

MAMOS – ONLINE MONITORING SYSTEM

User guide

Version: 9.3.1
08/2017

madur
E L E C T R O N I C S

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1. INTRODUCTION

Mamos is a high quality, compact-size online gas monitor. Madur's best-selling product, that is constantly being improved and upgraded with a new measurement techniques, new sensors and equipment. The device is produced using the latest technology and production techniques. Being over 15 years on the market, it has proven to meet the most demanding requirements. Hereby, we present manual that will guide you through mamos construction, possibilities and settings. We encourage to devote some time to reading the manual, to assure failure-free operation of the device.

Mamos online monitor has a modular construction, that allows to set the configuration of device, the best suited for user's needs. This approach also ensures the most cost effective composition of the analyser – user pays only for the elements that are really necessary in application.

Mamos can be paired with additional equipment for sample collection and sample conditioning. Those are stationary probes (various configurations), heated lines, heated filters, different versions of gas dryers.

Analyser can work in few configurations. By default it is compact version. Also available are split and twin-split versions, that allows to work with analyser and dryer separated, or to measure from two different locations, i.e. before and after process or scrubber, etc.

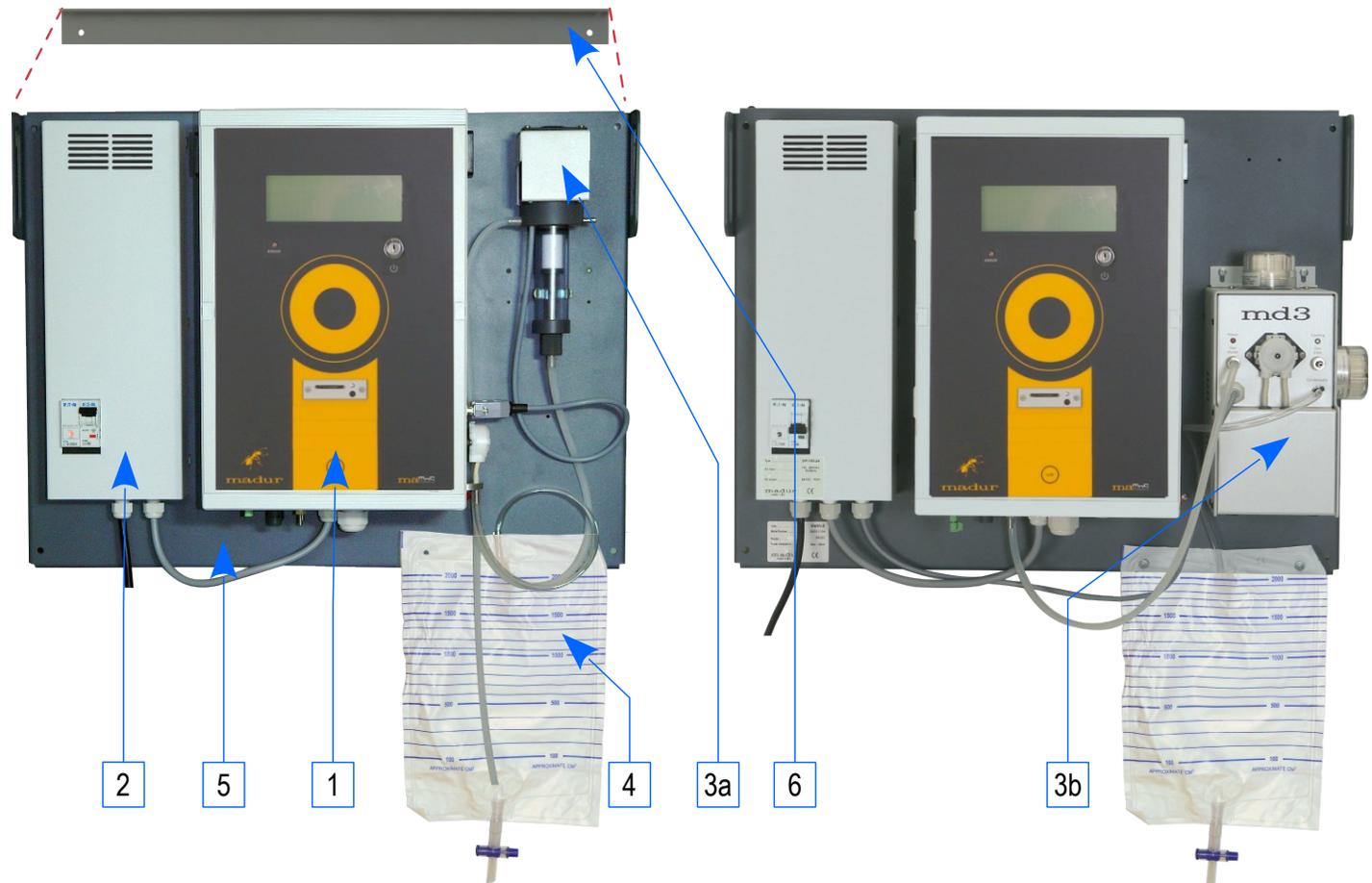
mamos' powerful software (and firmware) allows to individually configure how the analyser operates, and can be fully harmonised with customer process and application, what is also possible thanks to multiple communication interfaces, digital and analogue outputs.

