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MS-310e Micro-Salinometer

User Manual

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1 Introduction

1.1 General Description

The MS-310e Micro-Salinometer (Figure 1) is based upon a concept in which conductivity of the sample of seawater is simultaneously compared with the conductivity of Standard Seawater.

The dual cells remove 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 measurements. 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. Standardization 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-310e

1.2 Ethernet and Serial Ports

The MS-310e contains an Ethernet interface card. This provides the user with the ability to access and control a remotely located MS310 via an Ethernet connection.

When using the Ethernet connection the user can make use of the software pump control features described in Section 2.4.1. Instead of controlling the MS-310e using the manual switches at the front of the unit, users can operate the MS-310e remotely using the Ruskin software.

The MS-310e can also be connected to using a serial port. When using the serial port, the software pump control features cannot be used.

To prevent malfunction, cables connecting to the Ethernet and serial ports must not be connected to the MS-310e at the same time.

1.3 Mechanical Description

The front panel switches control the pump and are clearly marked for the proper filling and flushing of both cells.

On the rear panel are mounted the 12V DC power socket, a power switch, the RS-232 connector and the RJ-45 Ethernet connector.

The 2 litre bath is made from clear Lexan. 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. A 600mm steel heat exchanger brings the temperature of a sample close to the bath temperature.

The metal housing provides protection against RF interference and water ingress.

1.4 Pump System

The MS-310e is equipped with a pumping system, which provides filling and flushing of the cells.

The pumping system includes the following:

- peristaltic pump
- three 3-way solenoid valves
- 1/16” ID, 1/8” OD Tygon™ tubing
- flush bottle

Instructions for maintaining the pump are found in Appendix B.

1.5 Measurement Principle

The MS-310e 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.

1.6 Specifications

General

Power	110-240VAC; 12V, 18W
Communcations Ethernet	RJ-45
Communications serial	RS-232
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 (for temperature difference between sample and bath <= 1°C)
Set up time	1 hour
Bath volume	2.0 litres
Bath oil	Marcon-7 (by Imperial Oil) or similar

Temperature

Sensor	thermistor
Accuracy	±0.01 °C
Resolution	<0.00005°C
Drift	<0.002 °C/year

Conductivity Ratio R_t

Sensor	inductive conductivity cells
Range	0.05 to 1.2 (can be expanded to 4)
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 24 hours of standardization
Resolution	<0.001

2 Preparation

2.1 Filling the Oil Bath

The MS-310e is shipped empty but is supplied with a container of oil.

Steps

1. Remove the four screws (two at each side) holding the top cover of the unit in place. Remove cover.
2. Locate the oil fill hole to the right of the top of the lid of the oil bath.
3. Remove the black plug and, using the supplied funnel, pour oil into the bath to a level of 5 mm below the lid.

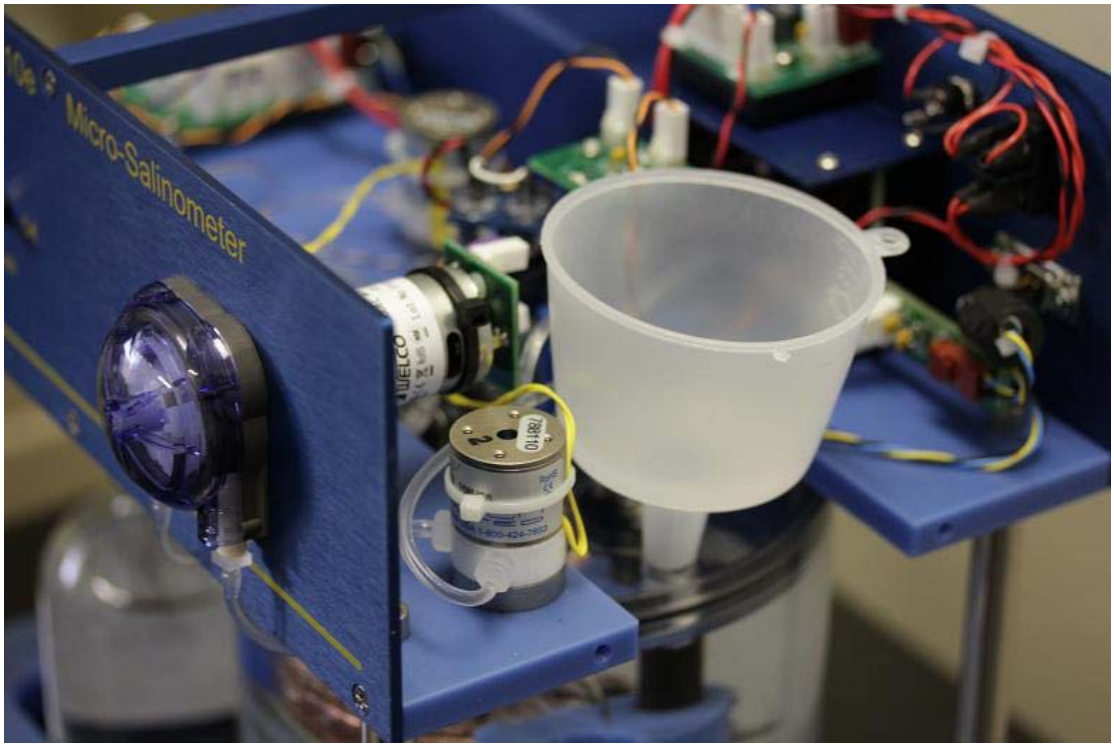


Figure 2 : Funnel placement

4. Replace the plug.
5. Restore the top cover of the unit, securing with the screws.
6. After filling the tank with the oil supplied, the MS-310e should be allowed to equilibrate for approximately 30 minutes.

2.2 Ruskin Software Startup – Serial Port Connection

The MS-310e is operated using Ruskin software. When using the serial port connection, the manual switches found on the front panel are used to control the pump functions.

2.2.1 Initial setup steps

1. Install Ruskin software on a PC, if not already installed. (For complete instructions on installation and general operation of Ruskin, please refer to the Ruskin User Guide.)
2. Connect the MS-310e RS-232 port to the PC with the supplied serial cable. Use RS-232 to USB adaptor, if needed.

   Important note: To prevent a malfunction, cables connecting to the Ethernet and serial ports must not be connected to the MS310e at the same time.
3. Plug the MS-310e DC adaptor cable into a 12Vdc socket.

2.2.2 Ruskin startup and serial connect

1. Switch power ON at the back panel of MS-310e.
2. Start the Ruskin software application.
3. The MS-310e will be listed on the left in the Navigator view after a few seconds.

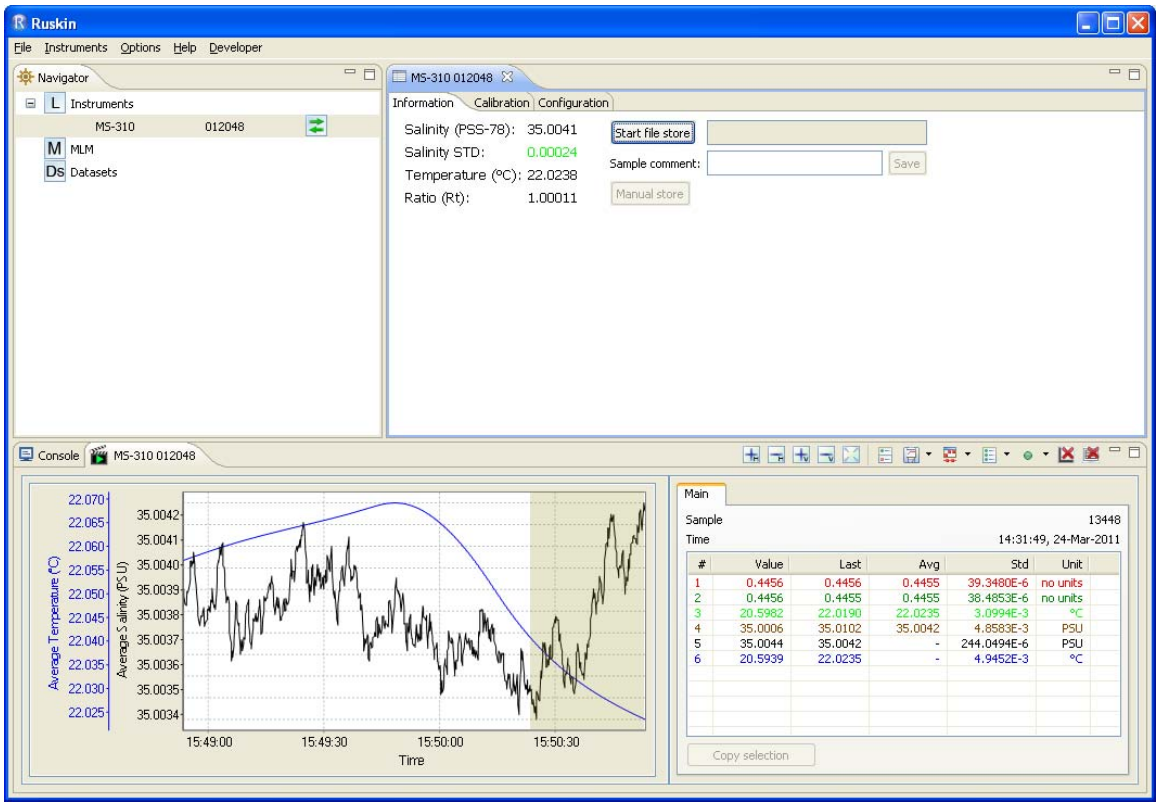


Figure 3 : Ruskin with MS-310e connected

2.3 Ruskin Software Startup – Ethernet Port Connection

The MS-310e is operated using Ruskin software.

