RBR Precision Instruments for over 30 years

MS-310 Micro-Salinometer

User's Manual

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Table of Contents

Introduction

General description

The MS-310 Micro-Salinometer (Figure 1) is based upon a concept in which conductivity of the sample of seawater is directly and simultaneously compared with the conductivity of a sample of standard seawater. The dual cell removes the need for highly stable bath temperatures, and the cells are surrounded by a well-stirred oil bath to ensure thermal uniformity. Every sample is therefore standardized, and the standard itself is enclosed in quartz glass to preserve the integrity of the reference measurement for weeks. By giving a direct reading of R_t against the reference, the instrument gives a rapid confirmation of the accuracy of a CTD with low operating costs. Standardisation of the instrument can be performed easily on board ship or in the field using IAPSO Standard Seawater.

Figure 1 A view of the MS-310

The front panel switches control the pump and are clearly marked for the proper filling and flushing of both cells. On the left side of the instrument are three plastic tubes which are used for filling and flushing the cells of the instrument. Each tube has a label next to it on the underside of the unit where the tubes emerge. On the rear panel are mounted the 12V DC power socket, a power switch and the RS-232 connector. The 2 litre bath is made from clear Lexan for good control of water condition in the cells. Blue light helps to evaluate the presence of air bubbles in the cells, which are unacceptable during the salinity measurements. A high efficiency propeller with brushless stirring motor ensures uniform temperature in both cells. 600mm steel heat exchanger brings temperature of a sample close to the bath temperature. The metal housing provides protection against RF interference and water ingress.

Measurement principle

The MS-310 uses two similar inductive conductivity measuring channels to obtain a direct measure of the conductivity ratio R_{tm}. The two cells are maintained at the same temperature in a well-stirred oil bath.

$$R_{tm} = \frac{C_{sample}}{C_{standard}}$$

where: C_{sample} is the conductivity of the sample

$C_{standard}$ is the conductivity of Standard Seawater.

To calculate the salinity, the value of R_{tm} from the measurement is multiplied by the K_{15} of the standard seawater to obtain a true value of R_t.

$$R_t = K_{15} R_{tm}$$

This value of R_t is then applied to the accepted equation to calculate the salinity according to the Practical Salinity Scale -1978 (PSS-78)[1]. This equation needs the temperature of the sample and this is measured from the temperature bath.

Specifications

Power: 110-240VAC; 12VDC, 10VA

Communications: RS-232 or USB via adapter

Size: 305mm × 280mm × 200mm

Weight: 4.6kg (bath empty), 6.6kg (bath filled)

Cell volume: 15ml, typical sample<100ml

Operating temperature: 0°C to +35°C

Standardization: IAPSO Standard Seawater

Settling time: ~2 minutes typical

Set up time: 30 minutes typical

Bath volume: 2.0 litres

Bath oil: Marcon-72 (by Imperial Oil) or similar

Temperature:

Sensor: thermistor

Accuracy: ±0.002 °C

Resolution: <0.00005°C

Drift: <0.002 °C/year

Conductivity Ratio Rt:

Sensor: Inductive Conductivity Cell

Range: 0.05 to 1.2

Linearity: ±0.00005

Repeatability: ±0.00005

Stability: ±0.00005 / 24hrs

Derived Practical Salinity (defined by PSS-78)

Range: 2 to 42

Accuracy: ±0.002 within ±4°C of temp. at standardization

Resolution: <0.0002

Preparation

Filling the oil bath

The MS-310 is shipped empty but is supplied with a container of oil. To fill the oil bath, remove the four screws (two at each side) holding the top cover of the unit in place. Locate the oil fill hole to the right of the top of the lid of the oil bath. Remove the black plug and, using the supplied oil pump, pour oil into the bath 5 mm below the lid. Replace the plug and top cover of the unit, securing with the screws.

Filling and Flushing the Cells

MS-310 is equipped with a pumping system, which provides filling and flushing of the cells. The pumping system includes a peristaltic pump, three 3-way solenoid valves, 1/16" ID Tygon™ tubing and a flush bottle. On the left side of the instrument are 3 plastic tubes which are used for filling and flushing the cells of the instrument. Each tube has a label next to it on the underside of the unit where the tubes emerge.