2. CONSTRUCTION

2.1. Standard equipment

The basic configuration of mamos analyser in compact version contains:

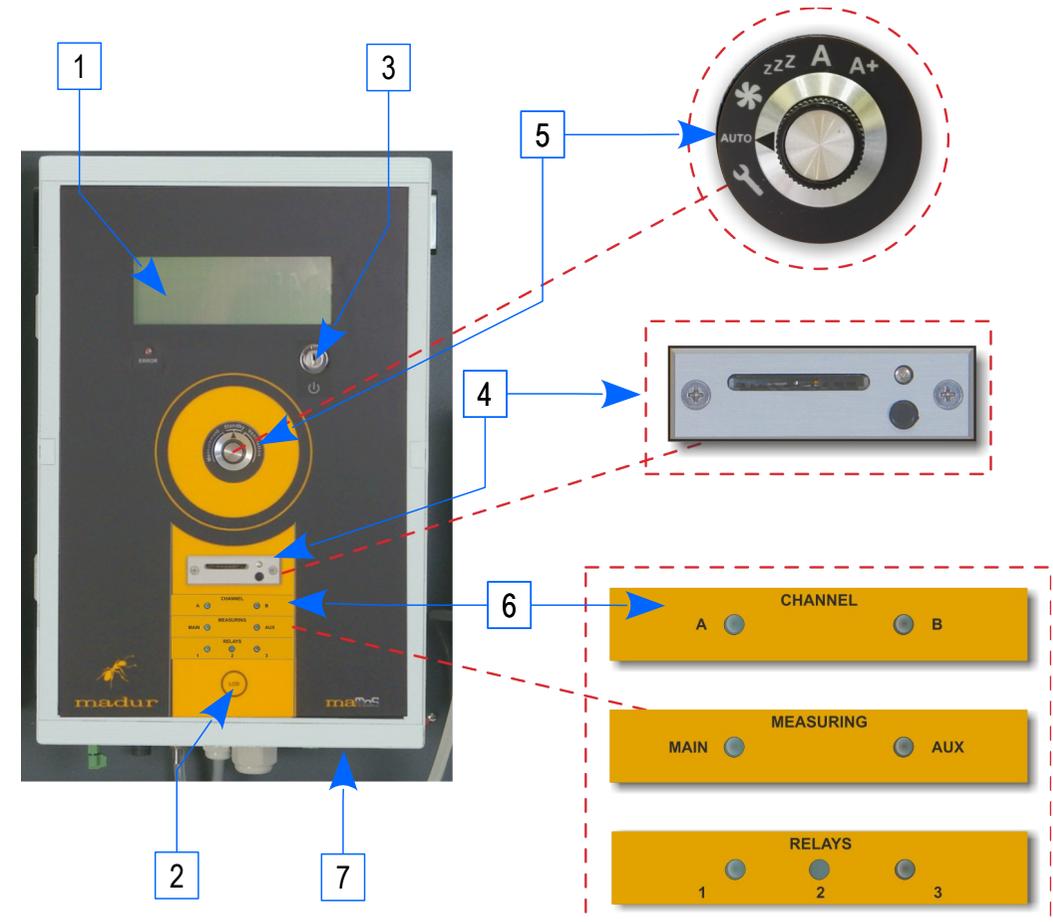
1. Analyser module
2. SMPS – switched mode power supply – converts 115VAC / 230VAC to 24VDC
3. Gas dryer
 - a) MD2 type
 - b) MD3 type
4. PVC condensate bag
5. Mounting plate
6. Hanger – allows for fast and convenient installation of mamos monitor



