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SBE 35 0054 CALIBRATION REPORT
04 OCT 2011

Initial Instrument Configuration

This instrument arrived for calibration with the following coefficients:

Linearization Coefficients: 17-May-04	Fixed Point Coefficients (Isotech s/n 114): 23-Sep-05
a0 = 3.92369924e-003 a1 = -1.03703687e-003 a2 = 1.63164061e-004 a3 = -9.15779994e-006 a4 = 1.97741369e-007	Slope = 1.000013 Offset = -0.001395

Linearization Calibration

A newly manufactured SBE35 is first calibrated in a temperature controlled bath against a Standard Platinum Resistance Thermometer (SPRT). The SPRT used for the calibration of the SBE35 has a history of calibrations in Triple Point of Water (TPW) and Gallium Melt Point (GaMP) Cells providing quality assurance of the measurement. The calibration of the SBE35 against the SPRT typically includes 11 calibration temperature points which are used to generate a set of calibration coefficients A0 through A4. This calibration is referred to as the Linearization Calibration.

This unit did not require a new linearization calibration and thus Figure 1 shows the historical linearization calibration and coefficients for this unit.

Fixed Point Calibrations - Overview

Following the Linearization Calibration assessment, the SBE35 is calibrated directly in the TPW and GaMP fixed point cells. For new units, a number of calibrations are performed over a period of 6 months or more to assure drift stability. The final fixed point calibrations are used to generate slope and offset coefficients that correct for the drift from the Linearization Calibration at the time of the fixed point calibration. Data from the TPW and GaMP calibrations are recalculated using the slope and offset coefficients, and a second set of plots are used to verify the accuracy of the new coefficients in producing the correct fixed point values. GaMP fixed point cells. Should any modifications be required, an additional set of calibrations will also be performed. Plots may be included for both the initial postcal data and the post modification data. The data are processed using the initial slope and offset, providing for the calculation of the daily drift of the instrument from the previous calibration to current calibration.

Figure 1: Linearization Calibration

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SENSOR SERIAL NUMBER: 0054
CALIBRATION DATE: 17-May-04