The two rear tubing marked 'Flush' should be connected to nipples on the top of the Flush Bottle. The front one marked 'Fill" is used for filling the cells and should be submerged in either the sample or the Standard Seawater. There are two switches on the front panel of the MS-310, which control water flow direction in the pumping system during filling and flushing procedure. The left hand switch is used for choosing the cell for operating and directs water flow in the pumping system into the chosen cell. 'Standard cell' position is used only once – at the stage of preparation for measurements, when filling the Standard cell with Standard Seawater.

Afterwards this switch has to be set in position 'Sample cell' and not switched back during the sample salinity measurements! The right hand switch on the pump control is used for changing pumping direction (forward-reverse) and positioning of the solenoid valves for fill and flush modes. It has 3 positions –'Fill', 'Flush' and 'Off'. In 'Fill' position, sample water comes from the inlet tubing to the chosen cell. Water excess comes into the Flush bottle through the rear tubing (overflow). This tubing in the 'Fill' mode works as the air vent from the cell water, so it is important to keep the outlet of this flushing tubing above the waste water level!

Always check water level in the Flush Bottle!

In ‘Flush’ position water flushes out from a cell to the Flush bottle or other external waste water container.

Maintenance of the peristaltic pump must be done according to the supplied pump manual.

Later in this document the term ‘adequate flushing’ is used. This means that the cell should be flushed with a volume of water equal to at least 3 to 5 times the volume of the cell. The fill-flush cycle should be continued until consecutive readings are within the accuracy of the MS-310.

RBR Windows Software

The MS-310 must be operated with the RBR Windows Software to run.

After connecting the serial line between the MS-310 and a PC, plug DC power connector, switch ON Power, run the RBR Windows Software and click on the ‘Micro-Salinometer’ menu item – Figure 3.

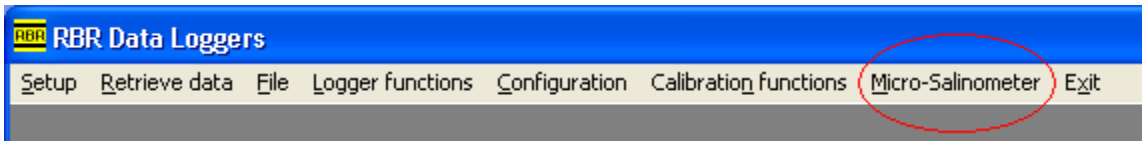

Figure 2 RBR Windows Software menu bar with "Micro-Salinometer" item

After the connection to the MS-310 has been made the control window shown in Figure 4 will appear If there is a problem with connection, check COM port setup in Configuration menu. The RBR Windows Software will run the Micro-Salinometer and display the value of salinity, temperature and conductivity ratio in the control window.

