ECHO INSTRUMENTS

Respirometer

USER MANUAL

ER-UM_092025_2.0 – PRE-RELEASE

Published by:

ECHO Instruments, d.o.o.
Zeče 25
3210 Slovenske Konjice
Slovenia
Tel: + 386 (0)3 759 23 80
E-mail: info@echoinstruments.eu
Internet: www.echoinstruments.eu

Contents

Preface

About this Manual

This manual provides information needed for installation, operation and maintenance of ER respirometer. Respirometer is an electromechanical device that can provide years of useful service with the proper care, as described in this manual.

This manual was written and illustrated using the best possible information available at the time of publication.

Any differences between this manual and the equipment reflect improvements introduced after the publication of the manual.

Changes, technical inaccuracies, and typographic error will be corrected in subsequent editions. As a part of our policy of continuous improvement, we reserve the right to alter design and specifications without further notice.

Respirometer is a modular device that can be upgraded to different extents and enables connection of multiple external systems to operate in sync with the main control unit. In these chapters and throughout the manual the focus will be on basic model with 12 channel control unit, oxygen and carbon dioxide gas sensors, with flow range 500 mL/min. Some other possible configurations (over 12 sample channels, additional gas sensors, …) and external units (pump, thermostatic cabinet, magnetic stirrer, different reactor models, …) are described in the appendix or accompany this manual as separate instructions. If additional information on operation, installation or maintenance is needed for operating the system, contact your local distributor or manufacturer.

Qualification of personnel

Installation and maintenance of the device must be performed by authorized and trained personnel. Training for the handling of products sensitive to electrostatic discharges must include the use of Electrostatic Discharge (ESD) protection devices and knowledge of the ESD symbol's meaning, as well as using original spare parts and respecting quality assurance and traceability rules approved by Echo Instruments.

Safety and Use

To promote safety awareness, you must read and understand **Chapter Safety Information** before installation, operation, or maintenance of the device.

1 Safety information

Purpose

The purpose of these instructions is to highlight the hazards and risks in a process or task and provide information necessary to assist all staff to perform activities safely. These instructions also assist in the training and orientation of new staff to reduce the risk of the tasks to be performed, as well as providing them with the rules and procedures necessary to ensure that they can perform their work in a safe manner.

1.1 Definitions

Throughout the manual notes, cautions and warnings are indicated with various icons and written in bold.

Warning symbols

	Warning (general) - The operator must observe and/or act according to the information to avoid any personnel injury.
	The operator must observe and/or act according to the information to avoid any mechanical or electrical damage to the equipment.
	Risk of high voltage.
	Danger of electrostatic discharge.

Information

 Note!	The operator should observe and/or act according to the information to obtain the best possible function of the equipment.

1.2 User responsibility

Intended use

ECHO respirometer is a laboratory device that measures respiration of living organisms. Respirometer determines aerobic or anaerobic biodegradability of solid or liquid samples in various applications.
Use the device only as described in User Manual. The manufacturer bears no responsibility for any other use.

Restrictions of use

Respirometer is not approved for use in potentially explosive atmosphere.

Designated user

Respirometer may only be installed and operated by authorised technicians who can assess the tasks and recognize the risk involved based on technical training and knowledge as well as knowledge of relevant regulations.

Special local conditions

Note valid legal regulations and safety at work regulations when working with equipment and materials.

1.3 Safety information and protective measures

Hazards & risks

	The measuring system is designed exclusively for professional laboratory use.
 Warning: high voltage	Disconnect main lines before working on main connections or parts carrying mains voltage.
	Respirometer is designed exclusively for professional laboratory use.

	Respirometer must be placed in the well ventilated area.

Protection devices

	Suitable protection devices and safety equipment for persons must be available according to the respective risk potential and be used by the personnel.

Preventive measures for operating safety

	User must ensure that the specified maintenance and inspection tasks are carried out regularly by qualified, experienced personnel.

Waste Disposal

	WEEE (Waste Electrical and Electronic Equipment). This product must not be disposed of with household waste. Observe local ordinances for proper disposal.

1.4 Malfunction recognition

Every deviation from normal operation must be taken into consideration as an indicator of a functional impairment. These are, amongst other:

- warning displays,
- significant drifts in measuring results,
- increased power consumption,
- higher temperatures of system components,
- smell and smoke emissions.

The operator must ensure the following to avoid malfunctions that can indirectly or directly lead to injuries or material damage:

- the responsible maintenance personnel are present at any time and as fast as possible,
- the maintenance personnel are adequately qualified to react correctly to malfunctions of the measuring system and any resulting operational interruptions,
- the malfunctioning equipment is switched off immediately in case of danger so that switching off does not cause collateral malfunctions.

2 Respirometer overview

Basic system configuration described throughout the manual:

- control unit with 12 sample channels,
- PC unit,
- reactor vessels for solid samples, approx. 2,7 L,
- AP03 pump,
- multitube connection between control unit and thermostatic cabinet,
- thermostatic cabinet ST5.

This manual mainly focusses on control unit and software use.

Additional information about external units (pump, thermostatic cabinet, magnetic stirrer, some reactor models, …) and other possible configurations (over 12 sample channels, additional gas sensors, …) are attached in the appendix of User manual or come as separate instructions.

Sample flow path/line – expression used when referring to active channel flown through analyzer.

Bypass flow path/line – expression used when referring to flow path of active channels not analysed at the moment.

2.1 Control unit

Control unit is responsible for distribution of carrier gas to reactor vessels, sample analysis, reducing possible dry out of the samples, data collection and system control.

2.1.1 Front panel

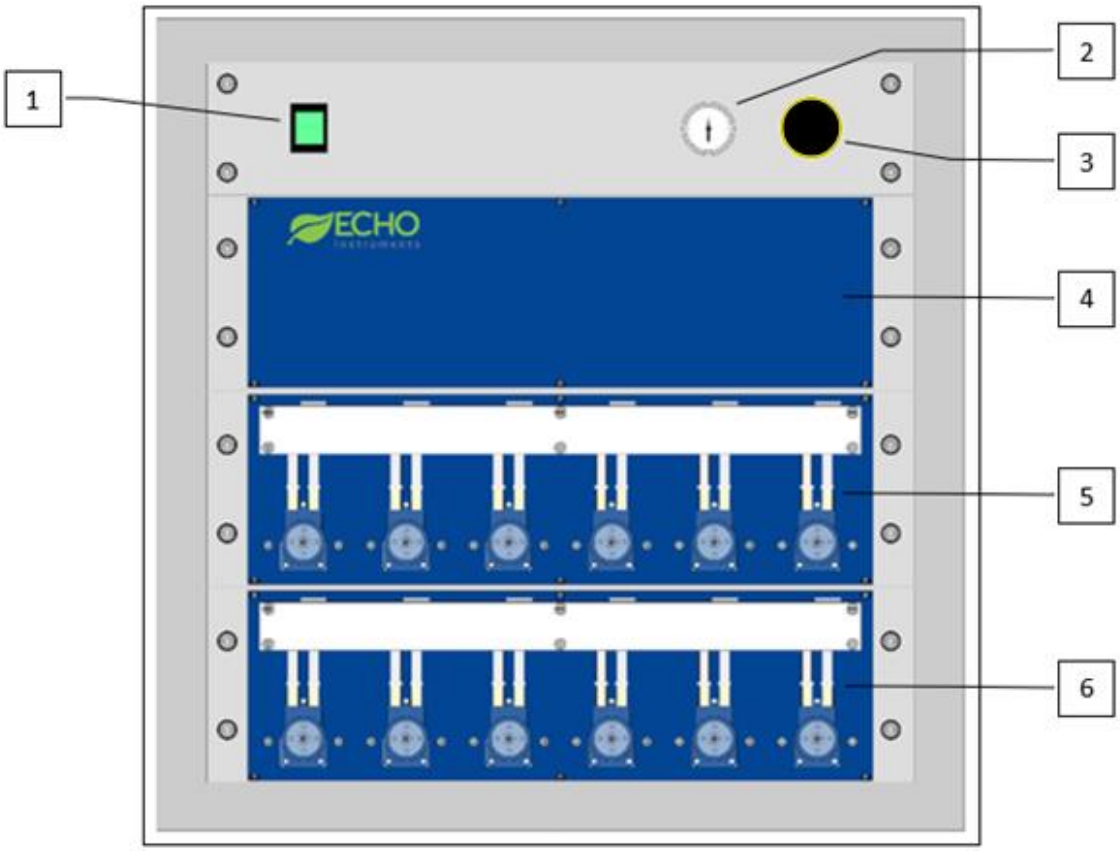


Figure 2-1: Front panel

1	Power switch	***2***	Manometer
3	Pressure regulator	***4***	Analyzer
5	Distributor 0 – 6	***6***	Distributor 7 – 12

2.1.2 Back panel

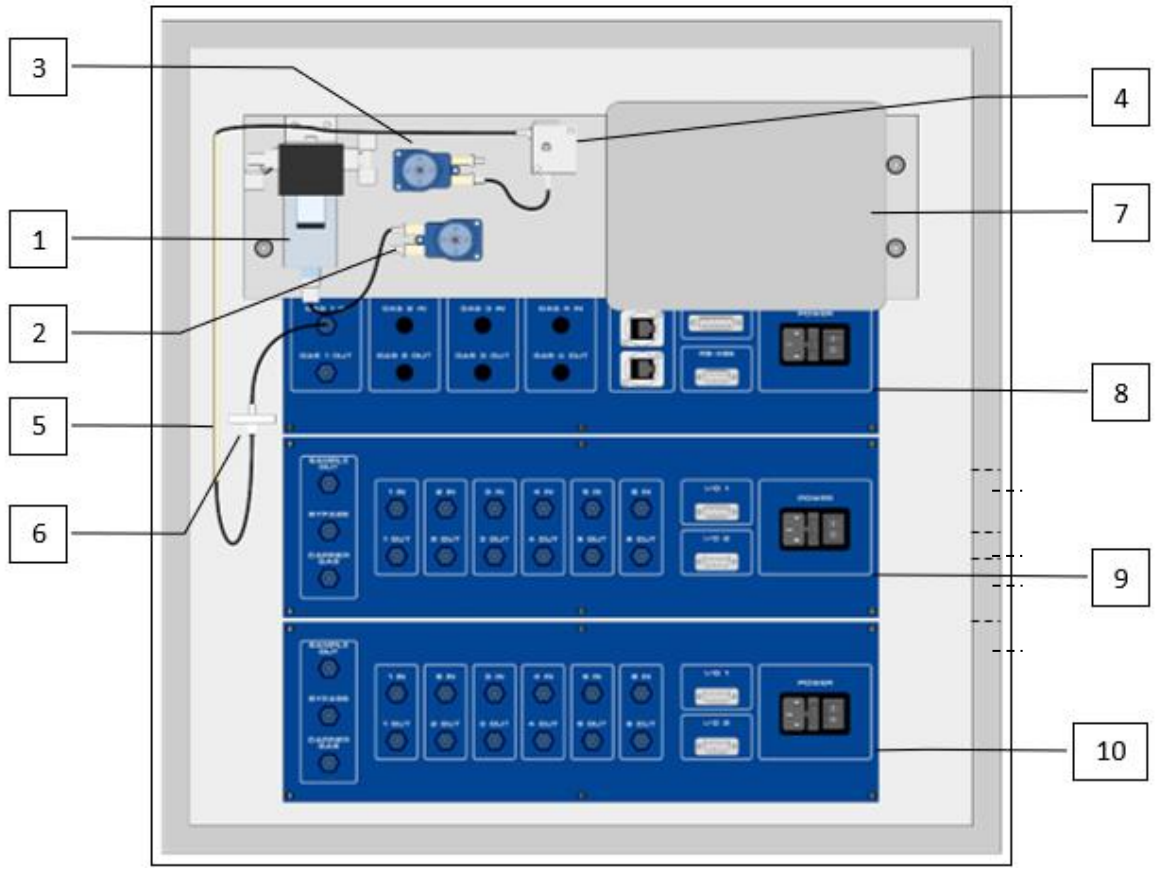


Figure 2-2: Back panel

1	Inlet filter	***2***	Carrier gas line peristaltic pump
3	Sample line peristaltic pump	***4***	Sample line condensate collector
5	Nafion tube	***6***	PTFE hydrophobic filter
7	Electrical box	***8***	Analyzer back
9	Distributor 0 – 6 back	***10***	Distributor 7 – 12 back

	Tubing at the back panel from **SAMPLE OUT** to **GAS 1 IN** must be regularly checked for liquid water content. If there is water present, see chapter **Maintenance**.

2.1.3 Side panels

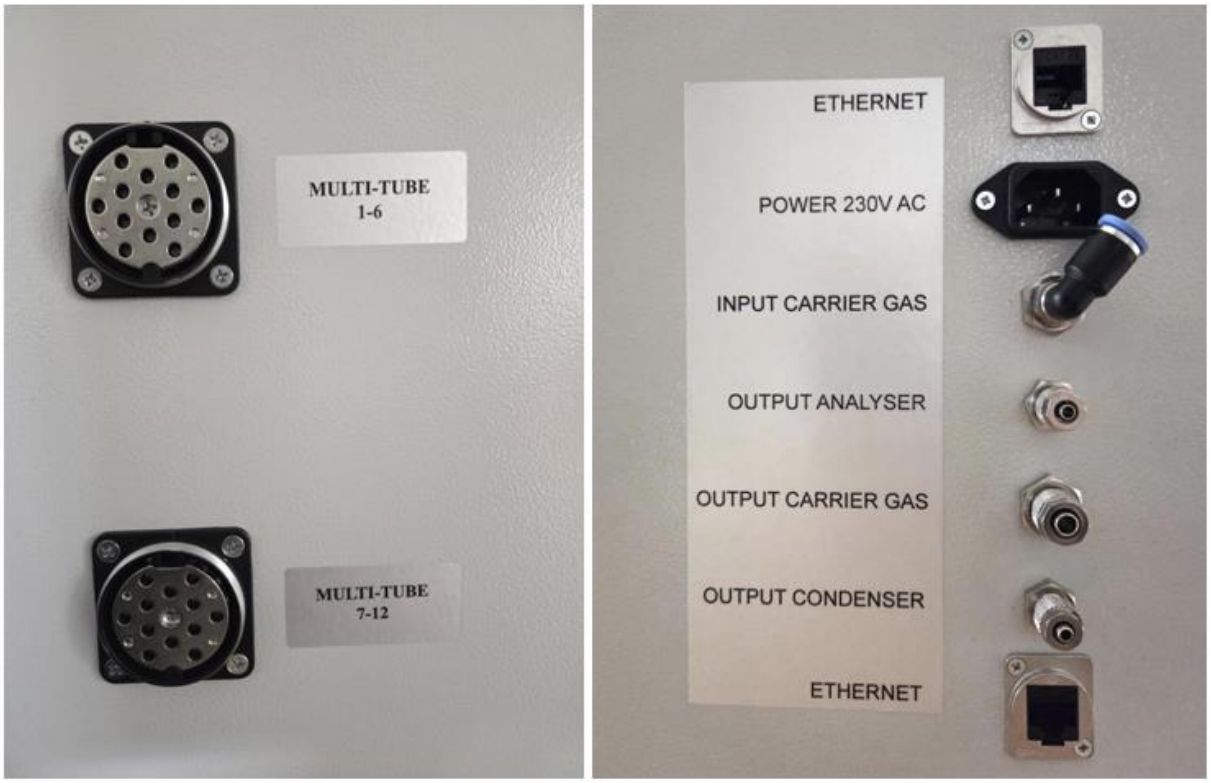


Figure 2-3: Side panels

Multitube 1 – multitube connector for channels 1 - 6	***Multitube 2*** - multitube connector for channels 7 - 12
Ethernet – communication port	***Power 230V AC*** – mains power supply (option 115 V, 60 Hz)
Input carrier gas[(1)] – air supply from AP03 pump	***Output analyzer***[(2)] – analysed sample outflow from control unit
Output carrier gas[(2)(3)] - outflow of carrier gas from bypass lines	***Output condenser***[(2)] – condensate outflow

(1) Other pressure sources are acceptable, such as compressed air, gas cylinder (synthetic air or nitrogen), or nitrogen generator. Contact local distributor or manufacturer for additional information.
(2) When working with samples that can produce unpleasant smell or toxic gases ensure all outputs are safely disposed according to safe practice and local legislation.
(3) Condensate possible in carrier gas outflow.

2.1.4 Pressure regulator/manometer

Respirometer operates under system pressure higher than ambient pressure. Therefore, it is important to prevent any undesired leakage, situation where pressure exceeds safety limits or running measurements with no pressure in the system.

Observe the current system pressure on the manometer. Turn regulator clockwise to increase system pressure. Turn regulator counterclockwise to decrease system pressure. Nominal system pressure is indicated with the label. ER model 1.6 operates on system pressure 0,25 bar.

	System pressure should never exceed 0,7 bar.

2.1.5 Filters

Filters prevent water, dust, and other contaminants from entering the system. Most sensors are sensitive to dust and liquids, therefore filters should be regularly checked and replaced if necessary. See chapter **Maintenance** for additional instruction.

	Operator must ensure that filters on control unit and pump are properly maintained at all times.

2.1.6 Peristaltic pumps

Distributor pumps remove condensed water from condensate collectors and return it to reactors. Peristaltic pumps are installed in different flow paths and run on different time intervals. All pumps should be checked regularly.

Peristaltic pump position	Time interval in seconds (ON/OFF)
Distributor (1)	60/120
Air supply	always ON
Sample	same as distributor

(1) Time interval for peristaltic pumps on distributor can be changed. Contact local distributor or manufacturer for additional information.

2.1.7 Analyzer

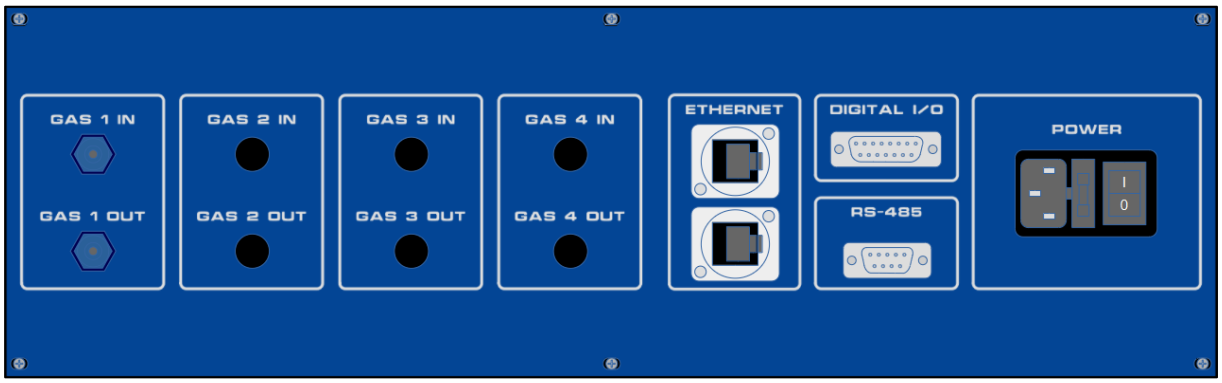


Figure 2-4: Analyzer back panel

Gas 1 in – sample inlet	***Gas 1 out*** – sample outlet
Ethernet – ethernet ports	***Digital I/O*** – digital port
RS 485 – RS485 port	***Power*** – power supply

Analyzer contains sensors used for gas sample analysis: there is one temperature sensor, one pressure sensor, one humidity sensor, one carbon dioxide sensor, one oxygen sensor and one flow sensor. Therefore, analysis from different reactors do not run simultaneously but consecutively. Sample from each reactor is run through analyzer at the specific time interval in measuring cycle. Only one sample is flown through the analyzer at a time, while others are flown through bypass line.

	All sensors used for sample gas analysis are sensitive to presence of water in liquid form.

2.1.8 Distributor

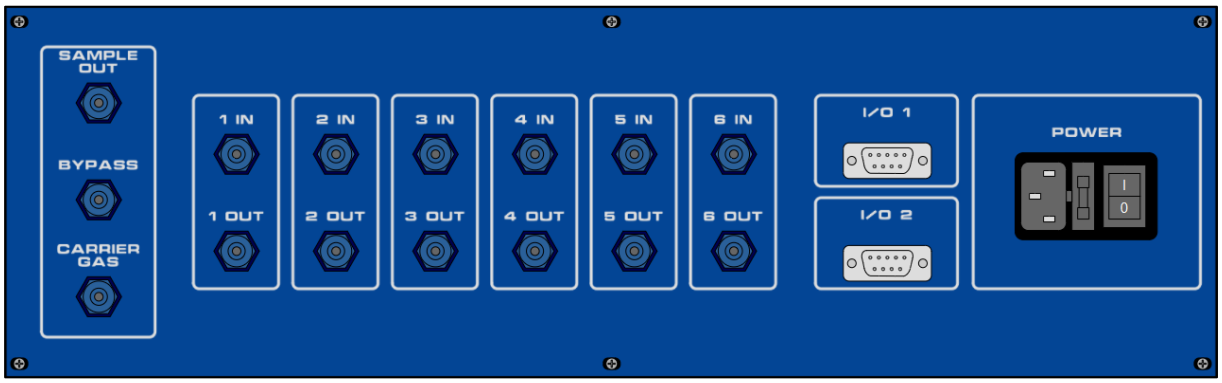


Figure 2-5: Distributor back panel

Sample out – sample outlet for analysed channel	***Bypass*** – gas outlet for active channels not being analysed at the moment
Carrier gas[(1)] – air supply	***1 (2, 3 …) In*** – inlet for individual channels
1 (2, 3, …) Out – outlet for individual channels	***I/O 1, I/O 2*** – RS-485 port
Power – power supply	

(1) Other pressure sources are acceptable, such as compressed air, gas cylinder (synthetic air or nitrogen), or nitrogen generator. Contact local distributor or manufacturer for additional information.

Distributor is a unit where carrier gas is regulated with mass flow controllers and supplied to individual reactors. Condensate collector is used for condensation of moisture, which is then returned to the reactors using peristaltic pumps. The condensate return system is not 100 % efficient, therefore reactors should be checked regularly for possible drying out of the sample.