SBE 35 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

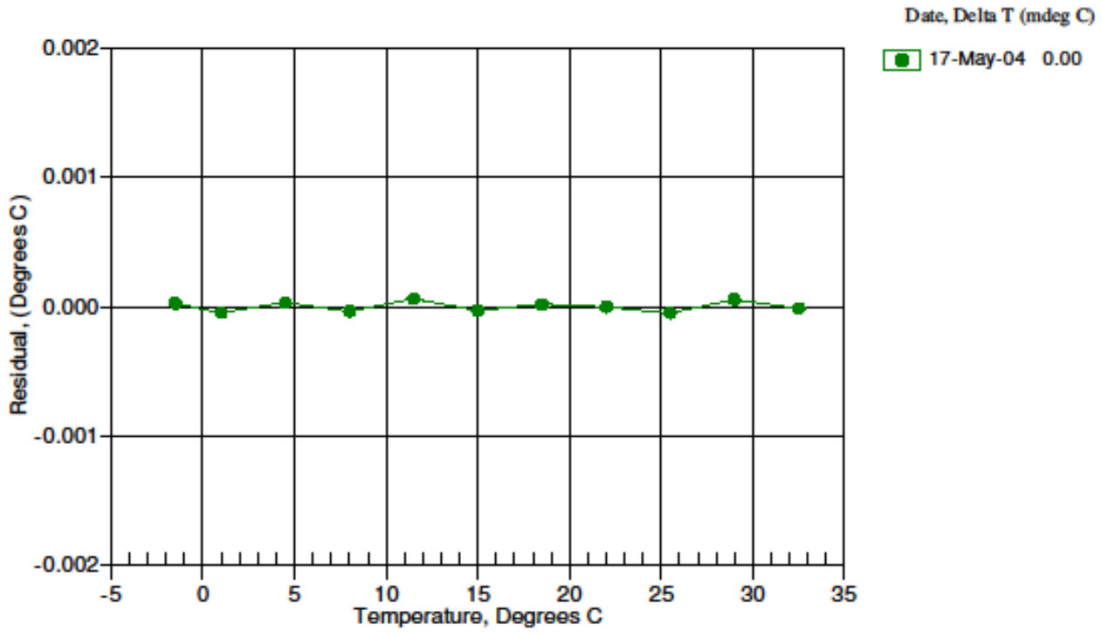
ITS-90 COEFFICIENTS

a0 = 3.92369924e-003
a1 = -1.03703687e-003
a2 = 1.63164061e-004
a3 = -9.15779994e-006
a4 = 1.97741369e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT (n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.500114	693475.37	-1.500089	0.000025
0.999957	621355.89	0.999908	-0.000049
4.499904	534048.14	4.499934	0.000030
7.999853	460257.06	7.999816	-0.000037
11.499833	397733.55	11.499892	0.000059
14.999982	344630.04	14.999952	-0.000030
18.499918	299415.20	18.499936	0.000018
21.999885	260819.41	21.999880	-0.000005
25.499890	227789.46	25.499839	-0.000051
28.999807	199450.41	28.999860	0.000053
32.499888	175074.76	32.499874	-0.000014

Temperature ITS-90 = $1/\{a0 + a1[ln(n)] + a2[ln^2(n)] + a3[ln^3(n)] + a4[ln^4(n)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



Triple Point of Water Calibrations

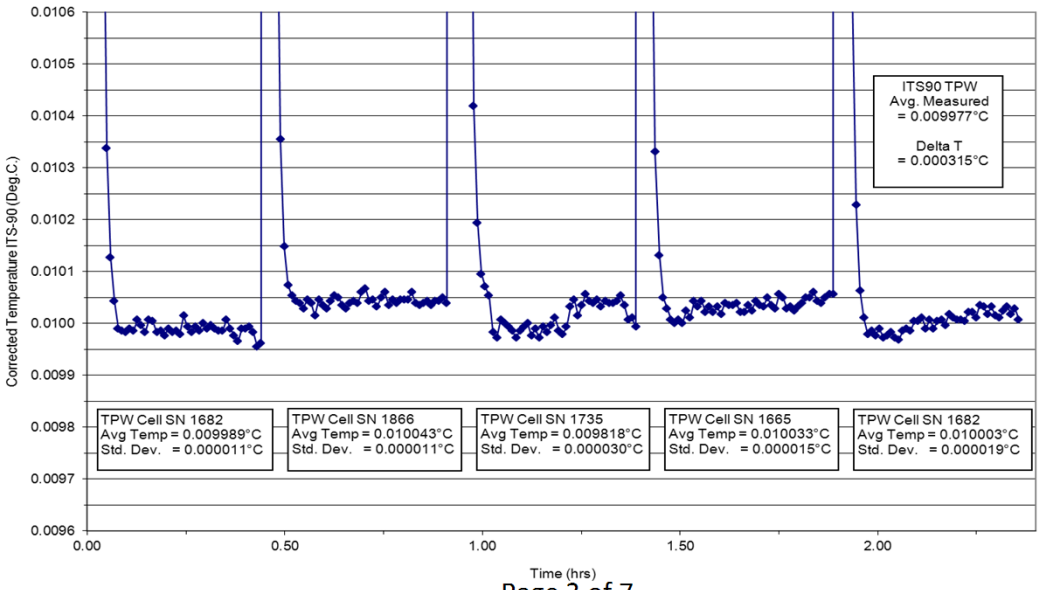
The TPW measurement is typically determined using a group of 4 TPW cells, with the first measured cell repeated at the end of the series of measurements. The repeated cell measurement provides assurance of TPW cell health, and can reveal SBE35 drift issues over the approximately 2½ hour time frame, as does the entire group of cell measurements. TPW cell temperatures are suppressed by known errors (especially impurities), so the highest temperature is taken to be the most correct, although all the measurements are averaged. The value of the TPW temperature as certified by the International Temperature Scale 1990 is defined as 0.01°C. When using a TPW cell, the temperature must be corrected for the effect of pressure at the depth of measurement in the reentrant well (a value estimated at -0.000198°C in the Jarrett TPW cells used at Sea-Bird) for a corrected TPW value of 0.009802°C. The TPW value was also given a NIST correction. The difference between the measured temperature (slope and offset corrected) and 0.009662°C is the residual offset error for the initial calibration, or the offset drift.

This unit was calibrated on two days with the following results:

Jarrett Cells 1682, 1866, 1735, 1665	Ideal Measurements	Initial Coefficients 21-Sep-11	Initial Coefficients 23-Sep-11
Average Temperature at Measurement Site:	0.009662 °C	0.009928 °C	0.009977 °C
Offset drift		0.000266 °C	0.000315 °C
Daily Drift Rate			1.439E-07 °C

Figure 2 details the initial calibration performed on 23 SEP 2011. Data from this calibration were used together with the gallium melt fixed point calibration data to generate new *and final fixed point coefficients*.