2.1.1. Analyser module

This is the main part of mammos online monitor. In this module gas sensors, and other necessary components are installed. The main elements of the analyser's module are:

1. 4-line Display for results and important notifications
2. "LCD" function button – for simple navigation between LCD screens
3. On/Off key
4. Optional Data-logger module with SD card for collection of measurement results
5. Work knob
6. LED status diodes
(installed for corresponding device configuration)
7. Panel with gas and electric connectors (at the bottom)
8. Peristaltic pump (only for analyser with MD2 dryer) – not presented in the picture

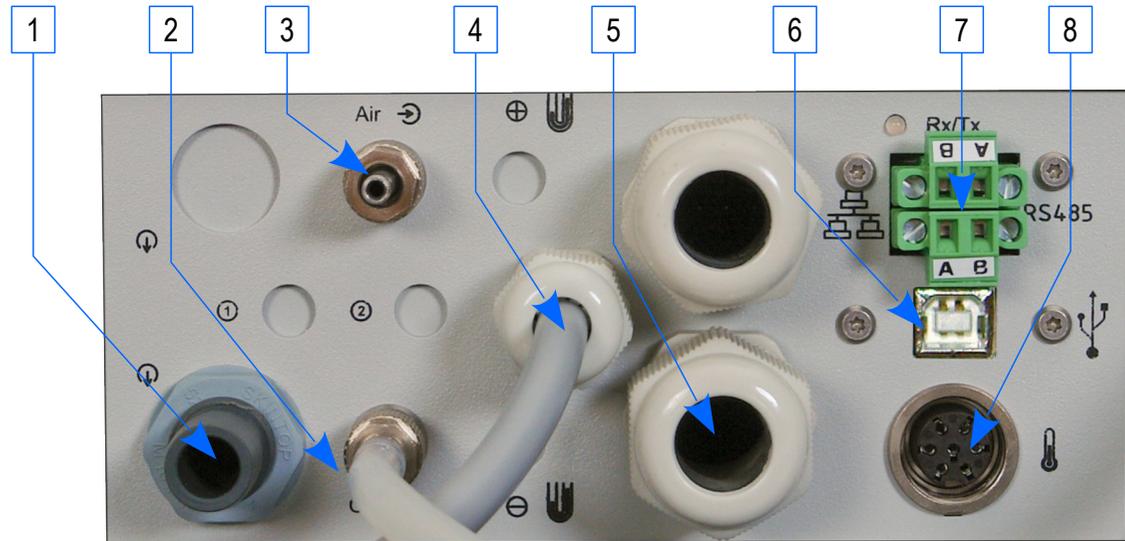


2.1.2. Panel with gas and electric connectors

All gas and electric connections to the analyser are located on one panel, installed in the bottom part of the analyser. Depending on the configuration of the device, connections may differ. For convenience, all of them are described with icons and, if necessary with text. Below we describe the typical gas and electric connectors.