2.1.9 Multitube

Multitube includes complete tubing from control unit to thermostatic cabinet for one distributor. It should be connected according to labels on side panels.

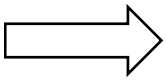
Presence of some water droplets in tubing connecting the distributor and reactors is normal.

2.2 External components

2.2.1 Air pump

Figure 2-6: AP03 pump

Pump outlet is connected to the input carrier gas at the side of the control unit. If using other sources for carrier gas, contact your local distributor or manufacturer. For additional information on pump, see chapter **Pump** in **Appendix**.

	Flow path is marked with arrows. **GAS INLET**  **GAS OUTLET**

2.2.2 Reactor vessel

Reactors are connected inside of the thermostatic cabinet. Carrier gas flows in along with return condensate through tubes labelled 'IN'. Gas then flows out of the reactor through tubes marked 'OUT' back to the distributor. For instructions on reactor assembly and other information, see chapter **Reactor vessels** in **Appendix**.

Reactors should be placed inside the thermostatic cabinet with enough space between them. This will allow free air circulation and enable even temperature distribution. For additional information, see chapter **Reactor vessels** in **Appendix.**

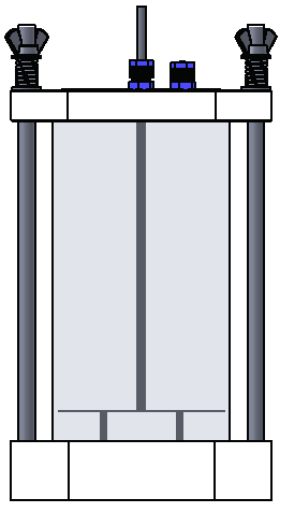


Figure 2-7: Reactor

2.2.3 Thermostatic cabinet

Thermostatic cabinet is used for temperature regulation of the reactors required by specific standard. Standard model operates in temperature range from 3 – 70 °C, while maximum temperature used for measurements is 58 °C. Thermostatic cabinet is connected to the control unit via multitube. For additional information, see chapter **Thermostatic cabinet** in **Appendix.**

2.2.4 Magnetic stirrer

Use the magnetic stirrer in accordance with the **Operation manual provided with the stirrer**.

3 Assembly and installation

3.1 Assembly

	Respirometer must be placed in the well-ventilated area.

Place control unit on a flat and stable surface so that its feet are all in contact with surface. Ensure there is enough room on each side of control unit for all necessary connection cables and tubing. Front door must have enough space to fully open to turn on the control unit and regulate pressure if needed.

Pump should be placed on flat stable surface near control unit. It can be placed in another room, but it should be taken in consideration that longer lengths of tubing between control unit and pump may result in insufficient pressure.

Thermostatic cabinet must be placed on flat stable surface. It should stand unplugged and in upward position for at least 1 day after transport. Do not place control unit on top of thermostatic cabinet without reinforced board. For additional information contact local distributor or manufacturer.

Reactors are fully assembled on arrival. For initial installation reactors can be placed inside thermostatic cabinet empty. For additional information on reactors, see **Appendix**.
Computer can be placed on top of control unit or nearby.

All components run on external power only. Connect PC, pump, control unit, thermostatic cabinet, and any other additional external units to required power supply.

	Samples might develop unpleasant smell or harmful gas compounds. Carrier gas output, analyzer output and condense output should be routed to well-ventilated area (outside, …)

Connect pump outlet with the input carrier gas on the control unit.

Connect control unit with thermostatic cabinet via multitube according to the markings.

Connect computer and control unit with ethernet cable.

Connect thermostatic cabinet and control unit with ethernet cable.

After all communication lines, power supplies and gas tubing are connected, turn on power switches.

When the pump is turned on and running, there should be noticeable increase in system pressure visible on manometer. If the pressure is unstable or insufficient, see chapter **Troubleshooting** or **Pump manual in Appendix**.

3.2 Software installation and set up

3.2.1 Set static IP address on your windows PC

Our PCs come pre-set with correct IP addresses, so configuration is not needed. If the Respirometer software is being run on a personal computer, the IP address must be configured to be in the same subnet as the respirometer's IP address.

Go to Settings on your Windows 10 PC and click ‘Network & Internet’. On the left column choose ‘Ethernet’ and ‘Change adapter options’ from the top-right side of the window.

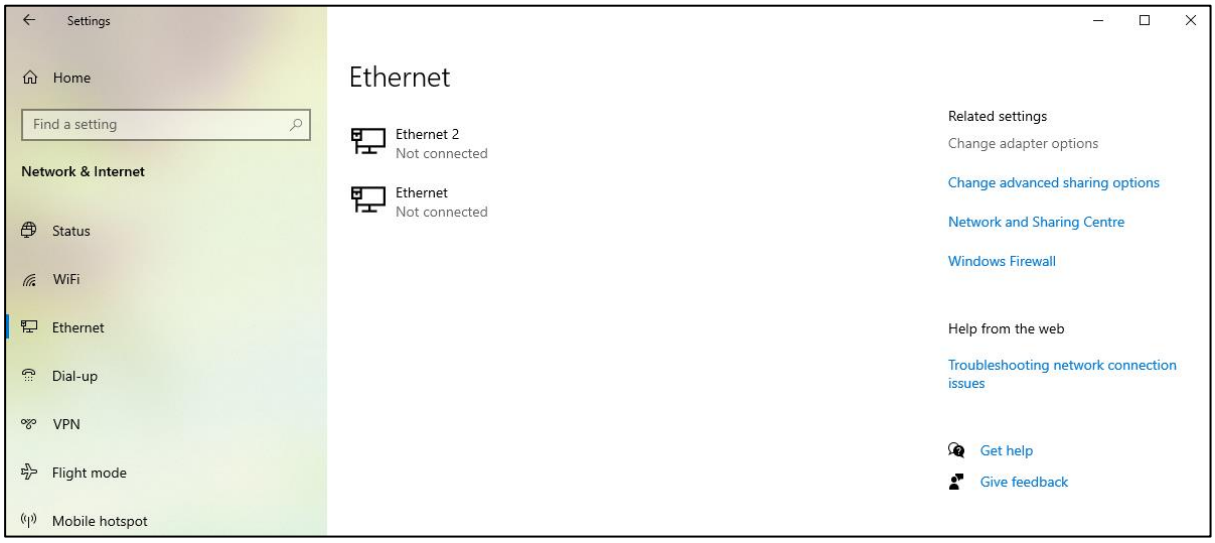


Figure 3-1: Ethernet main screen

Right-click the ‘Ethernet’ icon and click on ‘Properties’.

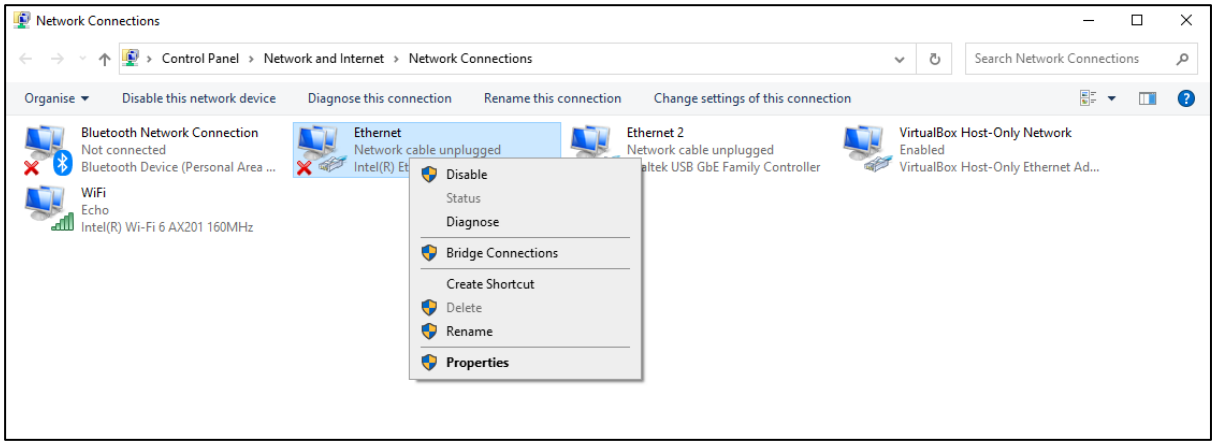


Figure 3-2: Ethernet settings

‘Ethernet Properties’ window pops up. Double-click ‘Internet Protocol Version 4 (TCP/IPv4)’ and insert the following IP address:

- IP address: 192.168.0.10
- Subnet mask: 255.255.255.0
- Default gateway: 192.168.0.1

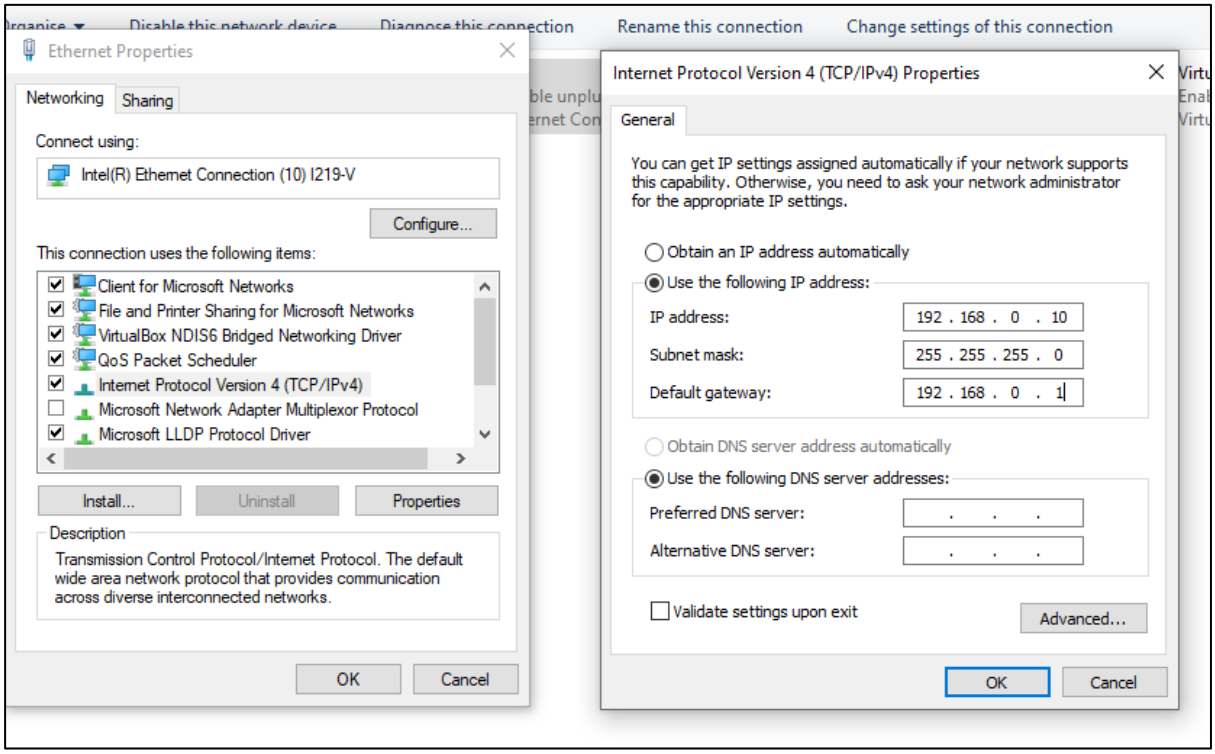


Figure 3-3: TCP/IP

When done, click ‘OK’ and start the Respirometer software.

3.2.2 Installing ECHO respirometer software

The system is made up of three connected applications. First, there's a **server application** that quietly runs in the background on a computer. Each server talks directly to the sensors and control device. Since there might be more than one set of devices, a computer can run multiple servers at the same time. To make it easy to manage these servers, there's a **tray app** that sits in the Windows taskbar, where you can start, stop, add or remove servers with just a few clicks. On Windows startup, the tray application is also responsible for auto-starting server applications. Finally, there's a **client application** with a user-friendly interface, where users can interact with the devices, view data, and control the system.

To install Respirometer software, double-click 'Setup Respirometer' installer file and follow the instructions.

Select all three components for installation: Respirometer Tray, Respirometer Client and Respirometer Server, and click 'Install'.

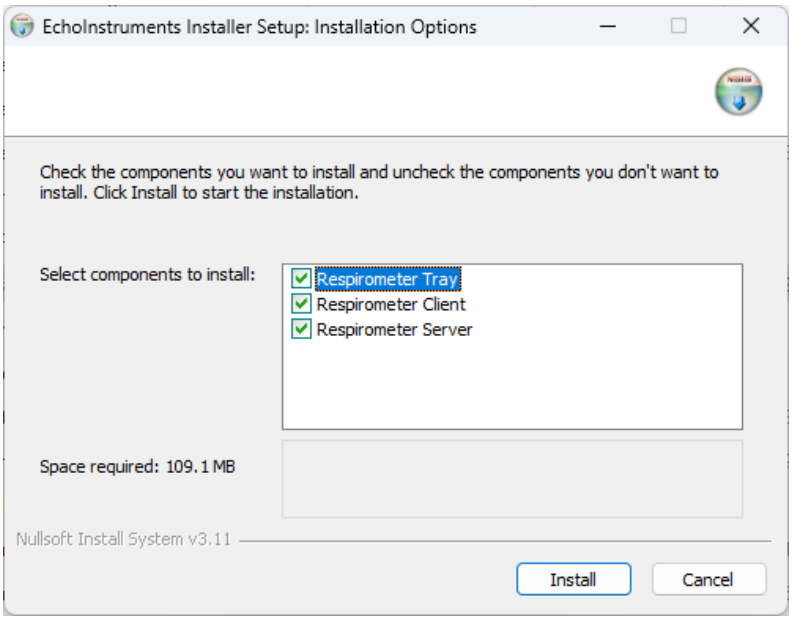


Figure 3-4: Select components for installation

Go to Windows taskbar in the lower right corner of computer's desktop and click on the 'Respirometer' icon. Click 'Add new service'.

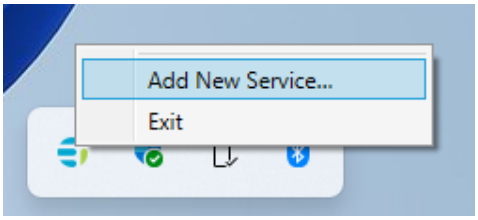


Figure 3-5: Add new service

Enter the communication port for new service and click ‘OK’. Factory recommended communication port setting is 5000 for first device. This communication port number is then used in combination with IP address for connection between this Server Service and Client software.

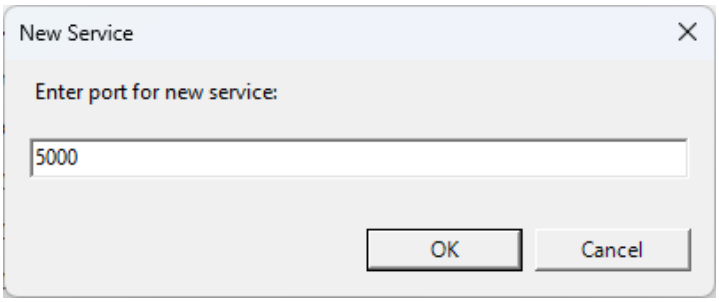


Figure 3-6: Enter port for new service

Click on the ‘Respirometer’ icon again and then on ‘Respirometer5000 [Stopped]’ icon. Click ‘Start’ to run the server. A red circle indicates the server is stopped.

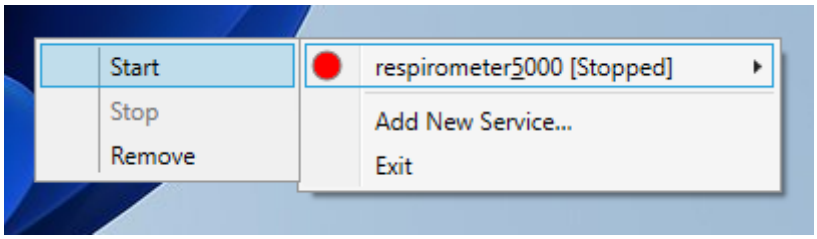


Figure 3-7: Click 'Start'

To start, stop or remove a server, click on appropriate action button. A green circle indicates the server is running.

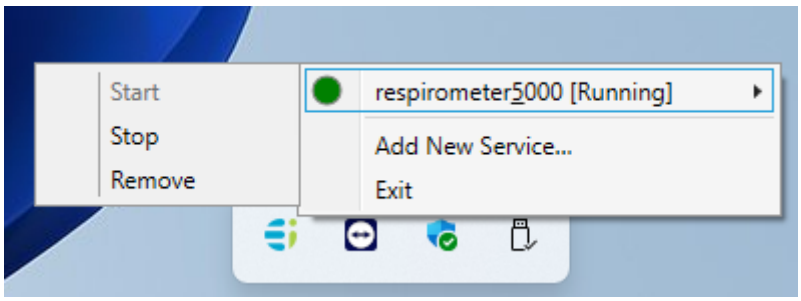


Figure 3-8: Running server

4 Running measurements

Before starting measurements, the following must be checked:

- electrical and signal cables are plugged in,
- power switches are turned on,
- pump is running, pressure reading on control unit is correct,
- reactors are properly assembled, gas tubing is connected.

Do not start measurements if there are any visible signs of damage on the equipment.

	Do not start measurements if there are any visible signs of damage on the equipment.
	Make sure gas tubing is always connected in a proper way (IN and OUT connections).

4.1 Taskbar

The icons positioned in the upper-right corner of the window are utilized for program navigation, user administration, and for providing information on connected devices and ongoing analysis. These function icons are described in the table below.

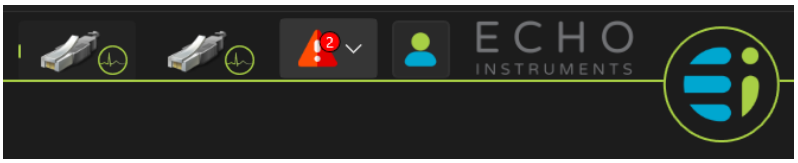


Figure 4-1: Taskbar

Table 4-1: Taskbar

	Main navigation menu.
	User administration.
	Warning notifications.
	Connected devices.

4.2 Main navigation menu

The main navigation menu serves as the central hub for navigating through various features of the Respirometer software.

Table 4-2: Main navigation menu structure

	***Options***	Includes: connections, settings, service menu.
	Info	Includes: company info, device info, support.
	Purging	Purging of channels and analyzer sensor set.
	Measurements	Setting up, reconfiguring, starting measurements and .
	Charts	Displaying selected values in charts.

4.3 General instructions

Two additional functions are embedded into the software, enabling the scope of operation to be expanded across various fields:

- **right-click function:** to expand options in a specific field, use the right mouse button. The right button click opens a drop-down menu of possible options,
- **function description:** for a description of specific functions, place the cursor on the desired function's icon, wait a second and a text description of the selected function will appear.

Throughout the manual, these two functions will be referenced in bold in all the fields where they can be used.

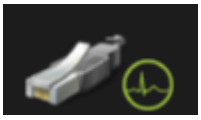
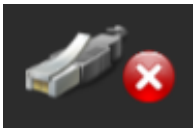
4.4 Connected devices

One or more devices can be connected to the software. In case more than one device are connected, multiple 'connection' icons appear, each representing one device. Place the cursor over an individual icon (**function description**) to reveal information about connection statuses between the respective device and its sensors.

4.4.1 Connection check

The connection status can be checked in the top right corner.

Table 4-3: Connection statuses

	An animated green line flashing in the circle below ethernet icon indicates a successful connection.
	The connection is being established if a circling green animation appears besides the ethernet icon.
	The connection is not established, if a red circle with a white cross appears below the ethernet icon.

4.5 Notifications

To indicate any error or malfunction, a red triangle with an exclamation mark will appear in the top right corner, next to the 'connection' icon. Click on it. A message will appear informing you of an error or malfunction, along with possible solutions to the problem.
Different types of notifications are explained in the table below. For more detailed information on notifications, see chapter **Warning and error dictionary**.

Table 4-4: Error notifications

Info notification	A message indicating an action has been completed.
Warning notification	A message indicating a non-critical error affecting device operation has been detected.
Error notification	A message indicating a critical error affecting data integrity has been detected.
Fatal notification	A message indicating a critical error affecting device operation has been detected.

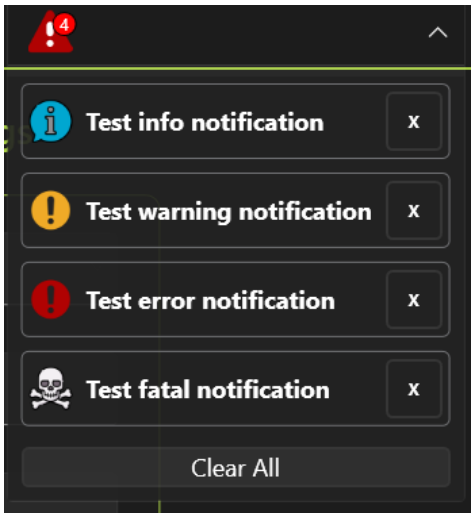


Figure 4-2: Error notifications

4.6 Measurements

4.6.1 Adding analysis

To start the measurements, double click on the 'Respirometer' icon on the desktop and open the software. A message appears, asking you to add a new analysis.

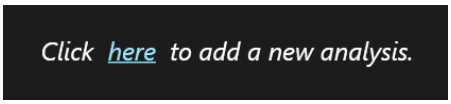


Figure 4-3: Add new analysis

Click on the 'here' hyperlink. Insert an 'Analysis name' into the input field that opens and click confirm.

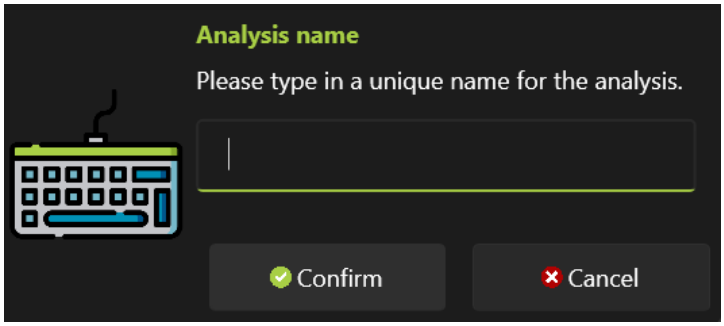


Figure 4-4: Adding an analysis

Another way to add analysis is to use the **right-click function** on the field 'Analysis'. Next, click the 'Add' icon and analysis will be added.