When using the Ethernet port connection, the pump functions can be controlled in two ways:

1. Using the manual switches found on the front panel of the MS-310e. ('Software pump control' checkbox on 'Information' or 'Calibration' tab is checked OFF.)

2. Using the software pump control features found on the Ruskin application 'Information' and 'Calibration' tabs. ('Software pump control' checkbox on 'Information' or 'Calibration' tab is checked ON.)

Note: When 'Software pump control' is checked ON, the positions of the manual switches are ignored. When 'Software pump control' is checked OFF, the position of the manual switches are used.

For more information on the software pump control features, please refer to Section 2.4.1.

2.3.1 Initial setup steps

2.3.1.1 Connecting to the network

1. Install Ruskin software on a PC, if not already installed. (For complete instructions on installation and general operation of Ruskin, please refer to the Ruskin User Guide.)

2. Connect an Ethernet cable to the Ethernet port of the MS-310e and to the network you intend to use the MS-310e on.

   Important note: To prevent a malfunction, cables connecting to the Ethernet and serial ports must not be connected to the MS310e at the same time.

3. Turn on the MS-310e unit.

4. On a Windows PC which is connected to the same network as the MS-310e, launchIPSetup.exe. (launchIPSetup.exe is included on the Ruskin installer CD.) The window shown in Figure 3 should display.

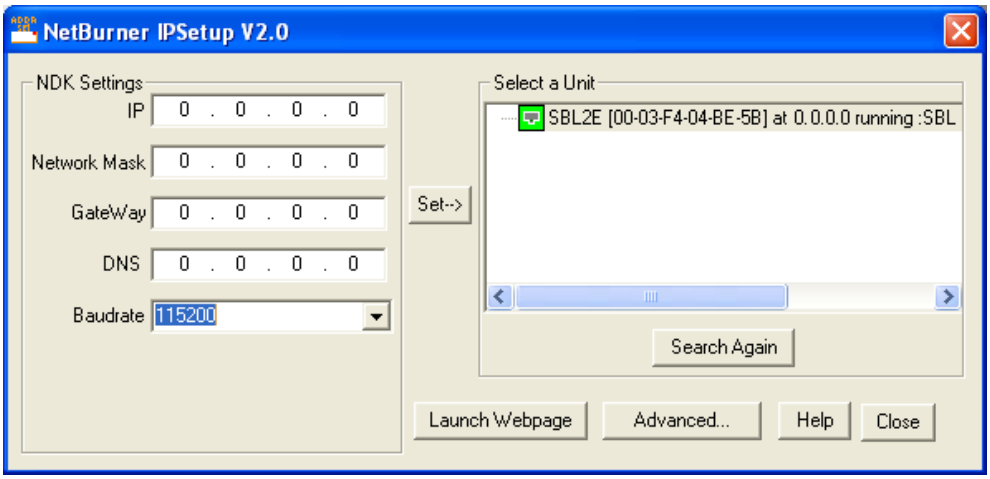


Figure 4 : NetBurner IPSetup

5. If there is no device found in the 'Select a Unit' area, then press the 'Search Again' field. The device will be found with the IP address of 0.0.0.0.
6. In the 'NDK Settings' group change the network parameters to match those of your network. NOTE: The IP address needs to be static to ensure that the address you assign is not in use by another device on the network.
7. Press the 'Set->' button to store the new 'NDK Settings' into the device. The device should now be visible at the address you just assigned it.

2.3.1.2 Accessing the configuration

1. Launch a web browser on a PC connected to the same network as the MS-310e.
2. In the address bar, type in the IP address of the MS-310e. This will bring up the main configuration page.

2.3.1.3 Configuring the serial port settings on the interface card

1. Click the 'Serial' link at the top right of the window.
2. Ensure that the settings on your Serial configuration screen match those in figure 4 below.

Figure 5 : Serial Settings Required

3. Click the ‘Submit New Settings’ button to store these new settings in the device.

2.3.1.4 Configuring GPIO settings to control the pump interface

1. Click the ‘GPIO’ link at the top right of the window.
2. Ensure that the ‘Power Up Pin Settings’ on your GPIO configuration screen match those in figure 5 below.

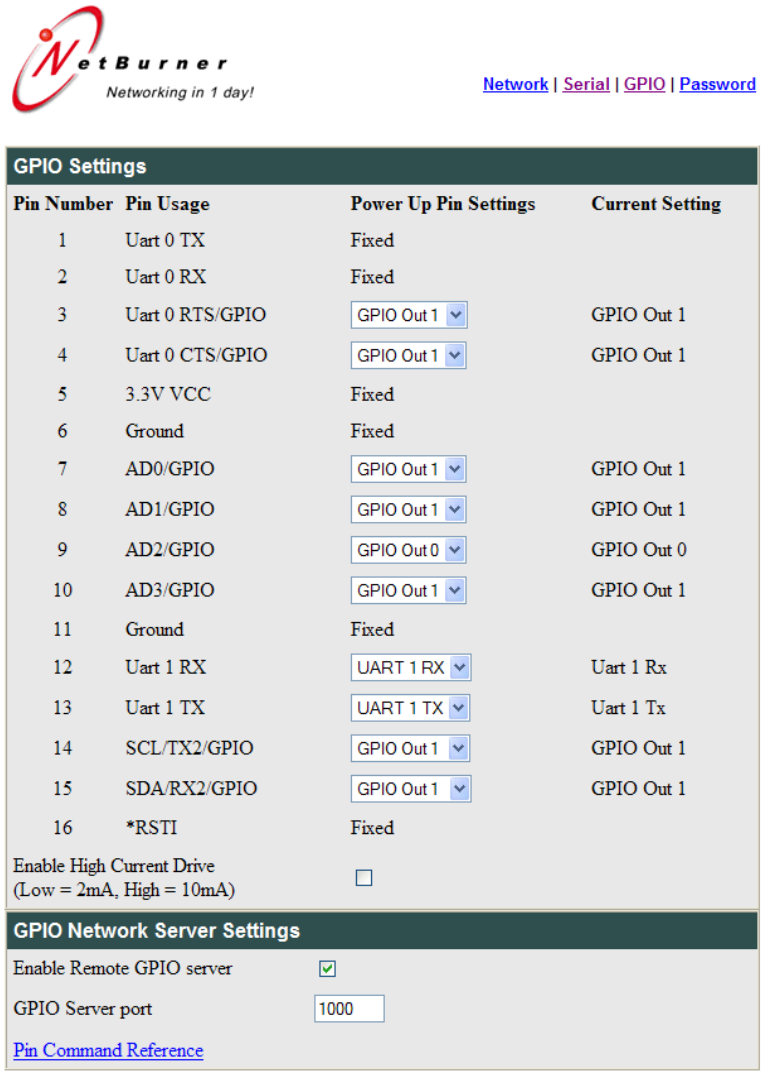


Figure 6 : GPIO Settings

3. Click the ‘Submit New Settings’ button to store these new settings in the device.

2.3.2 Ruskin startup and ethernet connect

1. Start the Ruskin application.
2. Power ON the MS-310e.
3. Select menu item: ‘Instrument/Connect to remote MS-310’. In the dialog that comes up, enter the MS-310e IP address.

