

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 03/11/08 **Incoming Evaluation**

Job No.: R-9874

Model Number: QSP-200L

Serial Number: 4553

Operator: TPC

Standard Lamp: 91537(10/25/06)

Operating Voltage Range: 6 to 15 VDC (+)

Note: The QSP-200 uses a log amplifier to measure the detector signal current with $V = \log I \text{ (Amps)} / I_{\text{Ref}}$

To calculate irradiance, use this formula:

$$\text{Irradiance} = \text{Calibration factor} * (10^{\text{Light Signal Voltage}} - 10^{\text{Dark Voltage}})$$

With the appropriate (solar corrected) Irradiance Calibration Factor:

Dry Calibration Factor: 2.10E+13 quanta/cm²·sec/"amps" 3.49E-05 μEinsteins/cm²·sec/"amps"

Wet Calibration Factor: 3.54E+13 quanta/cm²·sec/"amps" 5.88E-05 μEinsteins/cm²·sec/"amps"

Sensor Test Data and Results⁴⁾

Sensor Supply Current (Dark):	<u>71.4</u>	mA								
Supply Voltage:	<u>6</u>	Volts								
Lamp Integrated PAR Irradiance:	<u>8.83E+15</u>	quanta/cm ² ·sec			0.01467					μEinsteins/cm ² ·sec
SC3 Immersion Coefficient:	0.594		Scalar Correction:	<u>1</u>		PAR Solar Correction:	<u>1.0000</u>			
Nominal Filter OD	Calibrated Trans.	Sensor Voltage	Measured Trans.	Measured Signal (Amps)	Estimated Signal (Amps)	Calc. Output (Volts)	Error (Volts)	Error (%)	Test Irrad. (quanta/cm ² ·sec)	
No Filter	100.00%	<u>2.625</u>	100.00%	4.22E-08	4.22E-08	2.626	0.001	0.0	8.83E+15	
0.3	36.10%	<u>2.187</u>	36.31%	1.53E-08	1.52E-08	2.186	-0.001	-0.6	3.21E+15	
0.5	27.60%	<u>2.079</u>	28.22%	1.19E-08	1.16E-08	2.071	-0.008	-2.2	2.49E+15	
1	9.27%	<u>1.628</u>	9.79%	4.13E-09	3.91E-09	1.606	-0.021	-5.3	8.65E+14	
2	1.11%	<u>0.815</u>	1.24%	5.22E-10	4.68E-10	0.778	-0.036	-10.4	1.09E+14	
3	0.05%	<u>0.229</u>	0.09%	3.72E-11	2.25E-11	0.190	-0.039	-39.4	7.79E+12	

Dark Before: 0.122 Volts

Light - No Filter Hldr.: 2.625 Volts

Dark After - NFH: 0.122 Volts

Average Dark 0.122 Volts

$I_{\text{Ref}} = \underline{1.00E-10}$ Amps

$I_{\text{Dark}} = \underline{1.32E-10}$ Amps

$10^{V_{\text{Dark}}} = \underline{1.323884}$ Amps

RG780

0.411

Notes:

1. Annual calibration is recommended.
2. There is increasing error associated with readings below zero.
3. The collector should be cleaned frequently with alcohol.
- 4) This section is for internal use and for more advanced analysis.

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date 3/13/2008
Model Number QSR-240 With Top On
Serial Number 6294
Operator AMB
Standard Lamp 91537(10/25/2006)
Probe Excitation Voltage Range: 6 to 18 VDC(+)
Output Polarity: Negative

Probe Conditions at Calibration(in air):

Calibration Voltage: 6 VDC(+)
Probe Current: 0.8 mA

Probe Output Voltage:

Probe Illuminated -80.4 mV
Probe Dark -0.1 mV
Probe Net Response -80.3 mV
RG780 -0.2 mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

8.83E+15 quanta/cm²sec
0.01467 uE/cm²sec

Calibration Scale Factor:

(To calculate irradiance, divide the net voltage reading in Volts by this value.)

Dry: -9.0906E-18 V/(quanta/cm²sec)
-5.4744E+00 V/(uE/cm²sec)

Notes:

1. Annual calibration is recommended.
2. Calibration is performed using a Standard of Spectral Irradiance traceable to the National Institute of Standards and Technology (NIST).
3. The collector should be cleaned frequently with alcohol.
4. Calibration was performed with customer cable, when available.