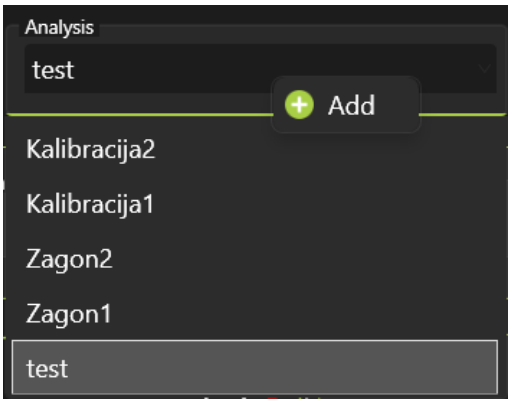
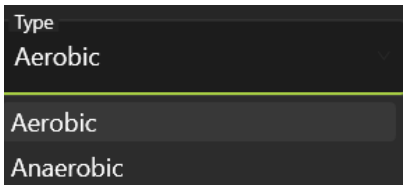
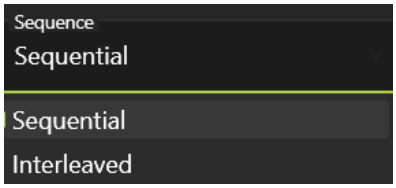


Figure 4-5: Adding an analysis

After an analysis is created, various settings can be configured. These settings are explained in the table below.

Table 4-5: Analysis settings

Analysis name	Name of the analysis.
Type	Aerobic/Anaerobic type of analysis. 
Sequence	*Sequential*: the carrier gas is measured first, then the rest of the reactors follow in sequence (e.g., carrier gas – reactor 1, reactor 2, reactor 3, etc.), *Interleaved*: the carrier gas is measured before measuring each reactor (e.g., carrier gas – reactor 1 – carrier gas – reactor 2 – carrier gas – reactor 3, etc.). 
Description	Description of the analysis.
Notes	Notes on the analysis/changes.

4.6.2 Adding reactors

After setting analysis parameters, a message appears, asking you to add a new reactor. Click on the 'here' hyperlink and add a new reactor.

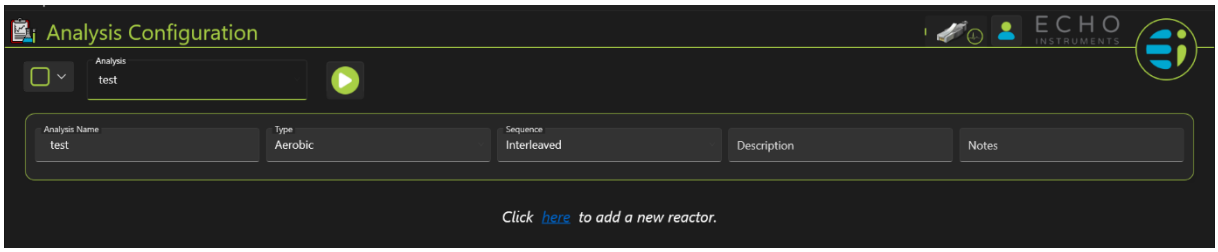


Figure 4-6: Adding reactors

A reactor's graphic appears along with required reactor parameters. Parameters are explained in the table below.

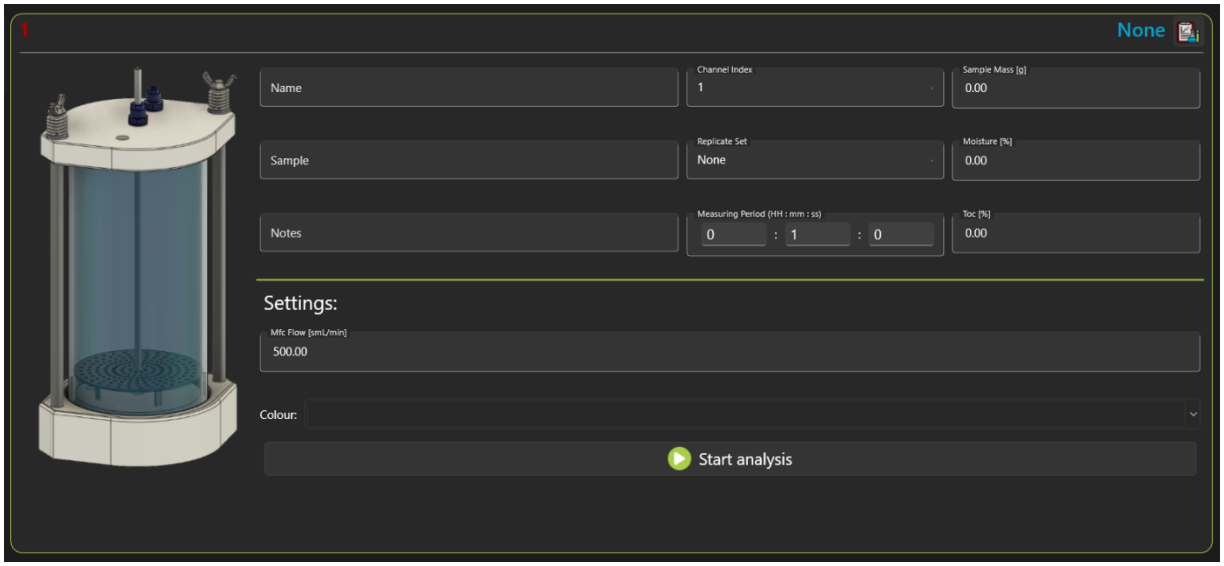
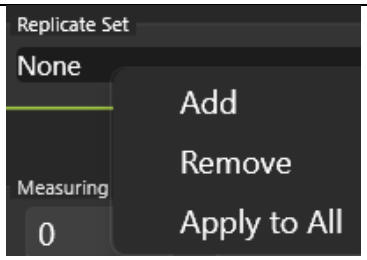


Figure 4-7: Reactor parameters

Table 4-6: Reactor parameters

Name	Name of the reactor.
Channel index	Index of the reactor.
Sample	Type/description of the sample.
Notes	Notes about the reactor/changes.
Replicate set	Choose a replicate set for the reactor. Reactors with the same replicate set will then be grouped together (e. g., blank, sample 1, sample 2 …). Use the **right-click function** to add or remove a replicate set or apply it to all.

	
Measuring period	Set measuring period, in hours/minutes/seconds (the **right-click function** – 'Apply to all'). Measuring period is automatically changed when changing MFC flow setting as the measurements require a certain minimum volume of gas to pass through.
Sample mass	Mass of the sample, in grams (the **right-click function** – 'Apply to all'). Required for biodegradation calculation.
Moisture	Moisture of sample, in percent (the **right-click function** – 'Apply to all'). Required for biodegradation calculation.
TOC	Total organic carbon, in percent (the **right-click function** – 'Apply to all'). Required for biodegradation calculation.
Settings	Flow on mass flow controllers, in mL/min (the **right-click function** – 'Apply to all'). Optional settings for additional periphery.
Colour	Colour for individual channel. 
Start analysis icon	Start the analysis on single channel.

To access additional functions for reactor management, use the **right-click function** on the reactor's graphic. A drop-down menu of different possibilities appears. These possibilities are described in the table below.

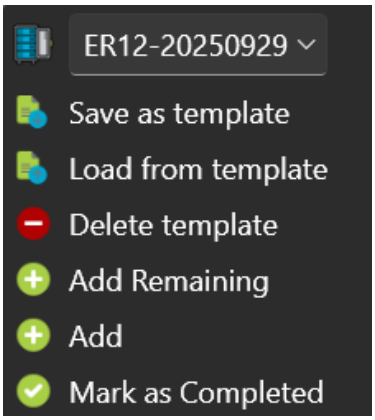
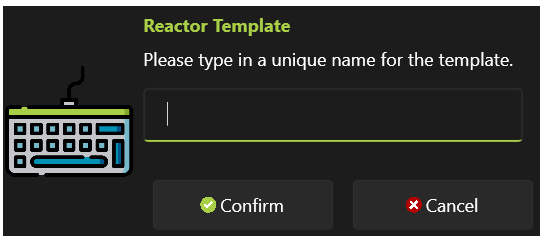
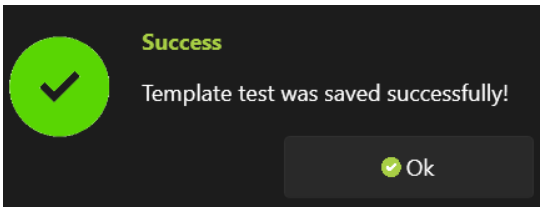
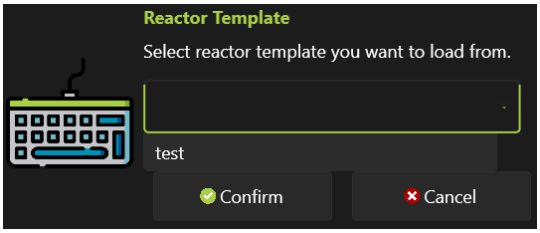
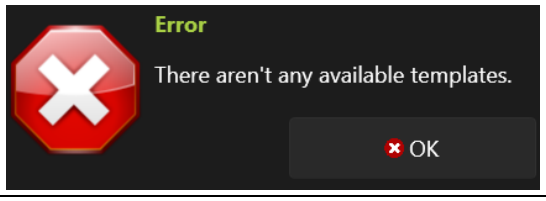
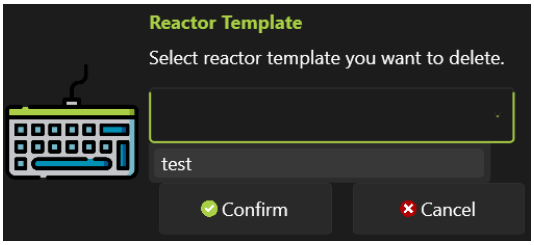
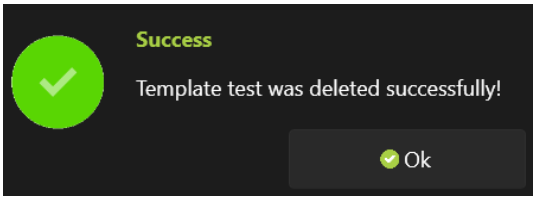
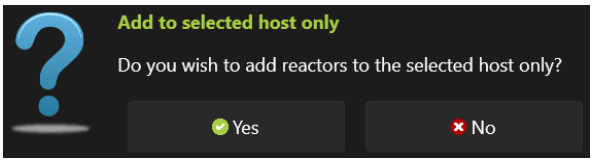


Figure 4-8: Additional functions for reactor management

Table 4-7: Additional functions for reactor management

ER12	ER respirometer. In case of multiple control units (e. g., 2 or 3 12-channel sets), this drop-down menu allows choosing the specific control unit.
Save as template	Save the set parameters of a reactor as a template for other reactors. A message box appears asking you to choose a unique name for the template.  
Load from template	Load a template for the added reactor. A drop-down menu to choose from appears.  If there aren't any available templates, a message box appears informing you of an error. 

Delete template	Delete the saved template. A drop-down menu appears to choose a template from.  
Add remaining	Add all remaining reactors – by using this function, the selected reactor's settings are automatically copied to all added reactors. A message box appears asking if you wish to add reactors to the selected host only. 
Add	Add a new reactor.
Mark as completed	Remove a reactor from the analysis overview. This will remove it from the analysis menu, but it will not remove it from the database. Used to reduce clutter. If the reactor has already been marked as completed and measurements need to be continued, the 'Show Completed Reactors and Analyses' option must be enabled in the view menu section.

If a reactor index which is already in use by another reactor is inserted, a message box appears informing you of an unsuccessful reactor addition.

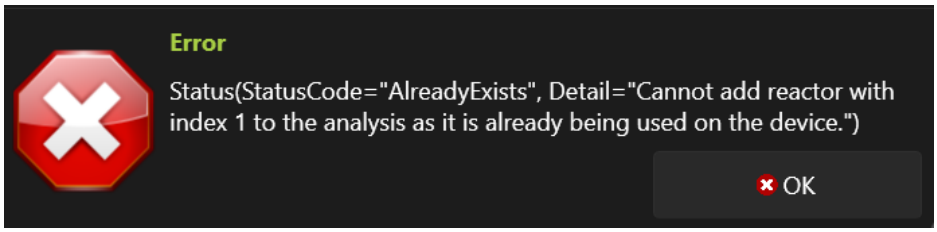


Figure 4-9: Message box

After adding multiple reactors, a list of all reactors appears on the left side of the reactor's graphic.

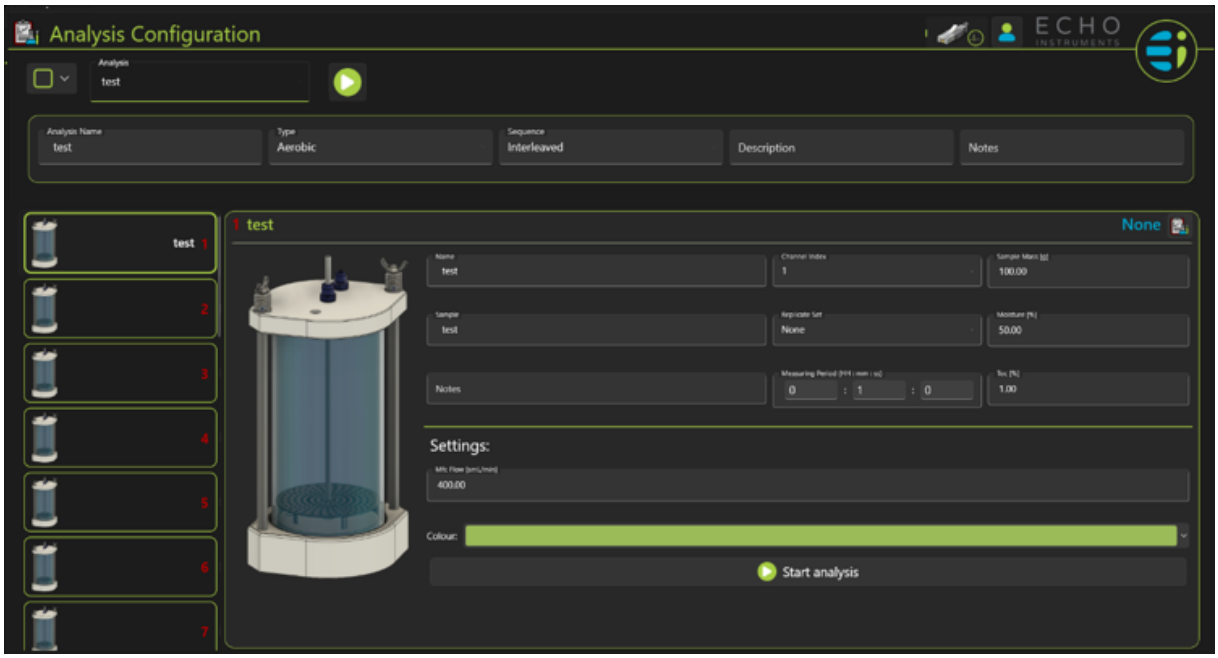


Figure 4-10: List of added reactors

If there are no available channels on any device, a message box appears informing you there are no free measurement channels when trying to add a reactor.

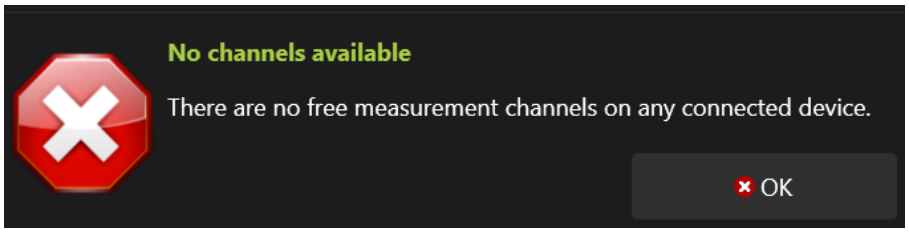


Figure 4-11: Message box

4.6.3 Experiment settings

Measurement interval

Measurement interval is a time interval for sampling for a single channel. The minimum measurement interval depends on the flow rate. To flush the internal volume of the system (tubing, sensors) with sample, minimum 500 mL of sample is needed. At flow rate of 500 mL/min, minimum measurement time is 1 minute. At flow rate of 100 mL/min, minimum measurement time is 5 minutes, etc. Maximum measurement time is not limited, but it must be short enough to capture dynamics in gas production.

Pause interval

Pause interval is the time after completion of each measurement cycle. It is set in menu Application settings (see chapter **Server – settings**). The pause is used to reduce the number of measurement points in long-term tests.

Leakage flow alarm

Determine the tolerance between the set and measured flow and the tolerance between the inlet and outlet flow from the reactor to indicate any leakage. Leakage flow alarm is set in Application settings (see chapter **Server – settings**).

The flow alarm should be set to 20 %. Difference higher than 20 % will trigger a warning notification a possible leak was detected. Place the cursor over the test warning notification and a more detailed message will display (**function description**). In addition, the measuring channel with detected leak will highlight the analyzer flow value in orange.

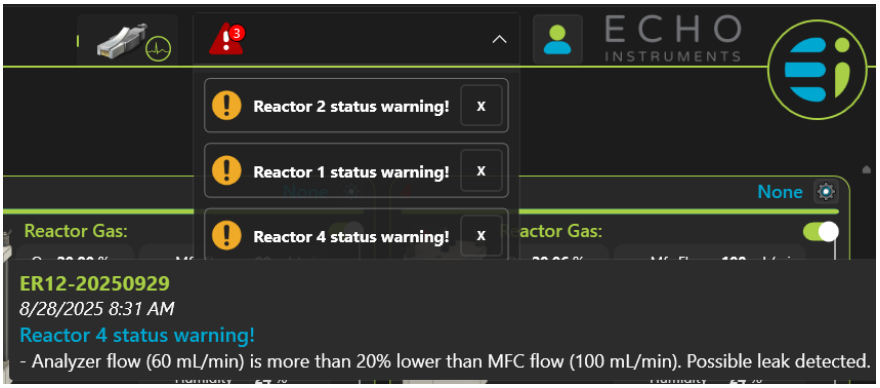


Figure 4-12: An example of a warning notification

If there is no flow on the MFC, an error notification will be triggered, indicating invalid measurements. Place the cursor over the test warning notification and a more detailed message will display (**function description**). In addition, the measurement channel where the lack of flow is detected will highlight the measurement results in red.

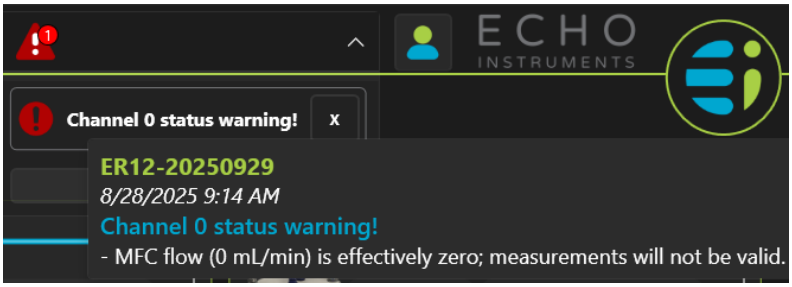


Figure 4-13: An example of an error notification – no flow on MFC

Flow

Carbon dioxide (CO_2) sensors have a limited measuring range. If the nominal range is exceeded, measurement accuracy gradually decreases until the sensor reaches saturation. At the lower end of the range, accuracy is also reduced as the signal approaches the sensor's noise level. For optimal accuracy, carbon dioxide concentration should be maintained between 10 % and 100 % of the sensor's measuring range. Due to the dynamic nature of

carbon dioxide production, it is practical to keep the concentration within 40 % to 80 % of the range during the measurement.

In an open-type respirometer, carbon dioxide concentration depends on the following factors:

- sample activity,
- sample quantity,
- flow rate.

An example of flow settings during an experiment is presented in the figure below to better illustrate the correlation between flow and carbon dioxide.

Normally, the measurement begins at the maximum flow rate of 500 mL/min. Over time, the carbon dioxide concentration decreases and stabilizes, allowing for a reduction in flow rate. Typical flow rates used are: 500, 200 (or 250), 100, 50, and 20 mL/min. To determine the appropriate flow rate:

- identify the highest current carbon dioxide concentration,
- compare it with the input carbon dioxide concentration,
- select a flow rate that keeps the measured carbon dioxide concentration within the optimal range (40–80 %).

$$C_{CO2\ difference} = C_{CO2\ highest} - C_{CO2\ input}$$

Two days after the start of the experiment, the highest carbon dioxide concentration was 1500 ppm on channel 12 (shown in the figure below). The input carbon dioxide concentration was 450 ppm, resulting in a concentration difference of 1050 ppm.

Carbon dioxide concentration at a different flow rate can be calculated using the following equation:

$$C_{CO2\ new} = \left(\frac{Flow\ old}{Flow\ new} * C_{CO2\ difference}\right) + C_{CO2\ input}$$

Put values from the graph to the equation:

$$C_{CO2\ new} = \left(\frac{500}{250} * 1050\right) + 450 = 2550$$

The calculated carbon dioxide concentration at 250 mL/min is 2550 ppm, which lies between 40 and 80 % of the sensor's range (5000 ppm). Therefore, it is acceptable to reduce the flow to 250 mL/min for optimal measurement accuracy.

The same procedure is applied later to set flow to 100, 50 and 20 mL/min.