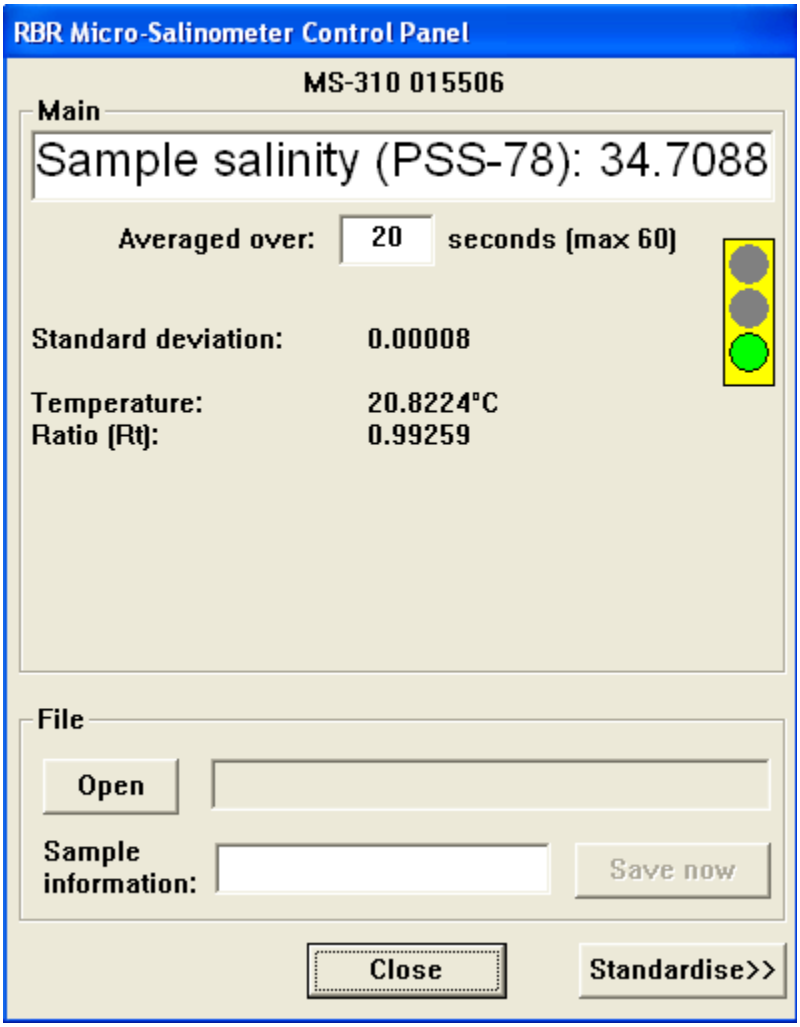

Figure 3 MS-310 in normal mode of operation

The readings from the MS-310 are averaged over a period which can be set in the control window, this enables any electronic noise to be reduced. Averaging interval can be set from 1sec to 60sec. The window provides an interface to save readings in a file for later review. Saving to the file can be set to a continuous mode (record data each 10sec) or to a manual mode (record data on demand by pressing “Save now” button). Additional information about sample (sample number, bottle number, station number, depth, etc.) can be written in the “Sample information” window. Saved data file is stored in ‘sal’ folder of the “RBR Software” installation folder.

At the lower right, is a button ‘Standardise»’ which provides access to an enlarged window for calibration and standardisation of the MS-310.

When a new sample is introduced into the sample cell, adequate flushing must be used and it must be allowed to stabilize in temperature with the instrument, typically it takes 2 minutes. To aid the user with determining when readings have come close to expected values, a green light indicator ‘go-no go’ is used in the

software. For more precise control of ready-to-read state an operator can monitor a real-time plot of salinity readings using a graphical window of the main RBR Windows Software, which displays the last 2 minutes of salinity and temperature data (Figure 5)

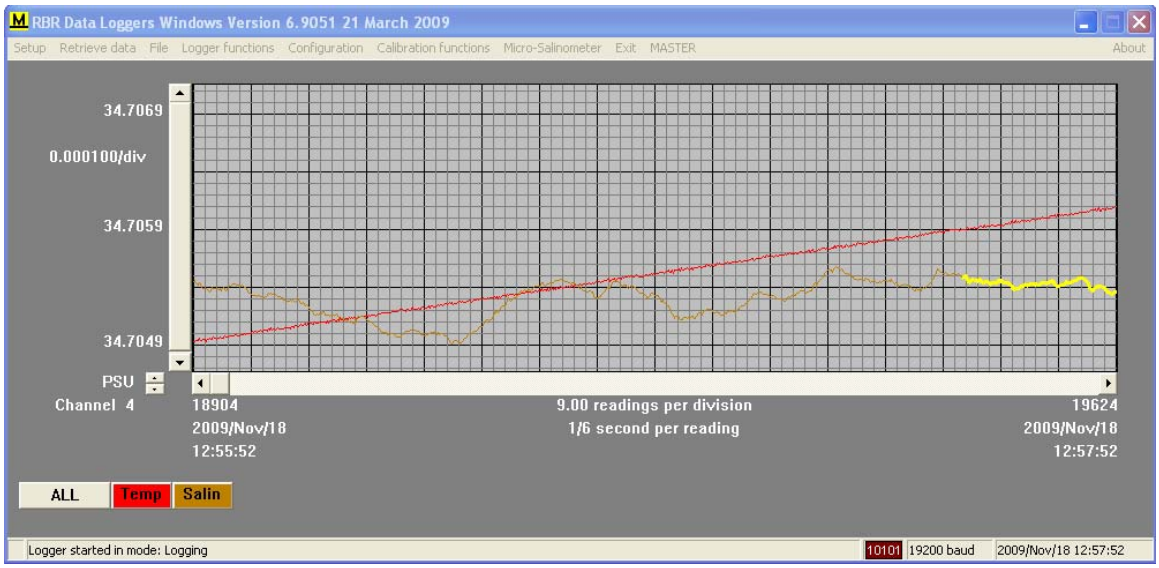

Figure 4 Main graphical window during MS-310 operation

Procedure

Calibration

Calibration of the MS-310 must be performed during setup and at any point that the standard cell has been refilled. This establishes the value of alpha.

