User manual

SBE 49 FastCAT CTD

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Section 1 Safety information

Please read this entire manual before this equipment is unpacked, set up, or operated. Pay attention to all danger, warning, and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

> ⚠ **DANGER**
>
> Indicates a potentially or imminently hazardous situation which, if not avoided, will result in death or serious injury.

> ⚠ **WARNING**
>
> Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

> ⚠ **CAUTION**
>
> Indicates a potentially hazardous situation that may result in minor or moderate injury.

> *NOTICE*
>
> Indicates a situation which, if not avoided, may cause damage to equipment. Information that requires special emphasis.

1.1 Hazard information

> ⚠ **WARNING**
>
> This product can expose the user to chemicals with silica, crystalline (airborne particles of respirable size), which is known to the State of California to cause cancer and birth defects or other reproductive harm. For more information, go to www.P65Warnings.ca.gov.

> ⚠ **CAUTION**
>
> AF24173 anti-fouling devices contain bis(tributyltin) oxide. Wear rubber or latex gloves and eye protection to replace these devices on the sensor if it is so equipped. Wash hands with soap and water when finished.
> Read the precautions on the product label.
>
> It is a violation of US federal law to use this product in a manner that is inconsistent with its label.

> *NOTICE*
>
> The manufacturer is not responsible for any damages due to misapplication of misuse of this product including, without limitation, direct, incidental and consequential damages, and disclaims such damages to the full extent permitted under applicable law. The user is solely responsible to identify critical application risks and install appropriate mechanisms to protect process during a possible equipment malfunction.

1.2 Equipment labels

Read all labels and tags attached to the equipment. Personal injury or damage to the equipment could occur if not observed. A symbol on the equipment is referenced in the manual with a precautionary statement.

Safety information

	ATTENTION! **Remove sticker before deployment!** This sticker protects your instrument during shipping. **REMOVE BEFORE DEPLOYMENT;**if it is not removed, your instrument will not operate properly and you may cause severe damage to the conductivity cell. The conductivity cell is made of glass and will break if mishandled or frozen while filled with water. Apply new sticker to protect instrument when not in use (see spares kit). NOTICE: Sticker may have come in contact with the AF24173 Anti-foulant device, which contains TBTO. Dispose of the removed sticker. See SDS for handling precautions.

	Electrical equipment marked with this symbol may not be disposed of in European domestic or public disposal systems. Return old or end-of-life equipment to the manufacturer at no charge to the user.

	EFUP: Hazardous material exists over the threshold of GB/T 26572.2011. The number in the center of the symbol is the Environmentally Friendly Use Period as specified by SJ/T 11364-2014, China's marking for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products. This product should be recycled after its environmentally friendly use period.

Section 2 SBE 49 FastCAT quick start guide

This quick start guide gives the steps necessary to make sure that the SBE 49 sensor operates correctly and collects data before it is deployed.

What's in the box:

- SBE 49, with internal pump, strain-gauge pressure sensor, and integrated T-C Duct
- Optional anti-fouling devices
- CD with software, calibration files, documentation
- Spare parts kit
- I/O cable for internal USB connector to connect the sensor to a PC.

1. Install the manufacturer-supplied software on a PC (refer to Set up sensor and verify operation on page 11 for details.)
2. Connect the sensor to the PC and double-click on **SeaTerm.exe** to start the software.
3. Set up the sensor for deployment:

   a. Set the date and time (DateTime)
   b. Configure the data collection settings.
   c. Send the DS and DC commands to verify the setup.
   d. For autonomous data collection, send StartNow to start operation immediately. Send StartDateTime= or StartLater to start at a user-selected time in the future.

4. Immediately after the sensor is recovered from a deployment:

   a. Rinse the sensor with fresh water.
   b. Keep the sensor out of direct sunlight between deployments.

5. Transmit data from the sensor to a PC.
6. To store the sensor, rinse thoroughly, then dry completely. Attach protective dummy plug with lock collar.

Section 3 Specifications

3.1 Mechanical

Depth rating, plastic	350 m
Depth rating, titanium	7,000 or 10,500 m
Weight in air and water, plastic	1.8, 0.5 kg
Weight in air and water, titanium	2.7, 1.4 kg

3.1.1 Bulkhead connector

Contact	Function	MCBH-4-MP
1	Ground	
2	RS232 RX	
3	RS232 TX	
4	Voltage in	

3.2 Electrical

Input	0.75 A, 9–24 VDC
Current draw, turn-on transient	750 mA
Current draw, operation (includes pump)	390 mA at 9 V 285 mA at 12 V 180 mA at 19 V
Data collection speed	16 Hz
Baud rates	1200, 2400, 4800, 9600 **(default)**, 19200, 38400

3.3 Analytical

Parameter	Range	Accuracy	Stability	Resolution
Conductivity	0–9	±0.0003 S/m	0.0003/month	0.00005[1] 0.00007[2] 0.00001[3]
Temperature	-5 to 35 °C	±0.002 °C	0.0002/month	0.0001
Pressure	not more than the SBE 49 rated depth	±0.1% full scale range	0.05% full scale range/yr	0.002% full scale range

[1] oceanic waters; resolves 0.4 ppm in salinity

[2] high salinity waters; resolves 0.4 ppm in salinity

[3] fresh waters; resolves 0.1 ppm in salinity

Specifications

Section 4 Operation overview

The SBE 49 FastCAT is a CTD sensor for use on towed vehicle, ROV, AUV, or other autonomous profiling applications in saltwater or fresh water environments. The SBE 49 is externally powered, and its data is transmitted by its RS232 interface. The FastCAT has no memory or internal batteries and does not support auxiliary sensors.

The FastCAT operates in either autonomous or polled modes:

Autonomous—the sensor operates continuously at 16 scans/second (16 Hz). It can be set to average up to 255 samples and transmit only the averaged data. The user can set the FastCAT to process data in real-time for applications for which post-processing in not possible.

Polled—The FastCAT takes one sample and transmits the data on command.

The SBE 49 can be used with an SBE 32 Carousel Water Sampler and the SBE 33 Carousel Deck Unit, OR the SBE 55 ECO Water Sampler and SBE 33 Carousel Deck Unit. The SBE 32 or SBE 55 supplies +15 VDC power to the FastCAT. Data from the FastCAT is converted into single-wire telemetry so it can be transmitted over long (10,000 m) sea cables.

SBE 55 Real-Time Operation

Real-time operation with SBE 55

Real-Time Configuration with
SBE 19, 19*plus*, 19*plus* V2, 25,
25*plus*, or 49

Real-time operation with SBE 32

The FastCAT can also be used with an SBE 36 CTD Deck Unit and Power Data Interface Module (PDIM). As with the SBE 32/SBE 33, the PDIM supplies + 15 VDC power to the FastCAT and is the interface for two-way RS232 communications.

Real-time operation with SBE 36 Deck Unit and PDIM

Section 5 Set up sensor and verify operation

Set up the hardware and install the software for the sensor to make sure that it operates correctly before deployment.

5.1 Install and set up software

Make sure that the sensor is connected to the PC through the serial connector on the supplied cable. Most PCs no longer have serial ports, so a serial-to-USB adapter is necessary. Make sure that the USB driver software is installed on the PC so that there is communication between the sensor and the PC.