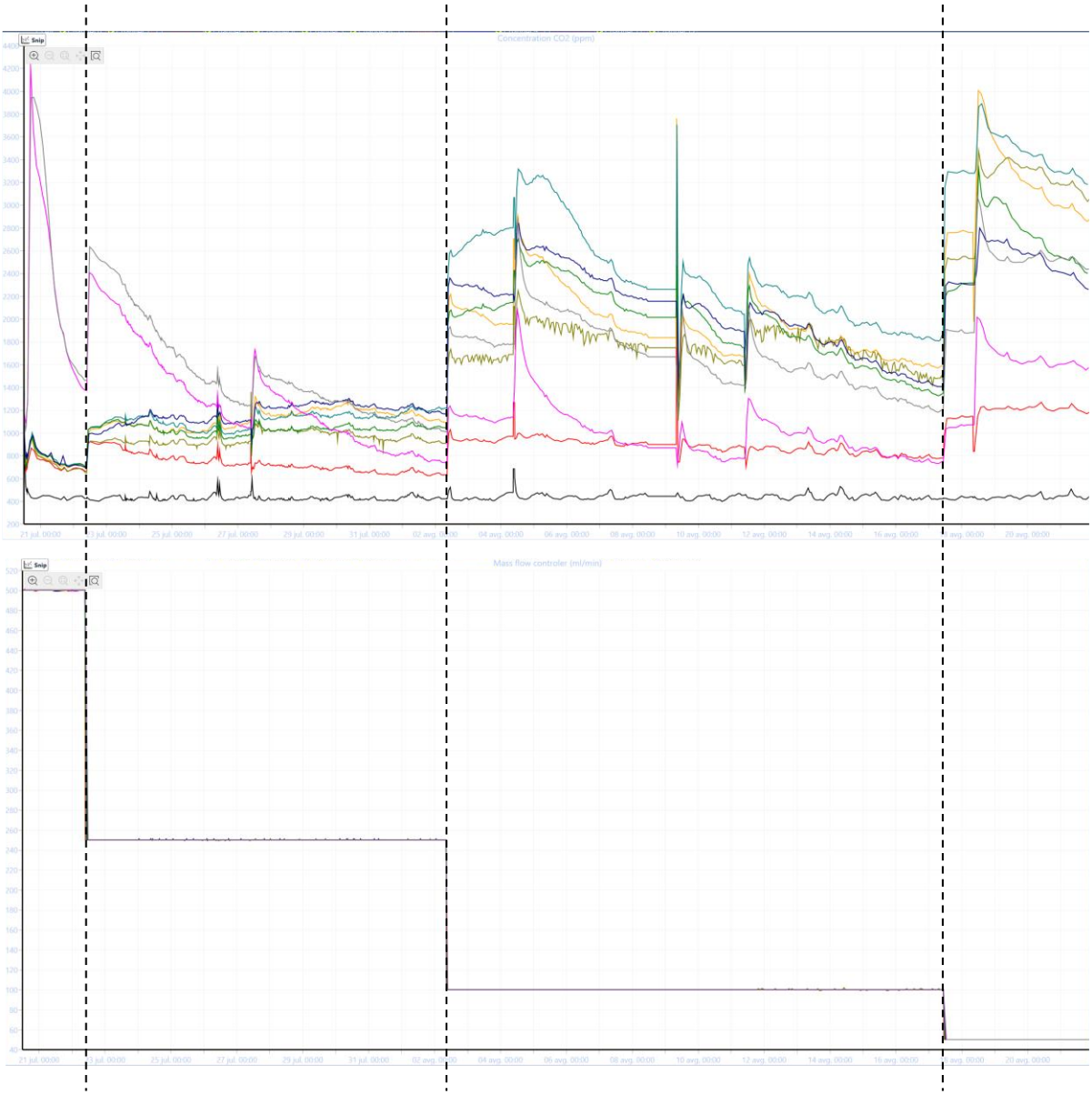


Figure 4-14: Graph no. 1: Carbon dioxide concentration
Graph no. 2: Set flow

Measurements can be stopped and started to change settings during experiment and still use the same database.

4.6.4 Starting analysis

After adding reactors and setting the required parameters, click on the 'Start idle reactor measurements' icon next to 'Analysis' field and start analysis on all channels simultaneously. To start analysis only on a specific channel, click on the 'Start analysis' icon of the specific channel. The icon is located at the bottom of the reactor's settings. To view the current analysis results, click on the 'measurements' icon in the top right corner of reactor's settings and current measuring results will appear.

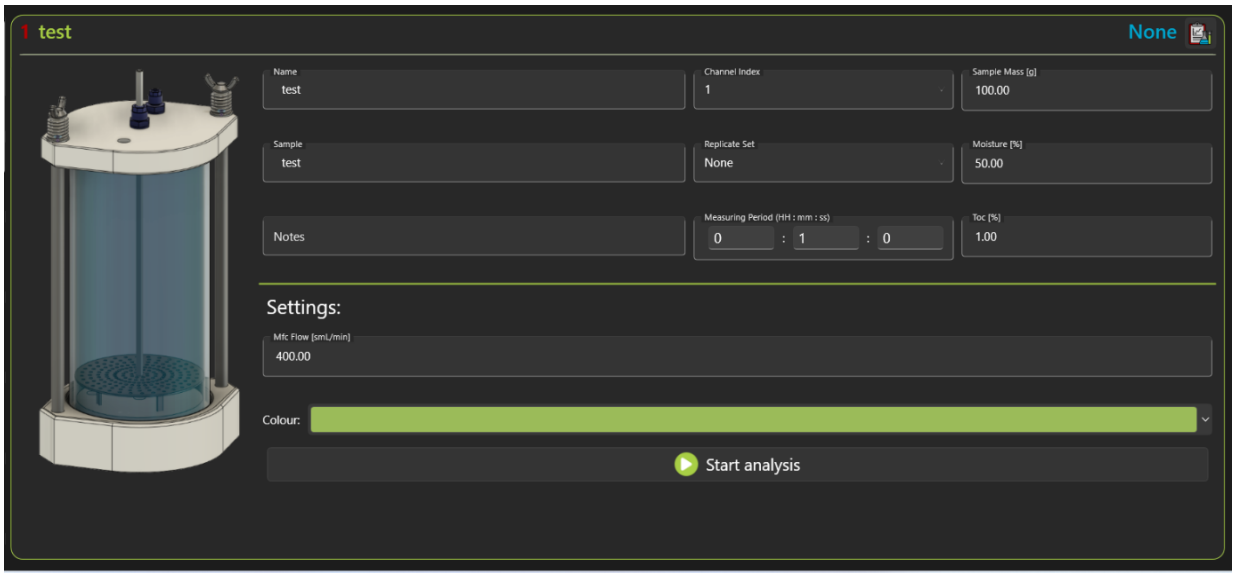


Figure 4-15: Start analysis

Figure 4-16: Analysis overview

View of the reactors can be changed in the upper left corner of the screen.

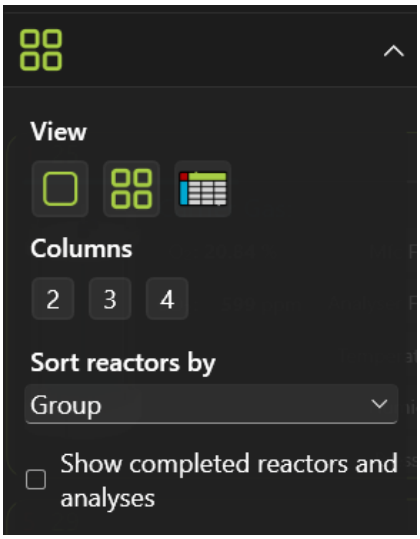


Figure 4-17: Options for different types of analysis overview

Table 4-8: Settings for different types of analysis overview

View	Individual view of reactors or analysis overview.
Columns	Group reactors into two, three or four columns in the analysis overview.
Sort reactors by	Sort reactors by different parameters.
Show completed reactors and analyses	Tick the checkbox for showing reactors and analyses previously marked as completed. Useful to reduce clutter.

To toggle between measuring results of the carrier gas and the reactor, use the blue and green 'toggle' buttons in the top right corner.

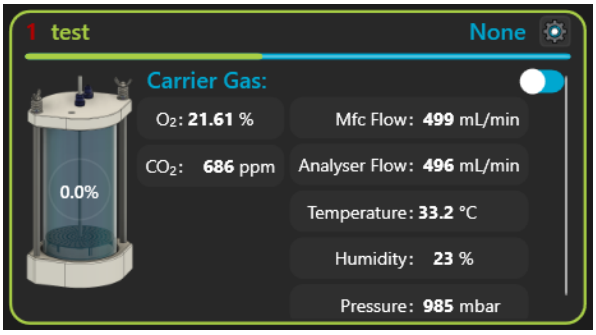


Figure 4-18: Current analysis results of the reference channel (carrier gas)

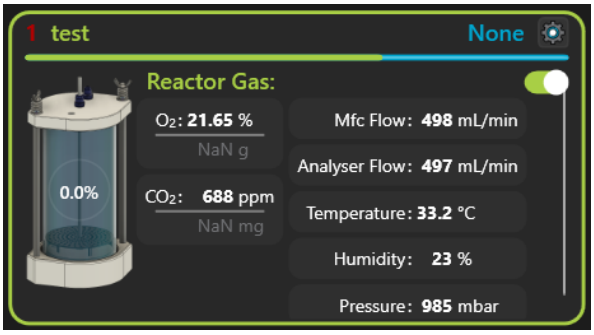


Figure 4-19: Current analysis results of the reactor

An icon of a blue or green circle is indicating the status of the analysis. A blue circle indicates measurements are being carried out on the reference channel (carrier gas) and the green circle indicates measurements are being carried out on the reactor. In the middle of the circle is a number of the currently measuring channel.

Figure 4-20: Measurement status indicating circles with a measuring channel number

Status of peristaltic pumps and remaining measuring time are displayed when the cursor is placed on the number in the blue and green circle (**function description**).

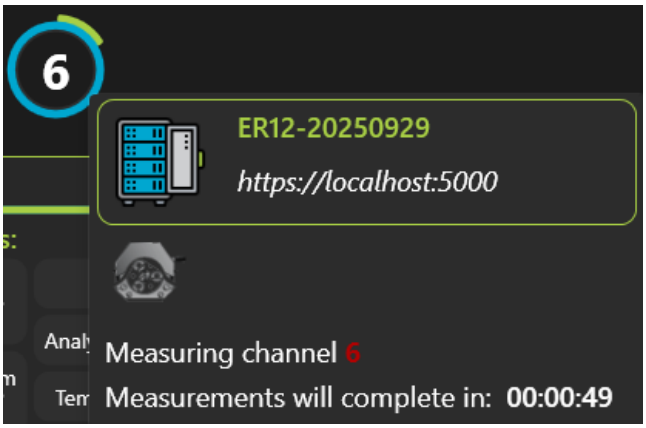


Figure 4-21: Status of peristaltic pumps and remaining measuring time

4.6.5 Cancelling analysis

To cancel an analysis on all channels simultaneously, click on the 'Stop active reactor measurements' icon. To cancel analysis only on a specific channel, go to the specific channel and click on the 'settings' icon in the top right corner. Scroll down to a 'Cancel analysis' icon at the bottom of the reactor's settings, click on it and the analysis will stop.

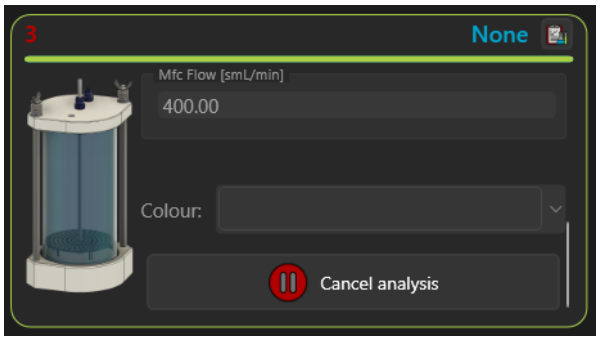


Figure 4-22: Cancel analysis

If analysis is cancelled in the middle of measurements in the reactor, a message box appears asking you to confirm the measurement cancellation.

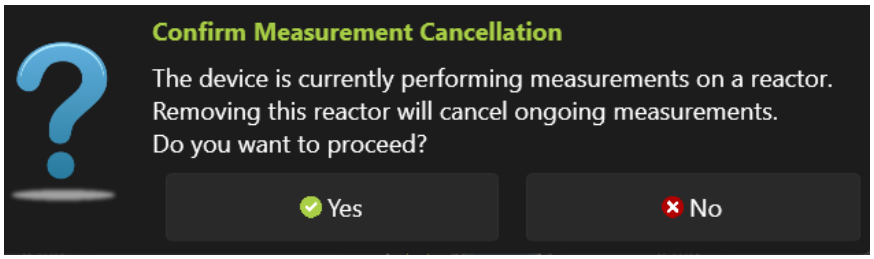


Figure 4-23: Message box

4.6.6 Completed analysis

After an analysis is finished, go to field 'Analysis' and use the **right-click function** on the desired analysis to mark it as completed. This will remove it from the drop-down menu of created analyses, but it will not remove it from the database.

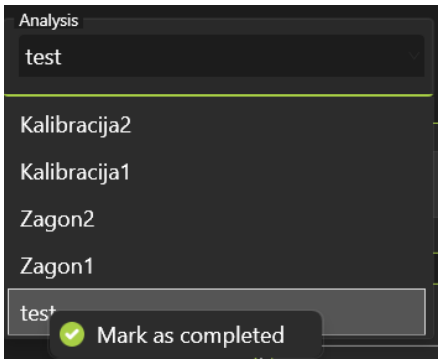


Figure 4-24: Mark an analysis as complete

4.6.7 Biodegradation value and carbon dioxide production

Biodegradation value is displayed on the reactor's graphic (in percent) when the following criteria are met:

- sample mass is greater than 0 g,
- moisture is less than 100 %,
- TOC is greater than 0 %,
- carbon dioxide production calculation is enabled (see chapter **Settings**). The carbon dioxide, temperature, humidity, and pressure sensor must be active in addition to the MFC flow for CO_2 production to be calculated.

Measurement values are accompanied by an icon that graphically indicates the status of the parameter trend. An 'upward arrow' icon indicates an increase of the measured value over time, a 'horizontal arrow' icon indicates stable measurements, and a 'downward arrow' icon indicates a decrease in the parameter measured value.

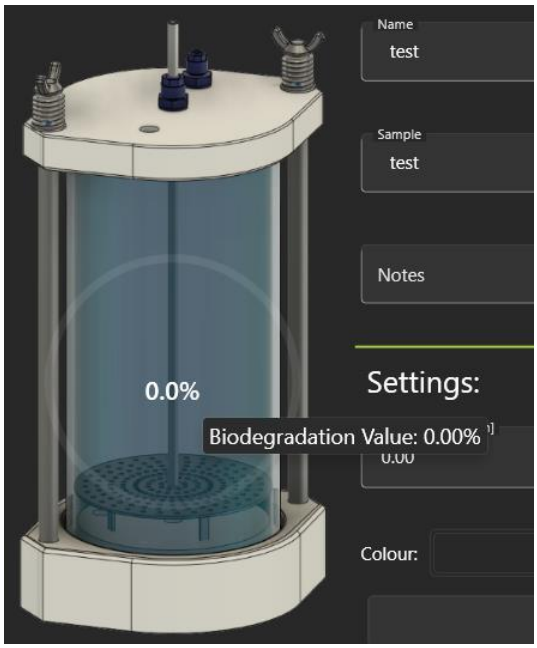


Figure 4-25: Biodegradation value displayed on the reactor

4.6.8 Reference channel

Carrier gas is measured with a reference channel. The reference channel measures background gas composition which is later subtracted from sample results when calculating production for each channel from 1 - 12. That ensures that regardless of the conditions and carbon dioxide concentration flown in the reactors (during the day the carbon dioxide values can vary even up to 2000 ppm in a closed room occupied by people) only the carbon dioxide produced in individual reactor is used for the production calculation.

Measurements on reference channel are indicated by the blue circle icon.

Figure 4-26: Measurements on the reference channel in progress

4.7 Charts

Go to main navigation menu and open Charts. Select an analysis from a drop-down menu in the upper left corner.

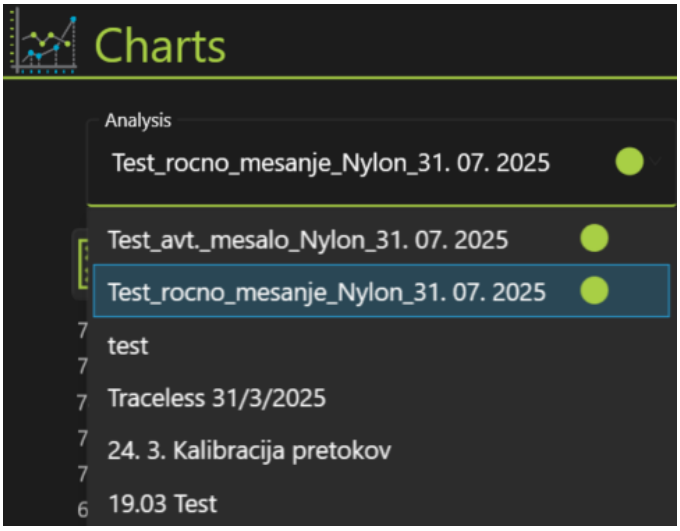


Figure 4-27: Drop-down menu

If all analyses are not available in the drop-down menu or if the chart needs to be refreshed with new data, click on the 'refresh' ↻ icon next to 'Analysis' field, and the missing analyses will appear.

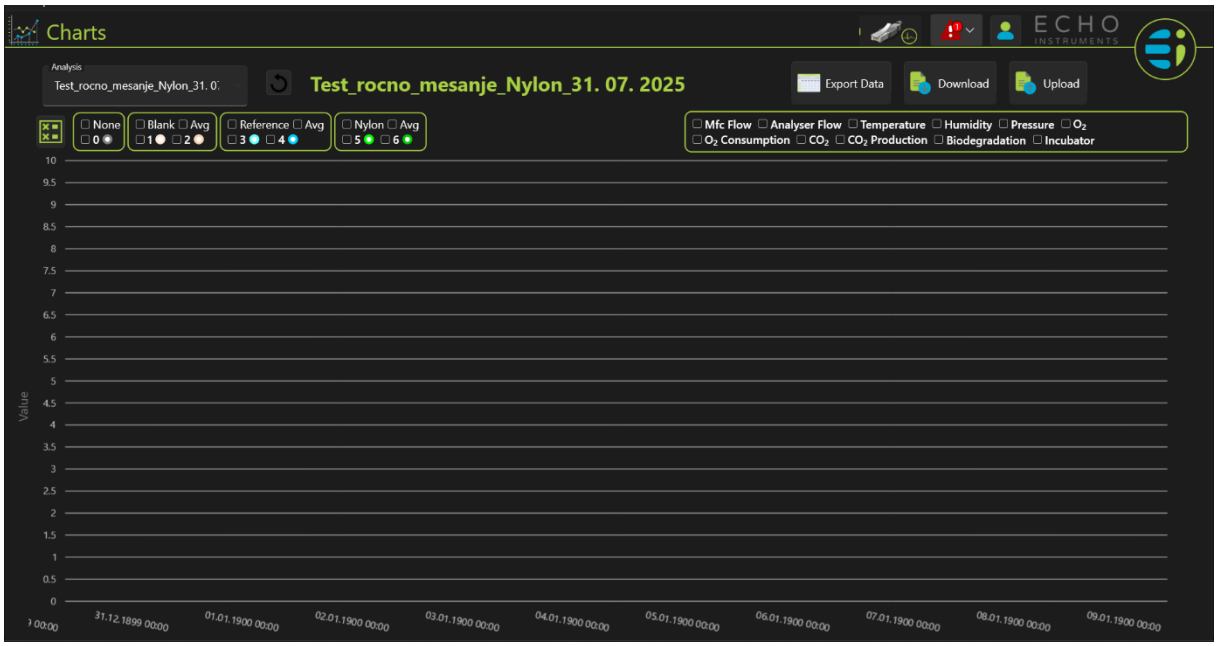


Figure 4-28: Selected analysis for chart viewing

Details about the selected analysis are displayed when the cursor is placed on the analysis name (**function description**).

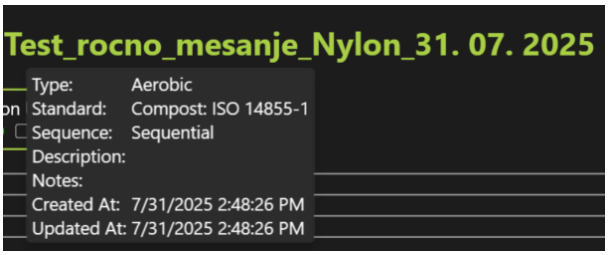


Figure 4-29: Details about the selected analysis

Select the reactors and parameters to be viewed in the graph. By clicking on the 'Un/Select All' icon, all reactors can be simultaneously selected or unselected from the selected analysis.

Figure 4-30: An example of a graph – multiple reactors and one parameter

Reactors are grouped together based on their 'Replicate Set' parameter. To display the average of reactors within a single group graphically, the 'Avg' checkbox of the selected group should be enabled. Tick the 'Avg' checkbox on a group to switch modes:

- **unchecked**: normal (all selected channels show at full opacity, no average line),
- **checked**: average mode (average is shown and the member channels stay visible but are dimmed).

The opacity setting (**right-click function** described in the text below) controls how transparent those dimmed member lines appear, e.g., 0.3 means 30 % opacity of their original opacity value, so you can keep context without the members shouting over the average.