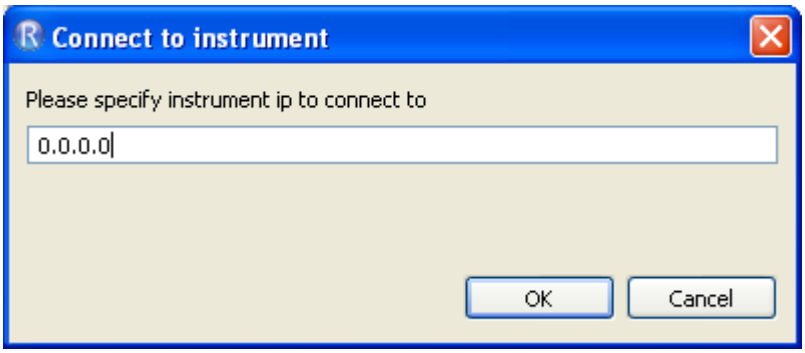


Figure 7 : Connect to instrument

4. The MS-310e will be listed on the left in the Navigator view after a few seconds.

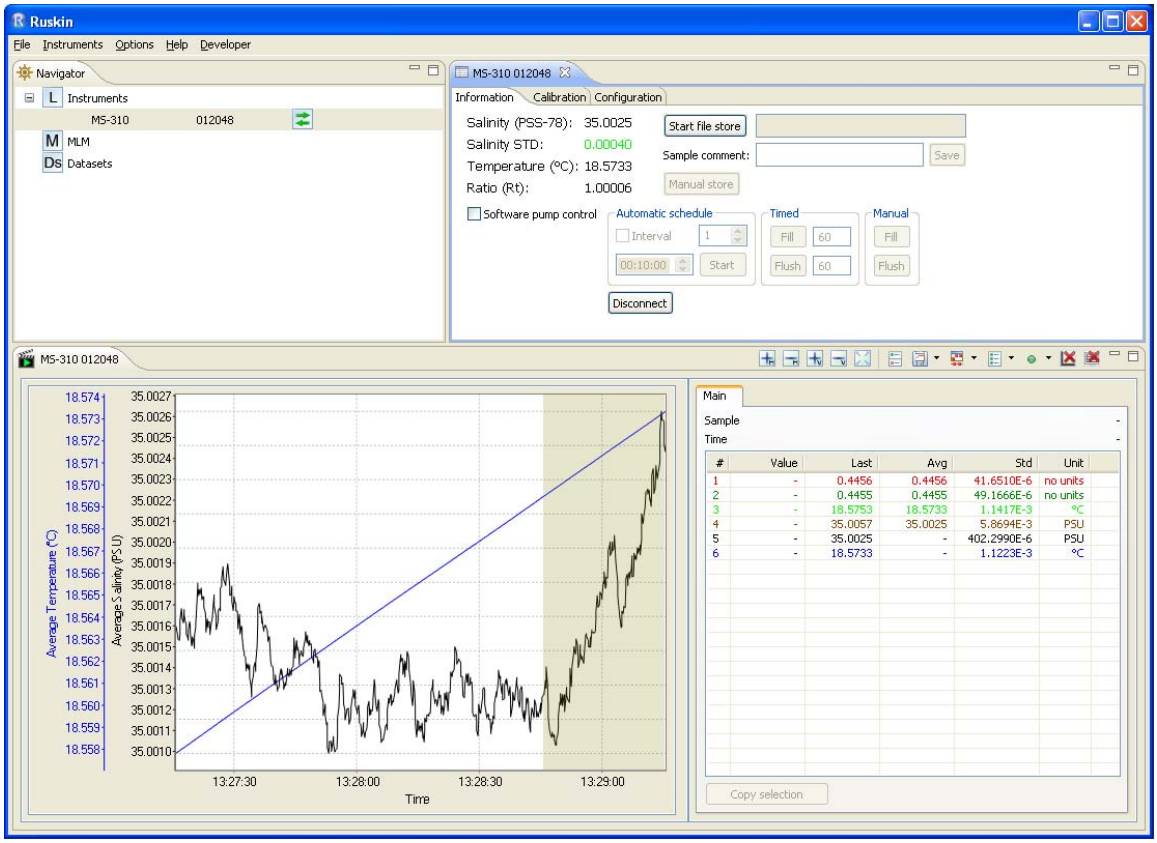


Figure 8 : Ruskin

2.4 Filling and Flushing the Cells

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.

Switches

There are two switches on the front panel of the MS-310e, which control water flow direction in the pumping system during filling and flushing procedure.

Sample Cell / Standard Cell Switch

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 calibration, when filling the standard cell with Standard Seawater.

Afterwards this switch has to be set in position ’Sample Cell’ and should not be switched back during the sample salinity measurements!

Important note 1 : In order to prevent accidental switching, the switch has a locking mechanism. To toggle the switch, pull it out, then up or down.

Important note 2 : The ‘Standard Cell’ switch position should only be used for a maximum of 30 minutes. Otherwise, there is a risk of overheating the solenoid valves.

Fill / Flush Switch

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.

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-310e.

2.4.1 MS-310e Software pump control

The MS-310e allows the user to bypass using the manual switches found at the front of the MS-310e unit.

The user can toggle the switches using the Information and Calibration tabs found in the Ruskin software application.

IMPORTANT NOTE: If the MS-310e network connection is lost during a Fill or Flush cycle when the pump is active, the pump will continue operating until the power is manually turned off on the MS-310e. Continual operation of the pump could result in damage to the instrument either through overheating or spillage due to overflow. Please monitor operation during pumping to avoid such an occurrence.

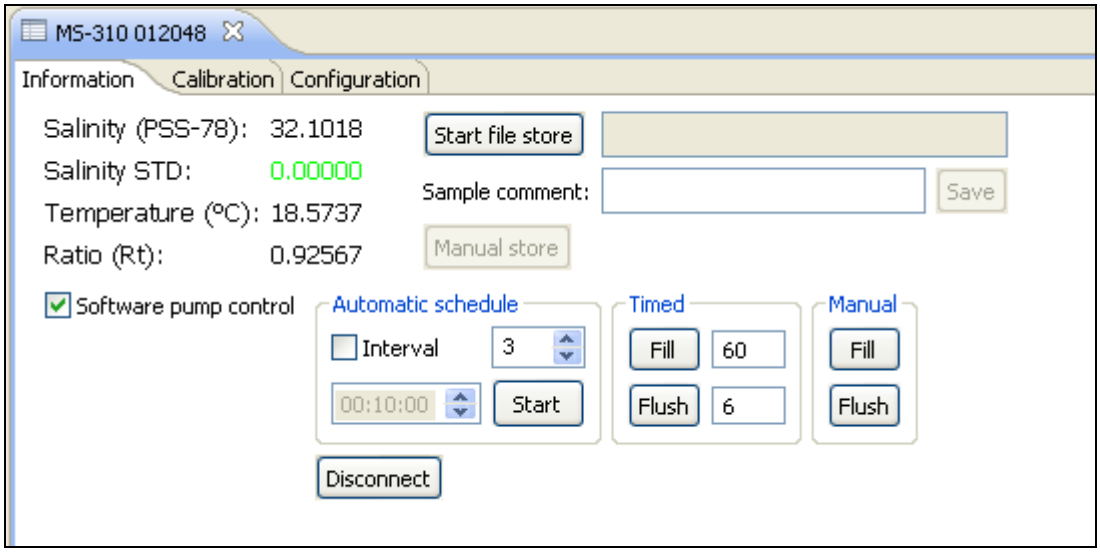


Figure 9 : Information tab MS-310e

Software pump control – ON/OFF

To use the software pump control features, check ON 'Software pump control' in the 'Information' or 'Calibration' tab.

Once this feature is turned on, the position of the physical switches is ignored.

To enable the mechanical switches, check OFF 'Software pump control'. Once the switches are enabled, the switch position is used immediately.

Software pump control

The software pump control buttons provided on the information page are used for sampling. Any actions initiated from this page will first set the MS-310e switch value to 'Sample Cell'.

The calibration tab can be used for 'Sample' or 'Standard' cell. The user can choose using the 'Cell' group.