1. Install the Seasoft V2 software from the manufacturer-supplied CD.
2. Double-click on **SeatermV2.exe** to start the launcher. If this is the first time the software is opened, a Seaterm Setup window opens. The software automatically connects at the default baud rate of 9600 but will try others if necessary. The software automatically looks for the serial port number of the connected sensor.
3. At the **Instruments** menu item, select the connected sensor.
4. Push **OK** to close this window.
   The main window opens. The menus and toolbars are at the top. The large area below them shows commands and the responses from the sensor to those commands.
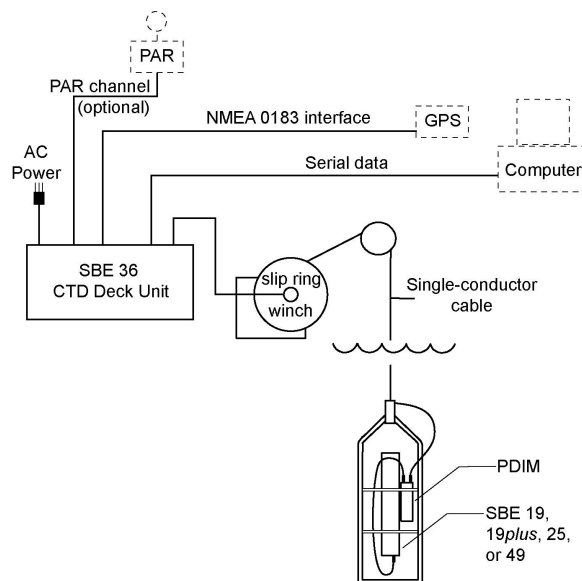
Toolbar button	Description	Command
Connect	Start communications with the FastCAT. An S> prompt shows.	**Enter**
Status	Show FastCAT setup and status	DS
Coefficients	Show calibration coefficients	DCal
Capture	Save the FastCAT responses to a file with a .cap filetype. Capture status shows in the Status bar. Push **Capture** again to turn off capture. If Seaterm is used to collect data, select Capture before data collection starts to save data for review and processing. The .cap file does not have the header information required by the SBE Data Processing. Use Seasave to collect data to be processed by the Data Processing software.	—
Diagnostics	Do one or more diagnostics tests. Tests accessed here do not overwrite any current settings.	DS, DCal, TS
Stop	Stop current activity, such as data collection or diagnostic test.	**Esc** or Ctrl C
Disconnect	Disconnect the COM port on the PC for use by another program.	—

5. From the **Configure** menu, select *SBE 49*.
   In the *COM Settings* tab:

   1. COMM Port: 1–10, as applicable
   2. Baud Rate: 9600, from Configuration Sheet
   3. Data Bits: 8
   4. Parity: None
   5. Mode: RS232 (Full Duplex)

   Push **OK** to save the settings.
6. From the **Communications** menu, select *Options/Cycle baud with connecting*.
7. Push **Connect** on the toolbar.
   The software tries to connect to the FastCAT at the baud rate set in step 5. If it cannot, it will try other possible baud rates to try to connect. When it connects, an S> prompt shows.
   If the system does not show an S> prompt, push **Connect** again. Verify that the correct sensor was selected in the **Configure** menu and that the settings were

entered correctly in the *COM Settings* tab of the **Configuration Options** window. Verify the FastCAT is connected to the PC correctly.

8. Look at the FastCAT status information: select **Status** on the toolbar.
    The display looks like this:

    ```
    SBE 49 FastCAT V 1.3a SERIAL NO. 0055

    number of scans to average = 1

    pressure sensor = strain gauge, range = 1000.0

    minimum cond freq = 3000, pump delay = 30 sec

    start sampling on power up = no

    output format = converted decimal

    output salinity = no, output sound velocity = no

    temperature advance = 0.0625 seconds

    celltm alpha = 0.03

    celltm tau = 7

    real-time temperature and conductivity correction enabled for
    converted data
    ```

9. Enter **TS**, then **Enter** to command the FastCAT to take one sample.
    The display, with converted decimal output and no salinity or sound velocity data, shows:

    ```
    23.7658, 0.00019, 0.062
    ```

    where 23.7658 is temperature, °C, 0.00019 is conductivity, S/m, and 0.062 is pressure, decibars.

    The FastCAT is ready to be configured and deployed.

Section 6 Deployment and operation

Set up the sensor hardware for deployment. Make sure the SBE 49 is attached correctly to any frame, and that all cables are attached correctly and the lock collars are tight. The manufacturer recommends that the sensor is deployed with the thermistor end down to keep sediment out of the thermistor.

Use the Seaterm software to set up the SBE 49 for deployment.

If the SBE 49 is connected directly to a PC or an SBE 33 or SBE 36 Deck Unit, use Seasave to collect and see real-time data with **OutputFormat=0**. The collected data is compatible with the SBE Data Processing software.

If the SBE 49 is connected directly to a PC, use Seaterm to collect and see real-time data with **OutputFormat=3**. Select **Capture** to save data to a .cap file. Data collected with Seaterm is **not** compatible with the SBE Data Processing software.

If the SBE 49 is connected to an ROV or AUV, the vehicle must have a data logger (controller) for the SBE 49 data. This data is typically not compatible with the SBE Data Processing software. However, if the controller saves **all** the SBE 49 data (complete time series) to an unaltered file, it can be processed with the Data Processing software. It is necessary to add the required header information, and the data format must be set to **OutputFormat=3**.

1. Connect the I/O cable to the PC or controller.
2. Connect the I/O cable red (+) and black (-) wires to a 9-24 VDC power supply.
3. If protective plugs are attached to the T-C Duct and exhaust, remove them before the SBE 49 is deployed.

Remove red plug from T-C duct and black plug from end of exhaust (straight or tee).

4. Immediately before the SBE 49 is deployed, supply power.

    •   If **AutoRun=Y**, the SBE 49 is started.
    •   If **AutoRun=N**, send **Start** from Seaterm.

Refer to the section on Cable length and external power on page 17 for details on the correct length of cable to use.

Refer to the Reference: command descriptions on page 33 section for details on specific commands to control the SBE 38.

Operate the SBE 49 in either a polled or autonomous mode.

6.1 Polled operation

Send the **TS** command: the SBE 49 takes one sample and transmits the data in real-time. The pump does not turn on automatically in this mode. To operate the pump before a sample is collected, send **PumpOn**. Send **TS**, then **PumpOff** to turn the pump off.

Example
Supply power to the SBE 49 and select **Connect** to turn on the SBE 49. Set up to not start automatic autonomous data collection, to transmit data in decimal engineering units, and transmit salinity and sound velocity data, in addition to conductivity, temperature, and pressure. Send **DS** to verify setup. Turn off power.

S>**AUTORUN=N**

S>**OUTPUTFORMAT=3**

S>**OUTPUTSAL=Y**

S>**OUTPUTSV=Y**

S>**DS**

Turn off power.

To take a sample, put the FastCAT in the water. Supply power and start the FastCAT. Send the pump on command. Send the take sample command, and turn the pump off. Turn off power.

S>**PUMPON**

S>**TS**

S>**PUMPOFF**

Turn off power.

6.2 Autonomous operation

The FastCAT operates continuously, collects data at 16 Hz, and transmits data in real-time. The FastCAT can be set to average up to 255 samples and transmit only the averaged data.

Function	Start	Stop
AutoRun=Y	Turn on power	Turn off power, OR
AutoRun=N	Send **Start**	Send **Stop**. Select **Stop** on the toolbar or type CTRL Z.

The manufacturer ships the FastCAT set to **AutoRun=N**.

After the conductivity cell enters the water, there is a user-set delay before the pump turns on so that all the air in the pump tubing is released. Air in the pump impeller can cause an incorrect flow rate. **The cell inlet and the pump outlet must stay below the surface of the water**. If these components come out of the water, stop data collection. Wait at least 5 seconds, then make sure that the FastCAT is below the surface of the water, start data collection again, wait for the pump delay time and then start the profile again.

1 = intake   2 = exhaust

The pump turns on when two user-set conditions are met:

1. Raw conductivity frequency is greater than the minimum conductivity frequency. Set the minimum conductivity frequency for the pump to turn on higher than the zero conductivity raw frequency so that the pump will not turn on when the FastCAT is in air.

- For saltwater and estuarine applications, a typical value for zero conductivity raw frequency is 500 Hz.
- For freshwater applications, a typical value for zero conductivity raw frequency is 5 Hz.

If the minimum conductivity frequency is too close to the zero conductivity raw frequency, the pump may turn on when the FastCAT is in air. It may be necessary to use the pump turn on delay time to control the pump. If this is the case, set a minimum conductivity frequency lower than the zero conductivity raw frequency.