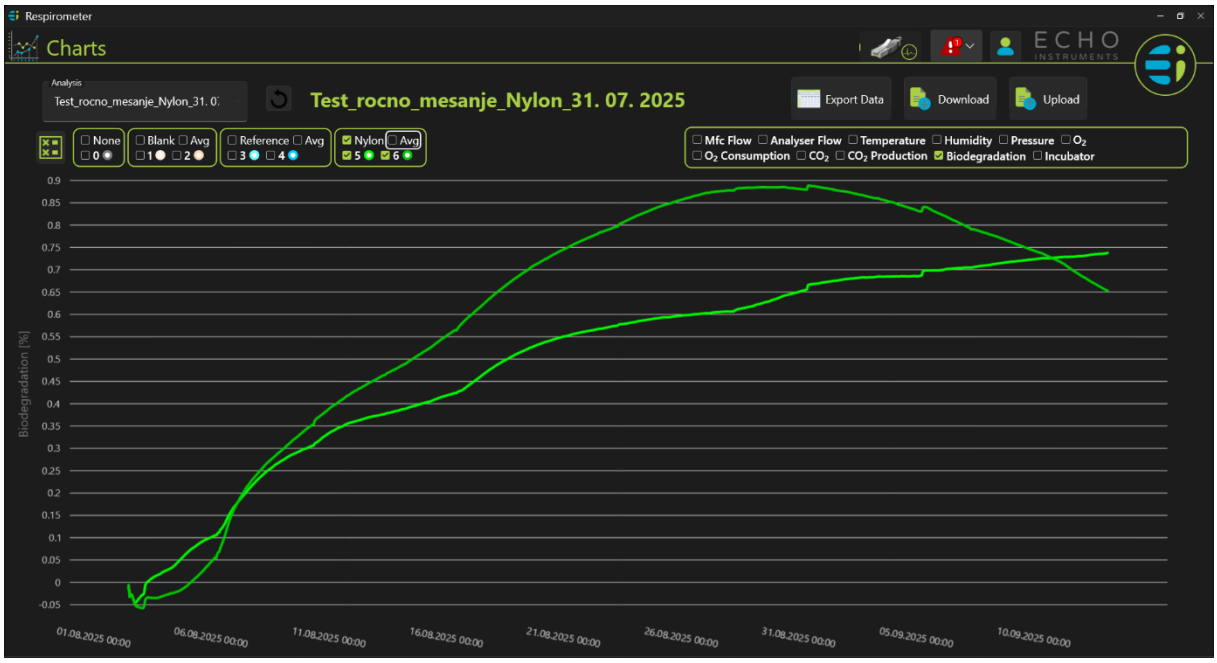


Figure 4-31: An example of a graph – chosen group

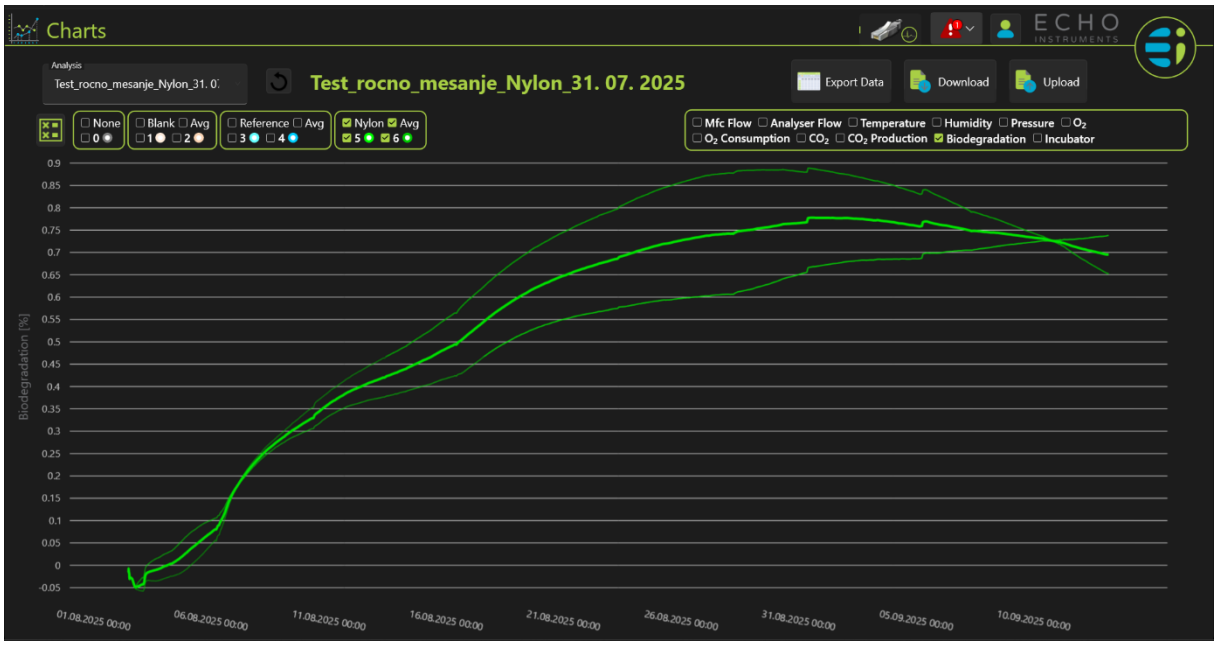


Figure 4-32: An example of a graph – average of the chosen group

Two parameters can be viewed at the same time in the same graph on multiple reactors.

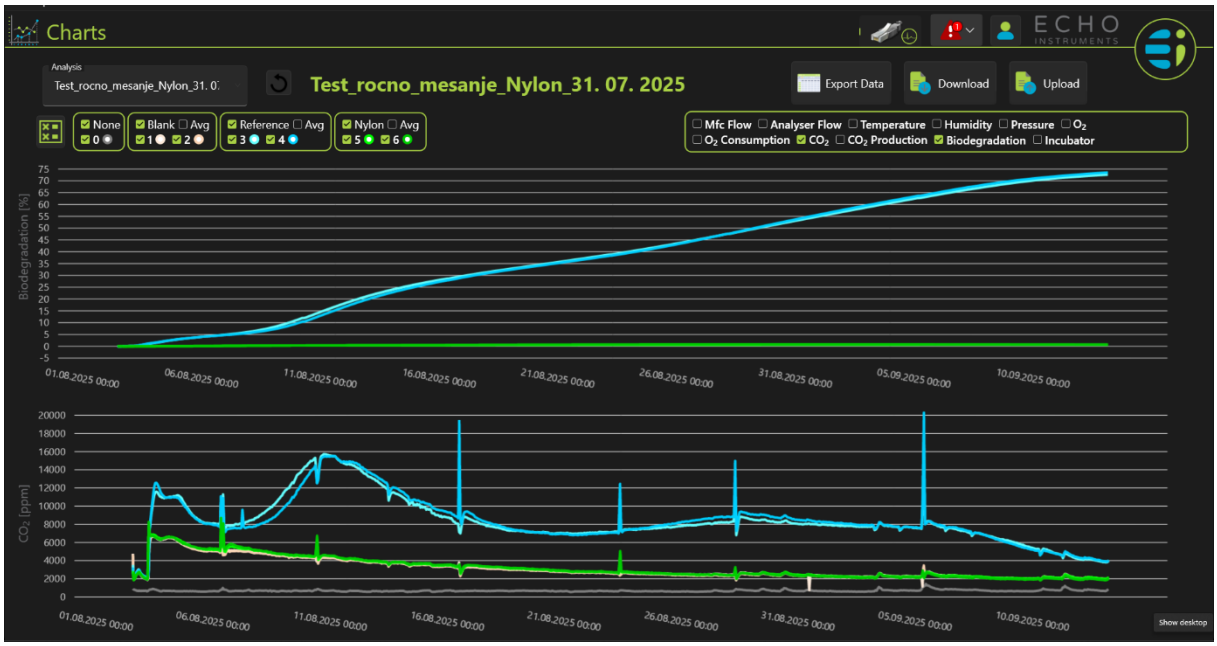


Figure 4-33: An example of a graph – multiple reactors and two parameters

To zoom in or out on a specific area of the graph, use the mouse scroll wheel. Place the cursor on the desired area of the graph or axes, then scroll to adjust the zoom level. Using the **right-click function** on the graph, various options open for customising the appearance of graphs, including saving the graph in form of a .png file.

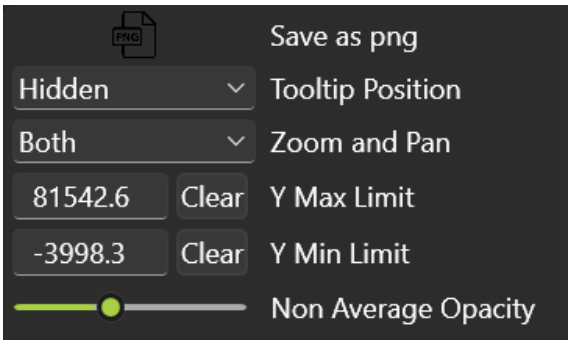


Figure 4-34: Right-click function – graph appearance

4.7.1 Export data

To export data, click on the 'Export Data'  icon. Data will be exported in a form of a spreadsheet (.xlsx).

To download or upload database file, click on the 'Download'  or 'Upload'  icon. The downloaded/uploaded item will be in a form of a .db file.

4.7.2 Removing analysis

To remove an analysis, use the **right-click function** on the field ‘Analysis’ in and click on the ‘Remove’  icon. A message box appears asking if you are sure about the deletion. The chosen analysis will be deleted from the database. **Data will be lost if it hasn’t been backed up!**

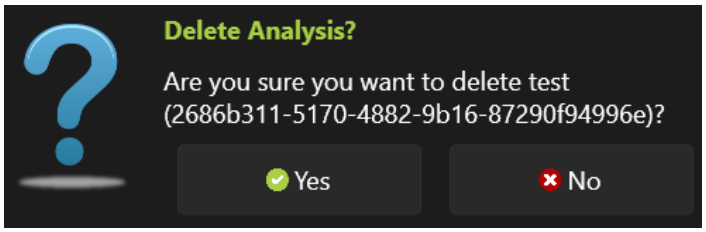


Figure 4-35: Removing an analysis

4.8 Purging

This function should be used after the analysis is complete and before starting a new one. It prolongs the lifetime of sensors, dry out excess moist in respirometer and tubing, flush out old sample, etc.

To purge the system with fresh air, short circuit the respirometer tubing or connect an empty reactor. Do not purge the system while the sample is in the reactor and reactor is connected to the respirometer.

Before starting the purging process, the analysis must be stopped, otherwise purging can’t be started.

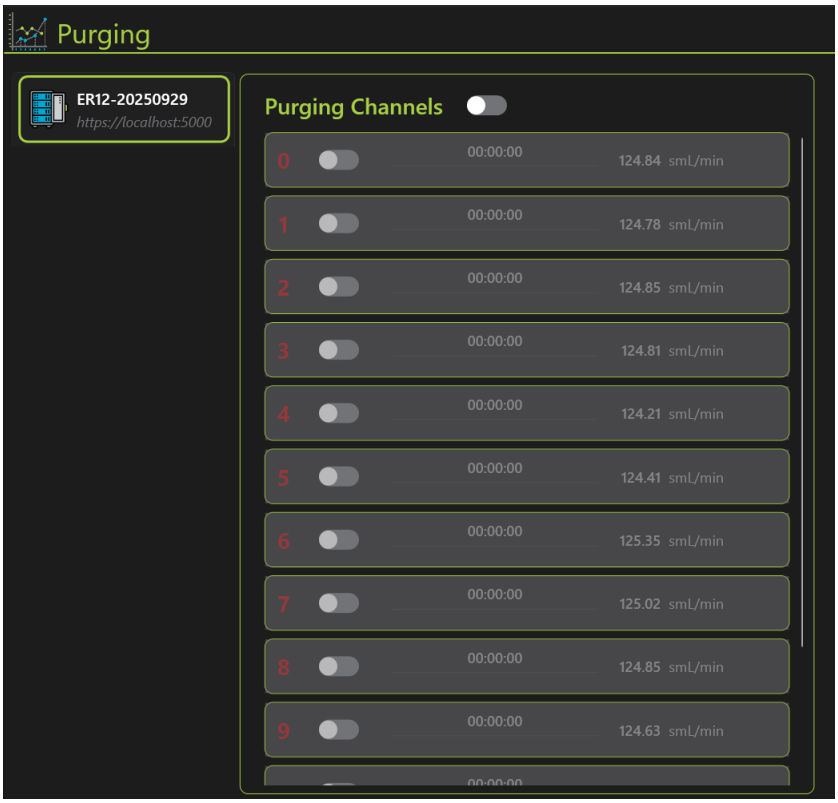


Figure 4-36: Purging can't be started – stop the analysis

Go to menu Purging in the main navigation menu and use the 'toggle' button to initiate the process individually or simultaneously on all channels.

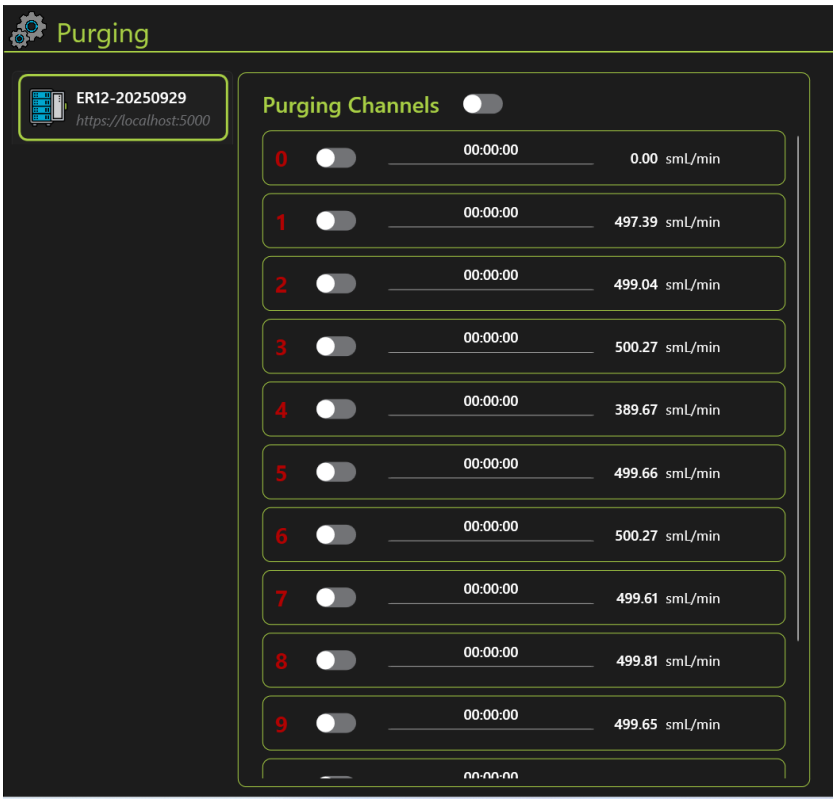


Figure 4-37: Start the purging process

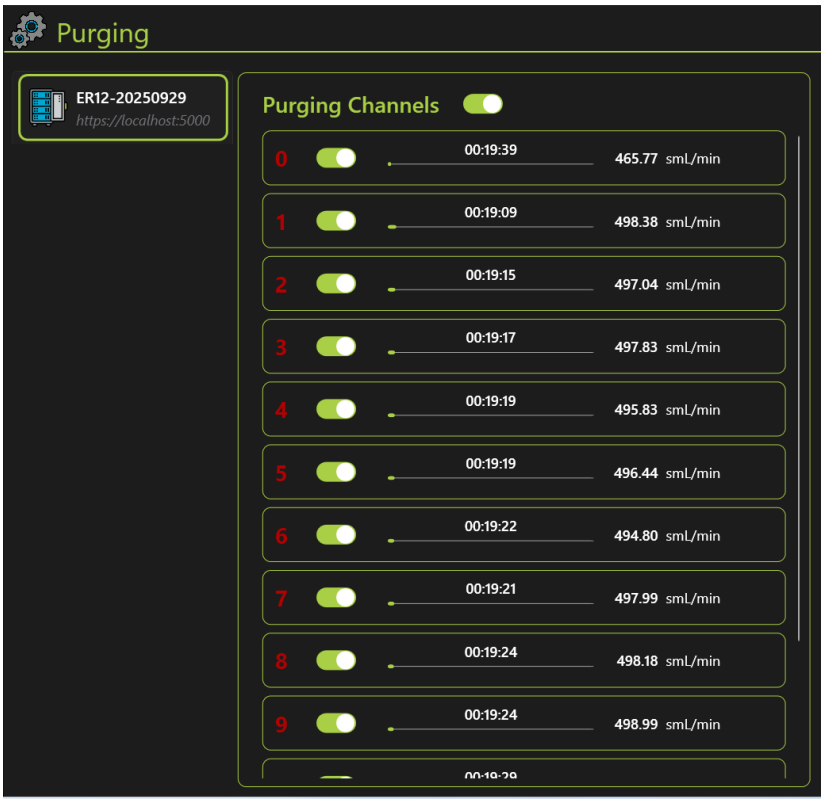


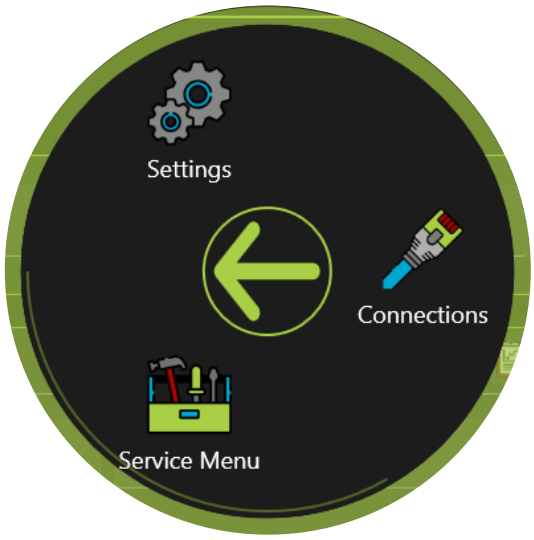
Figure 4-38: Purging in process

Process will be completed after the time set in the menu Settings (see chapter **Settings**). After purging process is completed, a notification will appear in the notification section.

5 Options

Select Options in the main navigation menu to access different options and settings.

Table 5-1: Options menu structure

	***Settings***	Access to client and respirometer settings.
	Service Menu	Access to service menu.
	Connections	Access to connections menu.

5.1 Connections

Go to menu Connections to add, remove or change TCP and serial connections. Available connections are displayed on the left side of the window.

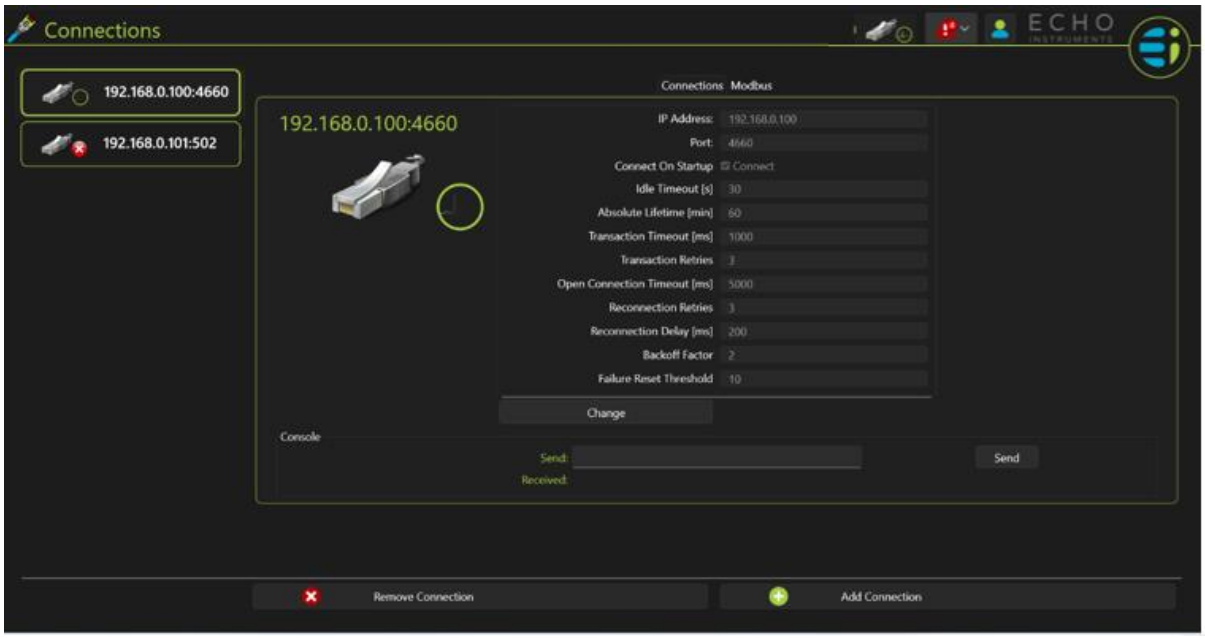


Figure 5-1: Connections menu

Connections menu contains graphical representations of all connections. Each connection should be set properly for respirometer to work. The connection status can be checked. If status is connected, an animated green line should be flashing in the circle next to the serial icon for each connection.

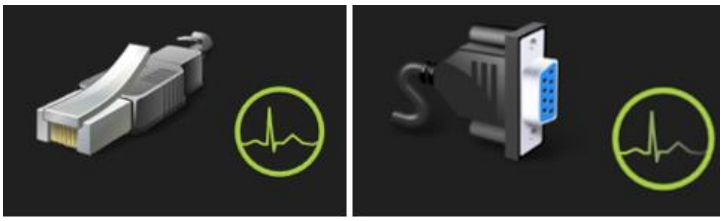


Figure 5-2: Animated green line next to TCP/serial connection – successful communication

If the connection is closed, a red mark appears.

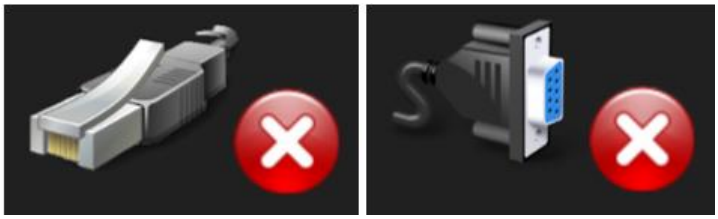
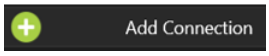


Figure 5-3: Red mark next to TCP/serial connection – problems with communication

To add a connection, click on the 'Add Connection' 

icon below connections.

A message box appears asking you to choose a type of connection. Choose the type and click on the 'Confirm' icon. A new connection is then created.

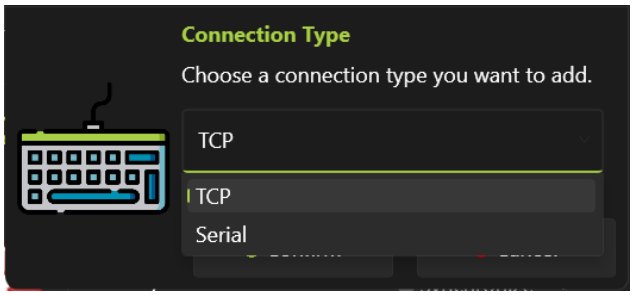


Figure 5-4: Drop-down menu with connection types

To remove a connection, it must first be selected, otherwise an error message appears.

