Premium CTD Temperature Sensor

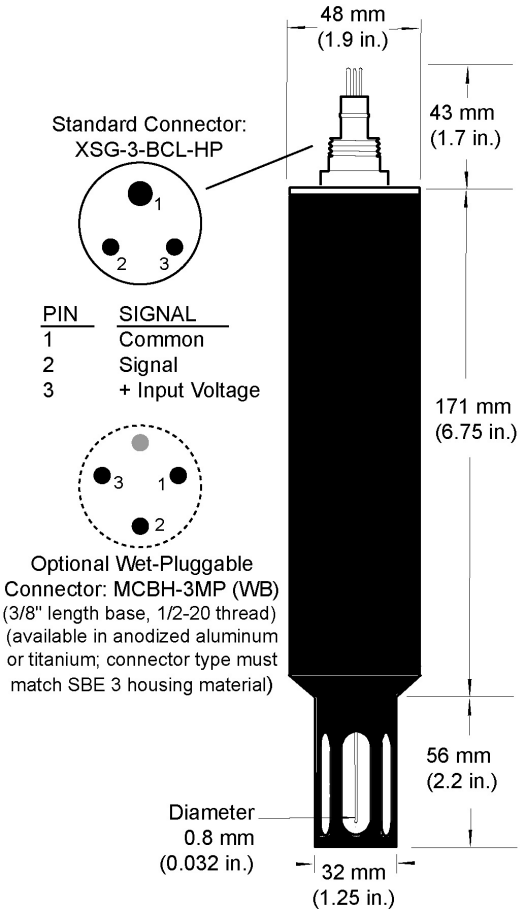
SBE 3*plus*

DESCRIPTION

The superior performance of the **SBE 3*plus*** results from its optimized electronic design, superior calibration, response characterization, and quality testing program. The SBE 3*plus* is a more rigorously tested and calibrated version of our SBE 3F temperature sensor. A sensor is designated as an SBE 3*plus* only after demonstrating drift of less than 0.001 °C during a six-month screening period. In addition, the time response is carefully measured and verified to be 0.065 ± 0.010 seconds.

Every SBE 3*plus* 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 Sea-Bird CTD, overall system accuracy is limited only by the accuracy of the CTD's master clock. Errors from this source are demonstrably negligible (in the SBE 911*plus* CTD, clock error contribution is 0.00016 °C based on a five-year worst case error budget including ambient temperature influence of 1 ppm total over -20 to +70 °C, plus 1 ppm first year drift, plus four additional year's drift at 0.3 ppm per year).



APPLICATION

Intended primarily for use on the SBE 911*plus* CTD system, the SBE 3*plus* can also be used as a component in custom oceanographic 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
Resolution[1]	0.0003 °C at 24 samples per second
Initial Accuracy[2]	± 0.001 °C
Stability	Must demonstrate less than 0.001 °C drift during the 6 months prior to delivery
Response Time[3] [sec.]	0.065 ± 0.010 (1.0 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] Achieved with Sea-Bird's SBE 911*plus* CTD.
[2] NIST-traceable calibration applying over the entire oceanographic range.
[3] Time to reach 63% of final value following a step change in temperature; water velocity 1 m/s.

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Premium CTD Temperature Sensor SBE 3*plus*

OPERATION

The sensing element is a glass-coated thermistor bead, pressure-protected in a 0.8 mm diameter thin-walled 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 3*plus* 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):

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

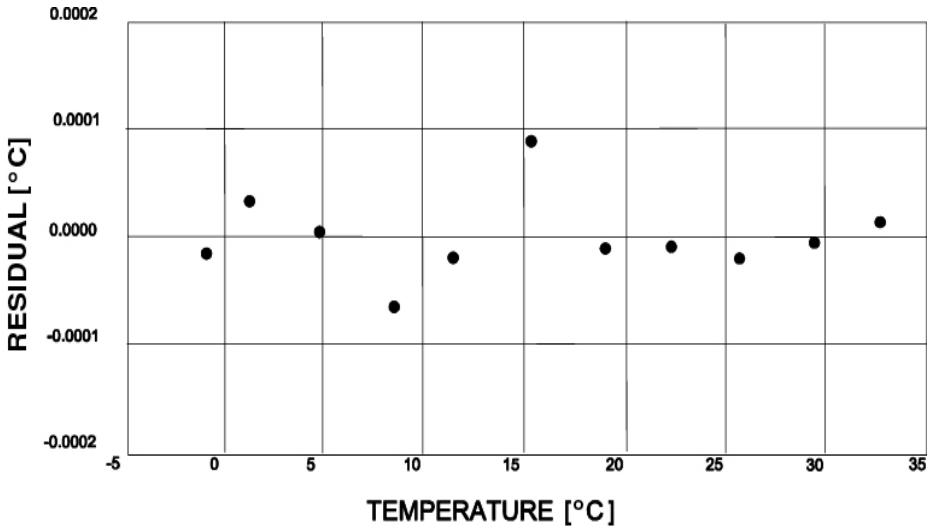
where T is temperature [°C], *ln* is the natural log function, and f is the SBE 3*plus* output frequency in Hz. Note that f_0, an arbitrary scaling term used for purposes of computational efficiency, was historically chosen as the lowest sensor frequency generated during calibration. For all calibration 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 2132

CALIBRATION DATE: 31 Oct 95

g = 4.12744629e-03 h = 6.26321187e-04
i = 2.05376982e-05 j = 2.13741203e-06
f_0 = 1000.000

BATH TEMP [°C]	INST FREQ [Hz]	INST TEMP [°C]	RESIDUAL (INST - BATH) [°C]
-1.4309	2075.334	-1.4309	-0.00002
1.0784	2195.385	1.0785	0.00004
4.5695	2370.650	4.5695	0.00001
8.1675	2561.590	8.1674	-0.00006
11.5994	2753.736	11.5993	-0.00002
15.1570	2963.518	15.1571	0.00009
18.6607	3180.898	18.6607	-0.00001
22.1592	3408.886	22.1592	-0.00001
25.7189	3652.317	25.7188	-0.00002
29.1334	3896.897	29.1334	-0.00001
32.6673	4161.665	32.6673	0.00001



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