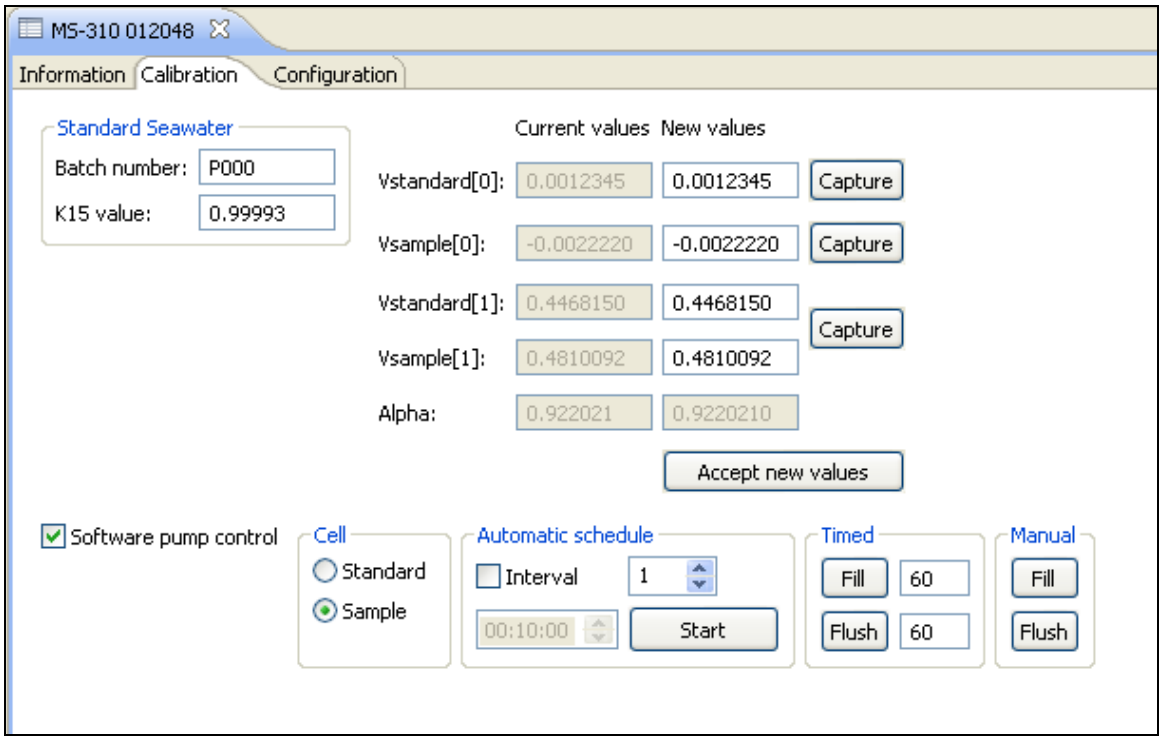


Figure 10 : Calibration tab MS-310e

Manual

The manual group has two buttons: ‘Fill’ and ‘Flush’.

Pushing ‘Fill’ is equivalent to setting the MS-310e switch to ‘Fill’.

Pushing ‘Flush’ is equivalent to setting the MS-310e switch to ‘Flush’.

Once a button is selected, the text changes to ‘Stop’. Pushing a ‘Stop’ button is equivalent to setting the MS-310e switch to ‘Off’.

Timed

The timed group has two buttons ‘Fill’ and ‘Flush’. It also has two fields to enter the number of seconds to ‘Fill’ or ‘Flush’ before stopping and setting to ‘Off’.

Example:

The ‘Fill’ seconds is set to 60.

Pushing ‘Fill’ is equivalent to setting the MS-310e switch to ‘Fill’ for 60 seconds, then setting switch to ‘Off’.

Automatic Schedule

The ‘Automatic schedule’ group is used with the ‘Timed’ group.

The user can setup an automatic schedule.

Flush/Fill time:

The values set in the ‘Timed’ group will be used to determine the time length of the ‘Flush’ and ‘Fill’.

Number of flush/fill cycles:

The number of flush/fill cycles can be set. This defines how many times a flush/fill cycle will be executed.

Interval:

A wait interval between fill/flush cycles can be specified. To define, check the checkbox ‘Interval’ ON and specify the wait time.

Important note: If ‘Interval’ is checked ON the flush/fill cycles will continue indefinitely until the user pushes ‘Stop’.

Example 1: Automatic schedule with interval

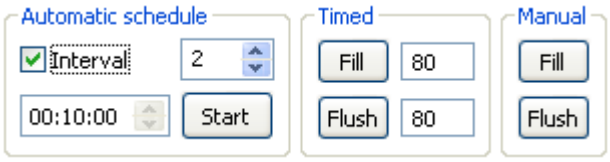


Figure 11 : Automatic schedule example

User pushes ‘Start’. Text on button changes to ‘Stop’.

Flush for 80 seconds.

Fill for 80 seconds.

Flush for 80 seconds.

Fill for 80 seconds.

Wait for 10 minutes.

Flush for 80 seconds.

Fill for 80 seconds.

Flush for 80 seconds.

Fill for 80 seconds.

Wait for 10 minutes.

…

This continues indefinitely until the user hits ‘Stop’.

Example 2: Automatic schedule with no interval

Figure 12: Automatic schedule example

User pushes ‘Start’. Text on button changes to ‘Stop’.

Flush for 80 seconds.

Fill for 80 seconds.

Flush for 80 seconds.

Fill for 80 seconds.

Text on button changes to ‘Start’.

2.5 Setup and Configuration

Using the Ruskin application, a connection is made to the MS-310e.

Once the MS-310e is connected, data can be viewed, configured and calibrated using the tabs on the right.

The Information tab contains important MS-310e data.

Several parameters can be configured using the Configuration tab.

The Calibration tab is used for calibration. This is covered in Section 3.1 Calibration.

2.5.1 Information tab

The current values of 'Salinity', 'Salinity STD', 'Temperature' and 'Ratio' are displayed in the Information tab.

The 'Salinity STD' value will be highlighted in green when the STD threshold has been met. The STD threshold can be set on the Configuration tab.

Instructions for how to use the 'Start file store', 'Sample comment' and 'Manual store' features are included in Section 2.6 Data Store.

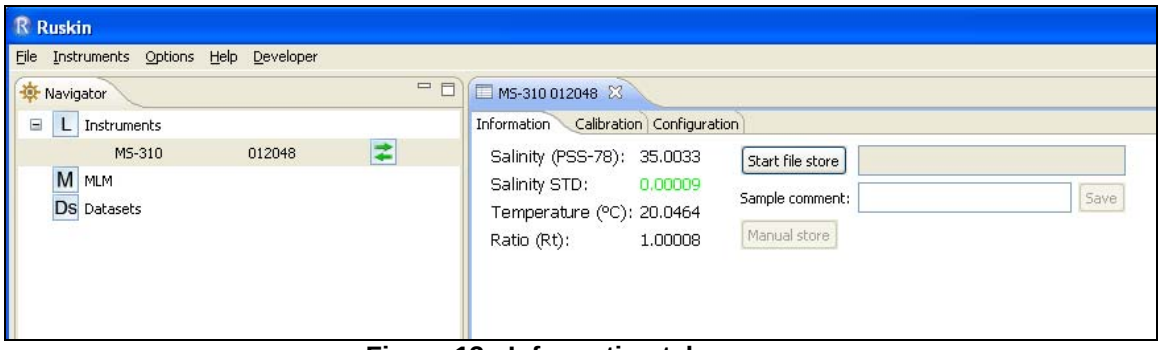


Figure 13 : Information tab

2.5.2 Configuration tab

This tab is used to configure various parameters for the MS-310e.

Time to average (s)

The readings from the MS-310e are averaged over a period which can be set under the Configuration tab, which enables any electronic noise to be reduced.

The time to average can be set from 1sec to 1000sec. A typical user will set the averaging time in the range of 20-60 sec. A higher averaging time will result in a more precise measurement, but there will also be an increase in the time it will take for your sample measurement.

STD threshold

The required standard deviation is set using the STD threshold box. Values for this parameter are typically between 0.0001 and 0.0004, depending on your measurement conditions, setup and precision

requirements. Again, as with averaging, the smaller the required precision, the longer the sampling time will take.

The optimal STD threshold value is dependent upon the sampling interval and the desired precision of the instrument.

Example – STD threshold value

-> MS-310e operating under laboratory conditions

-> averaging interval: 60 seconds

-> STD threshold: 0.0004

When you are actively measuring a salinity sample, the Salinity STD value under the Information tab will turn from red to green when the STD threshold value has been met.

Once the STD value is green, the graphical displayed can be used to determine the ready to read state. In order to determine the ready-to-read state, an operator can monitor a real-time plot of salinity readings using the graphical window of Ruskin, which displays salinity and temperature data.

Horizontal domain bounds (minutes)

Specify the number of minutes of data to be displayed in the graph.

Outgoing data socket

The MS-310e's streaming data can also be sent to an outgoing data socket. A user can connect to the socket through telnet and monitor the data being streamed.

By default the socket is set to 2 + the last 3 digits of the MS-310e serial ID.

Pushing the 'Close' button will close the socket. Pushing 'Open' will open the data socket and start the data streaming to that socket.

Please refer to section 2.7.1 for more details.

Incoming control socket

This feature is only available if the MS-310e is connected via the Ethernet port.

The incoming control socket than can used to send commands to the MS-310e to control the pump.

By default the socket is set to 5 + the last 3 digits of the MS-310e serial ID.

Pushing the 'Close' button will close the socket. Pushing 'Open' will open the socket allowing for commands to be sent to the MS-310e.

Please refer to section 2.7.2 for more details.

Continuous sample store

If ‘Continuous sample store’ is checked on, when the user selects ‘Start file store’ on the Information tab, samples will be written to the file continuously.

If ‘Continuous sample store’ is checked off, when the user selects ‘Start file store’ on the Information tab, the specified file will have additional samples written to it only when the ‘Manual store’ button is pushed.

Sampling interval

Set the sampling period.

