Deep Ocean Standards Thermometer   SBE 35

The SBE 35 is a laboratory standards thermometer with the unique ability to be used both in fixed point cells and at depths up to 6800 meters (22,300 ft). It is unaffected by shock and vibration encountered in shipboard and industrial environments, making it ideal for use in calibration laboratories in the range of -5 to +35° C, and in the thermodynamic method of measuring hydro turbine efficiency. The SBE 35 communicates via a standard RS-232 interface at 300 baud, 8 data bits, no parity.

DEEP OCEAN APPLICATIONS

The SBE 35 can be used with the SBE 32 Carousel Water Sampler and one of the following CTD systems:
- **Real-time** (bottles closed by command from ship)
  SBE 9*plus* CTD with SBE 11*plus* Deck Unit, *or*
  SBE 19, 19*plus*, 19*plus* V2, or 25 CTD with SBE 33 Deck Unit
- **Autonomous** (bottles closed based on programmed pressures or times)
  SBE 9*plus* CTD with SBE 17*plus* V2 SEARAM, *or*
  SBE 19, 19*plus*, 19*plus* V2, or 25 CTD with Auto Fire Module (AFM)

The SBE 35 makes a temperature measurement each time a bottle fire confirmation is received, and stores the value in EEPROM. Each stored value contains the time and bottle position in addition to the temperature data, allowing comparison of the SBE 35 record with CTD and water bottle data. Using one SBE 35 eliminates the need for reversing thermometers, and provides higher accuracy temperature readings at lower cost.

Real-Time Operation:

11*plus* —— 9*plus* CTD ——┬—— Carousel
                          │
                          35

33 – Carousel – 19, 19*plus*, 19*plus* V2, or 25 CTD
        │
        35

Autonomous Operation:

9*plus* CTD —— 17*plus* ——┬—— Carousel
                          │
                          35

19, 19*plus*, 19*plus* V2, or 25 CTD — AFM ┬ Carousel
                                          │
                                          35

INDUSTRIAL OR LABORATORY APPLICATIONS

The thermometer's digital output can be displayed in real-time and logged to a computer file. The SBE 35 is standardized in water triple point (TPW) and gallium melting point (GaMP) cells, following the methodology applied to a standards-grade platinum resistance thermometer (SPRT). Unlike SPRTs, it does not require an expensive resistance bridge, making the SBE 35 a dramatically cost-effective alternative. For measurements in fixed point cells, the protective guard is removed and a brass and plastic tip bushing is attached to give the SBE 35 the length, diameter, and thermal averaging characteristic of an SPRT. The SBE 35 resolves temperature in fixed point cells to approximately 0.000025° C (25 µK). Accuracy is better than 1 mK.

The SBE 35 is supplied with a small desktop Interface Box that is connected between the SBE 35 and a computer for setup and lab use. The Interface Box is 110/220 VAC powered, provides 15 VDC to the SBE 35, and buffers the communication lines to minimize interference from external noise.

User-selectable operating modes are:
- Sample continuously and output real-time data (data is not stored in EEPROM), or
- Take a single sample, store the data in EEPROM, and output real-time data.

Remove temperature guard for laboratory applications

SOFTWARE AND DATA UPLOAD

SEATERM, the terminal program in our SEASOFT©-Win32 software suite, provides easy SBE 35 setup and data uploading. Calibration coefficients stored in EEPROM allow the SBE 35 to transmit data in engineering units. When configured for a real-time ocean application, the SBE 35 can use the system modem channel for two-way communications; it is not necessary to change cable connections to communicate with and retrieve data from the SBE 35.

# Deep Ocean Standards Thermometer   SBE 35

MEASUREMENT METHOD

Temperature is determined by applying an AC excitation to reference resistances and an ultrastable aged thermistor with a drift rate of less than 0.001°C per year. Each of the resulting outputs is digitized by a 20-bit A/D converter. The reference resistor is a hermetically sealed, temperature-controlled VISHAY. The switches are mercury wetted reed relays with a stable contact resistance. AC excitation and ratiometric comparison using a common processing channel removes measurement errors due to parasitic thermocouples, offset voltages, leakage currents, and gain errors. Maximum power dissipated in the thermistor is 0.5 microwatts, and contributes less than 200 µK of overheat error.
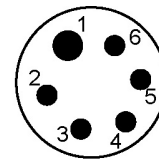
Standard Connector AG-306-HP-SS
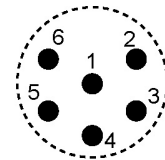
Optional Wet-Pluggable Connector MCBH-6MP (WB), AL (3/8" length base, 1/2-20 thread)

Pin	Signal
1	Ground
2	Receive from SBE 9*plus*, SBE 33, or Interface Box
3	Transmit
4	N/C
5	Bottle fire confirmation from Carousel
6	Power +9 to +16V

$$\text{Sensor Output (raw counts)} = 1048576 * (NT - NZ) / (NR - NZ)$$

where NR is reference resistor output, NZ is zero ohms output, and NT is thermistor output.

