CTD Temperature Sensor

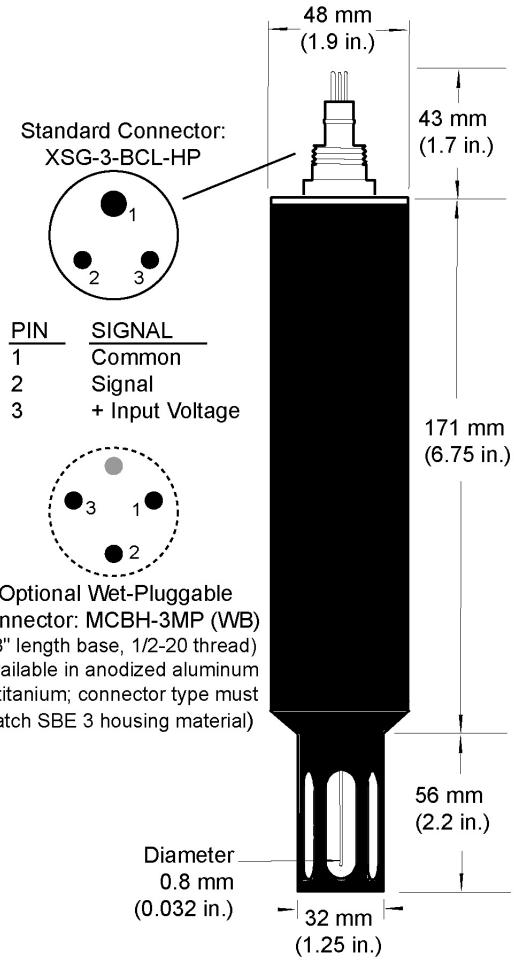
SBE 3F

DESCRIPTION

The **SBE 3F** is an enhanced version of Sea-Bird's proven SBE 3 temperature sensor. The superior performance of the SBE 3F results from its optimized electronic design combined with an extraordinarily precise calibration procedure and quality testing program. The SBE 3F has a time response of approximately 0.07 second, an initial accuracy of 0.001 °C, and is typically stable to 0.002 °C per year.

Every SBE 3F is calibrated in Sea-Bird's computer-controlled calibration baths. These super-low-gradient baths produce temperature calibrations with resolution and accuracy not previously available to oceanographers.

These sensors can be successfully calibrated as separate modules because they have built-in acquisition circuits and frequency outputs. When used with a CTD system, overall system accuracy is equal to the sensor accuracy degraded only by the uncertainty in the CTD's master clock. A typically small clock error of 1 ppm affords a temperature error of less than 50 μ°C.



APPLICATION

Intended primarily for use on the SBE 25 and 25*plus* Sealogger CTD system, the SBE 3F can also be used as a component in custom oceanographic profiling systems or for high-accuracy industrial and environmental temperature monitoring applications. Depth ratings to 6800 meters (aluminum) and 10500 meters (titanium) are offered to suit different application requirements.

SPECIFICATIONS

Range	-5.0 to +35 °C
Initial Accuracy[1]	± 0.001 °C
Stability	0.002 °C per year typical
Response Time[2] [sec.]	0.065 ± 0.010 (1.0 m/s water velocity) 0.070 ± 0.010 (0.5 m/s water velocity)
Self-heating Error	<0.0001 °C in still water
Settling Time	< 0.5 sec. to within 0.001 °C
Power Required	11 - 16 VDC, 25 ma
Signal Output	± 0.5V square wave

Housing	Depth Rating	Weight
7075 aluminum	6800 meters	0.63 kg (1.4 lbs) in air; 0.28 kg (0.6 lbs) in water
6Al-4V titanium	10500 meters	0.90 kg(2.0 lbs) in air; 0.55 kg (1.2 lbs) in water

[1] NIST-traceable calibration applying over the entire oceanographic range.

[2] Time to reach 63% of final value following a step change in temperature.