Sea-Bird Electronics, Inc.

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Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2271
CALIBRATION DATE: 14-Feb-12

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.33365550e-003
h = 6.41046238e-004
i = 2.31654312e-005
j = 2.15092946e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.68121200e-003
b = 5.99527333e-004
c = 1.63915893e-005
d = 2.15248444e-006
f0 = 2869.114

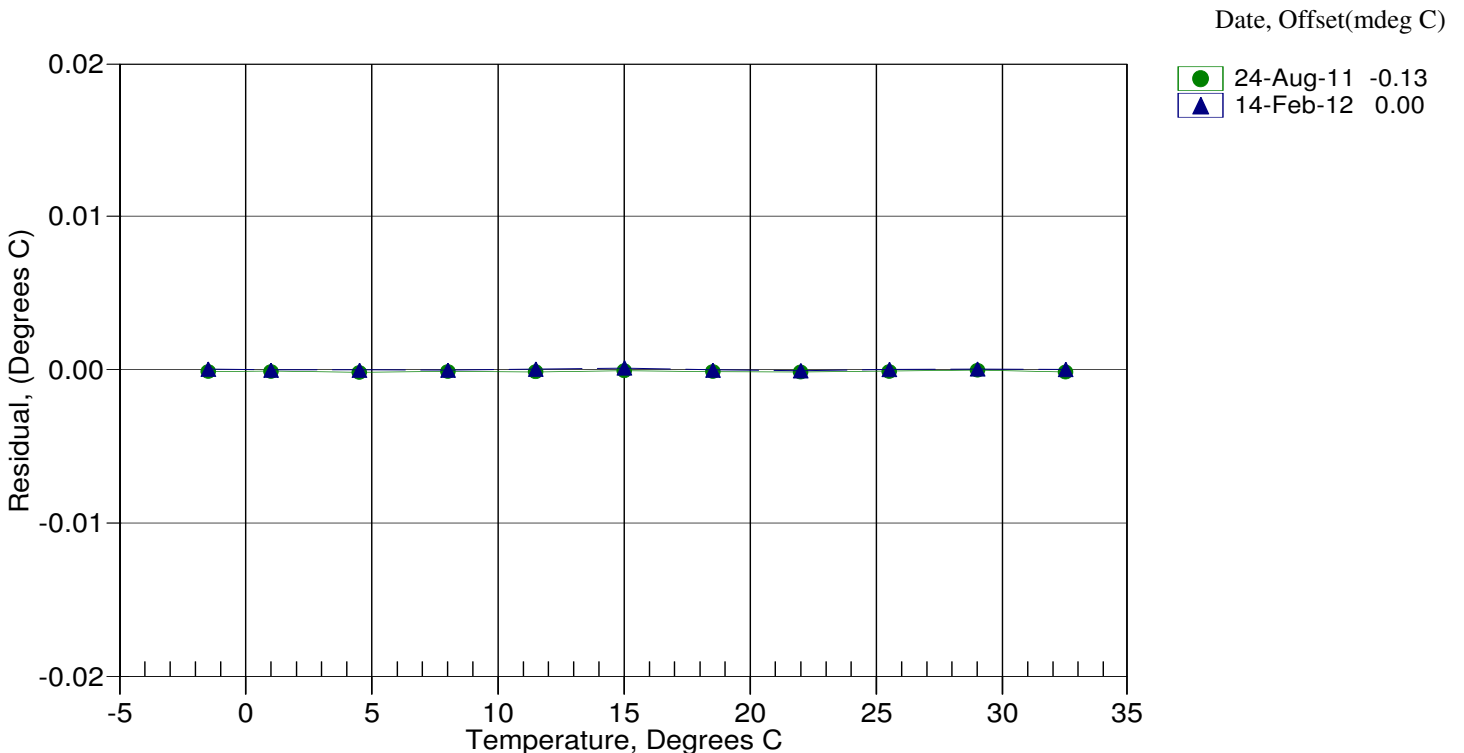
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2869.114	-1.5000	0.00002
1.0000	3034.644	1.0000	-0.00002
4.5000	3277.888	4.5000	-0.00002
8.0000	3534.897	8.0000	-0.00003
11.5000	3806.056	11.5000	0.00003
15.0000	4091.729	15.0001	0.00009
18.5000	4392.259	18.5000	-0.00001
22.0000	4708.009	21.9999	-0.00009
25.5000	5039.327	25.5000	-0.00001
29.0000	5386.519	29.0000	0.00004
32.5000	5749.890	32.5000	-0.00000