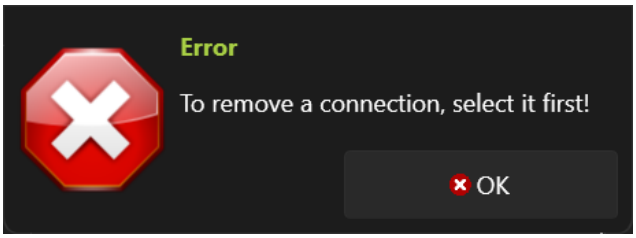
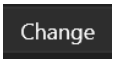


Figure 5-5: Error message – select a connection for removal

For unlocking each connection edit mode, click 'Change'  icon on connection graphical representation.

5.1.1 Multiple control units

In case of multiple control units, connections of individual devices can be managed by selecting a device in the upper right corner, next to the main navigation menu. Connections for that device are then listed on the left side of the software. A green bar on the left side of the device icon indicates the selected device.

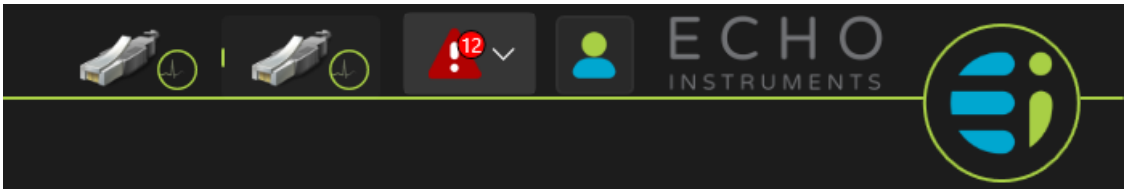


Figure 5-6: An example of two control units

5.1.2 TCP connection settings

Figure 5-7: TCP connection settings

Table 5-2: TCP connection settings

IP address	IP address of the connection.
Port	Port number used for establishing the connection.
Connect on startup	Tick the checkbox to automatically initiate the connection when the application starts.
Idle timeout	Maximum period of inactivity after which a connection is automatically terminated if no data is transmitted or received, in seconds.
Absolute lifetime	Maximum duration that a connection is allowed to exist, regardless of activity, in minutes.
Transaction timeout	Maximum time the system waits for a response during a transaction before declaring a timeout, in milliseconds.
Transaction retries	Number of times a failed transaction is automatically retried.
Open connection timeout	Specifies how long the application should wait when attempting to establish a connection before timing out, in milliseconds.
Reconnection retries	Number of reconnection attempts made after a connection failure.
Reconnection delay	Time delay between consecutive reconnection attempts, in milliseconds.
Backoff factor	A multiplier that increases the delay between reconnection attempts exponentially after each failure.
Failure reset treshold	Number of consecutive communication failures or errors after which the system resets the connection or initiates a recovery procedure.
Change	Change connection settings.
Save	Save connection settings.
Console	Manual sending of commands.

5.1.3 Serial connection settings

Figure 5-8: Serial connection settings

Table 5-3: Serial connection settings

Port name	Port used for the connection.
Baude rate	Port number for establishing the connection.
Parity	Communication speed.
Data bits	Number of data bits in each transmitted character.
Stop bits	Number of bits used to signal the end of a data packet.
Connect on startup	Tick the checkbox to automatically initiate the connection when the application starts.
Idle timeout	Maximum period of inactivity after which a connection is automatically terminated if no data is transmitted or received, in seconds.
Absolute lifetime	Maximum duration that a connection is allowed to exist, regardless of activity, in minutes.
Transaction timeout	Maximum time the system waits for a response during a transaction before declaring a timeout, in milliseconds.
Transaction retries	Number of times a failed transaction is automatically retried.
Open connection timeout	Specifies how long the application should wait when attempting to establish a connection before timing out, in milliseconds.
Reconnection retries	Number of reconnection attempts made after a connection failure.
Reconnection delay	Time delay between consecutive reconnection attempts, in milliseconds.

Backoff factor	A multiplier that increases the delay between reconnection attempts exponentially after each failure.
Failure reset treshold	Number of consecutive communication failures or errors after which the system resets the connection or initiates a recovery procedure.
Change	Change connection settings.
Save	Save connection settings.
Console	Manual sending of commands.

5.2 Settings

Menu Settings allows defining different client and server settings.

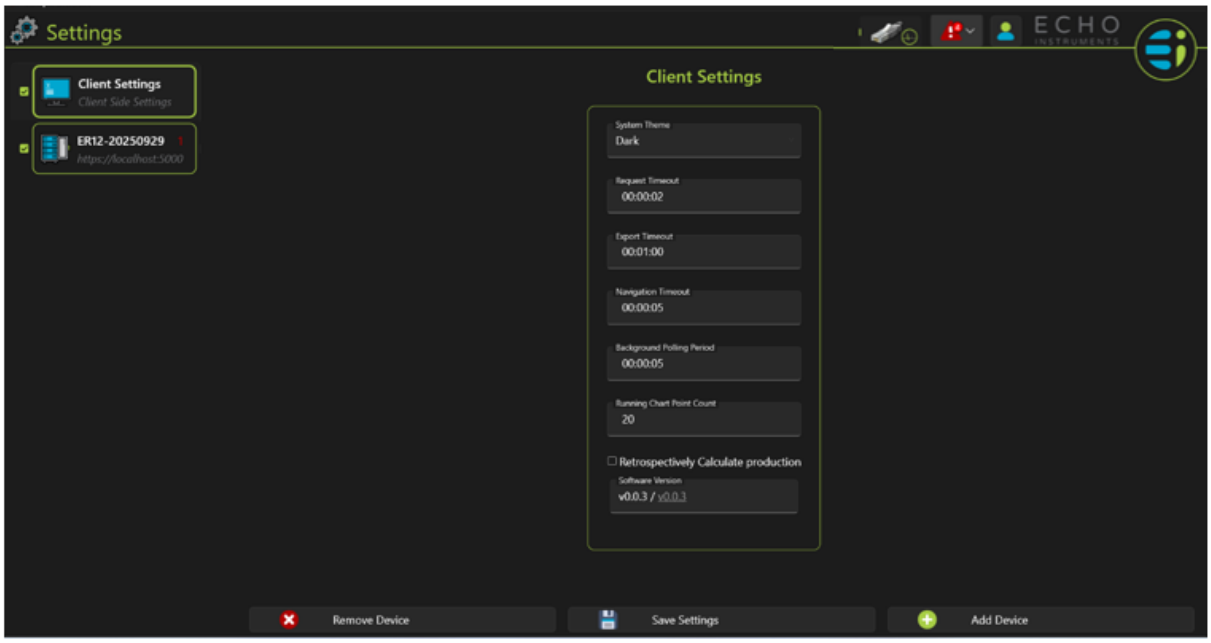
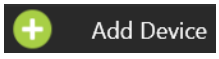


Figure 5-9: Menu Settings

Table 5-4: Client settings

System theme	Four background themes: dark, dark blue, light blue, light.
Request timeout	Maximum duration system waits for a response to a data request before it is considered failed.
Export timeout	Maximum time allowed for completing a data export operation before a timeout error is triggered.
Navigation timeout	Time limit for user interface or data navigation operations before an operation is aborted.
Background polling period	Interval at which background data is periodically requested from the device or system.
Running chart point count	Number of data points displayed in a live or running chart.
Retrospectively calculate production	Tick the checkbox for enabling recalculation of production based on existing logs or data.
Software version	Current version of the installed client application/latest available update. If the versions are different, click on the updated version, to update the software.

To add a device, click on the 'Add device' 

icon. A message box appears asking you to insert a host URL.

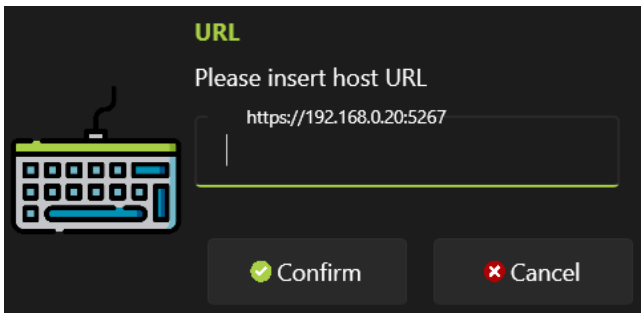


Figure 5-10: Insert a host URL

Next, click confirm and a new device is added. It appears in the device list on the left side of the software. Click on the created device and fill out the 'Client' form (see chapter **Client settings**). Make sure to click 'Save settings' 

icon to save the made changes.

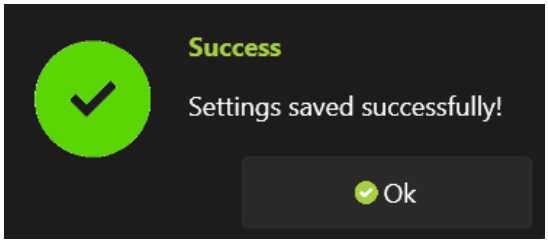


Figure 5-11: Settings saved successfully

After a device is added, it appears in the upper right corner, next to the main navigation menu.

Place the cursor on the 'connection'  icon to reveal information about the device (**function description**).

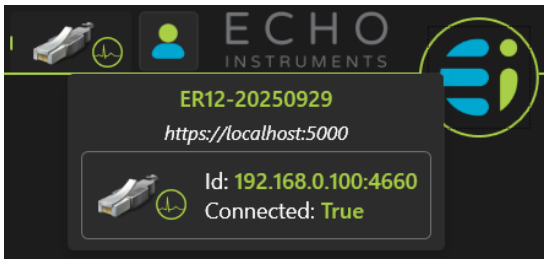
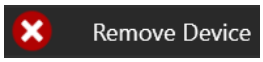


Figure 5-12: Device information

To remove a device, make sure to select it first, and then click on the 'Remove device' 

icon. The device will be removed.

5.2.1 Client settings

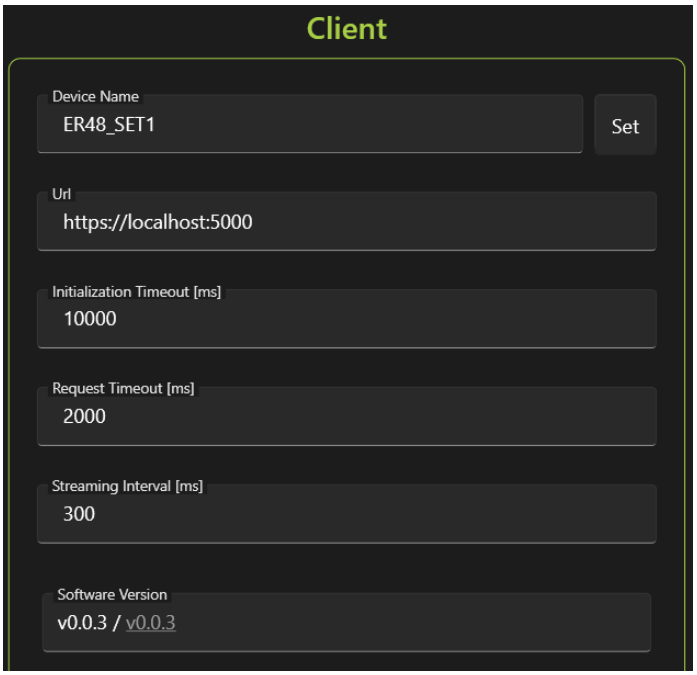


Figure 5-13: Client settings

Table 5-5: Client settings

Device name	Name of the device. After choosing a name, click the 'Set' Set icon.
Url	IP address or network endpoint of the device.
Initialization timeout	Maximum duration allowed for initializing the user interface or device connection, in milliseconds.
Request timeout	Time limit for executing a single command or request, in milliseconds.
Streaming interval	How often the application retrieves and updates real-time data, in milliseconds.
Software version	Current version of the installed server application/latest available update. If the versions are different, click on the updated version, to update the software.

5.2.2 Server – settings

Click on the ‘Settings’  icon to reveal server settings.

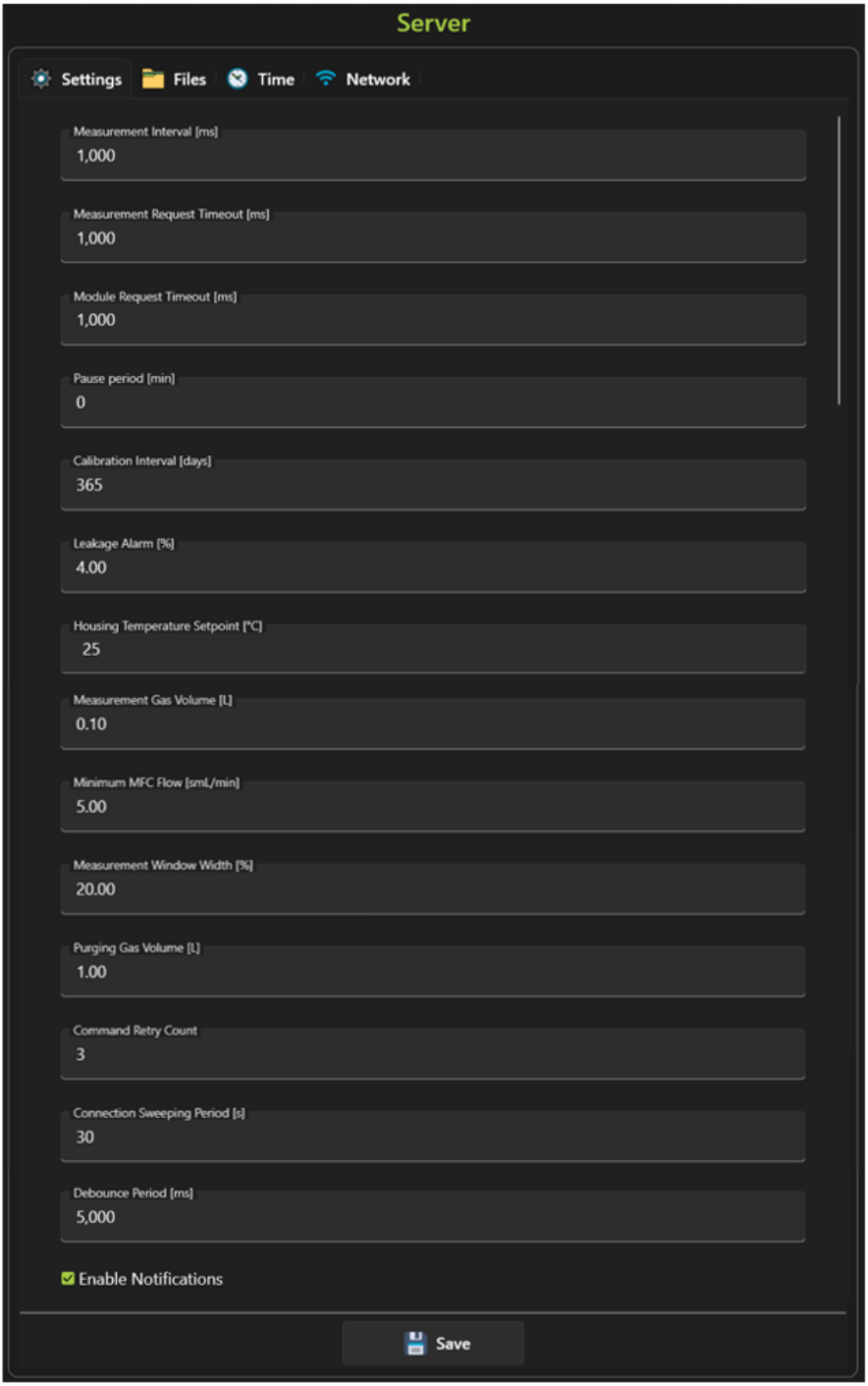


Figure 5-14: Server – settings

Table 5-6: Server – settings

Measurement interval	Time interval of how frequently measurements are initiated, or data is collected, in milliseconds.
Measurement request timeout	Maximum amount of time the system will wait for a response after a measurement request has been sent, in milliseconds.
Module request timeout	Maximum duration the system will wait for a response from a specific module after a request has been issued, in milliseconds.
Pause period	Duration during which no actions or measurements are performed between the measurement cycles, in minutes.
Calibration interval	Time interval between required calibration procedures, in days.
Leakage alarm	Threshold at which a leakage alarm is triggered, based on detected flow deviation, in percent.
Housing temperature setpoint	Target temperature value to which the internal or external housing of a device is regulated (if available), in °C.
Measurement gas volume	Total volume of gas required for a meaningful measurement, in litres. When the gas flow rate is changed, the duration of the measurement interval is automatically adjusted to maintain the measurement gas volume.
Minimum MFC flow	Minimum flow rate of the MFC to ensure stable value and valid measurements, in mL/min.
Measurement window width	Because gas needs time to travel from the reactor to the measuring chamber and to purge the previous sample, only the final portion of each measuring period is recorded. The window sets what fraction of the period is logged, taken from the end of the period, e.g., a 20 % window uses only the last 20 % of each measuring period. All measured values for that period are calculated from samples within this window; earlier samples are ignored.
Purging gas volume	Volume of gas used for purging the system, in litres.
Command retry count	Number of times a command is automatically retried in case of failure or timeout.
Connection sweeping period	Time interval between automatic connection checks or resets to ensure stable communication, in seconds.
Debounce period	Minimum time interval during which additional input signals are ignored following an initial signal activation, in milliseconds.
Enable notifications	Tick the checkbox for enabling notifications.
Save	Save server settings.

5.2.3 Server – files

Click on the 'Files'  icon to reveal shortcuts to folders and files required for proper operation of the device. To upload files, click on the 'Upload'  icon in the top left corner. Files can also be uploaded with the use of the **right-click function**, described below.

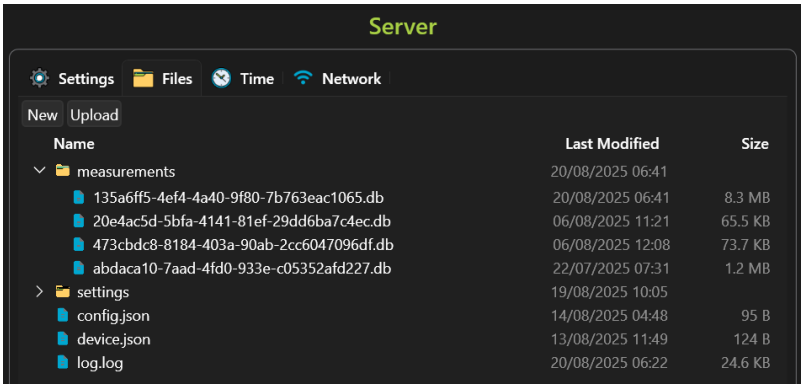


Figure 5-15: Server – files

To create a new folder, click on the 'New'  icon in the top left corner. A message box appears asking you to choose a name for the folder. Click the 'Confirm' icon. The folder created then appears in the folders list. A new folder can also be created with the use of the **right-click function**.

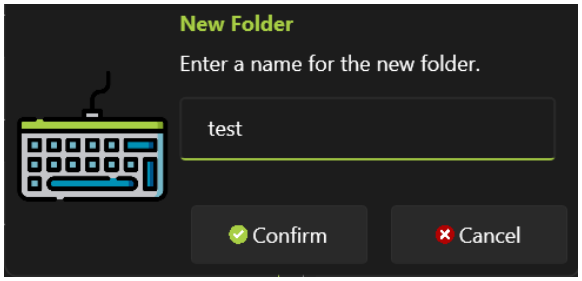


Figure 5-16: Create a new folder

Folders and files can be managed with the use of the **right-click function** on the desired folder or file.

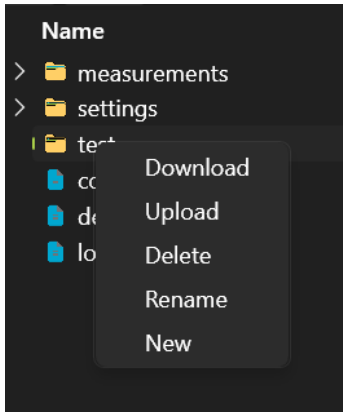


Figure 5-17: Manage folders and files

To download a file, click on the ‘Download’ Download icon. A message box appears informing you of a successful download.

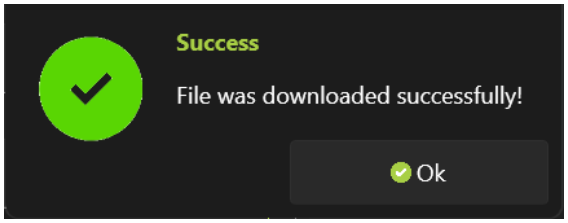


Figure 5-18: Download successful

To upload a file, click on the ‘Upload’ Upload icon. A message box appears informing you of a successful upload.

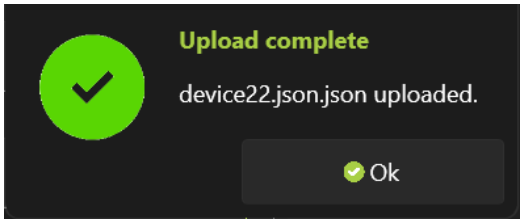


Figure 5-19: Upload successful

To delete a folder or a file, click on the ‘Delete’ Delete icon. A message box appears asking if you are sure about deleting the folder. Click the ‘Yes’ icon, to confirm the deletion.

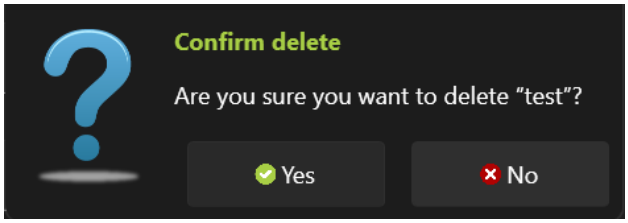


Figure 5-20: Confirm deletion

A message box appears informing you of a successful deletion.