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CTD Temperature Sensor SBE 3F

OPERATION

The sensing element is a glass-coated thermistor bead, pressure-protected in a thin-walled 0.8 mm diameter stainless steel tube. Exponentially related to temperature, the thermistor resistance is the controlling element in an optimized Wien Bridge oscillator circuit. The resulting sensor frequency is inversely proportional to the square root of the thermistor resistance and ranges from approximately 2 to 6 kHz, corresponding to temperature from -5 to +35 °C.

CALIBRATION

SBE 3F sensors are calibrated to ITS-90 temperature using Sea-Bird's computer-controlled calibration bath. Extremely well insulated, the baths provide a uniform toroidal circulation yielding an overall transfer accuracy against an SPRT within 0.0002 °C. Repeatability at each of twelve individually mapped sensor positions is better than 0.0001 °C. Sea-Bird's metrology laboratory underpins the temperature calibration baths. Following consultation with the U.S. National Institute of Standards and Technology, the met lab was configured to achieve temperature precision of 50 µK and accuracy of 0.0005 °C. To obtain this performance, premium primary references including four Jarrett water triple-point cells (with maintenance bath) and an Isotech gallium melt cell are operated in conjunction with two YSI 8163 standards-grade platinum resistance thermometers and an ASL F18 Automatic Temperature Bridge.

CALIBRATION EQUATION

The calibration yields four coefficients (g, h, i, j) that are used in the following equation (Bennett):

$$T = \frac{1}{g + h(ln(f_0/f)) + i(ln^2(f_0/f)) + j(ln^3(f_0/f))} - 273.15, \quad [°C]$$

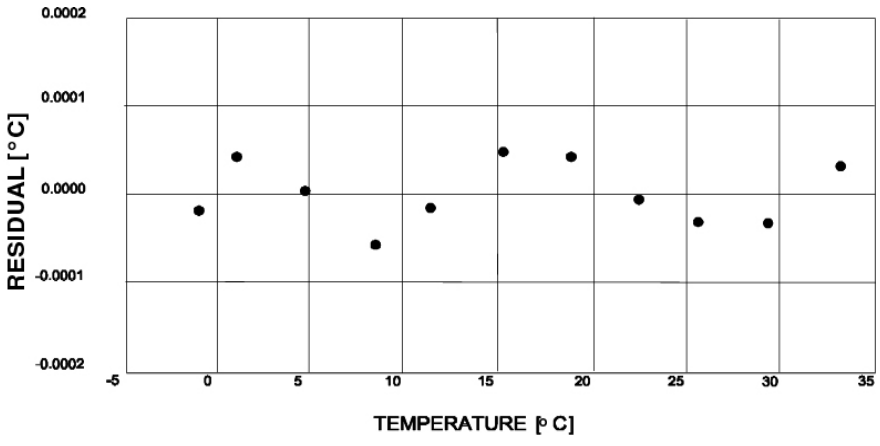
where T is temperature [°C], *ln* is the natural log function, and f is the SBE 3F output frequency in Hz. Note that f_0, an arbitrary scaling term used for purposes of computational efficiency, was historically chosen as the lowest sensor frequency generated during calibration. For all calibration results expressed in terms of ITS-90 temperatures, the f_0 term is set to 1000. Calibration fit residuals are typically less than 0.0001°C.

ACTUAL CALIBRATION DATA for Sensor Serial Number 2234

CALIBRATION DATE: 01 Jun 96

g = 4.31635693e-03 h = 6.41530157e-04
i = 2.27237634e-05 j = 2.17153096e-06
f_0 = 1000.000

BATH TEMP [°C]	INST FREQ [Hz]	INST TEMP [°C]	RESIDUAL (INST - BATH) [°C]
-1.4283	2787.505	-1.4283	-0.00002
1.0814	2948.210	1.0814	0.00004
4.5728	3182.770	4.5728	0.00000
8.1715	3438.281	8.1715	-0.00006
11.6037	3695.317	11.6037	-0.00001
15.1611	3975.833	15.1611	0.00005
18.6649	4266.480	18.6649	0.00004
22.1634	4571.240	22.1634	-0.00001
25.7229	4896.542	25.7228	-0.00003
29.1375	5223.350	29.1375	-0.00003
32.6712	5577.028	32.6712	0.00003



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