Temperature ITS-90 = $1 / \{g + h[\ln(f_0/f)] + i[\ln^2(f_0/f)] + j[\ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1 / \{a + b[\ln(f_0/f)] + c[\ln^2(f_0/f)] + d[\ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be $1.00024 * T_{90}$ (-2 to 35 °C)

Residual = instrument temperature - bath temperature





SEA-BIRD ELECTRONICS, INC.

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Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Temperature Calibration Report

Customer:	Woods Hole Oceanographic Institution		
Job Number:	67834	Date of Report:	2/14/2012
Model Number	SBE 03Plus	Serial Number:	03P2271

Temperature sensors are normally calibrated 'as received', without adjustments, allowing a determination sensor drift. If the calibration identifies a problem, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing coefficients to convert sensor frequency to temperature. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'offset' allows a small correction for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair apply only to subsequent data.

'AS RECEIVED CALIBRATION'

Performed Not Performed

Date:

Drift since last cal: Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR'

Performed Not Performed

Date:

Drift since Last cal: Degrees Celsius/year

Comments:

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SENSOR SERIAL NUMBER: 4406
CALIBRATION DATE: 14-Feb-12

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.33630903e-003
h = 6.36463726e-004
i = 2.06290680e-005
j = 1.71729728e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.68121258e-003
b = 5.98583749e-004
c = 1.51815040e-005
d = 1.71869863e-006
f0 = 2894.017

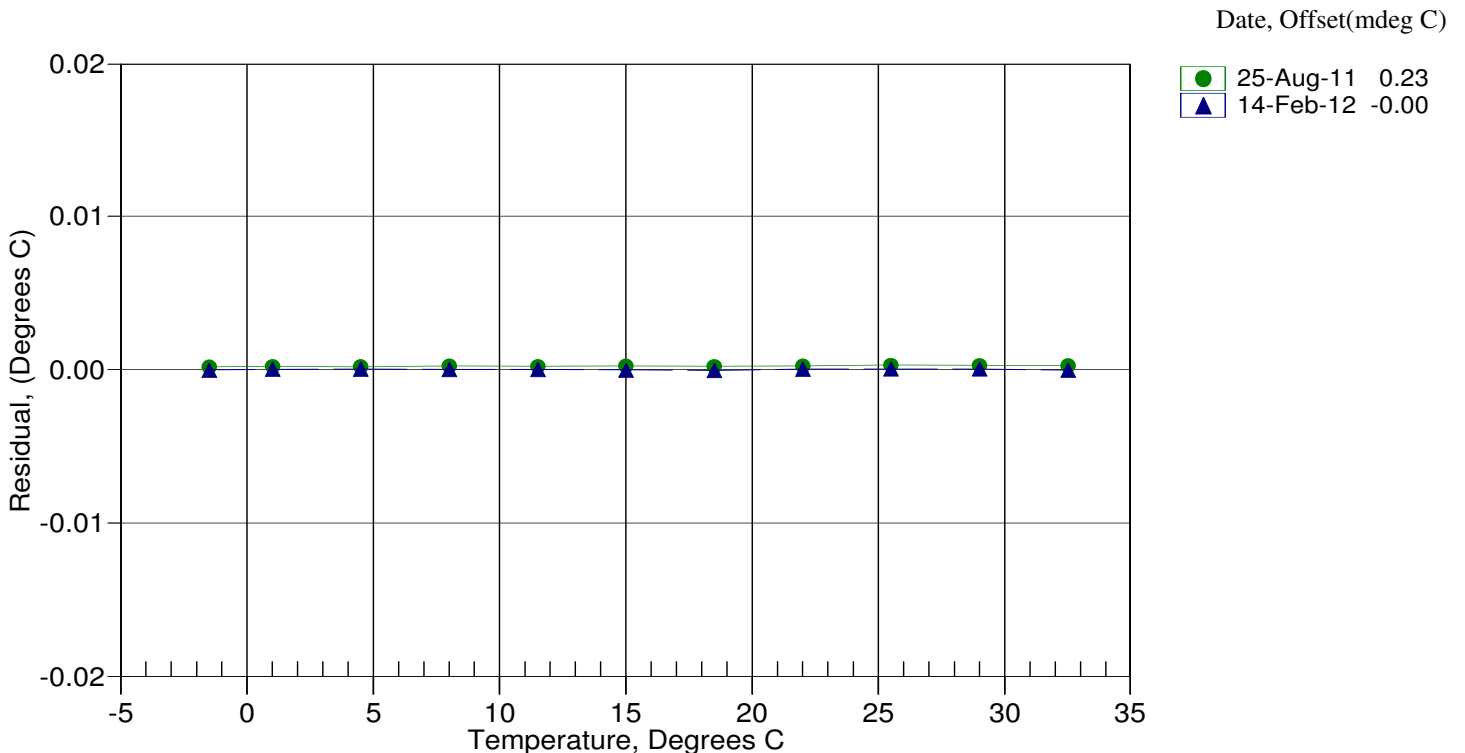
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2894.017	-1.5000	-0.00002
1.0000	3061.241	1.0000	0.00001
4.5000	3306.931	4.5000	0.00003
8.0000	3566.477	8.0000	0.00000
11.5000	3840.262	11.5000	-0.00000
15.0000	4128.655	15.0000	-0.00001
18.5000	4432.013	18.4999	-0.00006
22.0000	4750.701	22.0000	0.00003
25.5000	5085.038	25.5000	0.00003
29.0000	5435.358	29.0000	0.00003
32.5000	5801.969	32.5000	-0.00003