Figure 2: TPW Calibration with Initial Coefficients
Slope = 1.000013 Offset = -0.001395



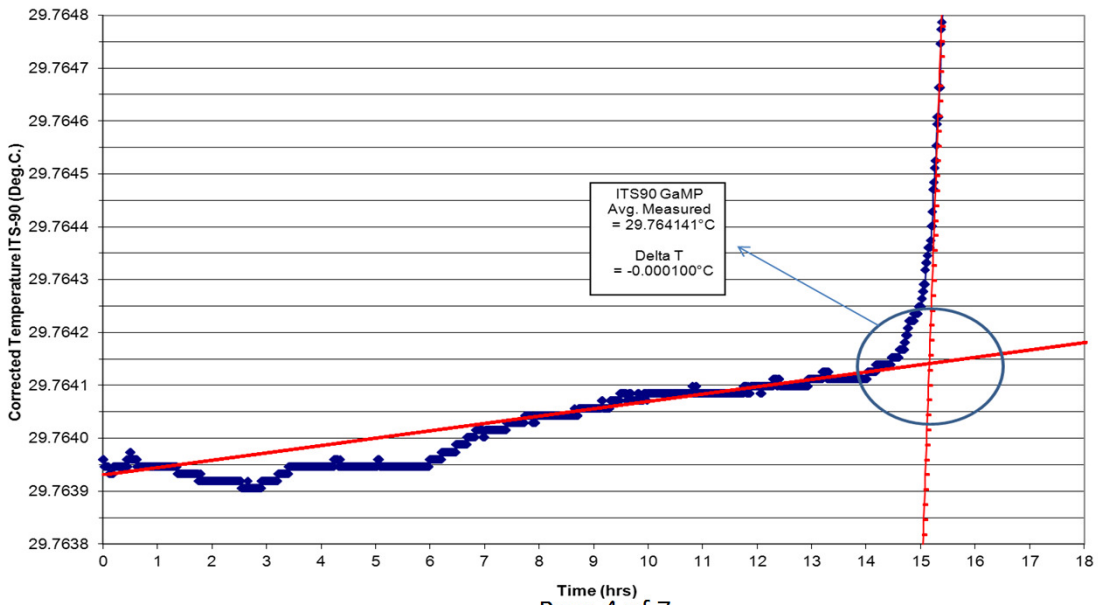
Gallium Melt Fixed Point Calibrations

The GaMP temperature is achieved by initiating a slow melt of the solid Gallium to the liquid phase. The total melt time for the Isotech Gallium cell and controller is approximately 15 hours. The point at which the temperature begins to accelerate from the plateau value is taken to be the end point since the last Gallium to melt corresponds to the first gallium frozen, and should be the purest. The process for determining the melt endpoint is to determine the slope of the last several hours of the plateau melt, and the slope of the 'melt' shortly after the temperature begins to accelerate. The intersection of the two lines is then interpreted to be the uncorrected endpoint temperature. When using the GaMP cell, the temperature must be corrected for the effect of pressure at the depth of measurement in the reentrant well (a value estimated at -0.000270°C in the Isotech GaMP cell used) for a corrected GaMP value of 29.764330°C. The GaMP was also given a NIST correction. The difference between the measured temperature (slope and offset corrected) and 29.764241°C is the initial residual offset error for the initial calibration, or the offset drift.

Isotech s/n 149	Ideal Measurements	Initial Coefficients 21-Sep-11	Initial Coefficients 23-Sep-11
Average Temperature at Measurement Site:	29.764241 °C	29.764079 °C	29.764141 °C
Drift Offset		-0.000162 °C	-0.000100 °C
Daily Drift rate			-4.573E-08 °C

Figure 3 details the initial calibration performed on 23 SEP 2011. These data were used together with the triple point of water calibration data to generate new and final fixed point coefficients.