Calibration proceeds as follows:

1. Connect MS-310 to PC with supplied serial cable. Use RS232 to USB adaptor, if needed.
2. Plug DC adaptor cable to 12Vdc socket. Switch power ON.
3. Run the Windows software and press ‘Micro-Salinometer’.
4. When available, click the ‘Standardise’ button. The active window will be similar to that shown in Figure 6, but values of sample salinity and Rt will be abnormal due to absence of Standard Seawater in the standard cell. The values on the right panel ‘Standardisation’ will reflect the previous calibration data set.
5. Using the Pump Control switches, flush both cells with distilled water and drain.

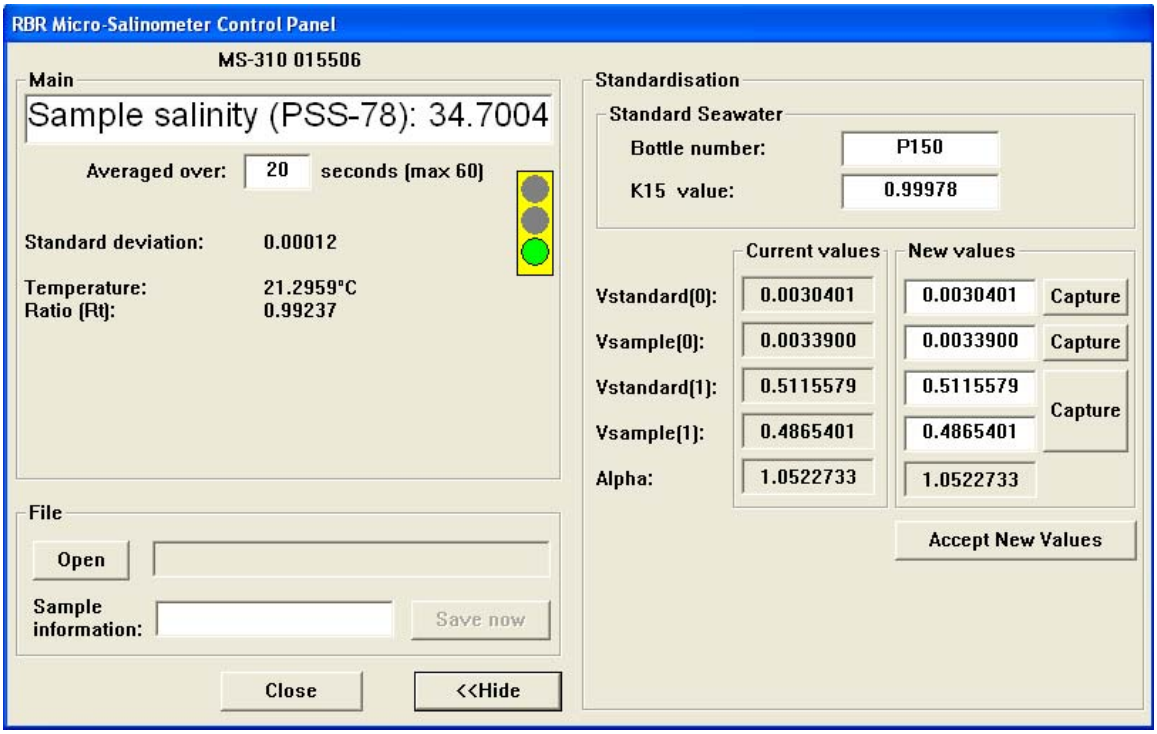

Figure 5 Example of the MS-310 control panel in Standardisation mode

6. Take a measurement of the standard channel while the standard cell is empty: Click the 'Capture' button to the right of the 'Vstandard(0)'.
7. Fill the standard cell with Standard Seawater: Set the left hand switch to the position 'Standard Cell', put the inlet of the filling tube in a bottle containing Standard Seawater and set the second switch to 'Fill'. After filling of the cell, set the switch to 'Flush' and completely flush Standard Seawater from the cell. To be able to minimize quantities of water used for flushing, it is important to flush out all water from the cell until no more water is seen dripping into the flush bottle. Repeat this operation for 3 to 5 times. Carefully control the final filling to avoid introducing bubbles into the cell. Always keep a bottle with Standard Seawater closed and perform filling with caution to prevent evaporation and/or contamination of the Standard Seawater.
8. Enter the Batch number and K15 value of the IAPSO Standard Seawater at the top of the window.
9. Take a measurement of the sample channel while the sample cell is empty: Click the 'Capture' button to the right of the 'Vsample(0)'.
10. Fill the sample cell with Standard Seawater: Set the left hand switch to 'Sample Cell' and put the inlet of the filling tube into the bottle of Standard Seawater. Ensure adequate flushing of the cell and sufficient time for the water to achieve a stable temperature in the cell.