Each measurement acquisition cycle takes 1.1 seconds. The number of cycles per measurement is programmable. Increasing the cycles increases acquisition time while reducing RMS temperature noise. In a thermally quiet environment, the temperature noise standard deviation is $82 * \sqrt{1/n \text{ cycles}}$ [µK].

LINEARIZATION AND CALIBRATION

Following the methodology used for SPRTs, the SBE 35's calibration is accomplished in two steps:

1. Characterize the non-linear temperature vs resistance response of the sensor. Temperature is computed using the Steinhart-Hart polynomial for thermistors (Steinhart and Hart, 1968; Bennett, 1972) which is based on thermistor physics (n = SBE 35 output):

$$t_{90L} = \frac{1.0}{a0 + a1\ln(n) + a2\ln^2(n) + a3\ln^3(n) + a4\ln^4(n)} - 273.15$$

Carried to fourth order, this equation characterizes the SBE 35 output to an error of ± 50 µK.

Unlike SPRTs where the basic non-linear calibration equation has fixed coefficients that apply to pure platinum, thermistors require individualized coefficients to the Steinhart-Hart equation because the thermistor material is an individualized mix of dopants. The individualized SBE 35 calibrations are performed at Sea-Bird in a low-gradient temperature bath and against ITS-90 certified SPRTs maintained at Sea-Bird's primary temperature metrology laboratory.

2. Certify the sensor by measurements in thermodynamic fixed point cells. The water triple point (0.0100 °C) and gallium melt point (29.7646 °C) are used because the SBE 35 is designed for ocean range temperatures (-5 to 35 °C). Like SPRTs, the slow time drift of the SBE 35 is adjusted by periodic recertification corrections.

$$t_{90L} = slope \times t_{90L} + offset \quad \text{[deg C, ITS-90]}$$

SPECIFICATIONS

Measurement range	-5 to +35 °C
Initial accuracy	0.001 °C
Typical stability (per year)	0.001 °C
Resolution	0.000025 °C
Sensor calibration	-1.5 to + 32.5 °C
Data storage	Up to 179 samples
Real-time clock	Watch-crystal type
External power	9 - 16 VDC
Current	
On power application (≈ 1 minute)	140 – 160 mA
Operating	60 – 70 mA
Housing materials	Aluminum, rated at 6,800 meters (22,300 feet)
Weight	0.5 kg (1.1 lbs) in water, 0.9 kg (2 lbs) in air

48 mm (1.9 in.)

79 mm (3.1 in.)

209 mm (8.25 in.)

387 mm (15.25 in.)
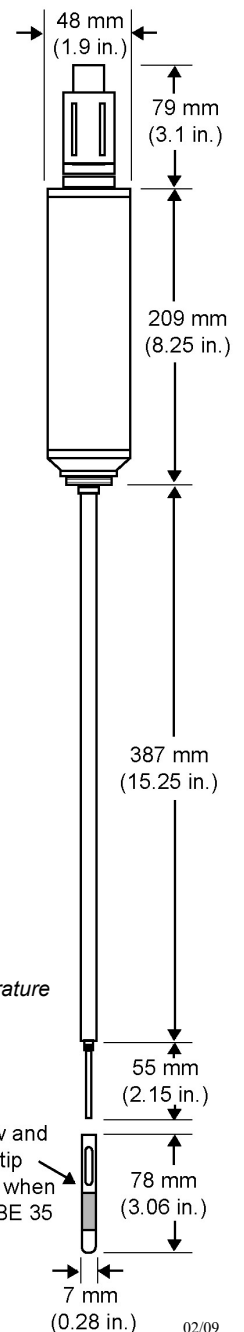
Note: Temperature sensor guard not shown.

55 mm (2.15 in.)

Unscrew and remove tip bushing when using SBE 35 at sea

78 mm (3.06 in.)

7 mm (0.28 in.)

02/09