Figure 3: GaMP Calibration with Initial Coefficients
Slope = 1.000013 Offset = -0.001395



Final Instrument Configuration

Data from the fixed point calibrations illustrated previously were used to generate new slope and offset coefficients. Instrument SBE 35 SN 0054 has been recalibrated with the following coefficients:

Linearization Coefficients: 17-May-04	Fixed Point Coefficients: 23-Sep-11
a0 = 3.92369924e-003 a1 = -1.03703687e-003 a2 = 1.63164061e-004 a3 = -9.15779994e-006 a4 = 1.97741369e-007	Slope = 1.000027 Offset = -0.001710

The same data were then re-evaluated using the newest slope and offset in order to verify that the SBE 35 readings now closely reflect the nominal fixed point temperatures. Figure 4 is the TPW verification and Figure 5 is the GaMP verification.

Figure 4: TPW Calibration with Final Coefficients
Slope = 1.000027 Offset = -0.001710

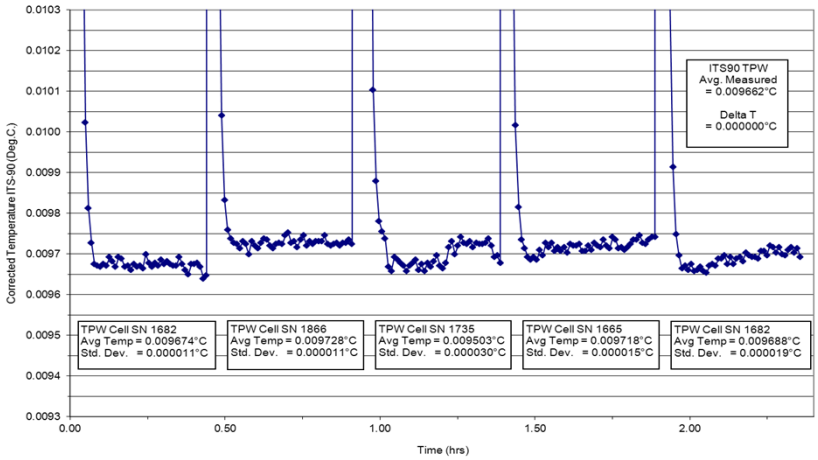
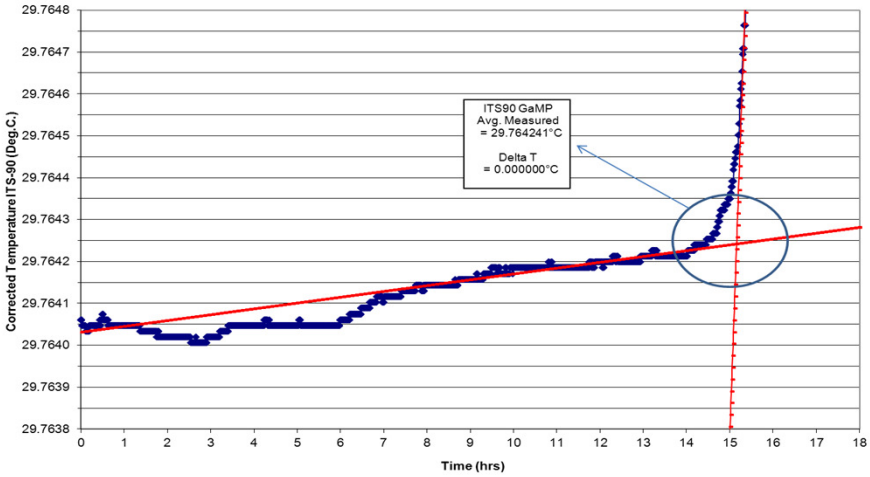


Figure 5: GaMP Calibration with Final Coefficients
Slope = 1.000027 Offset = -0.001710



Instrument Drift Characteristics

If one assumes the drift to be linear, a drift corrected value for any date can be obtained using the fixed point temperature.

Drift corrected Temp. = Measured Temperature
- Days from Previous Calibration * Daily Drift

The daily drift rate for this instrument can be found in the previous tables. Figures 6 & 7 detail the most recent drift history for this unit in both the TPW and GaMP fixed point calibrations.