2. Pump turn-on delay time has passed. Set the pump turn-on delay time so there is sufficient time for the pump to fill with water after it is put in the water. Measure the time necessary to completely fill the pump exhaust tubing. It is full when there are no more air bubbles in the exhaust, typically 20 seconds. Set the delay to approximately 30 seconds. When the FastCAT is deployed, make sure to "soak" the sensor just under the water surface for at least the time required for the pump to turn on.

The pump turns off when the conductivity frequency falls below the minimum conductivity frequency.

Example 1: AutoRun=N
Supply power, then select **Connect** from the toolbar. Set up to average every four samples. Data format is raw hexadecimal. Set up with a 60 second pump delay after the SBE 49 is in the water. Send **DS** to verify setup. Turn off power.

S>**NAVG=4**

S>**OUTPUTFORMAT=0**

S>**PUMPDELAY=60**

S>**AUTORUN=NO**

S>**DS**

To start data collection, supply power, select **Connect**.

S>**START**

Put the SBE 49 in the water and let it soak for at least the time required for pump turn-on (60 seconds), then start the cast. When the cast is complete:

S>**STOP**

Example 2: AutoRun=Y
Supply power, then select **Connect** from the toolbar. Set up to average every four samples. Data format is raw hexadecimal. Set up with a 60 second pump delay after the SBE 49 is in the water. Send **DS** to verify setup. Turn off power.

S>**NAVG=4**

S>**OUTPUTFORMAT=0**

S>**PUMPDELAY=60**

S>**AUTORUN=YES**

S>**DS**

To start data collection, supply power, put the FastCAT in the water and let it soak for at least the time required for pump turn-on (60 seconds), then start the cast. When the cast is complete, turn off the power or send **Stop**. (Send **Stop** to view or change the FastCAT setup immediately after data collection stops.)

6.3 Real-time data corrections

If real-time data corrections are enabled and the output format is converted hex or decimal, the FastCAT aligns and applies thermal mass corrections to the data. Note that real-time corrections are not done if **OutputFormat=0** or **2**, even if **ProcessRealTime=Y.**

1. **TAdvance=** advances the temperature by a user-selected value.
2. Temperature and conductivity are adjusted with cosine filter and five-scan window.
3. **Alpha=** and **Tau=** apply a user-selected value for cell thermal mass correction to conductivity.

4. If **NAvg=** is more than 1, averaged data for C, T, and P is calculated.
5. If **OutputSal=Y** and **OutputSV=Y**, salinity and sound velocity are calculated from corrected, averaged values of C, T, and P.

```
Example: Autonomous operation setup for real-time data processing
S>OutputFormat=3

S>ProcessRealTime=Y

S>TAdvance=0.0625

S>Alpha=0.03

S>Tau=7
```

Post-process CTD data from SBE 49

The post-processing of data aligns, adjusts, and corrects for conductivity cell thermal mass. Note that thermal mass corrections should not be applied to freshwater data.

- Align data: Misaligned data is caused by physical misalignment of sensors in depth, the inherent time delay of sensor responses, and the time it takes water to be transmitted in a plumbing line. When data is aligned, the derived parameters are calculated with measurements from the same parcel of water. This eliminates spikes caused by misaligned data in areas with steep temperature gradients.
- Adjust data: Adjust data to align T and C sensor time constants.
- Correct for conductivity cell thermal mass: The glass cell stores heat, which causes water in the cell to be a different temperature than the temperature sensor measured a moment earlier. When the thermal mass effects are removed from measured conductivity, the result is improved data in areas with steep temperature gradients.

The SBE Data Processing software can do these corrections to collected data so that derived parameters can be calculated, but only if a complete C, T, and P time series is recorded. Since the FastCAT is frequently integrated on an ROV or AUV, data may be recorded with uneven time intervals. This prevents the data from being aligned, adjusted, and corrected.

6.4 Data transmit rate

Without a SBE Deck Unit

The data transmit rate is a function of the quantity of data to be transmitted and the serial data baud rate:

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

where

Number of characters is the included data and the output format, plus 2 for carriage return (CR) and line feed (LF). For decimal output, formats 2 or 3, include decimal points, commas, and spaces.

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

NAvg	OutputFormat	Minimum Baud
1	0 or 1	4800
	2 or 3*	9600
2	0 or 1	2400
	2 or 3*	4800

* Includes salinity and sound velocity values.

Example 1: What is the fastest rate to transmit real-time data of 800 m with **OutputFormat=0** (raw hex)? 800 m of cable requires a baud rate of 1200 or less.
Number of characters for **OutputFormat=0** =

6 (T) + 6 (C) + 6 (P) + 4 (P temperature compensation) + 2 (CR and LF) = 24

Time required to transmit data = (24 characters × 10 bits/character) ÷ 1200 = 0.2 seconds > 0.0625 seconds at 16 Hz

So, set **NAvg=4**, to average 4 measurements/sample, with 1 sample transmitted every 0.25 seconds.

Example 2: **OutputFormat=3** (engineering units in decimal), and**OutputSal=Y** and **OutputSV=Y**?
Number of characters for **OutputFormat=3** =

8 (T) + 2 (comma and space) 8 (C) + 2 (comma and space) 8 (P) + 2 (comma and space) + 8 (salinity) + 2 (comma and space) + 8 (sound velocity) + 2 (CR and LF) = 50

Time required to transmit data = (50 characters × 10 bits/character) ÷ 1200 = 0.42 seconds > 0.0625 seconds at 16 Hz

So, set **NAvg=7**, to average 7 measurements/sample, with 1 sample transmitted every 0.4375 seconds.

With a SBE Deck Unit

Set the FastCAT baud rate to 4800 to use with:

- SBE 36 CTD Deck Unit and PDIM
- SBE 33 Carousel Deck Unit and SBE 32 Carousel Water Sampler
- SBE 33 Carousel Deck Unit and SBE 55 ECO Water Sampler

The data telemetry link can support 10,000 m of cable at 4800 baud. The relation between transmit rate, quantity of data transmitted and baud rate is as above for a FastCAT without a Deck Unit.

Example: FastCAT with SBE 36 and PDIM. What is the fastest rate to transmit real-time data of 800 m with **OutputFormat=0** (raw hex), which is the required data format for use with the Deck Unit? With a Deck Unit, the FastCAT requires a baud rate of 4800.
Number of characters for **OutputFormat=0** =

6 (T) + 6 (C) + 6 (P) + 4 (P temperature compensation) + 2 (CR and LF) = 24

Time required to transmit data = (24 characters × 10 bits/character) ÷ 4800 = 0.05 seconds < 0.0625 seconds at 16 Hz

So, set **NAvg=1**, to operate at 16 Hz, 1 sample every 0.0625 seconds.

6.5 Cable length and external power

Calculate IR loss for real-time data collection with external power and no Deck Unit.

1. The communications IR loss should be 1 V or less when real-time data is transmitted. The SBE 49 will not transmit data if the IR loss is greater than 1V because of the difference in ground potential.
2. Supply enough power so that sufficient power is available to the sensor after IR loss is calculated.

Limit IR loss to 1 V to transmit real-time data

Maximum communications current draw × common wire resistance on the power wire = limit to the length of the cable.

$V_{limit} = 1\ V = IR_{limit}$

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

I = current required by SBE 49 during communication:

- 390 mA at 9 V
- 285 mA at 12 V
- 180 mA at 19 V

Deployment and operation

Example: For 12 V power supply and 20 gauge wire, what is the maximum cable length to supply power to the SBE 49?
$R_{limit} = V_{limit} \div I = 1\ V \div 0.285\ A = 3.5$ ohms

Maximum cable length = 3.5 ohms ÷ 0.0107 ohms/ft = 327 ft (100 m)

100 m < 800 m (maximum distance the SBE 49 can transmit data at 1200 baud) so cable is limited to 100 m because of power limits. Alternately, data could be transmitted over 800 m with a power source closer to the FastCAT.

Supply sufficient power to FastCAT

In addition to considerations of IR loss, the cable must supply sufficient power to the FastCAT. There is a 0.75 A turn-on transient, two-way power resistance. Supply at least 9 V after IR loss. V - IR > 9 V,

where I = FastCAT turn-on transient of 0.75 A.

