Test Report

SBE Glider Payload CTD (GPCTD)
serial number 0026

Property of:

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS Trieste

Riccardo Gerin, Cinzia Comici, Stefano Kuchler and Gilda Savonitto

Oceanographic Calibration and Metrology Center, Oceanography Section

Instrument Test Report

Unit under test: SBE GPCTD Glider Payload CTD s/n 0026

Visual Inspection ————————————————— *Date: 7 November 2024*

	Satisfactory	Unsatisfactory
General Condition	[x]	[ ]
Clean housing & exposed surfaces	[ ]	[x]
Check connectors	[x]	[ ]
Check communications	[x]	[ ]

Sensor Cleaning ———————————— *Date: 7, 11 and 12 November 2024*

Rinse with de-ionized water.	[x]
Scour with 1000 ppm bleach solution (2 min), drain & flush with de-ionized water.	[x]
Scour with 1% Triton X-100 (1 hour), drain & flush with de-ionized water.	[x]
The above cleaning procedure was performed	[4] times

Notes: *The cleaning procedure that was utilized is based on the one that is described in Sea-Bird Electronics, Inc. Application Note no. 2D entitled "Instructions for Care and Cleaning of Conductivity Cells" (last revision: March 2024).*

Test Equipment

Instrument	Model	Serial number
Seawater Calibration Bath[a]	Fluke 7052	C2A012
Deep Ocean Standards Thermometer[b]	SBE 35	0084
CTMO-Pumped Conductivity Transfer Standard[c]	SBE 4 + SBE 5T	1489 + 7029
DC Power Supply	Agilent E3631A	MY40007143

[a] Calibration bath filled with 50 l of natural seawater, filtered (filter size/type: 0.45 μm/Millipore) and UV sterilized seawater.

[b] CTMO Temperature Transfer Standard last control on 30 September 2022 using SPRT Fluke 5699-S s/n 1440 and Super Thermometer Fluke 1595A s/n B46159;

[c] CTMO Conductivity Transfer Standard last validated on 05 September 2024;

Expanded uncertainty for the reference temperature and conductivity measurement (95% level of confidence; k = 2): 0.0016 °C (ITS-90) and 0.00033 S/m, respectively (Gerin and Savonitto, 2024).

---

* Testing Level 1: testing performed using recognized standards and/or transfer standards;
Testing Level 2: testing performed using internal laboratory transfer standards and/or reference instrumentation traceable to standards/transfer standards employed under Testing Level 1.

Temperature - 1

Test date: 13 November 2024   **GPCTD Glider s/n 0026**

Ambient conditions:
Temperature: 21 °C ± 1 °C
Relative Humidity: 45 % ± 10%
Atmospheric pressure: 992 hPa

Old temperature calibration coefficients[1]:

a0 = -6.895849e-05
a1 = 2.970433e-04
a2 = -3.658231e-06
a3 = 1.791494e-07

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

REF (°C)	INST Output (n)	INST (°C)	Residual* (°C)
1.9838	555155.60	1.9845	0.0007
5.1575	482117.27	5.1581	0.0006
10.2424	386776.64	10.2430	0.0006
15.1890	314176.06	15.1899	0.0009
20.0700	257447.46	20.0712	0.0012
24.9553	212141.04	24.9565	0.0012
26.9167	196585.98	26.9178	0.0011

* Initial accuracy declared by the Manufacturer = ±0.002 °C.

where:
    REF = the set-point temperature (°C; ITS-90) of the bath seawater, measured using the laboratory temperature reference;
    INST Output = the raw data output (n) from the instrument for the temperature of the bath seawater at the specific bath set-point temperature;
    INST = the temperature (°C; ITS-90) of the bath seawater, as measured by the unit under test using its new calibration settings for the parameter;
    Residual = **INST - REF** (°C, ITS-90).

---

[1] Temperature Calibration Sheet, Sea-Bird Scientific, 25 October 2018

Test date: 13 November 2024   **GPCTD Glider s/n 0026**

Ambient conditions:
Temperature: 21 °C ± 1 °C
Relative Humidity: 45 % ± 10%
Atmospheric pressure: 992 hPa

NEW temperature calibration coefficients:

a0 = -1.7659806e-04
a1 = 3.2251869e-04
a2 = -5.6665048e-06
a3 = 2.3188716e-07

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

REF (°C)	INST Output (n)	INST (°C)	Residual* (°C)
1.9838	555155.60	1.9838	0.0000
5.1575	482117.27	5.1576	0.0001
10.2424	386776.64	10.2424	0.0000
15.1890	314176.06	15.1890	0.0000
20.0700	257447.46	20.0700	0.0000
24.9553	212141.04	24.9552	-0.0001
26.9167	196585.98	26.9167	0.0000

* Initial accuracy declared by the Manufacturer = ±0.002 °C.

where:
REF = the set-point temperature (°C; ITS-90) of the bath seawater, measured using the laboratory temperature reference;
INST Output = the raw data output (n) from the instrument for the temperature of the bath seawater at the specific bath set-point temperature;
INST = the temperature (°C; ITS-90) of the bath seawater, as measured by the unit under test using its new calibration settings for the parameter;
Residual = **INST** - **REF** (°C, ITS-90).