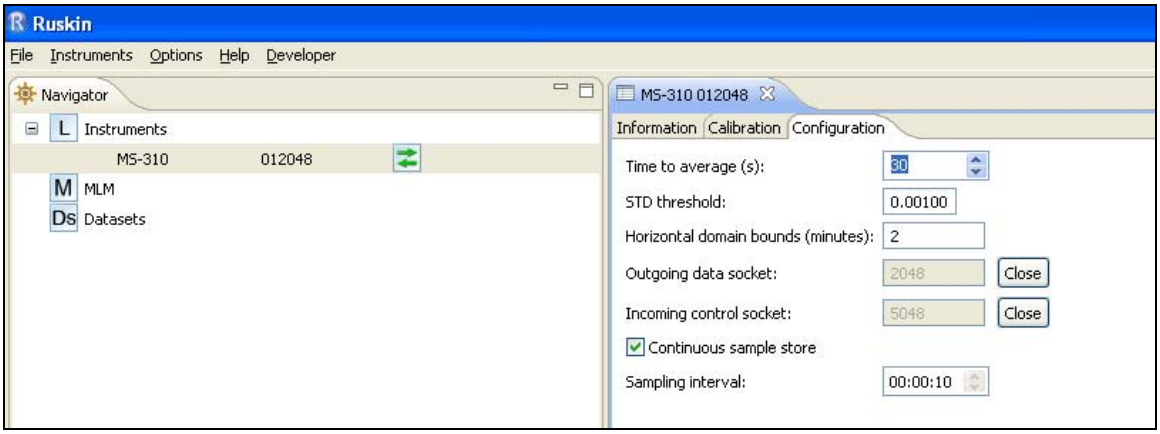


Figure 14 : Configuration tab

2.6 Data Store

Readings from the MS-310e can be saved to a file for later review.

The data is saved on demand, either in continuous or manual mode.

If continuous save mode is set, the data samples are saved automatically without user prompting. If manual mode is set, the data samples are saved only when the user specifically forces a sample save by clicking on the 'Manual store' button.

2.6.1 Continuous save mode

Steps

1. Startup Ruskin and connect to MS-310e.
2. Select the 'Continuous Sample Store' check box under the Configuration tab.
3. In the Sample Interval box, specify the interval between samples to be saved. For a typical user, the sampling interval could be set to the same value as the averaging period.
4. On the Information tab, click 'Start File Store'. The Save as SAL dialog box appears.
5. Specify a location and name for the data file.
6. Additional information about sample (sample number, bottle number, station number, depth, etc.) can be written in the 'Sample Comment' window. Click 'Save' to store the comment into the data file. Multiple comments can be entered into a single data file.
7. 'Start File Store' has now changed to 'Stop File Store'. When you wish to stop recording your data, click this button.

2.6.2 Manual save mode

Steps

1. Startup Ruskin and connect to MS-310e.
2. Ensure that the 'Continuous Sample Store' check box under Configuration is deselected.
3. On the Information tab, click 'Start File Store'. The Save as SAL dialog box appears.
4. Specify a location and name for the data file.
5. Additional information about sample (sample number, bottle number, station number, depth, etc.) can be written in the 'Sample Comment' window. Click 'Save' to store the comment into the data file. Multiple comments can be entered into a single data file.
6. 'Start File Store' has now changed to 'Stop File Store'. When you wish to stop recording your data, click this button.

7. To save a data point, click ‘Manual Store’.

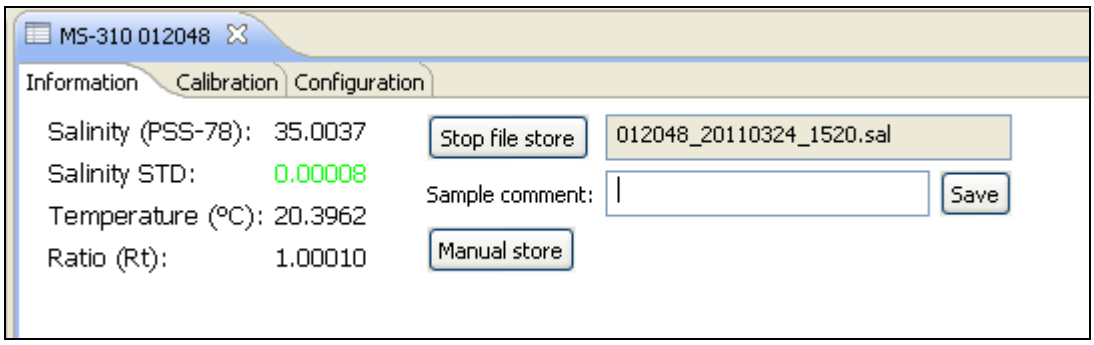


Figure 15 : Stop file store

2.7 Data and Control Sockets

The Ruskin software allows for data access and pump control using sockets.

The outgoing and incoming sockets help to facilitate automated laboratory setup.

Ruskin must be running to use these features. The sockets can be configured and set to ‘Open’ or ‘Close’ on the Ruskin ‘Configuration’ tab.

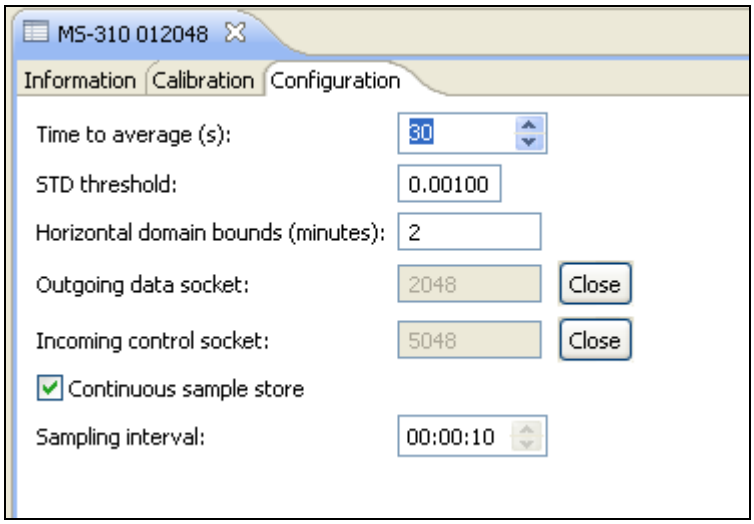


Figure 16 : Configuration tab

2.7.1 Outgoing data socket

The MS-310e’s streaming data can also be sent to an outgoing data socket.

A user can connect to the socket through telnet and monitor the data being streamed. By default this feature is turned on.

By default the socket is set to 2 + the last 3 digits of the MS-310e serial ID.

Pushing the ‘Close’ button will close the socket. Pushing ‘Open’ will open the data socket and start the data streaming to that socket.

Sampling Rate

The socket retrieves one sample per second. This is slower than the sampling rate of the Ruskin graphical view. The graphical view retrieves 6 samples per second.

Data Format

The data contains one sample per line. Each line is terminated with the carriage return and line feed characters.

Each sample contains 7 values. The values are separated by a space.

Date	YYYYMMDD
Time	HHMMSS
Temperature	5 decimal places
Rt ratio	4 decimal places
Salinity	4 decimal places
Standard deviation	5 decimal places
Time to average	seconds

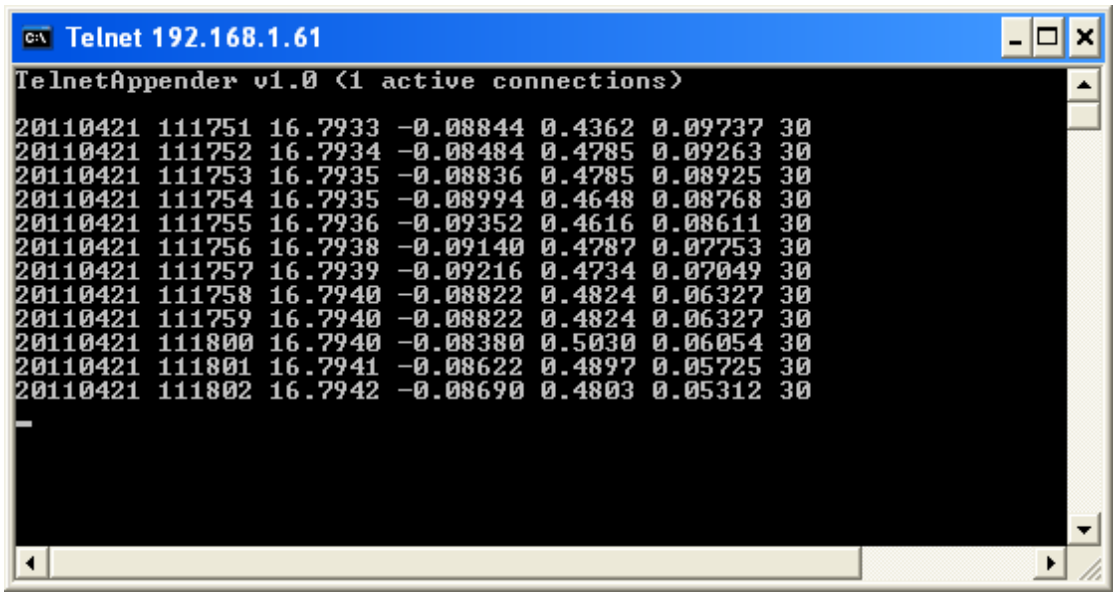


Figure 17 : Streaming data

2.7.2 Incoming control socket

This feature is only available if the MS-310e is connected via the Ethernet port.