Example: For 20 gauge wire, what is the maximum distance to transmit power to FastCAT from a 12 V power source?
12 V - 0.75 A × (0.0107 ohms/ft × 2 × cable length) > 9 V

3 V > 0.75 A × (0.0107 ohms/ft × 2 × cable length) Cable length < 187 ft = 57 m

57 m < 100 m (maximum distance for communication IR loss). So the power supplied during power-on transient is the limiter in this example. Use another wire gauge to increase the permitted cable length.

Example: For 20 gauge wire, what is the maximum distance to transmit power to **four** FastCATs from a 12 V power source?
12 V - (0.75 A × 4 FastCATs) × (0.0107 ohms/ft × 2 × cable length) > 9 V

3 V > 0.75 A × 4 FastCATs) × (0.0107 ohms/ft × 2 × cable length) Cable length < 46 ft = 14 m

Table 1 Common wire resistances

Gauge	Ohms/ft.
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

Table 2 Maximum cable length and baud rate

Length, m	Baud rate
1600	600
800	1200
400	2400
200	4800
100	9600
50	19200
25	38400
16	57600
8	115200

6.6 Data formats

Data format is **OutputFormat=** 0, 1, 2, or 3. Each line of data ends with a carriage return <CR> and line feed <LF>.

To use the Seasave software to collect real-time data, set **OutputFormat=0**.

To process real-time data, set **OutputFormat=1** or **3** and **ProcessRealTime=Y**.

The pressure sensor for the FastCAT is an absolute sensor, so its raw data includes the effect of atmospheric pressure (14.7 psi). The FastCAT calibration information is in terms of psia. When pressure data is in engineering units, the FastCAT transmits pressure data relative to the ocean surface (0 decibars). The FastCAT converts psia to decibars with:

Pressure (db) = [pressure (psia) -14.7] × 0.689476.

6.6.1 OutputFormat=0

Raw data in hexidecimal

The data output comes in the order listed below, with no spaces or commas between parameters.

1. Temperature A/D counts = tttttt
2. Conductivity frequency, Hz = cccccc ÷ 256
3. Pressure = pppppp
4. Pressure temperature compensation = vvvv ÷ 13,107

Example scan = ttttttccccccppppppvvvv = 0A53711BC7220C14C17D82

1. Temperature = tttttt = 0A5371 (676721 decimal); temperature A/D counts = 676721
2. Conductivity = cccccc = 1BC722 (1820450 decimal); conductivity frequency = 1820450 ÷ 256 - 7111.133 Hz
3. Pressure = pppppp = 0C14C1 (791745 decimal); pressure A/D counts = 791745
4. Pressure temperature compensation = vvvv = 7D82 (32,130 decimal); pressure temperature = 32,130 ÷ 13,107 = 2.4514 volts

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6.6.2 OutputFormat=1

Engineering units in hexidecimal

The data output comes in the order listed below, with no spaces or commas between parameters. If **ProcessRealTime=Y**, the data output has been aligned, filtered, and corrected for cell thermal mass effects.

1. Temperature, °C, ITS-90 = (tttttt ÷ 100,000) - 10
2. Conductivity, S/m = cccccc ÷ 1,000,000) -1
3. Pressure, decibars = (pppppp ÷ 1,000) - 100

Example scan = ttttttccccccpppppp = 3385C40F42FE1086DE

1. Temperature = tttttt = 3385C4 (3376580 decimal); temperature = (3376580 ÷ 100,000) -10 = 23.7658
2. Conductivity = cccccc = 0F42FE (1000190 decimal); conductivity = (1000190 ÷ 1,000,0000) - 1 = 0.00019
3. Pressure = pppppp = 0186DE (100062 decimal); pressure = (100062 ÷ 1,000) - 100 = 0.062

6.6.3 OutputFormat=2

Raw data in decimal

The data output comes in the order listed below, with a comma followed by a space between each parameter. Each parameter shows the number of digits and the placement of the decimal point. Only the zero left of the decimal point shows.

1. Temperature A/D counts = tttttt
2. Conductivity frequency, Hz = cccc.cc
3. Pressure sensor pressure A/D counts = pppppp
4. Pressure sensor temperature compensation voltage = v.vvvv

Example scan = tttttt, cccc.ccc, pppppp, v.vvvv = 676721, 7111.133, 791745, 2.4514

1. Temperature = tttttt =676721; temperature A/D counts = 676721
2. Conductivity = cccc.ccc = 7111.133; conductivity frequency = 7111.133 Hz
3. Pressure = pppppp = 791745; pressure A/D counts = 791745
4. Pressure temperature compensation = v.vvvv = 2.4514; pressure temperature = 2.4514 volts

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6.6.4 OutputFormat=3

Engineering units in decimal

The data output comes in the order listed below, with a comma followed by a space between each parameter. Each parameter shows the number of digits and the placement of the decimal point. Only the zero left of the decimal point shows. If **ProcessRealTime=Y**, the data output has been aligned, filtered and corrected for the cell thermal mass effects.

1. Temperature, °C, ITS-90 = ttt.tttt
2. Conductivity, S/m = cc.ccccc
3. Pressure, decibars = pppp.ppp
4. Salinity, psu = sss.ssss (if **OutputSal=Y**)
5. Sound velocity, m/sec = vvvv.vvv (if **OutputSV=Y**)

Example scan with **OutputSal=N** and **OutputSV=N** = ttt.tttt, cc.ccccc, pppp.ppp = 23.7658, 0.00019, 0.062

1. Temperature = ttt.tttt = 23.7658
2. Conductivity = cc.ccccc = 0.00019
3. Pressure = pppp.ppp = 0.062

6.7 Get quality data

Below are guidelines to get the best quality data from the FastCAT. Some of these guidelines may not agree with the goals of a specific deployment because there can be tradeoffs between quality data and deployment goals.

6.7.1 Remove air from plumbing on upcast

The best orientation of the FastCAT for a single vertical profile from an upcast is vertical, with the sensors pointed up. The "U-shape" of the plumbing lets air release quickly during a brief soak time just below the surface. If air is not removed from plumbing, the top 10 meters of data may not be usable.

A pump that operates correctly keeps surface oils and other contaminants out of the plumbing and conductivity cell.

On deployment: Fill the cell with a 0.1% surfactant solution one hour before deployment, and deploy the FastCAT with the solution still in the cell. As the FastCAT breaks the surface, oils and other contaminants will float on the surfactant solution at the intake and exhaust. Hold the FastCAT below the surface until the pump turns on and pushes the surfactant out of the cell and seawater is pulled in.

On recovery: Turn the pump off before the FastCAT gets to the surface. If the FastCAT is set to operate autonomously, send **Stop** to turn off the pump. Water is held in the "U"-shaped plumbing. As the FastCAT breaks the surface, oils and other contaminants will float on the water at the intake and exhaust, so contaminants do not get into the plumbing and conductivity cell. When the FastCAT is on deck, turn it upside down to empty the water from the cell and exhaust plumbing to keep contaminants out of the system.

6.7.2 Remove air from plumbing on downcast

The best orientation of the FastCAT for a single vertical profile from a downcast is horizontal, with the temperature sting at the bottom. This lets air release quickly during a

---

brief soak time just below the surface. If air is not removed from plumbing, the top 10 meters of data may not be usable.

Enlarged View

Orient with temperature sting at bottom

6.7.3 Remove air from plumbing on upcast or downcast for multiple cycles

If the FastCAT is deployed for multiple cycles on an ROV or an AUV, for example, and will not break the surface of the water, orientation may not be critical. If the FastCAT will collect tens or hundreds of profiles, only the data from the shallow part of the first profile will be affected.

6.7.4 Bernoulli pressures, exhaust, and intake

It is important to keep the exhaust water away from the intake water. If mixed, there will be errors in the temperature data because the pump transfers heat to the exhaust water.