Figure 6: SBE 35 SN 0054 TPW Fixed Point Drift History

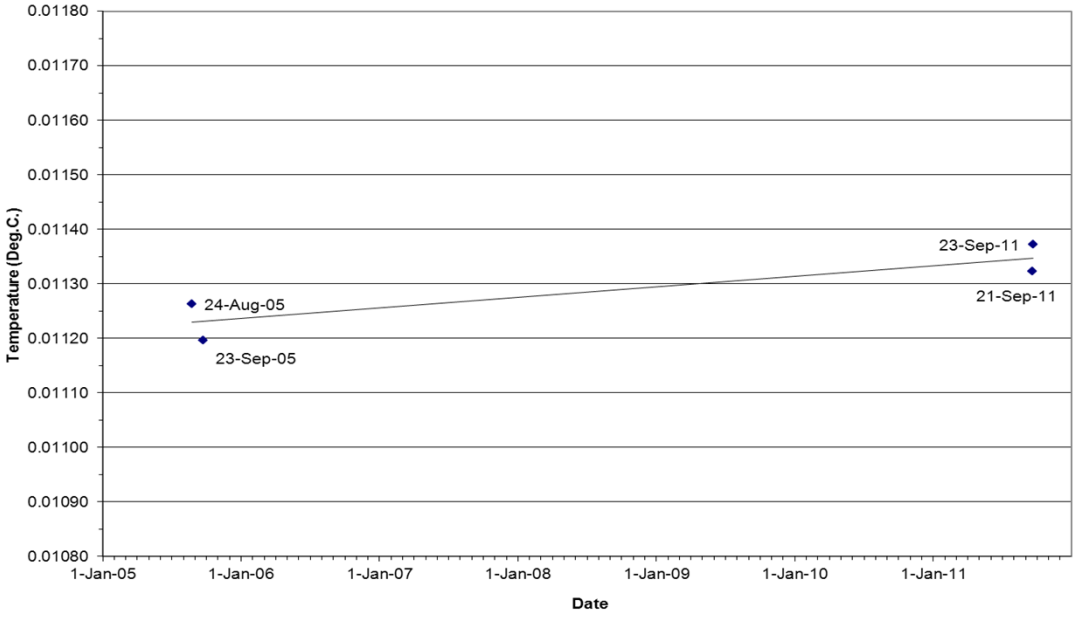
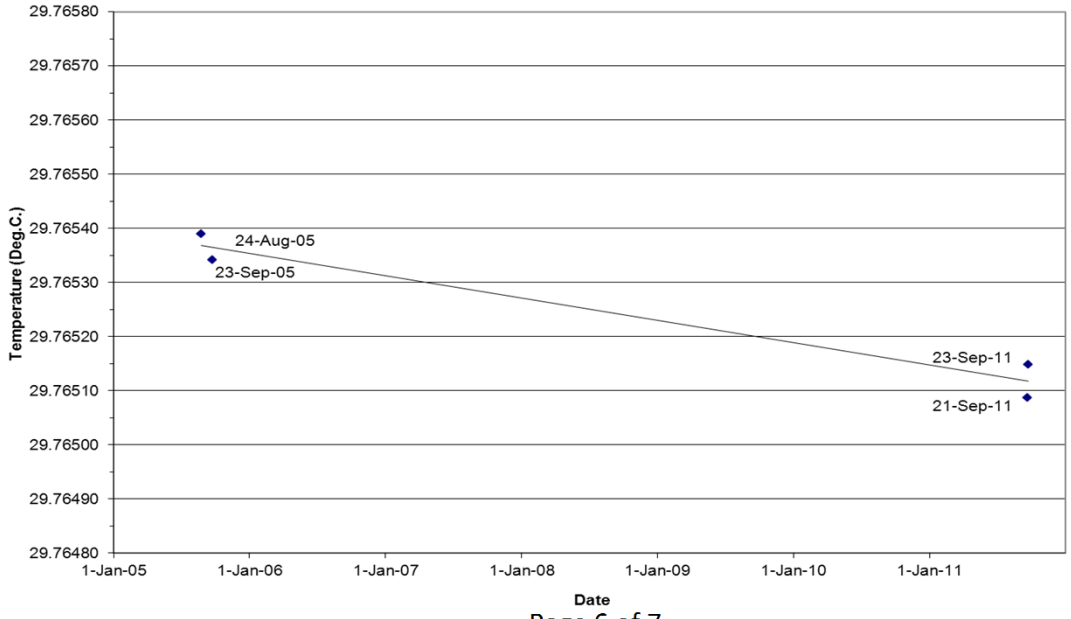


Figure 7: SBE 35 SN 0054 GaMP Fixed Point Drift History



Notes

The calibrations for this unit were typical. Any questions about the content of this report may be directed to Dick Guenther at dguenther@seabird.com.