Test date: 13 November 2024   **GPCTD Glider s/n 0026**

Ambient conditions:
Temperature: 21 °C ± 1 °C
Relative Humidity: 45 % ± 10%
Atmospheric pressure: 992 hPa

Check zero conductivity frequency[2]   Satisfactory [x]   Unsatisfactory [   ]

Old conductivity calibration coefficients[3]:

g = -9.940420e-01   CPcor = -9.5700e-08
h =   1.619515e-01   CTcor = 3.2500e-06
i = -4.104616e-04   WBOTC = 8.3917e-07
j =   5.785648e-05

f = Inst Freq [Hz] * sqrt (1.0 + WBOTC * t) / 1000.0 [Hz]

t = Temperature [°C]; p = pressure [decibars] = 0; δ = CTcor; ε = CPcor

Conductivity = $(g + hf^2 + if^3 + jf^4) / (1 + \delta t + \varepsilon p)$ [S/m]

Temperature (°C)	REF (S/m)	INST Freq (Hz)	INST (S/m)	Residual[§] (S/m)
21.6590	0.0000	2482.52	0.0000	0.0000
1.9838	3.2522	5129.09	3.2512	-0.0010
5.1575	3.5514	5306.16	3.5503	-0.0011
10.2424	4.0497	5588.35	4.0484	-0.0013
15.1890	4.5547	5860.20	4.5532	-0.0015
20.0700	5.0699	6124.92	5.0684	-0.0015
24.9553	5.6003	6385.61	5.5987	-0.0016
26.9167	5.8155	6488.42	5.8141	-0.0014

[§]Accuracy declared by the Manufacturer = ±0.0003 S/m.

where:

Temperature = the set-point temperature (°C; ITS-90) of the bath seawater, measured using the laboratory temperature reference;

REF = the set-point conductivity (S/m) of the bath seawater, measured using the laboratory conductivity reference;

INST Freq = the instrument output frequency (Hz) for the conductivity of the bath seawater at the specific bath set-point conductivity;

INST = the conductivity (S/m) of the bath seawater, as measured by the unit under test using its old ("as received") calibration settings for the parameter;

Residual = **INST** - **REF** (S/m).

---

[2] Zero conductivity frequency = 2482.54 (±1) Hz; Conductivity Calibration Sheet, Sea-Bird Scientific., 25 October 2018.
[3] Conductivity Calibration Sheet, Sea-Bird Scientific, 25 October 2018

Conductivity - 2

Test date: 13 November 2024

Ambient conditions:
Temperature: 21 °C ± 1 °C
Relative Humidity: 45 % ± 10%
Atmospheric pressure: 992 hPa

NEW conductivity calibration coefficients:

g = -9.9220693e-01   CPcor = -9.5700e-08
h = 1.6114235e-01   CTcor = 3.2500e-06
i = -1.5186702e-04   WBOTC = 8.3917e-07
j = 3.7008591e-05

f = Inst Freq [Hz] * sqrt (1.0 + WBOTC * t) / 1000.0 [Hz]

t = Temperature [°C]; p = pressure [decibars] = 0; δ = CTcor; ε = CPcor

Conductivity = $(g + hf^2 + if^3 + jf^4) / (1 + \delta t + \varepsilon p)$ [S/m]

Temperature (°C)	REF (S/m)	INST Freq (Hz)	INST (S/m)	Residual[§] (S/m)
21.6590	0.0000	2482.52	0.0000	0.0000
1.9838	3.2522	5129.09	3.2522	0.0000
5.1575	3.5514	5306.16	3.5514	0.0000
10.2424	4.0497	5588.35	4.0497	0.0000
15.1890	4.5547	5860.20	4.5547	0.0000
20.0700	5.0699	6124.92	5.0699	0.0000
24.9553	5.6003	6385.61	5.6002	-0.0001
26.9167	5.8155	6488.42	5.8156	0.0001

[§]Accuracy declared by the Manufacturer = ±0.0003 S/m.

where:

Temperature = the set-point temperature (°C; ITS-90) of the bath seawater, measured using the laboratory temperature reference;

REF = the set-point conductivity (S/m) of the bath seawater, measured using the laboratory conductivity reference;

INST Freq = the instrument output frequency (Hz) for the conductivity of the bath seawater at the specific bath set-point conductivity;

INST = the conductivity (S/m) of the bath seawater, as measured by the unit under test using its old ("as received") calibration settings for the parameter;

Residual = **INST** - **REF** (S/m).

The general condition of the instrument was good except for the pump-pipes circuit and some small damages and scratches from previous service on the instrument and due to usage/aging. The pump-pipes circuit was completely covered internally with a black film and externally with a yellowish film of probable biological origin.

Damaged/scratched screw and pry slot.

The tubes and pump were subjected to a soak with warm water overnight. This intervention thoroughly cleaned the pump-tube system.

Cracked support of the bar which protect the conductivity cell and dirty pump-tubes circuit.

The conductivity cell, on the other hand, was cleaned following the Application Notes of Sea-Bird Electronics, Inc.
After 4 cleaning reiterations, the residuals at the test temperature of 20 °C went from about 0.0020 S/m to 0.0015 S/m, stabilizing around the latter value.
The calibration was done considering 7 temperature steps from 27 to 2 °C. The temperature sensor showed residuals below the accuracy stated by the manufacturer, but of the same

order, while the conductivity sensor showed residuals an order of magnitude worse than the stated accuracy. New coefficients were calculated for both sensors and entered into the instrument's EEPROM. Finally, the instrument was tested at the test temperature of 20 °C confirming the correctness of all the performed operations.

References

Gerin R. and Savonitto G. (2024). Uncertainty estimate associated with the measurement of ITS-90 temperature and conductivity at the Oceanographic Calibration and Metrology Center (CTMO) of OGS, Rel. OGS 2024, Trieste, Italy, 7 pp.