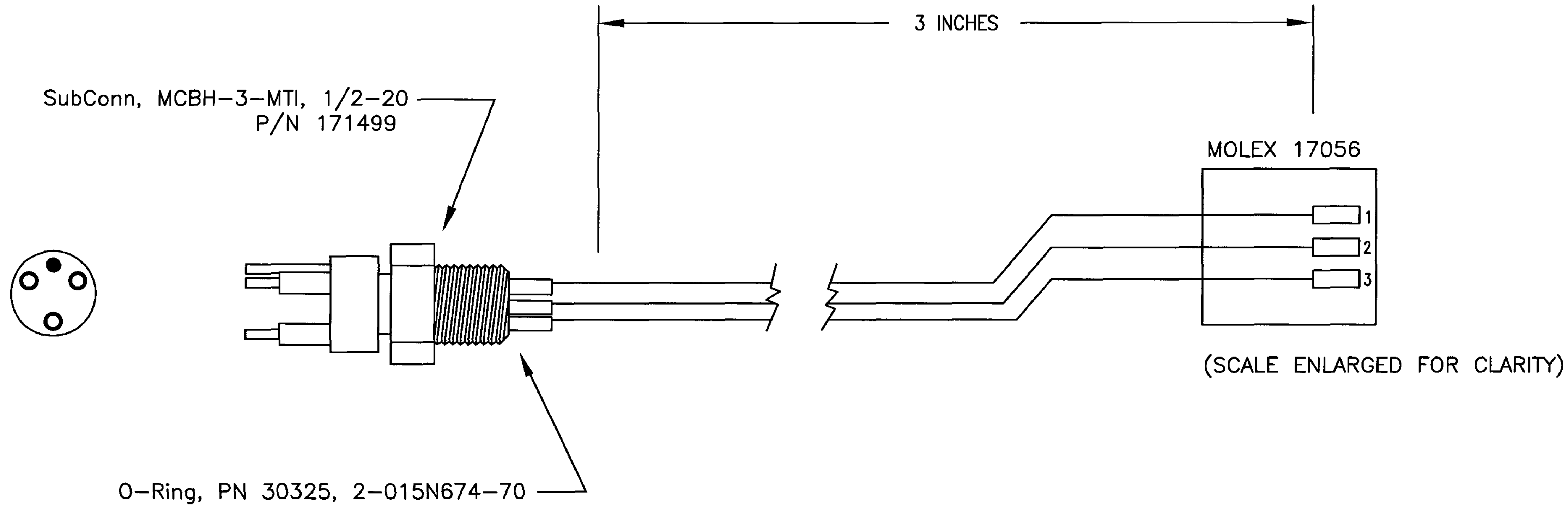
A 1. ROTATIONAL ALIGNMENT ON CONNECTORS VARIES

TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N	SCALE FULL	DRAWN BY MJ APPROVED BY
DECIMAL	TITLE EXTERNAL I/O WIRING (SUBCONN) SBE 26 WITH CONDUCTIVITY INTERFACE		
ANGULAR	DATE 03.26.02	DRAWING NUMBER 50194	REV A

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.



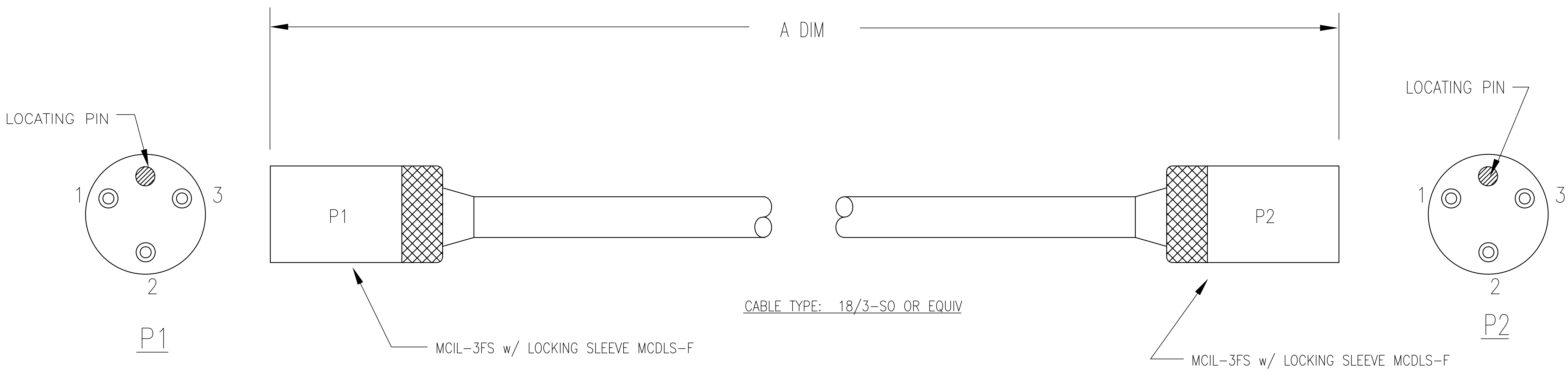
DATA I/O	
PIN 1	PIN 2
PIN 2	PIN 3
PIN 3	PIN 1
PIN 4	PIN 4