11. Take measurements of both channels when both cells are filled with Standard Seawater. Click the 'Capture' button to the right of the 'Vstandard(1)' and 'Vsample(1).
12. At this point, capturing of the 'New values' will be completed and calibration coefficient 'Alpha' will be automatically calculated.according to equations in Appendix2
13. Click 'Accept New Values' to finish calibration and have the 'New values' written in the MS-310 memory for future use.
14. After calibration, recheck the readings of R_t and Salinity, these should be those of the Standard Seawater.

Standardisation

The fact that the Standard Seawater in the standard cell is a sealed unit is a major advantage of the MS-310. This reference seawater may be held for a long time. Periodic standardization of the MS-310 may be made by reviewing the values from the sample cell. This procedure can be done by flushing the sample cell with distilled water and starting with it empty while leaving the standard cell full with Standard Seawater and then performing steps 7-13 of the above procedure.

Measurement of sample salinity

Sample salinity measurement must be proceeds as follows:

1. Connect MS-310 to PC with supplied serial cable. Use RS232 to USB adaptor, if needed
2. Plug DC adaptor cable to 12Vdc socket. Switch power ON.
3. Run the Windows software and press 'Micro-Salinometer'. Operation with RBR Windows Software described in the chapter 'RBR Windows Software'.
4. Fill the sample cell with sample:

   - Set the left hand switch to "Sample Cell". **Important:** Never set this switch in position 'Standard Cell' during operation with the Sample Cell to avoid contamination of Standard Seawater!
   - Put the inlet of the filling tube into the sample bottle.
   - Set on the Pump control the right hand switch to 'Fill'.
   - After filling of the cell, set the switch to 'Flush' and completely flush sample from the cell. It is important to flush out all water from the cell until no more water is seen dripping into the flush bottle**.**
   - Ensure adequate flushing of the cell and absence of bubbles into the cell. Keep a bottle with sample always closed and perform the filling with caution to avoid evaporation and contamination of the sample.

5. Monitor appearance of green light on ‘go-no go’ indicator. Thereafter check ready-to-read’ state on main or graphical display, when salinity readings stabilize within 0.002.
6. Flush and refill cell with sample and measure salinity again. Difference between two consecutive salinity readings, taken from one sample bottle must be within 0.002

Reference

1. Background Papers and Supporting data on the Practical Salinity Scale, 1978. UNESCO Tech. Pap. Mar. Sci. 37, 144p.
2. F.Johnson, I.Shkvorets: "*Ocean Performance of the New MS-310*", Sea Technology, 10, 2006, pp.15-19

3. B.Howe, T.Chereskin: *Oceanographic Measurements*, in Springer Handbook of Experimental Fluid Mechanics, 2007, pp.1184-1185

Appendix

Practical Salinity Scale 1978 for the salinometer application

Practical salinity in laboratory salinometers is derived according to equation:

$$S = \sum_{i=0}^{5} a_i R_t^{i/2} + \frac{T-15}{1+k(T-15)} \sum_{i=0}^{5} b_i R_t^{i/2} \qquad 1$$

where: a0=0.0080, a1=-0.1692, a2=25.3851, a3=14.0941,
a4=-7.0261, a5=2.7081
b0=0.0005, b1=-0.0056, b2=-0.0066, b3=-0.0375, b4=0.0636, b5=-0.0144
k=0.0162

Calibration Calculations

The MS-310 is calibrated taking two points for each channel, these being the empty cell values, $V_{standard}(0)$ and $V_{sample}(0)$, and the full cell values, $V_{standard}(1)$ and $V_{sample}(1)$. Each cell is filled with the standard seawater from the same bottle. These values will provide the crude ratio R_{tm}:

$$R_{tm} = \frac{V_{sample}(1) - V_{sample}(0)}{V_{standard}(1) - V_{standard}(0)} \qquad 2$$

What must be calculated now are the calibration coefficients to make the value of R_t be equal to the K_{15} value of the standard seawater which fills the cells following Equation 2.

$$\alpha = K_{15} \frac{V_{standard}(1) - V_{standard}(0)}{V_{sample}(1) - V_{sample}(0)} \qquad 3$$