Temperature ITS-90 = $1 / \{g + h[\ln(f_0/f)] + i[\ln^2(f_0/f)] + j[\ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1 / \{a + b[\ln(f_0/f)] + c[\ln^2(f_0/f)] + d[\ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be $1.00024 * T_{90}$ (-2 to 35 °C)

Residual = instrument temperature - bath temperature





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Temperature Calibration Report

Customer:	Woods Hole Oceanographic Institution		
Job Number:	67834	Date of Report:	2/14/2012
Model Number	SBE 03Plus	Serial Number:	03P4406

Temperature sensors are normally calibrated 'as received', without adjustments, allowing a determination sensor drift. If the calibration identifies a problem, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing coefficients to convert sensor frequency to temperature. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'offset' allows a small correction for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair apply only to subsequent data.

'AS RECEIVED CALIBRATION'

Performed Not Performed

Date:

Drift since last cal: Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR'

Performed Not Performed

Date:

Drift since Last cal: Degrees Celsius/year

Comments:

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SENSOR SERIAL NUMBER: 1474
CALIBRATION DATE: 14-Feb-12

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

GHIJ COEFFICIENTS

g = -4.21351634e+000
h = 5.39243337e-001
i = -2.08827162e-004
j = 3.95099976e-005
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 9.51747861e-006
b = 5.38684683e-001
c = -4.21231220e+000
d = -9.05795542e-005
m = 4.4
CPcor = -9.5700e-008 (nominal)

BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.79602	0.00000	0.00000
-0.9999	34.9847	2.81688	7.74387	2.81688	-0.00000
1.0001	34.9849	2.98901	7.94643	2.98900	-0.00000
15.0001	34.9849	4.29011	9.33457	4.29010	-0.00001
18.5001	34.9845	4.63827	9.67178	4.63831	0.00003
29.0001	34.9824	5.72646	10.65557	5.72641	-0.00005
32.5001	34.9712	6.09995	10.97253	6.09998	0.00003