For fast-moving applications, it is important that the Bernoulli pressures on the intake and exhaust are equal. Make sure that the intake and exhaust are on the same plane to keep acceleration of the water in the plumbing to a minimum. Water acceleration in the plumbing overrides the constant flow from the pump, so temperature and conductivity data can be difficult to align.

1. intake 2. straight exhaust	"tee" exhaust

Fast-moving applications, > 0.5 m/sec

The possible errors that are caused by the mix of intake and exhaust water are small compared to Bernoulli pressures at these speeds. The straight exhaust fitting keeps Bernoulli pressure errors to a minimum. In addition, at these speeds, the exhaust flow is blown back as the system moves forward, so the mix of intake and exhaust water decreases.

Slow-moving applications, < 0.5 m/sec

Bernoulli pressure errors are small compared to the errors caused when the intake and exhaust water at these speeds. The "tee" fitting keeps the exhaust water flow perpendicular to the FastCat axis so that the mix of intake and exhaust water is kept to a minimum. The "tee" fitting is part of the manufacturer-supplied spare parts kit.

6.7.5 Keep pressure equal on a vehicle

It is important to attach the FastCAT to a vehicle, such as an AUV or ROV, so that the plane that passes through the axis of the intake and exhaust is parallel to the major surface to which the FastCat is attached.

6.7.6 Profile speed from a ship

Data collected at a speed of approximately 1 m/sec will generally be good quality, but the quantity of ship motion accounted for as conditions change. In rough seas or on small boats where the dynamic motion is large, increase the profile speed to as much as 2 to 3 m/sec to reduce dynamic errors such as spikes, that are caused by rapid changes in ascent or descent of the FastCAT.

If a CTD does not have a pump, slow profile speeds can reduce the water flushed from the conductivity cell, and salinity spikes can occur where there are strong temperature gradients. Since the pump in the FastCAT keeps a constant flow, the FastCAT can be raise slowly to give better vertical resolution of the data, especially in lakes or bays or other calm conditions. On a very calm lake, for example, 10 cm/sec is possible if used with a constant winch speed.

Spikes in derived values for salinity, density, or sound velocity can come from a mis-matched response time of the conductivity and temperature sensors, especially when the profile rate is not constant. Spikes are related to the temperature gradient, and are worse when surface motion causes the FastCAT to stop, or even reverse its descent. If there is heavy ship motion, it may be useful to let the FastCAT free-fall. When very heavy seas cause ship motion and periodic reversals of descent to occur, remove the scans taken when the pressure value did not increase. This will improve the quality of the data.

Make sure that the FastCAT is in a position that the water that flows past the sensors is not thermally contaminated by other instruments or hardware. Attach the FastCAT in front of or at the front of the vehicle.

FastCAT soak time

Where the water temperature is very different from the temperature at which the FastCAT has been stored, let it adjust to the water temperature at the surface for several minutes before a profile is started. This decreases the thermal influence of the FastCAT housing on the water that enters the cell.

6.8 Recover FastCAT from deployment

⚠ **WARNING**
If the user thinks that a sensor has water in the pressure housing: Disconnect the sensor from any power supply. Put on safety glasses and make sure that the sensor is pointed away from the body and other people. In a well ventilated area, use the purge port (if the sensor is so equipped), or very SLOWLY loosen the bulkhead connector to let the pressure release.

Flush the conductivity cell with fresh water. Refer to Clean flow path on page 27 for details to do maintenance on the conductivity cell.

Attach Tygon tubing over the end of the T-C Duct. Use a syringe of wash bottle to flush water through the tubing, conductivity cell, and exhaust tubing.

Section 7 Collect and convert data

After the contents of the configuration file are verified, collect data in real-time with Seasave software and converted with Data Processing software.

7.1 Verify the configuration file information

The Seasave SBE Data Processing software require a configuration file. This file gives the data rate, serial number, calibration date, and calibration coefficients for the CTD. The software uses the information in the configuration file to "read" and process the raw data. **The configuration of the FastCAT and the configuration file must agree or the software cannot process data correctly.**

1. Start the Seasave software.
2. Select **Configure Inputs**, then the *Instrument Configuration* tab, and select **Open**.
3. Select **Modify...** to open the window to change or see the calibration coefficients.

   - In the "Scans to average" box, enter the number of samples to average for each scan. The FastCAT collects samples at 16 Hz (0.0625 seconds), averages the data, and transmits that data in real-time. This value must agree with the **NAvg=** value.
   - If an NMEA device is used, put a check in the applicable boxes. If the NMEA device is connected to a PC, select the related button.
   - Optional: put a check in the "Scan time added" box so the software will append the time (in seconds since January 1, 1970 GMT) to each data scan.

4. Push **Save** or **Save As** to save any changes to the .xmlcon or .con file.
5. Push **Exit** when done.

7.2 Collect data in real-time with Seasave

The steps below are for a FastCAT without a SBE Deck Unit. Refer to the applicable Deck Unit user manual for details to deploy a FastCAT with a SBE 33 or 36 Deck Unit.

1. Start data collection:

   - If **AutoRun=Y**, turn on power. The FastCAT starts data collection and transmits data to the PC.
   - If **AutoRun=N**, turn on power. Start Seaterm and send **Start** to command the FastCAT to start data collection. Push **Disconnect** and close Seaterm.

   Data will show in Seasave when it starts real-time data collection.

2. Start Seasave.
3. Do any setup necessary from the **Configure Inputs**, **Configure Outputs**, and **Display** menus.
4. In the **Real-time Data** menu, push **Start**. There are three main areas in which to enter selections: Data Archiving Options, Configuration Options, and Timeout options.

   a. Data Archiving Options

      - "Begin archiving data immediately" stores raw real-time data as soon as **Start** is pushed and communication is started.
      - "Begin archiving data when 'Start Archiving' command is sent" controls when data is written to a file. This lets the user prevent scans from a FastCAT deployed from a ship's deck and soak time. The SBE Data Processing software also lets the user remove these scans. When the user pushes **Start**, a window with a **Start Archiving** button shows. Push this when ready to save scans to file, or select *Start Archiving* in the **Real-Time Data** menu.
      - "Do not archive data for this cast" will not save data to a file. The real-time data will still show in the display.

- • Push **Select Output Data File Name** to enter the filename and location of the data to save, then push **Save**.
    b. Configuration Options
    The currently selected configuration file shows. Push **Configure Inputs** or **Configure Outputs** to change input or output settings.
    c. Timeout

    - • "Timeout in seconds at startup" is the time before the first data scan is received from the FastCAT. Seasave will "time out" and stop data collection if data is not received from the FastCAT within this time period.
    - • "Timeout in seconds between scans" is the maximum interval between scans after the first scan is received from the FastCAT. Seasave will "time out" and stop data collection if data is not received from the FastCAT within this time period.

5. In the **Start Real-Time Data Acquisition** window, push **Start**.

    a. If "Begin archiving data immediately" or "Begin archiving data when 'Start Archiving' command is sent" is selected, and "Prompt for Header Information" in the *Header Form* setup in **Configure Outputs** is selected, the **Header Information** window shows so the user can enter any header information necessary.
    b. If "NMEA position data added" is selected in the .xmlcon or .con file, Seasave starts communications with the NMEA device.
    c. If "Check Scan Length" is selected from the **Options** menu, Seasave looks at the configuration file to verify that the scan length stated in the configuration file agrees with the FastCAT. If a "Scan length error" message shows, verify that the .xmlcon or .con file is correct, and that the configuration file has been updated if NMEA was added or removed.
    d. Seasave sends a message, "Waiting for data..." and will time out if data is not received within "Timeout seconds at startup."
    e. Real-time data shows in the screen displays.

6. To stop real-time data collection, push **Stop** in the **Real-Time Data** menu.
7. To stop data collection:

    - • If **AutoRun=Y**, remove external power.
    - • If **AutoRun=N**, Close Seasave, then open Seaterm and send **Stop**.

8. In the SBE Data Processing software **File** menu, select *Data Conversion* to convert the raw hex data to engineering units (.cnv file).
    The Data Conversion and some other modules require the .xmlcon or .con file for input.
9. The .cnv file can be further processed and have plots made in other modules of the SBE Data Processing software.