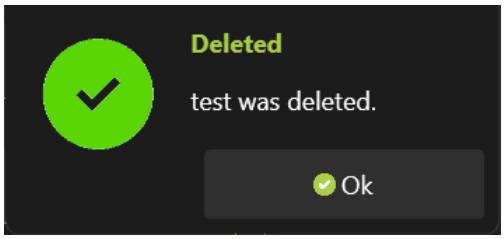


Figure 5-21: Folder was deleted

To rename a folder or a file, click on the ‘Rename’ Rename icon. A message box appears asking you to choose a new name. Click the ‘Confirm’ icon and the folder or file name will be changed.

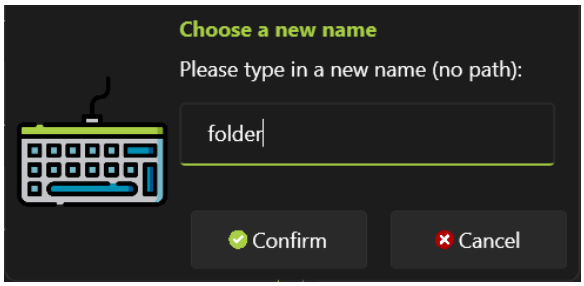


Figure 5-22: Rename a folder or a file

5.2.4 Server – time

Click the ‘Time’ icon to reveal time and date settings.

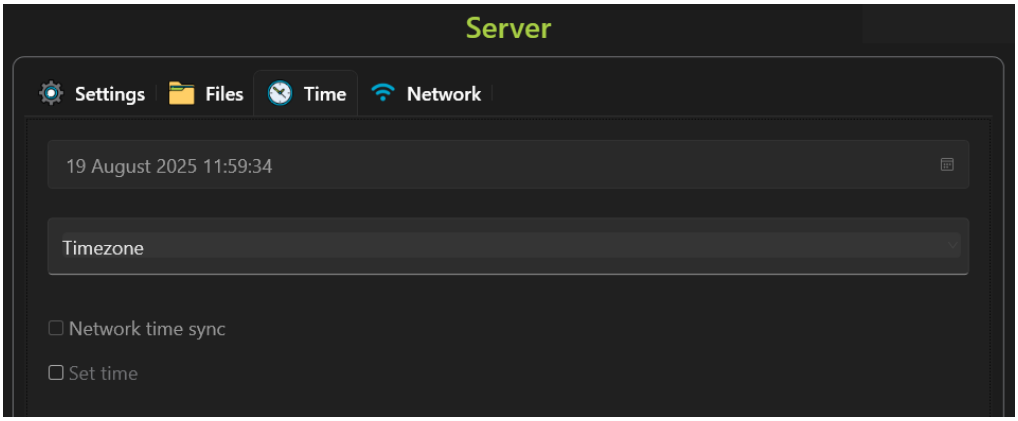


Figure 5-23: Server – time

Tick the ‘Set time’ checkbox and change settings as desired.

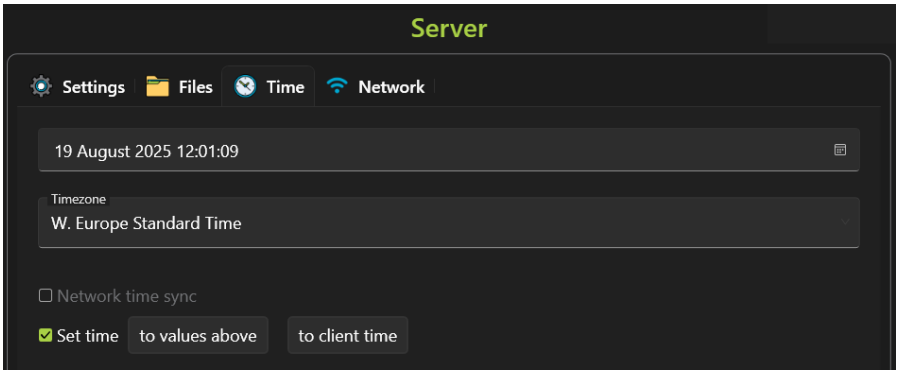


Figure 5-24: Server – time

Click on the ‘calendar’  icon in the right corner of ‘date and time’ field to use the calendar to change the date.

Figure 5-25: Calendar

5.2.5 Server – network

Click the ‘Network’  icon to reveal wifi connection settings.

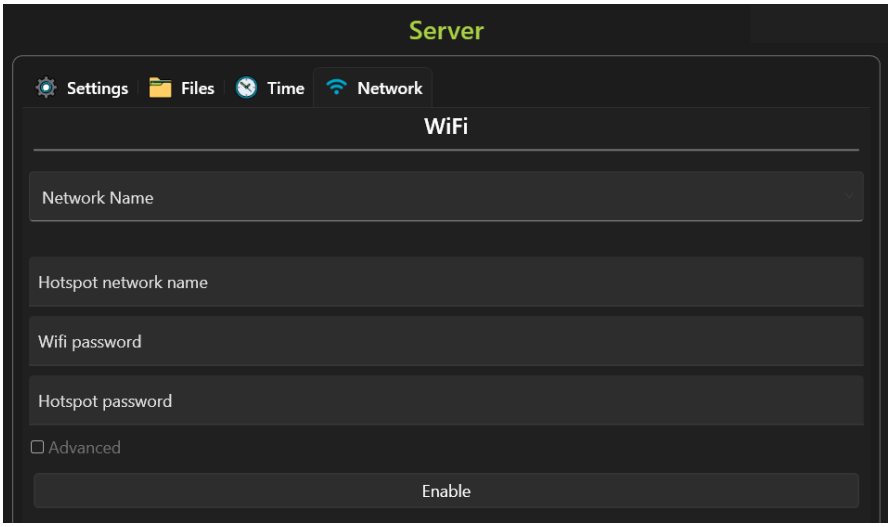


Figure 5-26: Server – network

5.3 Service menu *(authorized personnel only)*

Service menu is accessible to authorized personnel only. It enables various functions, including sensor addition, sensor calibration, etc.

Any unauthorized modifications made in Service menu will void the device warranty and may lead to improper functioning and unresponsiveness of the device. **In case of any troubles, contact ECHO Instruments at** support@echoinstruments.eu**!**

	Modifications in the Service menu are strictly prohibited.

6 Info

Select Info in the main navigation menu to view information about the company, the device, and to access help form in case of an occurring problem.

6.1 Company info

Go to menu Company info for general and contact information about the company.

Figure 6-1: General and contact information

6.2 Device info

Go to menu Device info for information about the device. All sensors installed into respirometer are listed below general device information (serial number of the device, software version). In case of multiple control units, change between devices in the list on the left side of the software, to discover device information for the desired device.

Figure 6-2: Device information

6.3 Support

Go to menu Support to access Product support form. Fill out the ‘Contact Support’ form. ‘End client’, ‘Email’ and ‘Describe your problem’ fields are conditional for sending a message to our support team. If TeamViewer support is needed, make sure to write down your TeamViewer ID and password.

Tick the checkbox ‘Is it under warranty’ if the device is still under warranty. Tick the checkbox ‘Previous service/calibration’ if the device has already had any service or calibration.

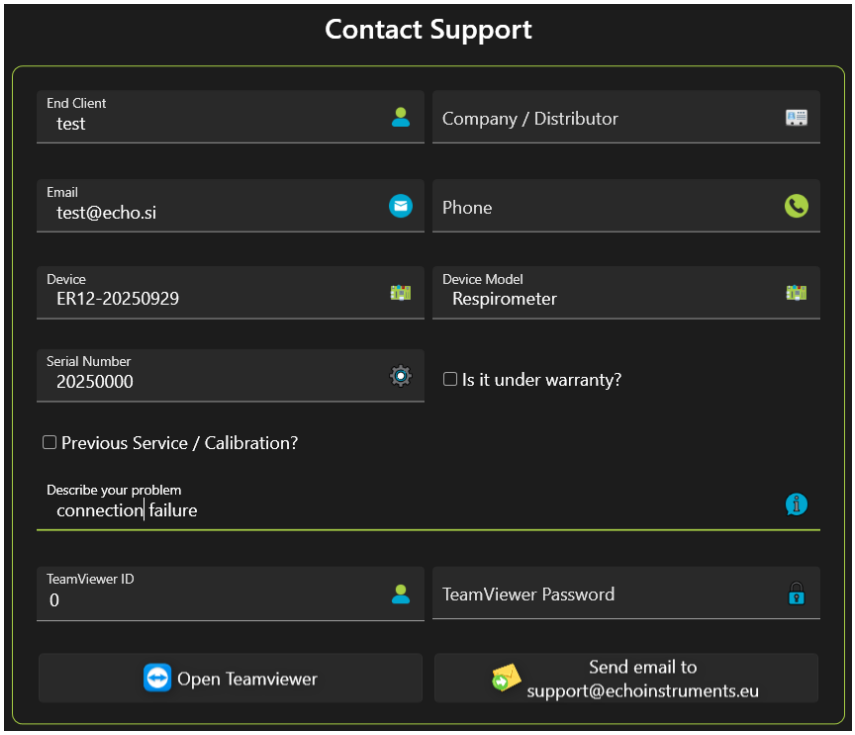


Figure 6-3: Product support form

Click ‘Send email to support@echoinstruments.eu’ icon and the message will be sent to Echo instruments support team. A message box appears informing you of a successfully sent email.

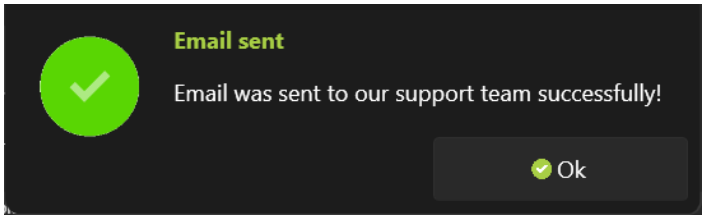


Figure 6-4: Email successfully sent

7 Troubleshooting

7.1 Warning and error dictionary

The most common warning and error notifications are presented in the tables below, along with their possible causes and suggested solutions.

7.1.1 Flow

Notification	Possible cause	Suggested solution
Analyzer flow (# mL/min) is more than # % lower than MFC flow (# mL/min). Possible leak detected.	Input pressure might be too low.	Increase the input pressure.
	There might be a blockage in the tubing.	Check the tubing and remove the possible blockage.
	Condensate in hydrophobic PTFE filter in front of the analyzer (possibility of a failed peristaltic pump).	Replace the PTFE hydrophobic filter.
	Lid of the reactor – not tightened enough.	Tighten the lid properly.
	Lid of the reactor – not tightened evenly.	Tighten the lid properly.
	Output fitting – not tightened enough.	Tighten the output fitting properly.
	Output fitting – missing a seal or an aluminium ring.	Tighten the output fitting with all required parts.
	Reactor seal – might be damaged.	Replace the reactor seal.
MFC flow (0 mL/min) is effectively zero. Measurements will not be valid.	Pressure source is turned off.	Turn on the AP03 pump or any other pressure source.
Analyzer flow exceeds MFC flow by more than # %.	Sensor drift, incorrect or unstable input pressure or malfunctioning MFC valve.	Check inlet pressure and sensor calibration.

MFC flow deviates from setpoint by more than # %.	Incorrect or unstable input pressure or malfunctioning MFC valve, blockage in the tubings, filters.	Check inlet pressure, possible valve or sensor malfunction.

7.1.2 Sensor issues

Notification	Error	Possible cause	Suggested solution
No data was collected for #.	There was no response from the sensor.	Damaged sensor, lost connection.	Check the sensor. In case of damage, sensor needs replacement. Check the connection. Increase measurement timeout, if necessary.
	No sensor modules found for '#' on channel #.	Invalid Module configuration.	Check sensor configuration in the Service menu.
	"Units '{sensor.Unit}' not recognized for quantity '{sensor.Quantity}'.	Wrong sensor unit configuration.	Check sensor and gas-parameter unit configuration in the Service menu.
	Conversion from '{sensorQuantity.QuantityInfo.Name}' to '{targetQuantityInfo.Name}' is not supported due to quantity mismatch.	Mismatch between sensor and gas parameter quantities.	Check sensor and gas-parameter quantity configuration in the Service menu.

	{sensor.MeasuredParameter} Sensor ({sensor.Id}) value {Math.Round(valueResult.Value, sensor.DecimalPlaces)} " + $"is not in valid range({sensor.Range.Min}-{sensor.Range.Max}).	Damaged sensor, incorrent range setting.	Power-cycle the sensor, then verify status.

7.1.3 Saturation

Notification	Possible cause	Suggested solution
### is saturated. Aggregated value # is above the threshold of # % of the fullscale #.	Accumulating carbon dioxide due to low aeration.	If carbon dioxide sensor is saturated, consider using higher flow.
Humidity level (# %) exceeds alarm threshold (# %)! This may cause damage to sensors.	Malfuctioning condenser pumps, humid ambient conditions, too high flow.	Stop analysis immediately!

7.1.4 General Analysis

Notification	Possible Cause	Suggested solution
Failed to insert measurements in the database for reactor {CurrentReactor.Id}!	Full disk, software does not have write permissions.	Free up disk space or consider contacting support.

If troubles continue, contact your local distributor or the manufacturer.

7.2 Flow issues

7.2.1 Flow on analyzer lower than MFC

1. Disconnect tubes from the reactor and connect them together with a short circuit. If this resolves the issue, the leak is located in the reactor. Inspect the reactor seal for damage and ensure all fittings are properly tightened. If the issue persists, proceed to the next step.
2. Disconnect tubes from the rear side of the distribution unit for the problematic channel and connect 'IN' and 'OUT' connections with a short tube. If this resolves the issue, the leak is within the multitube assembly. Tighten connections on multitube and reactors to solve the issue.
3. If the issue persists despite following the steps above, it could be a drift of the flow sensor that is causing the issue. In this case, sensor requires calibration.

7.2.2 Unstable flow

1. Check the pressure which should be around 0,25 bar (ER models 1.4 and higher).
2. Stir the samples regularly. Some types of samples can induce variable flow resistance and in turn, flow instability.
3. If the solutions above do not fix the lack of stability, the proportional valve needs to be replaced.

7.2.3 No flow on all channels

1. Ensure all devices are turned on and properly connected.
2. Air pump must be turned ON and connected to 'Carrier gas' input.
3. The pressure should be set to 0,25 bar.
4. Connection between PC and control unit must be established.
5. If the issue remains unresolved, contact customer support.

7.2.4 No flow on some channels

1. Restart the control unit.
2. If restarting does not resolve the issue, check the sample on the problematic channel and stir it.
3. Should the issue persist, disconnect the channel from the rear panel of the distribution unit, go to the service menu, and try setting the flow on said channel. If sensor does not respond to the set flow, it needs replacing.

7.3 Pressure issues

7.3.1 No pressure

1. Check if all the devices are powered and connected properly. Air pump should be turned ON and connected to 'Carrier gas' input tube connector on the control unit.
2. If Echo pump is not working, check the fuse and if it is blown, replace it. If the issue persists, replace the pump.
3. Rotate pressure regulator clockwise to increase pressure.

7.3.2 Insufficient pressure

1. Rotate the pressure regulator on the control unit clockwise to increase pressure.
2. If the pressure does not increase, turn the control unit off and check connection between Echo pump and the control unit.
3. Open rear door of the control unit and check if 'Carrier gas' inlet tubes are connected to their respective gas distribution units.
4. If the pump is not supplying sufficient pressure, try adjusting its regulator clockwise.
5. If the solutions above don't fix the issue, the pump may need replacing.

7.4 Communication issues

1. Control unit must be turned on and connected to a PC via ethernet cable.
2. If the connection is not successful, open the rear door of the control unit and check connections between devices marked 'I/O'. Connectors must be firmly plugged in.
3. Restart the control unit.
4. Should the issue persist, contact customer support.

7.5 Unit does not turn ON

	Make sure the unit is unplugged when changing fuses or opening electrical junction box!

If any of the units do not turn on, check the fuses, and replace them if they are blown. Main fuse for control unit is in the electrical junction box on the rear side of the control unit. Make sure the unit is unplugged when changing fuses! Fuses for distribution and gas analysis units are on the rear panel of their respective units. There are spares in the extra slots.

8 Specifications

8.1 Physical

Control unit	600x600x600 mm, 65 kg
PC	500x400x200 mm, 5kg
Pump AP03	260x400x600 mm, 23 kg
Thermostatic cabinet ST5	620x1500x650 mm, 75 kg

* Dimensions are listed as width x height x depth

8.2 Electrical

Control unit	230 VAC, 50 Hz, 300 W (option 115 V, 60 Hz)
PC	100 – 240 VAC, 50 – 60 Hz, 65 W
Pump AP03	230 VAC, 50 Hz, 300 W
Thermostatic cabinet ST5	230 VAC, 50 Hz, 350 W

* Electrical properties are listed as voltage, frequency, nominal power

8.3 Operating conditions

Temperature	absolute min.	15 °C
	absolute max.	30 °C
	recommended min.	20 °C
	recommended max.	25 °C
	max variation	5 °C/day
Humidity	max (temperatures up to 25 °C)	60 % RH
	max (temperatures above 25 °C)	50 % RH

8.4 Sensors (control unit)

Carbon dioxide	5000 ppm, ± 2 % FS
Oxygen	25 %, ± 1 % abs
Flow	500 SmL/min, ± 1,5 % FS
Pressure	150 – 1150 mbar, ± 5 mbar
Temperature	0 to 100 °C, ± 1,0 °C
Humidity	0 – 100 % RH, ± 5 %

* Sensor specification listed as range, accuracy.

9 Appendix

9.1 Pump

Figure 9-1: Pump

 Warning	Do not expose unit to water and prevent any liquids from entering inlet or outlet. Do not obstruct vent holes.
	The Air Pump is designed exclusively for professional laboratory use.
 Warning: high voltage	Work on electrical device may only be carried out by skilled personnel.

9.1.1 Setting up

Always make sure that the tubes are clean and undamaged before making any connections. Pump should be turned off, while connecting. Connect the outlet of the Air Pump with the inlet of the respirometer. Secure the connections on both ends with nuts to prevent tube from falling off due to high pressure. Turn on the pump. System is ready for use.

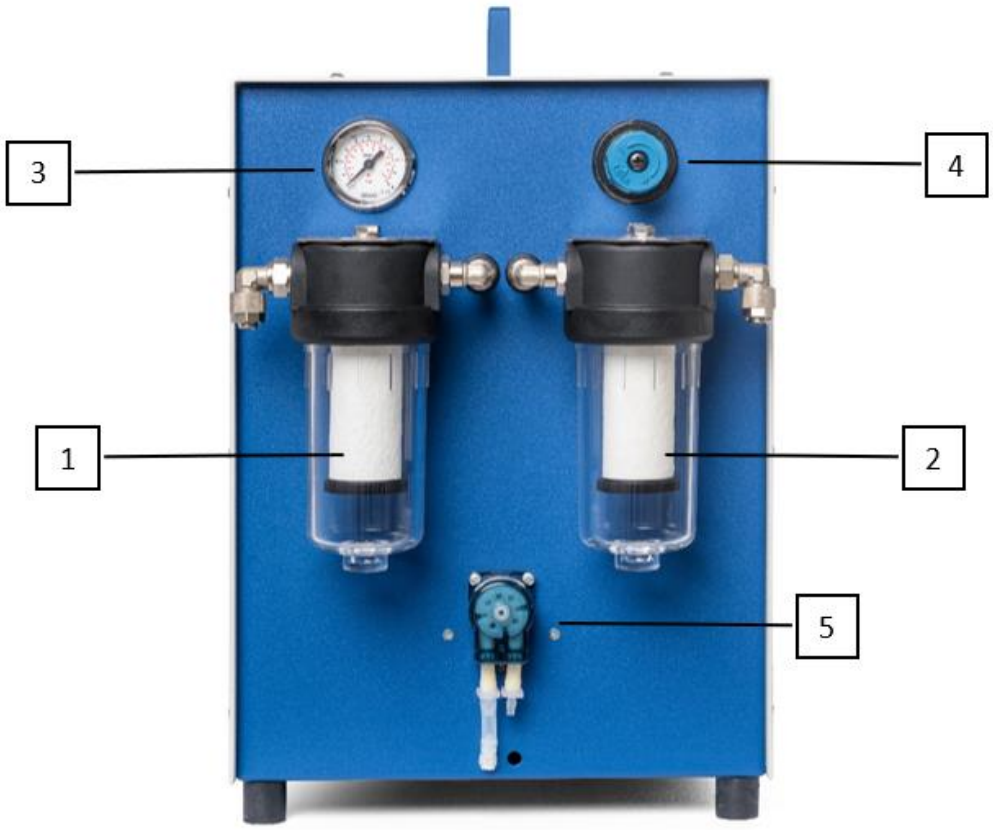


Figure 9-2: Pump AP03

1	Inlet filter	***2***	Outlet filter
3	Manometer	***4***	Pressure regulator
5	Peristaltic pump		

9.1.2 Maintenance

Filters should be changed at least once a year or more often, if needed. Filters should also be changed if there are visible signs of impurities/dirt on filter's surface, or if they are suspected to reduce air pump performance due to any other deficiencies.

Remove the bottom of the filter chamber and rinse it with water. Before assembly, wipe it dry with a cloth. Replace the filter and reattach the housing by first pressing it next to the cover and then screwing it into place.

9.1.3 Troubleshooting

Pump stopped working

1. Overheating: turn off the power supply, wait at least 3 hours for pump to cool down, try to restart.
2. Mechanical failure: in case of suspected mechanical malfunction of the pump, contact the distributor before taking any other action.
3. Power supply failure: turn off the Air Pump and make sure power cables are intact, and power source is working properly.
4. Blown fuse: replace the fuse located between ON/OFF switch and power socket.

Hissing sound (distinguished change in Air Pump working sound)

1. Obstructed flow path: check the complete flow path for any obstacles, damage, or water entry. Check the filters.
2. Deteriorated or damaged membrane: contact your local distributor.

9.2 Thermostatic cabinet

9.2.1 First start-up

During the first boot, the screen will display proposing to save the ‘Download’ folder (among others with instruction manual) on the USB flash drive. Insert the USB flash drive and wait a second to detect the hardware, then press ‘OK’. By pressing ‘Cancel’, the folder is not downloaded. The window will appear again during the next start. Tick ‘Don’t show again’ to prevent the window from being displayed the next time.