The incoming control socket than can used to send commands to the MS-310e to control the pump.

By default the socket is set to 5 + the last 3 digits of the MS-310e serial ID.

Pushing the ‘Close’ button will close the socket. Pushing ‘Open’ will open the socket allowing for commands to be sent to the MS-310e.

The pump commands are outlined below.

HELP

Displays a list of the pump commands.

HELP [commandX]

Displays help for commandX.

FILL [time] [-s]

Enables the filling pump for a given cell for a given amount of time.

FILL the sample cell until the STOP command is given.

[time] – The time, in seconds, taken to fill the cell. No STOP required.

[-s] – FILL the standard cell. If not specified, FILL the sample cell.

FLUSH [time] [-s]

Enables the flushing pump for a given cell for a given amount of time.

[time] – The time, in seconds, taken to flush the cell.
No STOP required.

[-s] – FLUSH the standard cell. If not specified, FLUSH the sample cell.

CYCLE <NumberOfCycles> <time> [fillTime] [-i<interval>] [-s]

Starts a flush/fill cycle for a given cell.

<NumberOfCycles> - The number of flush/fill cycles to perform.

<time> - The time, in seconds, taken to flush the cell.

[fillTime] – The time, in seconds, taken to fill the cell.
-If missing, the fill time equals flush time.

[-i<interval>] – Interval cycle time in the form hhmmss.

- If missing, the NumberOfCycles will be performed only once.

[-s] – CYCLE the standard cell. If not specified, CYCLE the sample cell.

STOP

Stops any pump activity.

MODE <on|off>

Sets the software pump control to ON or OFF.

ON – Enables software controls. Disables hardware switches.

OFF- Disables software controls. Enables hardware switches.

REPLY<on|off>

Sets confirmation replies from the server to ON or OFF.

ON – Enables replies from the server.

OFF- Disables replies from the server.

If a command is sent with an incorrect parameter, the command does not execute and an error message is returned to indicate an unsuccessful command attempt.

3 Procedure

3.1 Calibration

Calibration of the MS-310e must be performed during setup and at any point when the standard cell has been refilled.

Steps

1. Power ON the MS-310e unit. Start the Ruskin application.
2. Click on the Calibration tab. The current values for Vstandard[0], Vsample[0], Vstandard[1], Vsample[1] and Alpha will reflect the previous calibration data set.
3. Using the pump control switches or the software pump control features, flush both cells with distilled water and drain.
4. Take a measurement of the standard channel while the standard cell is empty: Click the ‘Capture’ button to the right of ‘Vstandard[0]’.
5. Fill the standard cell with Standard Seawater.

   Steps

   - Set to ‘Standard Cell’.
   - Put the inlet of the filling tube in a bottle containing Standard Seawater.
   - Set to ‘Fill’. Fill the cell.
   - Once fill is complete, set 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 3 to 5 times. In order to economize the Standard Seawater usage, the first flushings can be done using substandard seawater and the last 2 using Standard Seawater. Substandard seawater is defined as Standard Seawater left from previous calibrations.

   Carefully control the final filling to avoid introducing bubbles into the cell.

   Always keep a bottle with Standard Seawater closed.

   Perform filling with caution to prevent evaporation and/or contamination of the Standard Seawater.
6. Enter the Batch number and K15 value of the IAPSO Standard Seawater at the top of the window.
7. Take a measurement of the sample channel while the sample cell is empty. Click the ‘Capture’ button to the right of ‘Vsample[0]’.
8. Fill the sample cell with Standard Seawater.

   Steps

- Set to ‘Sample Cell’.
- Put the inlet of the filling tube into the bottle of Standard Seawater.
- Set to ‘Fill’. Fill the cell.
- Once the fill is complete, set 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 flush/fill cycle 3 to 5 times.

Once the final filling is complete, allow the water in the cell to achieve a stable temperature by waiting for approximately 2 to 5 minutes.

In order to economize the Standard Seawater usage, the first flushings can be done using substandard seawater and the last 2 using Standard Seawater. Substandard seawater is defined as Standard Seawater left from previous calibrations.

Carefully control the final filling to avoid introducing bubbles into the cell.

Always keep a bottle with Standard Seawater closed.

Perform filling with caution to prevent evaporation and/or contamination of the Standard Seawater.

9. Take measurements of both channels when both cells are filled with Standard Seawater. Click the ‘Capture’ button to the right of ‘Vstandard[1]’ and ‘Vsample[1]’.
10. At this point, capturing of the ‘New values’ will be completed and calibration coefficient ‘Alpha’ will be automatically calculated according to the equations in Appendix 2.
11. Click ‘Accept New Values’ to finish calibration and have the new calibration values written to the MS-310e memory for future use.
12. After the calibration, recheck the readings of R_t and Salinity, these should be those of the Standard Seawater.

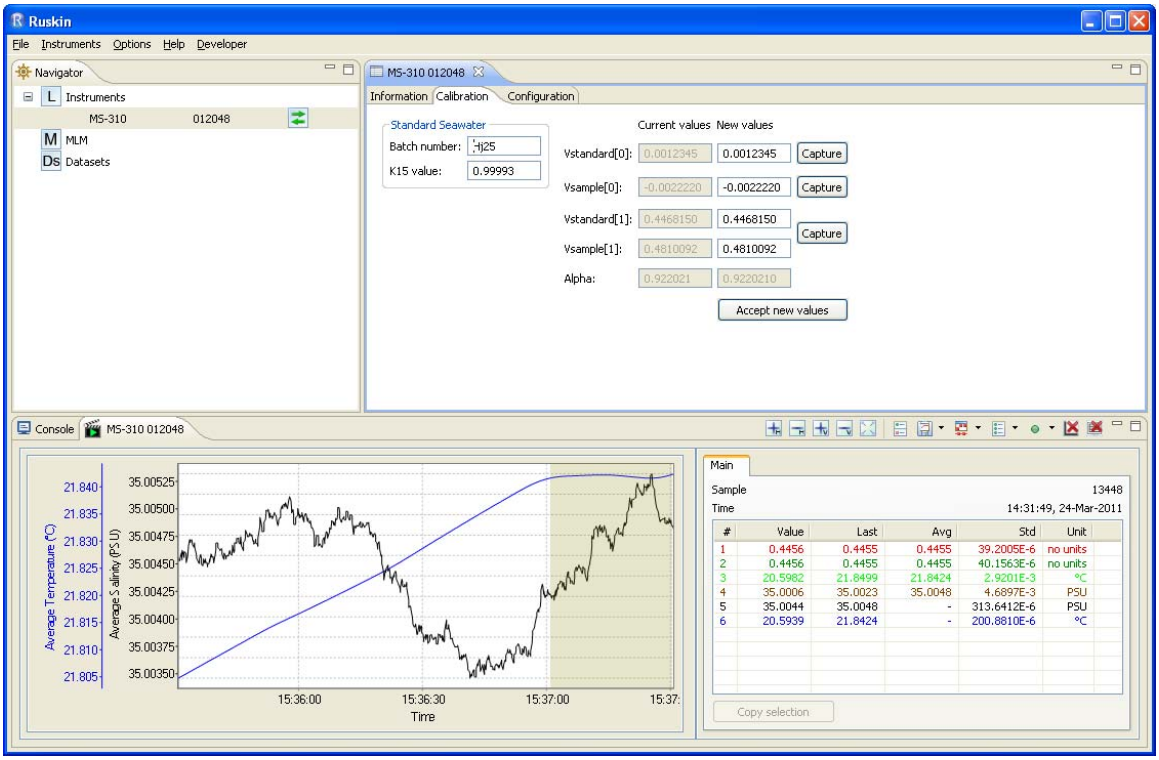


Figure 18 : Calibration tab

3.2 Standardization

The fact that the Standard Seawater in the standard cell is a sealed unit is a major advantage of the MS-310e. The conductivity of the sample seawater is simultaneously compared with the conductivity of Standard Seawater.

The reference seawater may be held for a long time. However, routine standardization of the MS-310e must be performed at least once in 24 hours to achieve the specified accuracy of 0.002psu.

Periodic standardization of the MS-310e can be made by reviewing the Vsample[0], Vstandard[1] and Vsample[1] values.