7.3 Collect data with an ROV or AUV

When a FastCAT is used with an ROV or AUV, **all** of the data is saved (complete time series) to an unaltered file.

1. Verify that the FastCAT is set to **OutputFormat=3** and **AutoRun=Y**.
2. Turn on power to the FastCAT to start data collection.
3. Turn off power to the FastCAT to stop data collection.
4. Transmit the FastCAT data file from the vehicle.
5. Open the data file with a text editor and delete any command lines and lines with partial scans.
6. Save the file as a .txt file and close the file.

7. Rename the .txt file with a .asc extension.

8. From the **File** menu in the SBE Data Processing software, select *ASCII In*.

9. At the *Data Setup* tab, enter the scan interval (0.0625 seconds for 16 Hz data, 0.125 for 8 Hz data, etc.) and push **Select Column Names**:

   a. Column 1—Temperature, ITS-90, deg C.
   b. Column 2—Conductivity, S/m
   c. Column 3—Pressure, strain gauge, db
   d. Column 4—Salinity, psu (if **OutputSal=Y**)
   e. Column 5—Sound Velocity, Chen-Millero, m/s (if **OutputSV=Y**)

10. Push **Start Process**.
    ASCII In will make a .cnv file from the .asc file and the information entered at the *Data Setup* tab.

11. Optional: use other modules in the SBE Data Processing software to further process and make plots of the .cnv file. Some modules require the .xmlcon or .con file as well as the data file for input.

Section 8 Maintenance

<table>
<tr><td>⚠ WARNING</td></tr>
<tr><td>If the user thinks that a sensor has water in the pressure housing: Disconnect the sensor from any power supply. Put on safety glasses and make sure that the sensor is pointed away from the body and other people. In a well ventilated area, use the purge port (if the sensor is so equipped), or very SLOWLY loosen the bulkhead connector to let the pressure release.</td></tr>
</table>

8.1 Clean pressure housing

After every deployment, flush the pressure housing with clean fresh water. Make sure to keep the sensor out of direct sunlight between deployments.

Sensors with plastic or acetyl pressure housings are lighter and less expensive than the more durable titanium or aluminum housings, but require extra care.

- Plastic can become brittle in cold environments. It is possible for cracks to form around screw holes. Make sure that screws are tightened to 15 in-lbs., or finger-tight, then 45 degrees more.
- Plastic scratches easily. Do not use screwdrivers or metal tools to remove the end flange. Make sure that O-ring surfaces are clean, and monitor the pressure housing for deep scratches that can become a point of weakness during deep deployments or very cold temperatures.

For titanium and aluminum pressure housings: do not let the pressure housing come into direct with another type of metal. Wrap metal clamps and other hardware used to attach the sensor to a frame with electrical tape.

8.2 Clean flow path

<table>
<tr><td>⚠ WARNING</td></tr>
<tr><td>Bleach is caustic. Wear nitrile gloves and safety glasses and work in a well ventilated area to use bleach. Wash hands after use.</td></tr>
</table>

<table>
<tr><td>⚠ CAUTION</td></tr>
<tr><td>Do not mix bleach with water > 1 PSU salinity or let bleach into a sensor that has not been flushed with clean, fresh (< 1 PSU) water.</td></tr>
</table>

The manufacturer recommends that the user thoroughly clean the flow path before and after a deployment to make sure that the sensor continues to collect accurate, high-quality data. Correct maintenance of the flow path is critical for the multi-parameter measurement capabilities.

Supplies:

- 500 ml bottle of DI water
- Container for waste water
- Container for sensor
- De-ionized or distilled water. If unavailable, use fresh tap water. Do not use shipboard fresh water because it can have traces of oil in it.
- Non-ionic surfactant. The manufacturer supplies this with each sensor. It is a secondary alcohol ethoxylate, a non-ionic detergent that is biodegradable. Make sure that any alternative detergent that is used is scientific grade, with no colors, perfumes, glycerins, lotions, etc.
- Bleach mixed 50:1—Household bleach is usually 4–7% (40,000–70,000 ppm) sodium hypochlorite with stabilizers.
- Manufacturer-supplied tubing and syringe to clean the plumbing.

Procedure notes:

Use warm 30 °C (86 °F) water and 1% non-ionic surfactant to flush the flow path for one minute.

It may be necessary to do these steps up to five times to clean the flow path.

If there is bio-fouling on the sensor it may be necessary to fill the flow path with the non-ionic surfactant solution for approximately 12 hours to loosen debris.

Make sure to remove the anti-fouling assembly if necessary.

1. Remove the pH sensor (if so-equipped) and store it in the white plastic holder with KCl solution or de-ionized (DI) water if non-ionic surfactant or bleach is necessary to clean the flow path. The pH sensor can stay installed on the sensor if DI water is used. Do not expose the pH sensor to air for longer than a few minutes. Refer to "Prepare pH sensor for storage" for details to remove the pH sensor.
2. Remove the copper assembly and anti-fouling devices from the sensor.
3. Use a 3/16-inch hex wrench to remove the flushing port plug, a ¼-20 x 1 inch socket head screw.
   Keep the plug to install again.
4. Put the instrument in a container with the bulkhead connector face-up.
5. If a cleaning solution is necessary, pull approximately 30 ml of DI water into the syringe.
6. Push the syringe plunger to fill the sensor flow path until 3–5 cm of solution shows in each tube.
7. Push and pull the plunger to mix the solution in the flow path. Do this 2–3 times.
8. Drain the solution from the sensor into a waste container. Push the syringe plunger to help remove all of the solution from the sensor.
9. Remove the tubing and shake the sensor.
10. If the flow path is still not clean, do the above steps again with the bleach solution.
11. Flush the flow path with DI water.
12. Install the flushing port plug again.
    The sensor is ready for a functional test in the laboratory or a deployment.

8.3 Clean bulkhead connectors

> # *NOTICE*
>
> Do not use WD-40® or petroleum-based lubricant on bulkhead connectors. It will cause damage to the rubber.
> Damaged connectors can cause a loss of data and additional costs for service.
>
> Damaged connectors can cause damage to the sensor and make it unserviceable.
>
> Use silicone-based lubricants only.

Examine, clean, and lubricate bulkhead connectors at regular intervals. Connectors that are not lubricated increase the damage to the rubber that seals the connector contacts. The incorrect lubricant will cause the failure of the bulkhead connector.

1. Apply isopropyl alcohol (IPA) as a spray or with a nylon brush or lint-free swab or wipes to clean the contacts.
2. Flush with additional IPA.
3. Shake the socket ends and wipe the pins of the connectors to remove the IPA.
4. Blow air into the sockets and on the pins to make sure they are dry.
5. Use a flashlight and a magnifying glass to look for:

Any corrosion.		
Cracks, scratches, or other damage on the rubber pins or in the sockets.		
Separation of the rubber from the pins.		
Swelled or bulging rubber pins.		

6. Use a silicone-based lubricant on each of the contacts of the bulkhead connector. The manufacturer recommends any of the products listed below.

- 3M™ Spray Silicone Lubricant (3M ID# 62-4678-4930-3). Make sure to let it dry.
- Dow Corning Molykote® III Compound (DC III)
- Dow Corning High Vacuum Grease® (DC 976 V)
- Dow Corning 4 Electrical Insulating Compound® (DC 4)
- Dow Corning Molykote 44 High Temperature Grease® (DC 44)

Use a finger to put a small quantity (approximately 1 cm in diameter) of silicone grease on the socket end of the connector and push as much of the lubricant as possible into each socket. Do not use too much lubricant, as that will prevent a good seal.

7. Connect the connectors.
8. Use a lint-free wipe to clean any unwanted lubricant from the sides of the connectors.

8.4 Examine O-rings

NOTICE

Do not use petroleum-based lubricants on O-rings. It will cause damage to the O-rings. Damaged O-rings can cause the sensor to flood and make it unserviceable.