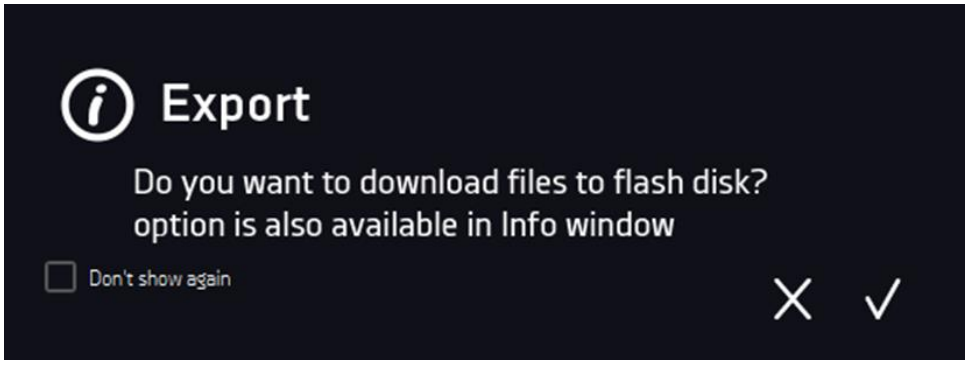


Figure 9-3: Export

The ‘Download’ folder can always be downloaded in the information panel. Press , enter to info panel , press icon .

9.2.2 Base window

The base window is used to read the current temperature in the cabinet and to program and set the device parameters.

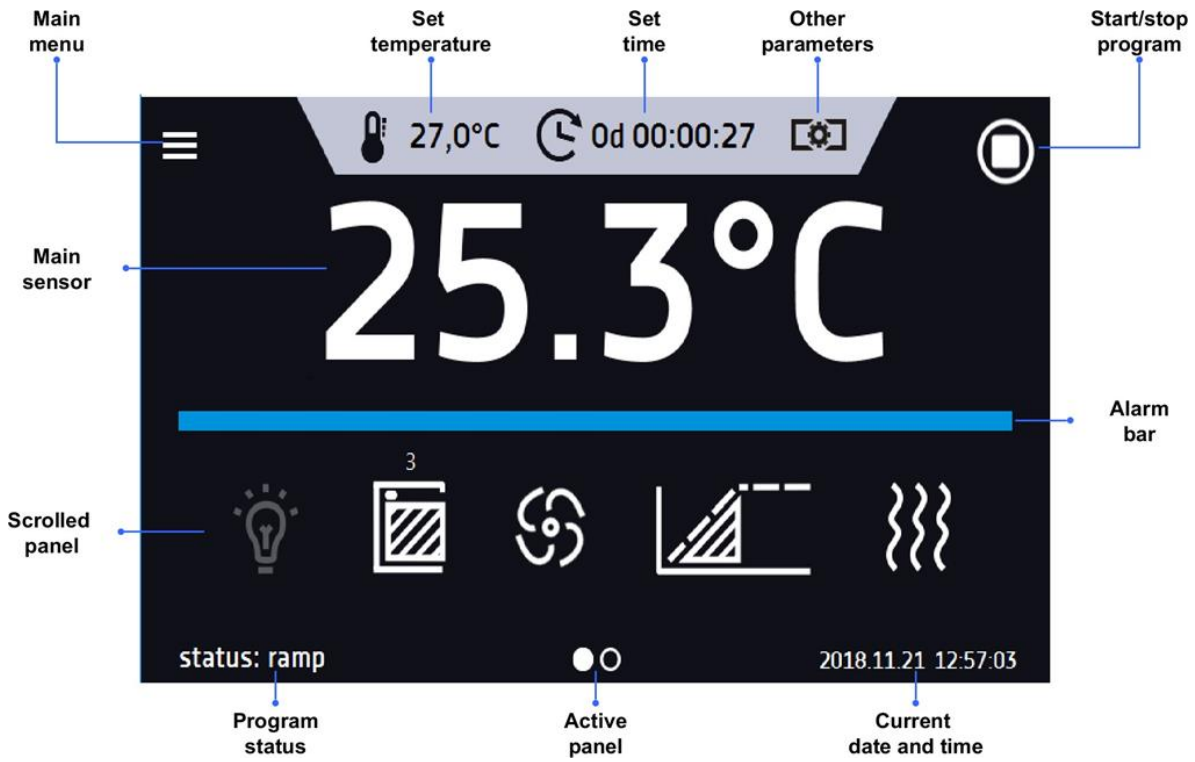


Figure 9-4: Main screen

9.2.3 Quick Program

Quick Program allow a quick start of the program from the home screen position without entering and creating a menu. After switching on the device, a symbol will be available on the main screen.

Figure 9-5: Settings 1

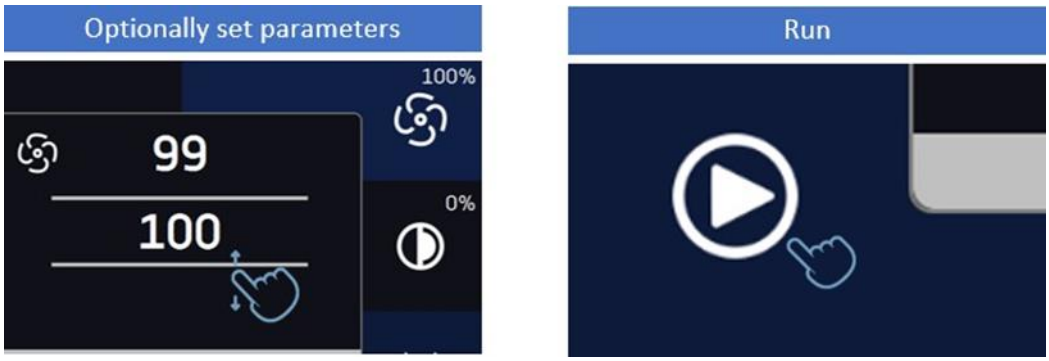
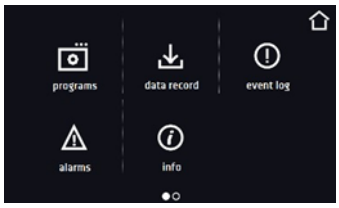
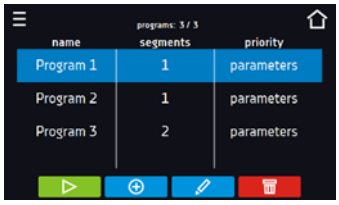
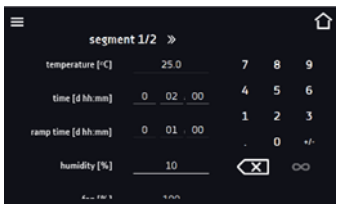
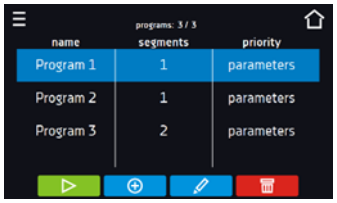


Figure 9-6: Settings 2

9.2.4 Creating and starting up the program

	Press ☰ in the base window to enter the menu.
	Press programs ⚙.
	In **Programs** panel, press ⊕.
	Set the other program's parametres (scroll up and down for more parameters). Go to program segments by pressing ⚙.
	Using the side keyboard, set the parameters of the **Temperature, Time** (the number of parameters depends on the device and additional options). To reach the set temperature as quickly as possible, allow the ramp time to 0.

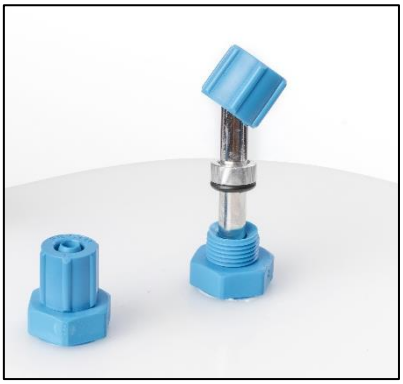
	Navigating between the program parameters, segments and summary are done by swiping up the segment with the finger or touching the icon  .
	After setting parameters for all segments, move to the last window - **Summary**. In this window, all segments are visible along with the entered settings. If everything is correct, move the window down and press 
	The saved program will automatically be displayed on the list. To start the program, press  . To stop a running program, press  .

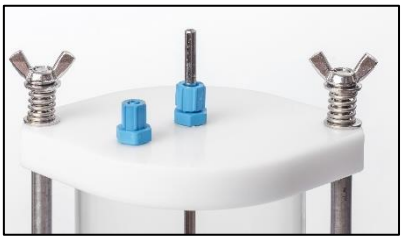
9.2.5 Quick start/stop the program

	In the main menu, press  to start the program and  to stop the program.

Full user manual for thermostatic cabinet is available on USB drive supplied with the respirometer.

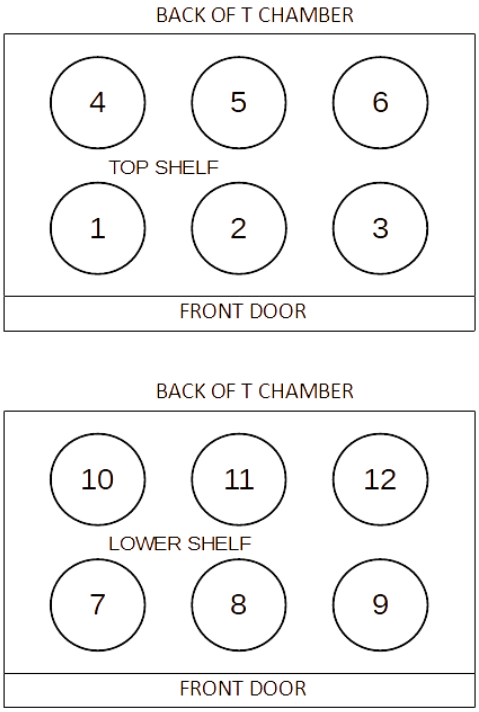
9.3 Reactor vessels

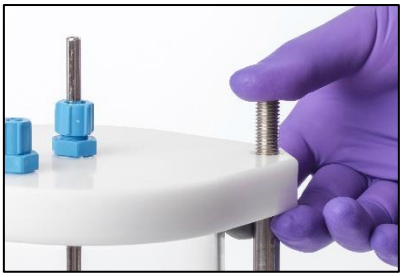
	Put the glass vessel in the recess of the base and put the stand in the vessel. Up to 100 ml of water for humidifying can be poured into the vessel.
	Make sure that central fitting is just loosely fit; if it is fitted too tight, loosen it with a few counterclockwise turns, otherwise the stand tube will not be able to be inserted. Put the lid on the vessel; tube of the stand should fit the central connector. Correct assembly of the central connector.
	Check if the vessel fits in the seal, otherwise correct the placement of the vessel.



Place the following elements on each of the metal carrier in turn: washer, spring, second washer and wing nut. The wing nuts should be tightened until resistance is felt — indicating that the spring is fully compressed — then loosened by half a turn. Tighten the central connector. Later in the process additional humidifying water can be added through the tube of the stand.

Placement of reactors in thermostatic cabinet.



	In thermostatic cabinet, put the quick connector on the tube of the stand. This is air inlet. Air outlet is on the side connector; put the tube on and screw the cap; screw it easily, as too much force will damage the tube.
	When disassembling air inlet, be aware not to pull the connector; the blue plate should be pushed up.
	To remove the lid, press the right stand tube with your thumb and simultaneously pull the edge of the lid upward with your fingers. Then press the left stand tube with the thumb of your other hand and pull the edge of the lid upward. Alternately pull upward from the left and right sides, one after the other, until the lid detaches from the glass vessel.

9.4 Sample bottles

Air inlet connector is quick coupling and air outlet is compression fitting. It is important that inlet is under the sample level and outlet above the sample level.

	When disassembling air inlet, be aware not to pull the connector; the blue plate should be pushed up.

9.5 Carbon dioxide scrubber

Carbon dioxide scrubber is used to remove carbon dioxide from air by absorption with soda lime.

Soda lime is a mixture of calcium oxide and sodium hydroxide. It should also include indication dye that changes colour when the soda lime reaches its carbon dioxide absorbing capacity.

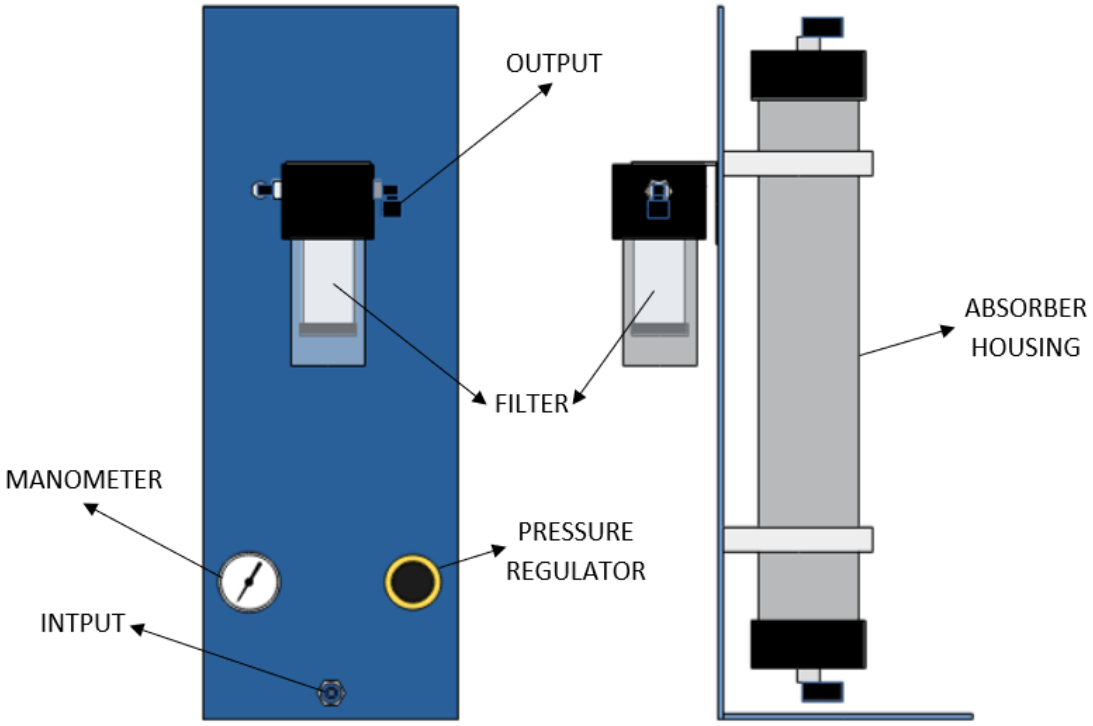


Figure 9-7: Carbon dioxide scrubber

Absorbing housing volume is 2,7 L. Disconnect the tube and unscrew top cap. Put one filter pad on the bottom of the housing, fill with soda lime and put another filter pad on top of soda lime. Depending on soda lime type (producer) and flow, the scrubber will absorb up to 500 L of carbon dioxide.

Soda lime filling cycle is dependent primarily on background carbon dioxide and flow. At 500 ppm background and 1L/min flow, carbon dioxide amount is 0,7 L/day.

Scrubber should be placed between the carrier gas source (pump, compressor) and the control unit. Maximum inlet pressure is 0,7 bar. Outlet pressure should be set to 0,5-0,6 bar.

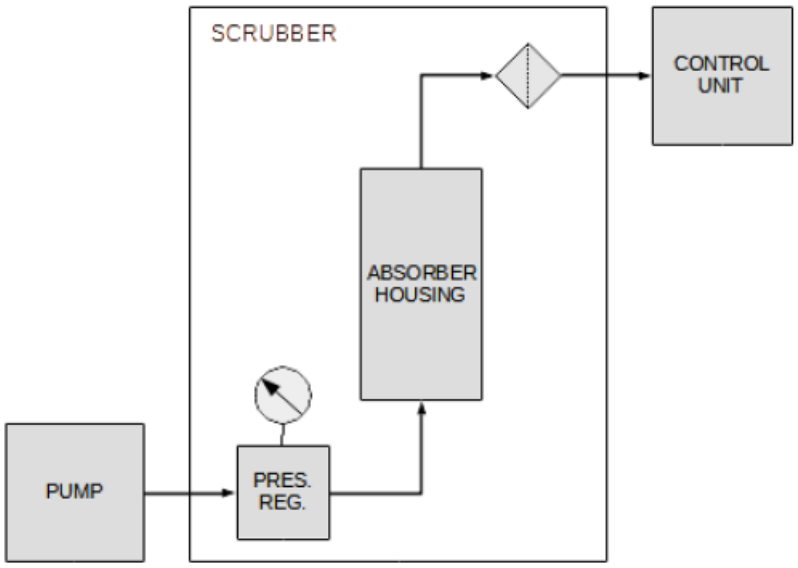


Figure 9-8: Carbon dioxide scrubber placement

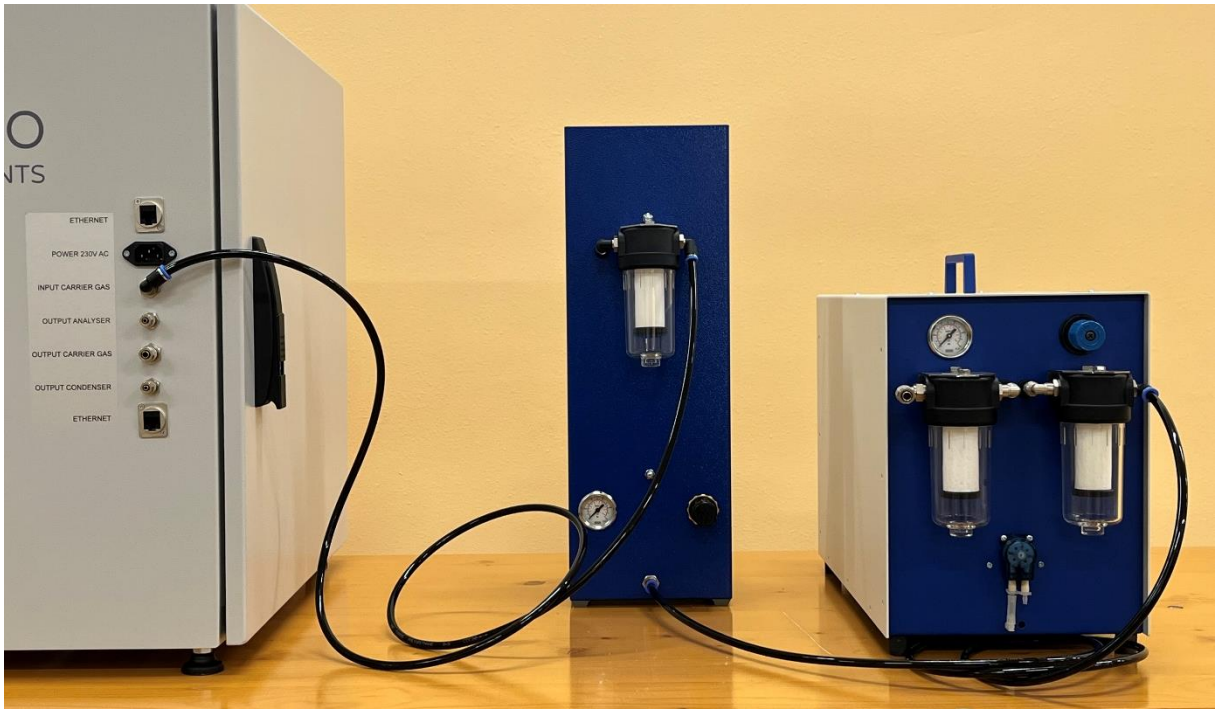


Figure 9-9: Carbon dioxide scrubber placement

1. Connect pump output to scrubber input, turn the pump on.
2. Block scrubber output and set the scrubber pressure regulator to app. 0,6 bar.
3. Connect scrubber output to control unit input carrier gas.
4. Set the overpressure regulator in control unit to app. 0,5 bar.
5. Now, control the pressure in control unit with scrubber pressure regulator. Overpressure regulator will release gas just in case of excessive pressure on input.

9.6 Systems over 12 channels

Individual respirometer unit can contain up to 60 channels. It is also possible to control multiple control units with one PC unit and software.

Connecting two or more single control units to one PC requires software and communication upgrade. Contact your local distributor or manufacturer for more information.

One set consists of 12 channels. Therefore, sets are labelled as Channels 1-12, Channels 13-24, Channels 25-36, … Zero channels are always marked as 0, even though each set has their own 0 channel. For example, 36 channel unit has 3 different zero channels (0 channel 1-12, zero channel 13-24, zero channel 25-36).

If there are more than 12 channels in one housing, there are different possible arrangements of analyzers and distributors. See the labelling at the back panel to determine the positioning of analyzer and distributors. General rule is that first 6 channels are positioned at the top of control unit, and last 6 channels are positioned at the bottom. All the rest is positioned in between from top to bottom. It is also common that analyzer for specific set is placed directly above the two distributor units.

To toggle between different sets of channels, use the 'connection'  icons in the upper right corner of the screen. Each icon represents one control unit.

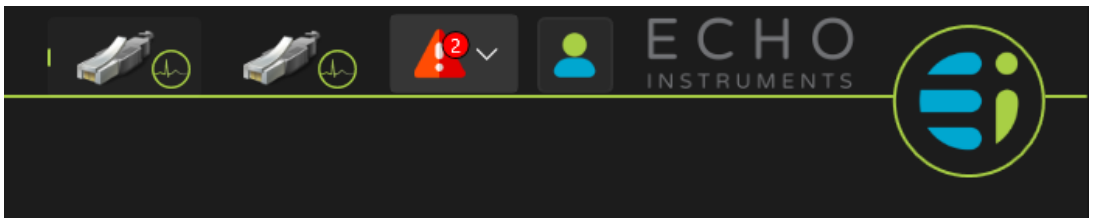


Figure 9-10: An example of a 24-channel software

It is important that all tubing is connected as labelled to avoid cross contamination of different sets.

Otherwise, the unit is used as described in this user manual.

The company reserves the right to make technical changes on the product.

The warranty period for the device is one year.

In case of physical or mechanical damage or using different procedures than described in the manual the guarantee cannot be claimed.

The company provides all parts for 5 years.