SBE4 I/F	
PIN 1	PIN 1
PIN 2	PIN 2
PIN 3	PIN 3

TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N	SCALE –	DRAWN BY MJ APPROVED BY
DECIMAL	TITLE SBE26 Internal I/O Wiring: Subconn Connectors		
ANGULAR	DATE 03.26.02	DRAWING NUMBER 41186	REV

DATE	REV	REVISION RECORD	AUTH.	DR.	CK.
06/18/09	A	CHANGED CABLE TYPE	CB	PC	CB



SBE PART NUMBER	A DIM	
171669	30 INCHES	76 cm
171752	11 INCHES	28 cm
172058	5 FEET	1.5 m
172169	79 INCHES	2 m
172330	20 INCHES	50 cm

P1 (MCIL-3FS)	P2 (MCIL-3FS)
PIN 1	PIN 1
PIN 2	PIN 2
PIN 3	PIN 3

SEA-BIRD ELECTRONICS, INC

P/N	SCALE	DRAWN BY	
SEE TABLE	NTS	MJ	
		APPROVED BY	CB

CABLE: MCIL-3FS TO MCIL-3FS

DATE	DWG NO.	SHEET	REV
5.22.02	32671	1 of 1	A

WARRANTY POLICY 2010

PRODUCT WARRANTY

5-YEAR LIMITED WARRANTY (NEW PRODUCTS)

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

LIMITED WARRANTY ON SERVICE & REPAIRS

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

MODIFICATIONS / EXCEPTIONS / EXCLUSIONS

1. The SBE 43 DO sensor is warranted to function properly for 5 years. Under normal use however, the electrolyte in an SBE 43 DO sensor will require replenishment after about 3 years (or longer, depending on conditions of use). Anytime during the warranty period (typically after 3 years), the SBE 43 will be refurbished once without charge, Return the sensor freight pre-paid to our factory. We will refurbish it for free (electrolyte refill, membrane replacement, and recalibration) and pay the cost of shipping it back to you. Membrane damage or depletion of electrolyte caused by membrane damage is not covered by this warranty.

2. The pH sensor electrode used in the SBE 18 pH sensor and SBE 27 pH/ORP sensor has a limited design life caused by depletion of their chemical constituents during normal storage and use, and is covered under warranty for the first 90 days only. Other components of the sensor (housing, electronics, etc.) are covered for 5 years.

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

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

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

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

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

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

WARRANTY ADMINISTRATION POLICY

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

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

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

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

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

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

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

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

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

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

SOFTWARE WARRANTY

SOFTWARE LICENSE AGREEMENT

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

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

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

SOFTWARE WARRANTY

Sea-Bird Electronics expressly disclaims any warranty for software. Software and any related documentation is provided "as is" without warranty of any kind, either expressed or implied, including and without limitation, the implied warranties or merchantability, fitness for a particular purpose, or non infringement. The entire risk arising out of use or performance of SEASOFT remains with you.

In no event shall Sea-Bird Electronics or its representatives or suppliers be liable for any damages whatsoever (including, without limitation, damages for loss of business profits, business interruption, loss of business information, or any other pecuniary loss) arising out of the use of or inability to use this Sea-Bird Electronics product, even if Sea-Bird has been advised of the possibility of such damages.

Sea-Bird Service Request Form

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

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

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

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

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

CONTACT INFORMATION

Your Name:____________________Institution/Company:____________________

Shipping/Delivery address for packages:____________________

____

____

Phone:____________________Fax:____________________E-mail:____________________

SERVICE INFORMATION

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

Quantity:____________________Serial Numbers:____________________

____

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

____

____

____

[ ] Calibration Services (includes basic diagnostic):

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

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

____

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

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

____

____

[ ] System Upgrade or Conversion____________________

____

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

____

____

____

[ ] Download Data from instrument Memory____________________

____

PAYMENT/BILLING INFORMATION

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

Name on Card:____

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

[ ] Purchase Order (P.O.)

P.O. Number:____

Billing Address (If different than shipping address):______________________________

____

____

____

Instructions for Returning Goods to Sea-Bird

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

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

2. **International Shipments** –
   Option A. Ship via **PREPAID AIRFREIGHT to SEA-TAC International Airport (IATA Code "SEA")**:
   Sea-Bird Electronics, Inc.
   13431 NE 20th Street
   Bellevue, WA 98005, USA
   Telephone: [+1] 425-643-9866, Fax: [+1] 425-643-9954, E-mail: seabird@seabird.com

   Notify: MTI Worldwide Logistics for Customs Clearance
   Seattle, WA, USA
   Telephone: [+1] 206-431-4366 Fax: [+1] 206-431-4374 E-mail: bill.keebler@mti-worldwide.com

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

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

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

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

Note: Due to changes in regulations, if Sea-Bird receives an instrument from outside the U.S. in a crate containing non-approved (i.e., non-heat-treated) wood, we will return the instrument in a new crate that meets the requirements of ISPM 15 (see http://www.seabird.com/customer_support/retgoods.htm for details). We will charge $50 to $150 for the replacement crate, based on the crate type. These prices are valid only for crate replacement required in conjunction with return of a customer's instrument after servicing, and only when the instrument was shipped in a crate originally supplied by Sea-Bird.