Examine the O-rings on the sensor every time they are exposed—on the connector end flange and other parts. O-rings must be pristine. If there is any question about whether an O-ring is clean and undamaged, replace it with a new one.

1. Dry the O-rings and O-ring grooves with a lint-free cloth or tissue.

2. Examine each O-ring to make sure there is no damage, dirt, lint or hair on it.

3. Replace an O-ring if necessary.

4. Apply a small quantity of silicone-based Parker Super O Lube® or Dow Corning® high vacuum grease to each O-ring.

   • The lubricant helps the O-ring move into its groove with no twist, which can compromise the seal.
   • Do NOT use petroleum-based lubricants on any O-ring.

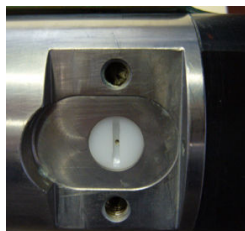## 8.5 Clean pressure sensor

NOTICE
Do not put a brush or any object in the pressure port. It may damage or break the pressure sensor.

The nylon pressure capillary fitting has a pressure port fitting and an external capillary tube that is filled with silicone oil. The oil transmits hydrostatic pressure from the capillary tubing to the pressure sensor. The oil also prevents corrosion if the sensor is exposed to water.

Because of temperature and pressure changes over long time periods, some oil will slowly leak out of the external capillary tube. Use P/N 50025, Pressure Sensor Oil Refill Kit to refill the oil in the tube if no oil can be seen in the tube.

At regular intervals, or annually, inspect and clean the pressure port of sensors that are so equipped.

1. Use a flathead screwdriver to remove the pressure port plug.

2. Flush the pressure port with warm DI water to remove any contamination.

3. Replace the pressure port plug. Do not over-tighten the nylon screw.

8.6 Replace anti-fouling devices

⚠ CAUTION
AF24173 anti-fouling devices contain bis(tributyltin) oxide. Wear rubber or latex gloves and eye protection to replace these devices on the sensor if it is so equipped. Wash hands with soap and water when finished. Read the precautions on the product label.
It is a violation of US federal law to use this product in a manner that is inconsistent with its label.

The FastCAT can have optional anti-fouling devices installed in the T-C Duct assembly and as part of the external pump exhaust tubing.

1. Remove the large screw that attaches the T-C Duct to the mast .

1. Temperature sting
2. Conductivity cell

3. Mast

2. Carefully pull the T-C Duct straight out. There will be some resistance as the seals disengage. **Do not twist the T-C Duct or apply any sideways movement as that can cause damage to the conductivity cell**.

3. Remove the two small Phillips-head screws that attach the T-C Duct top to the base.

Left: T-C Duct top   Right: T-C Duct base

4. Pull the top off of the base.

5. Remove the old anti-fouling device.
   It may be necessary to use needle-nose pliers to carefully break up the material.

6. Put a new anti-fouling device (AF24173) in the T-C Duct base.

7. Put the T-C Duct top on the base and install the Phillips-head screws again.

8. Carefully put the T-C Duct assembly over the temperature sting and make sure to align the large screw hole with the mast.
   There will be some resistance as the seals engage. **Do not twist the T-C Duct or apply any sideways movement as that can cause damage to the conductivity cell**.

9. Install the large screw to attache the assembly to the mast.

10. Replace the anti-fouling device in the pump exhaust tubing:

    a. Carefully cut the plastic cable tie that attaches the Tygon tubing to the anti-fouling device cap, and pull the tubing off of the device cap.

    b. Use a socket wrench to loosen the cap.

    c. Remove the old anti-fouling device.
       It may be necessary to use needle-nose pliers to carefully break up the material.

    d. Put a new anti-fouling device (AF24173) in the cup.

    e. Attach the cap onto the cup but be careful not to tighten too much.

    f. Push the Tygon tubing onto the cap again. Attach a new cable tie.

8.7 Spare parts and accessories

Part number	Description	Qty
801206	Connector, 4-contact MCIL-FS to 9-contact DB9S I/O cable with power leads, 2.4 m	1
171398.1	Dummy plug, 4-contact MCIL-FS, with lock collar (171192)	1
30411	Non-ionic surfactant solution to clean conductivity cell	1
311521	Anti-fouling shipping label	1
801542	AF24173 Anti-fouling device pair	2
233493	T-C Duct top to hold AF24173 in base	1
233515	T-C Duct base, holds AF24173 device	1
232395	Straight exhaust fitting that attaches to sensor guard	1
60037	Spare parts kit, titanium SBE 49	1
60052	Spare parts kit, plastic SBE 49	1
50312	Anti-fouling assembly	1

Section 9 Reference: command descriptions

This is a reference for advanced users. The values of these commands are stored in the sensor until the user changes them. Notes about terminal commands are listed below.

- Commands are not case-sensitive. Use "Enter" to store a command.
- The sensor sends `? CMD` if an invalid command is sent.
- If the system does not show an `S>` prompt after a command is sent, push **Enter** to see the `S>` prompt.
- Push **Connect** on the toolbar or push **Enter** to start communications.
- To stop the FastCAT during data collection, send **Stop**: select **Stop** on the toolbar or type Ctrl Z. Push **Enter** to get the `S>` prompt.
- The FastCAT responds to DS, DCal, and Stop during data collection. If one of these commands is sent during data collection, the FastCAT will stop temporarily. Data collection starts again after the FastCAT responds to the command.
- User entries for the commands below are in bold.

9.1 Status

S>**DS**	
SBE 49 FastCAT V 1.3a SERIAL NO. 0055	
NAvg=	number of scans to average = 1
PRange=	pressure sensor = strain gauge, range = 1000.0
MinCondFreq=, **PumpDelay=**	minimum cond freq = 3000, pump delay = 30 sec
AutoRun=	start sampling on power up = no
OutputFormat=	output format = converted decimal
OutputSal=, **OutputSV=**	output salinity = yes, output sound velocity = yes
TAdvance=	temperature advance = 0.0625 seconds
Alpha=	celltm alpha = 0.03
Tau=	celltm tau = 7.0
ProcessRealTime=	real-time temperature and conductivity correction enabled for converted data

9.2 General setup

Baud=x	x=baud rate, 1200, 2400, 4800, 9600 (**default**),19200, 38400
OutputFormat=x	x=0, output raw data in hex x=1, output converted data in hex x=2, output raw data in decimal x=3, output converted in decimal (**default**)
OutputSal=x	x=Y, calculate and show salinity in psu. Only applies if OutputFormat=3 (**default**) x=N, do not calculate and show salinity

OutputSV=x	x=Y, calculate and show sound velocity in m/sec. Only applies if OutputFormat=3 (**default**) x=N, do not calculate and show sound velocity
SetDefaults=x	reset to default values OutputFormat=3 OutputSal=Y OutputSV=Y NAvg=1 MinCondFreq= 3000 PumpDelay=30 ProcessRealTime=Y TAdvance=0.0625 Alpha=0.03 Tau=7.0 AutoRun=N

9.3 Data collection

Table 3 Autonomous

NAvg=x	x= number of samples to average. Default=1.
MinCondFreq=x	x= minimum conductivity frequency, Hz, to enable pump turn-on. Pump stops when frequency is below *x*. Default=3000. Manufacturer-set to 0 conductivity frequency + 500 Hz.
PumpDelay=x	x= time in seconds to wait after minimum conductivity frequency is reached before pump turns on. Default=30 seconds.
ProcessRealTime=x	x=Y apply alignment, filter, and conductivity cell thermal mass corrections to data. Only applies if OutputFormat=1 or 3. Default. x=N do not apply corrections.
TAdvance=x	x= time to advance temperature data in relation to conductivity and pressure data. Range, 0 to 0.125 seconds. Default=0.0625. Only applies if ProcessRealTime=Y and OutputFormat=1 or 3.
Alpha=x	x= conductivity cell thermal mass alpha correction, range, 0.02 to 0.05. Default=0.03. Only applies if ProcessRealTime=Y and OutputFormat=1 or 3.
Tau=x	x= conductivity cell thermal mass tau correction, range, 5.0 to 10.0. Default=7.0. Only applies if ProcessRealTime=Y and OutputFormat=1 or 3.
AutoRun=x	x=N wait for command when power is supplied. Default. x=Y start autonomous data collection when power is supplied.
Start	start autonomous data collection now.
Stop	stop autonomous data collection. Push **Enter** to see the S> prompt, then enter **Stop**.