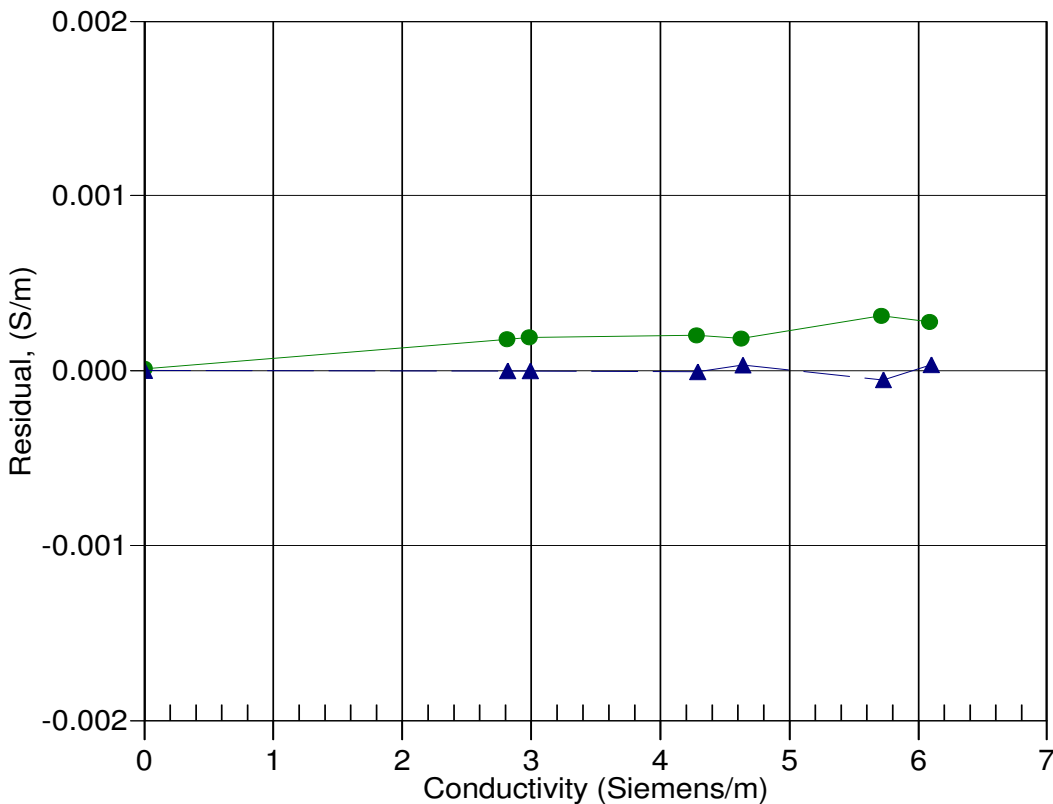
Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \epsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10(1 + \epsilon p)]$ Siemens/meter

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

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients

Date, Slope Correction



● 25-Aug-11 0.9999504
▲ 14-Feb-12 1.0000000



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Conductivity Calibration Report

Customer:	Woods Hole Oceanographic Institution		
Job Number:	67834	Date of Report:	2/14/2012
Model Number	SBE 04-02/0	Serial Number:	041474

Conductivity sensors are normally calibrated 'as received', without cleaning or adjustments, allowing a determination of sensor drift. If the calibration identifies a problem or indicates cell cleaning is necessary, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing the coefficients used to convert sensor frequency to conductivity. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'slope' allows small corrections for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair or cleaning apply only to subsequent data.

'AS RECEIVED CALIBRATION' Performed Not Performed

Date: Drift since last cal: PSU/month*

Comments:

'CALIBRATION AFTER CLEANING & REPLATINIZING' Performed Not Performed

Date: Drift since Last cal: PSU/month*

Comments:

**Measured at 3.0 S/m*

Cell cleaning and electrode replatinizing tend to 'reset' the conductivity sensor to its original condition. Lack of drift in post-cleaning-calibration indicates geometric stability of the cell and electrical stability of the sensor circuit.

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SENSOR SERIAL NUMBER: 2707
CALIBRATION DATE: 14-Feb-12

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

GHIJ COEFFICIENTS

g = -1.07258216e+001
h = 1.55968861e+000
i = -1.50749109e-003
j = 2.09512327e-004
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 4.96302969e-006
b = 1.55614173e+000
c = -1.07195656e+001
d = -8.72619162e-005
m = 5.3
CPcor = -9.5700e-008 (nominal)

BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.62450	0.00000	0.00000
-0.9999	34.9847	2.81688	4.99741	2.81686	-0.00002
1.0001	34.9849	2.98901	5.10671	2.98901	0.00000
15.0001	34.9849	4.29011	5.86691	4.29013	0.00002
18.5001	34.9845	4.63827	6.05404	4.63830	0.00003
29.0001	34.9824	5.72646	6.60439	5.72636	-0.00010
32.5001	34.9712	6.09995	6.78298	6.10001	0.00007