Steps

1. Power ON the MS-310e unit. Start the Ruskin application. Connect to MS-310e, and select the 'Calibration' tab.
2. Using the pump control switches or software pump control features, flush the sample cell with distilled water and drain.
3. Enter the batch number and the K15 value of the IAPSO Standard Seawater in the 'Calibration' tab.
4. Take a measurement of the sample channel while the sample cell is empty. Click the 'Capture' button to the right of 'Vsample[0]'.
5. Fill the sample cell with Standard Seawater.

   Steps

   - Set to 'Sample Cell'.
   - Put the inlet of the filling tube into the bottle of Standard Seawater.
   - Set to 'Fill'. Fill the cell.
   - Once the fill is complete, set 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 flush/fill cycle 3 to 5 times.

   Once the final filling is complete, allow the water in the cell to achieve a stable temperature by waiting for approximately 2 to 5 minutes.

   In order to economize the Standard Seawater usage, the first flushings can be done using substandard seawater and the last 2 using Standard Seawater. Substandard seawater is defined as Standard Seawater left from previous calibrations.

   Carefully control the final filling to avoid introducing bubbles into the cell.

   Always keep a bottle with Standard Seawater closed.

Perform filling with caution to prevent evaporation and/or contamination of the Standard Seawater.

6. Click the ‘Capture’ button to the right of ‘Vstandard[1]’ and ‘Vsample[1]’.
7. At this point, capturing of the ‘New values’ will be completed and calibration coefficient ‘Alpha’ will be automatically calculated according to the equations in Appendix 2.
8. Click ‘Accept New Values’ to finish standardization and have the new calibration values written to the MS-310e memory for future use.

3.3 Measurement of Sample Salinity

1. Power ON the MS-310e unit. Start the Ruskin application.
2. Fill the sample cell with sample.

   Steps

   - Set to ‘Sample Cell’.

   Note: It is important to never set this switch to the ‘Standard Cell’ position during operation with the Sample Cell to avoid contamination of Standard Seawater in the standard cell!

   - Put the inlet of the filling tube into the sample bottle.
   - Set to ‘Fill’. Fill the cell.
   - Once the fill is complete, set 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.
   - Repeat flush/fill cyle 3-5 times. Ensure absence of bubbles in the cell. Keep the bottle with sample closed at all times and perform the filling with caution to avoid evaporation and contamination of the sample.

3. Monitor the appearance of the Salinity STD value on the Information tab. As indicated in the Configuration section of this manual, the line will turn green when the STD threshold has been met.

   In order to determine the ready to read state, an operator can monitor the real time plot of salinity readings using the graphical plot view. When the salinity readings stabilize to within 0.001 for 2 minutes, the sample salinity is ready to read.

4. Flush and refill the cell with sample seawater and measure salinity again. The difference between two consecutive salinity readings, taken from one sample bottle, must be within 0.002.

4 Operation Guidelines

The MS-310e is an accurate and sensitive instrument that is designed to measure salinity to the best state of the art theoretical limits.

The following points are recommended operation guidelines.

1. Standard laboratory procedures and precautions should be followed always.

2. Do not shake or agitate the samples and fill gently to avoid turbulence or bubbles.

3. Do not draw from the last bottom third of the sample bottle.

4. For highest accuracy, the sample bottles should be rinsed 3 times with sample water before the final fill for salinity measurement.

5. The sample cell in the MS-310e should be filled and flushed at least 3 times. Draw and measure samples repeatedly from the same sample bottle. When consecutive readings are within the instrument accuracy, the reading can be accepted.

6. Observe the cells as they are filling. De-gassing water may introduce bubbles which must be removed by reversing the fill slightly and repeating.

7. Before proceeding to a new sample bottle, remove the tube from the previous bottle and use “Fill” to empty the tube, and then wipe the outside with a clean paper towel.

8. The MS-310e is designed to be independent of influence from temperature. However, shielding from draughts etc. will help to shorten the settling time.

9. If the MS-310e is to be left for long periods of disuse, it is advisable to flush the cells and pipes with distilled water and leave empty.

5 MS-310e Troubleshooting

5.1 Stability Check

Fill both cells with Standard Seawater, lock all outlet and inlet tubings and leave the MS-310e running for a few hours.

Check salinity readings every 10 minutes.

5.2 Repeatability Check

Prepare 4L-bottle of seawater (preferably using a glass bottle with spigot).

Take direct samples from the bottle every 10 min and measure sample salinity.

5.3 Sealing Check

1. Make a visual check. Are there any oily spots in the flush water bottle? Are there any oily drops in the cells?

2. Fill a cell with water and lock outlet tubing (overflow water outlet). There must not be any trace of water leaking from the glass cells and the tubing in the oil chamber.

5.4 Bubble Control

It is very important to keep control of the bubbles in both cells during the entire measuring period.

If bubbles appear, redo the measurement with a new portion of water. Check tubing connectors for better sealing to avoid getting air in the pumping system.

5.5 Valve Check

The peristaltic pump will start to draw air into the cells if there is a problem with the solenoid valve #1. Air bubbles may also be seen in the pump inlet tubing.

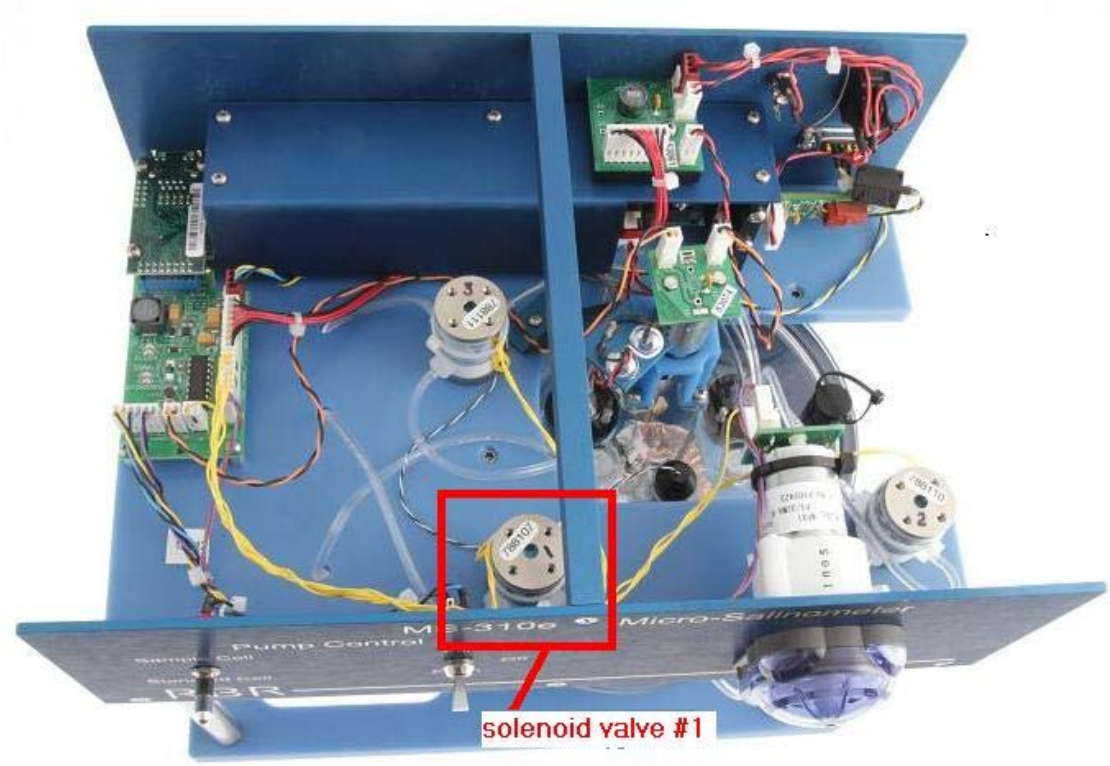


Figure 19 : Solenoid valve #1 inside MS-310e

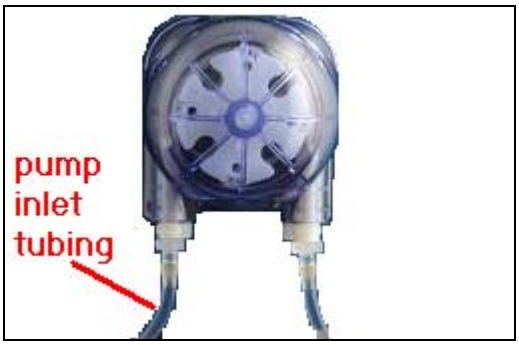


Figure 20 : Pump inlet tubing

There are 2 checks for this issue. As the checks should happen in a specific order, steps to complete the checks are enumerated below.