Table 4 Polled

PumpOn	turn pump on
PumpOff	turn pump off

9.4 SBE 49 tests

Take and transmit 100 samples for each test. Push **Esc** or **Stop** on toolbar to stop a test.	
TS	take one sample and transmit data
TT	measure temperature, transmit converted data
TC	measure conductivity, transmit converted data

TP	measure pressure, transmit converted data
TTR	measure temperature, transmit raw data
TCR	measure conductivity, transmit raw data
TPR	measure conductivity, transmit raw data

9.5 Calibration coefficients

F = floating point number. S = String with no spaces.

Calibration coefficients are set by the manufacturer and should be the same as the Calibration Certificates that ship with the FastCAT.

Command	Description
DCal	Show calibration coefficients. All coefficients and dates are included in the display. Use the commands below to change a specific coefficient or date.
Temperature	
TCalDate=S	S=temperature calibration date
TA0=F	F=temperature A0
TA1=F	F=temperature A1
TA2=F	F=temperature A2
TA3=F	F=temperature A3
TOffset=F	F=-temperature offset correction
Conductivity	
CCalDate=S	S=conductivity calibration date
CG=F	F=conductivity G
CH=F	F=conductivity H
CI=F	F=conductivity I
CJ=F	F=conductivity J
CPCor=F	F=conductivity cpcor
CTCor=F	F=conductivity ctcor
CSlope=F	F=conductivity slope correction
Pressure	
PCalDate=S	S=pressure calibration date
PRange=F	F=pressure sensor full scale range, psia
POffset=F	F=pressure offset correction, decibars
PA0=F	F=pressure A0
PA1=F	F=pressure A1
PA2=F	F=pressure A2
PTempA0=F	F=pressure temperature A0
PTempA1=F	F=pressure temperature A1
PTempA2=F	F=pressure temperature A2
PTCA0=F	F=pressure ptca0
PTCA1=F	F=pressure ptca1

PTCA2=F	F=pressure ptca2
PTCB0=F	F=pressure ptcb0
PTCB1=F	F=pressure ptcb1
PTCB2=F	F=pressure ptcb2

Section 10 Troubleshooting

10.1 No communications with sensor

The S> prompt shows that there is communication between the sensor and PC. If the S> prompt does not show, push **Enter** several times.

Cause: The I/O cable is not connected correctly.

Solution: Make sure the cable is connected at the PC and the sensor.

Cause: The sensor communication settings were not entered correctly in the software.

Solution: Make sure that the settings agree with the values on the Configuration Sheet that shipped with the sensor.

Cause: The I/O cable is not the correct cable.

Solution: Make sure that the cable is a standard 9-pin RS232 cable.

10.2 No real-time data shows

Cause: The I/O cable is loose.

Solution: Make sure all cables are connected correctly.

Cause: Communications settings are incorrect.

Solution: Make sure that the communications settings in the software are correct. Make sure the COM port is correct.

10.3 Scan length errors

Cause: The software shows a scan length error and data does not show. This can occur, for example, if the configuration file has an NMEA device added, but the NMEA device is not physically connected to the PC. The software continues to collect data in real-time, but does not show the data.

Solution: The data quality is not affected and can be corrected later.

Solution: Make sure the configuration file and the .xmlcon file agree. Correct the configuration file as necessary.

10.4 Salinity spikes

Cause: The conductivity cell is dirty, broken, or that there is an object in the cell.

Solutions:

1. Clean the conductivity cell. Refer to Clean flow path on page 27 for details.
2. Blow *clean* air (not compressed) through the cell to remove large drops of water from the cell.
3. Enter the **TCR** command to look at the raw conductivity frequency. It should be within 1 Hz of the zero conductivity value on the Calibration Sheet. If it is very different, the cell is probably damaged.

10.5 Data looks incorrect

Cause: Data that looks incorrect, with values out of range, for example, may be caused by incorrect calibration coefficients in the sensor.

Solution: Make sure that the calibration coefficients in the sensor are the same as the Calibration Sheet from the manufacturer.

Section 11 General information

Revised editions of this user manual are on the manufacturer's website.

11.1 Warranty

Refer to the manufacturer's website for warranty information (seabird.com/warranty).

11.2 Service and support

The manufacturer recommends that sensors be sent back to the manufacturer annually to be cleaned, calibrated, and for standard maintenance.
Refer to the website for FAQs and technical notes, or contact the manufacturer for support at support@seabird.com. Do the steps below to send a sensor back to the manufacturer.

1. Complete the online Return Merchandise Authorization (RMA) form or contact the manufacturer.
    Note: The manufacturer is not responsible for damage to the sensor during return shipment.
2. Remove all anti-fouling treatments and devices.
    Note: The manufacturer will not accept sensors that have been treated with anti-fouling compounds for service or repair. This includes AF 24173 devices, tri-butyl tin, marine anti-fouling paint, ablative coatings, etc.
3. Use the sensor's original ruggedized shipping case to send the sensor back to the manufacturer.
4. Write the RMA number on the outside of the shipping case and on the packing list.
5. Use 3rd-day air to ship the sensor back to the manufacturer. Do not use ground shipping.
6. The manufacturer will supply all replacement parts and labor and pay to send the sensor back to the user via 3rd-day air shipping.

11.3 China RoHS disclosure table

Name of Part	Hazardous substance or element in product					
	Pb	Hg	Cd	Cr(VI)	PBB	PBDE
PCBs	X	O	O	O	O	O
This table is compiled to the SJ/T 11364 standard.						
O: This hazardous substance is below the specified limits as described in GB/T 26572. X: This hazardous substance is above the specified limits as described in GB/T 26572.						

11.4 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 WITH SEA-BIRD ELECTRONICS' CONDUCTIVITY SENSORS TO CONTROL THE GROWTH OF AQUATIC ORGANISMS WITHIN ELECTRONIC CONDUCTIVITY SENSORS.

ACTIVE INGREDIENT: Bis(tributyltin) oxide 52.1%
OTHER INGREDIENTS: 47.9%
TOTAL 100.0%

DANGER
Refer to conductivity sensor manual for the complete label and additional precautionary statements and information on the handling, storage and disposal of these devices.

Net contents: Two anti-foulant devices   EPA Registration No. 74489-1
Sea-Bird Electronics, Inc.   EPA Establishment No. 74489-WA-1
13431 NE 20th St.
Bellevue, WA 98005

AF24173 ANTI-FOULANT DEVICE

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

ACTIVE INGREDIENT: Bis(tributyltin) oxide 52.1%

OTHER INGREDIENTS: . . . . <u>47.9%</u>

TOTAL 100.0%

DANGER

See Precautionary Statements for additional information.

FIRST AID	
If in eyes	• Hold the 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.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15–20 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.
HOT LINE NUMBER	
Note to Physician	Probable mucosal damage may contraindicate the use of gastric lavage.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. For further information, call National Pesticide Telecommunications Network (NPTN) at 1-800-858-7378.	

Net contents: Two anti-foulant devices

Sea-Bird Electronics, Inc.

13431 NE 20th St.

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. May be fatal if swallowed or absorbed through the skin. Do not get in eyes, on skin, or on clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove and wash contaminated clothing before reuse.

PERSONAL PROTECTIVE EQUIPMENT

Users must wear: protective gloves (rubber or latex), goggles or other eye protection, long-sleeved shirt, long pants, and shoes plus socks.

USER SAFETY RECOMMENDATIONS

Users should:

- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Follow the 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.

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.

Intended for professional use by military, government, academic, commercial, and scientific personnel.

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 into a labeled container for treatment or disposal.

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

CONTAINER HANDLING: Nonrefillable container. Do not reuse this container for any other purpose. Offer for recycling, if available.