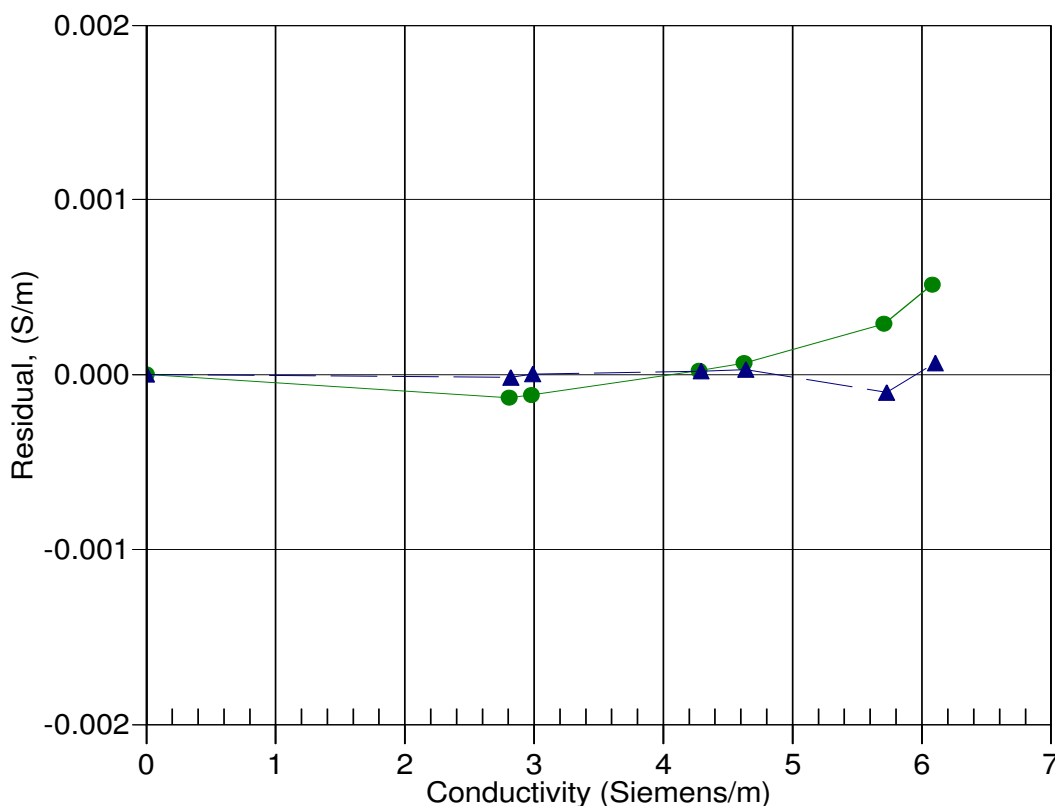
Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \epsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10(1 + \epsilon p)]$ Siemens/meter

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

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients

Date, Slope Correction



● 23-Jul-10 0.9999646
▲ 14-Feb-12 1.0000000



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Conductivity Calibration Report

Customer:	Woods Hole Oceanographic Institution		
Job Number:	67834	Date of Report:	2/14/2012
Model Number:	SBE 04	Serial Number:	042707

Conductivity sensors are normally calibrated 'as received', without cleaning or adjustments, allowing a determination of sensor drift. If the calibration identifies a problem or indicates cell cleaning is necessary, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing the coefficients used to convert sensor frequency to conductivity. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'slope' allows small corrections for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair or cleaning apply only to subsequent data.

'AS RECEIVED CALIBRATION' Performed Not Performed

Date: Drift since last cal: PSU/month*

Comments:

'CALIBRATION AFTER CLEANING & REPLATINIZING' Performed Not Performed

Date: Drift since Last cal: PSU/month*

Comments:

**Measured at 3.0 S/m*

Cell cleaning and electrode replatinizing tend to 'reset' the conductivity sensor to its original condition. Lack of drift in post-cleaning-calibration indicates geometric stability of the cell and electrical stability of the sensor circuit.