Steps

1. Remove the four screws (two at each side) holding the top cover of the MS-310e unit in place. Remove the cover.

2. Locate solenoid valve #1.

3. Check 1: Check the 3 fittings on the solenoid valve #1 to see if any of them are loose. Fix any loose fittings by tightening the fittings by hand. Please use caution and do not over tighten the fittings.

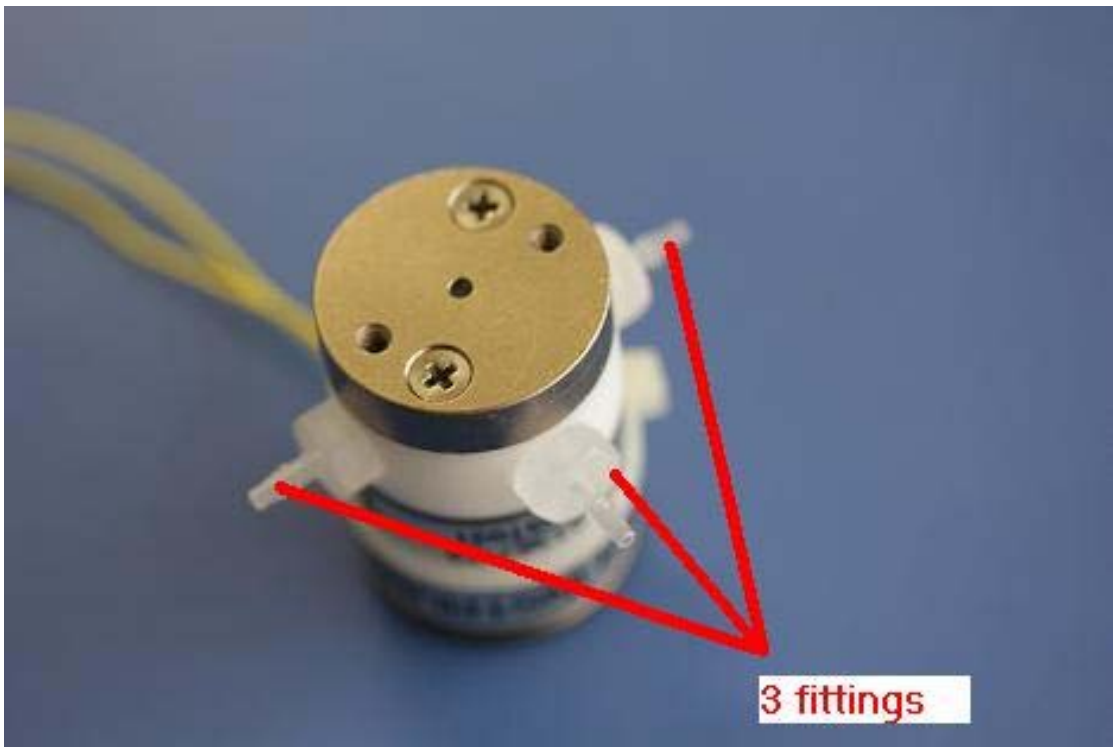


Figure 21 : Solenoid valve #1 fittings

If this fixes the problem, go to step 7. Otherwise, proceed to step 4.

4. Remove the solenoid valve #1 from the MS-310e unit. There are two screws on the bottom panel that are screwed into the solenoid valve #1. Unscrew and remove the valve.

5. Check 2: There should be no external debris or sediment in the valve. To verify, unscrew the two screws at the bottom of the valve, and examine the internal area of the valve. Clean the valve by removing external matter if necessary. Reassemble the valve and replace the screws. Verify that the valve parts are assembled together tightly. The two screws on the bottom of the valve should be secure. If these two screws are loose, the entire assembly of the valve will be loose.

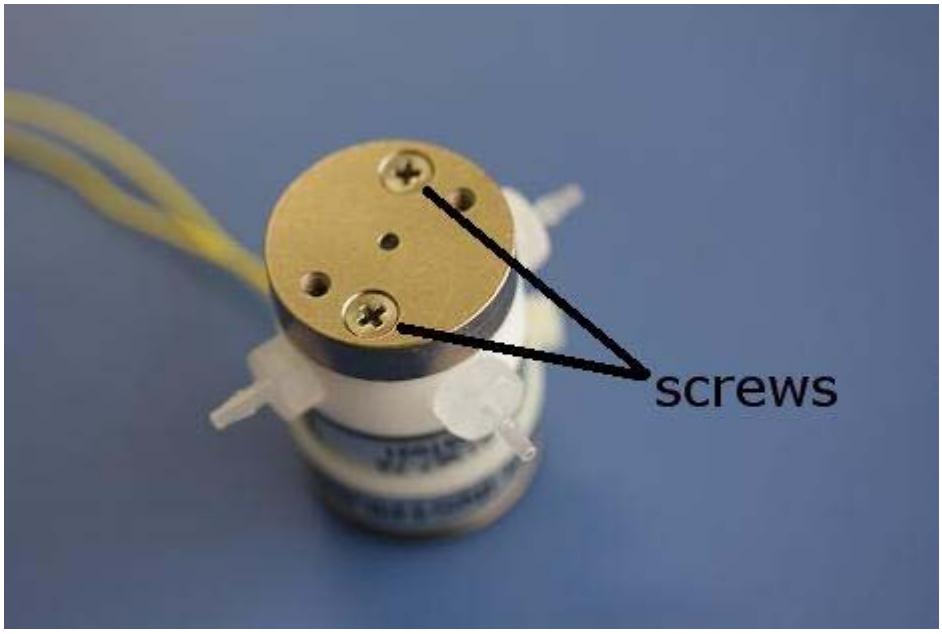


Figure 22 : Solenoid valve #1 – screws

6. Replace the solenoid valve #1 into MS-310e unit. . Screw in the two screws through the bottom panel of the MS-310e unit.

7. Restore the top cover of the unit, securing with the screws.

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 A

Practical Salinity Scale 1978 for the salinometer application

Practical salinity for 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.

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

Appendix B - Pump Maintenance

Remove Tubing from Pump

1. Remove Hoses

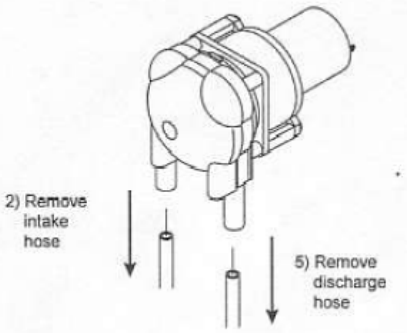
1) Turn off power to the equipment in which the Pump is installed.

2) Remove the intake hose carefully to avoid spilling fluid still in the tubing and the hose.

3) Turn on power to the equipment in which the Pump is installed and squeeze out fluid in Tubing.

4) Turn off power to the equipment in which the Pump is installed.

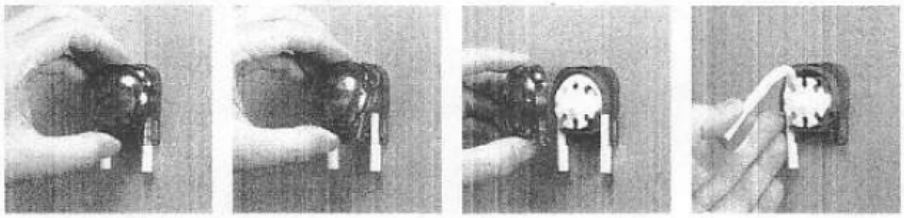
5) Remove the discharge hose carefully to avoid spilling fluid still in the tubing and the hose.



⚠ Warning

Any dangerous liquid in the Tubing or the Hose may cause injury if it touches skin.

2. Remove Pump Cover



1) Hold top and bottom of Pump Cover .

2) Pick up Pump Cover from bottom side.

3) Pull off Pump Cover.

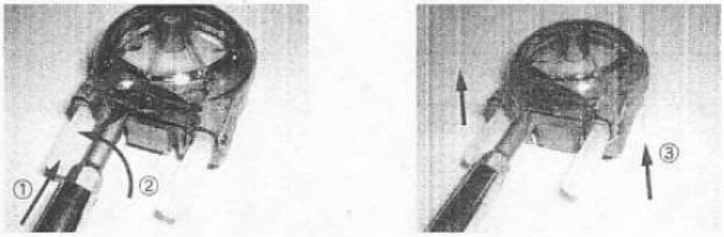
4) Remove Tubing.

⚠ Caution

Be careful not to be cut by the edge of the Pump Cover

Using Screwdriver to remove Pump Cover

WPX-1 is basically designed as Tool-Free for Installation and Tubing replacement. However if Pump Cover is too tight to remove by hand, use a minus screwdriver as shown below to prevent hand injury.



① Place a minus screwdriver in the space between either the Holding ear and Inlet (or Outlet) tubing part of Pump Base.

② Rotate the minus screwdriver, and Pump Cover will pop up.

③ Remove the Pump Cover with your hand.