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SENSOR SERIAL NUMBER: 0723
CALIBRATION DATE: 11-Feb-12

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS

Soc = 0.5528
Voffset = -0.5125
Tau20 = 1.33

A = -2.4781e-003
B = 9.2148e-005
C = -1.8426e-006
E nominal = 0.036

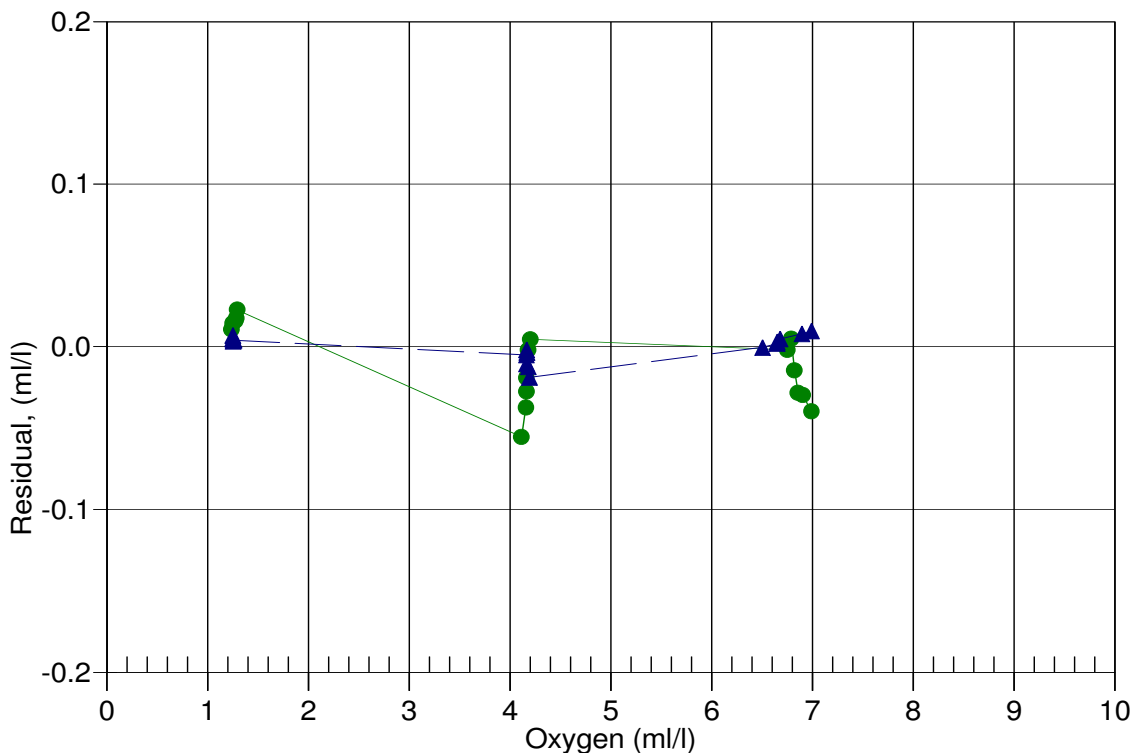
NOMINAL DYNAMIC COEFFICIENTS

D1 = 1.92634e-4 H1 = -3.30000e-2
D2 = -4.64803e-2 H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.25	12.00	0.03	0.820	1.25	0.00
1.25	6.00	0.03	0.777	1.26	0.01
1.25	2.00	0.03	0.748	1.26	0.01
1.25	20.00	0.03	0.880	1.26	0.00
1.26	30.00	0.03	0.963	1.26	0.00
1.26	26.00	0.03	0.930	1.26	0.00
4.16	20.00	0.03	1.728	4.16	-0.01
4.17	12.00	0.03	1.530	4.16	-0.01
4.17	30.00	0.03	1.998	4.17	-0.00
4.17	26.00	0.03	1.887	4.16	-0.00
4.18	6.00	0.03	1.389	4.17	-0.01
4.19	2.00	0.03	1.297	4.17	-0.02
6.50	30.00	0.03	2.832	6.50	-0.00
6.65	20.00	0.03	2.457	6.65	0.00
6.65	26.00	0.03	2.708	6.65	0.00
6.68	12.00	0.03	2.149	6.69	0.00
6.90	6.00	0.03	1.964	6.90	0.01
6.99	2.00	0.03	1.827	7.00	0.01

Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T² + C * T³) * OxSol(T,S) * exp(E * P / K)
V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU] K = temperature [deg K]
OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen

Date, Delta Ox (ml/l)



● 07-Sep-11 1.0030
▲ 11-Feb-12 1.0000