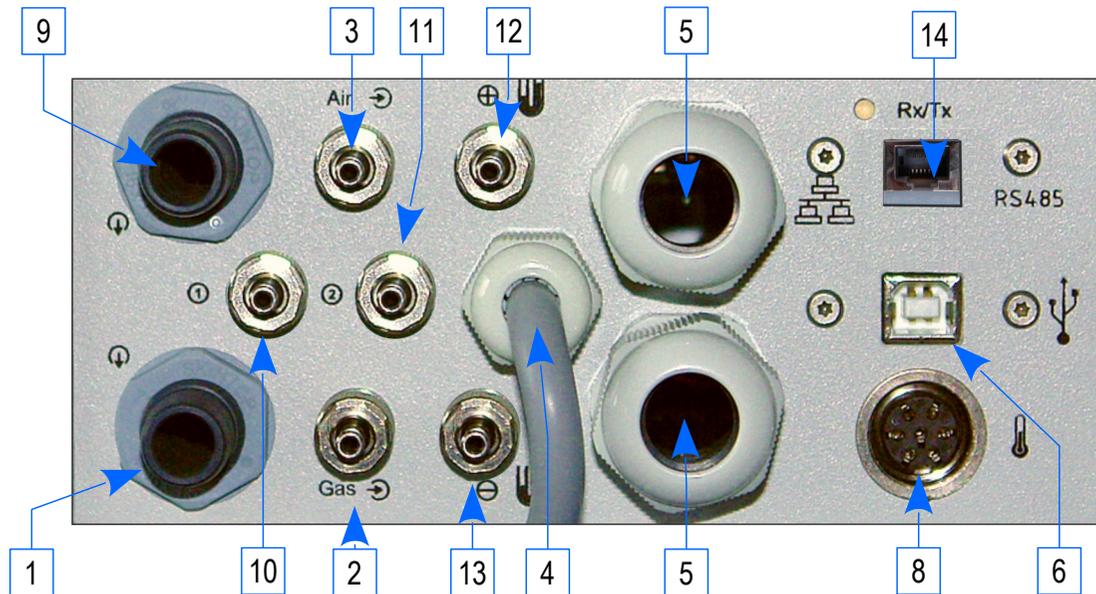
Connectors for basic mamos configuration:

1. Gas outlet – waste gas
2. Gas inlet (from the gas dryer) (Błąd: Nie znaleziono źródła odwołania)
3. Fresh air inlet (ventilation) (Błąd: Nie znaleziono źródła odwołania)
4. Power supply cable (from SMPS)
5. Cables' pass
6. USB B connector – connection with PC (with madur software)
7. RS485 connector – connection with PC (with madur software)
8. Thermocouple connector



Connectors for Hi-press version of analyser with 2 gas channels:

9. Waste outlet from AUX gas channel (for analyser with 2 gas channels)
10. Gas inlet from gas dryer (High-pressure configuration)
11. Gas outlet to gas dryer (High-pressure configuration)
12. Differential pressure port (+)
13. Differential pressure port (-)
14. LAN connector – connection with PC within LAN network only (with madur software) – replaces RS485 connector (7)



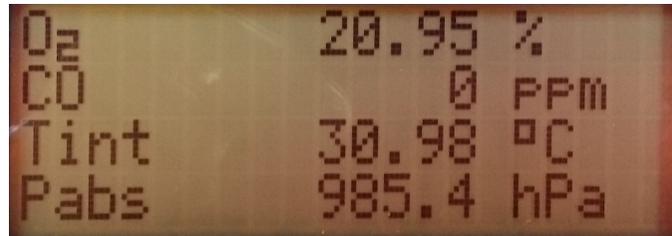
On the bottom part of mamos analyser, besides the connectors panel, there is also a separate MODBUS RTU (RS485) connector.

2.1.3. Display

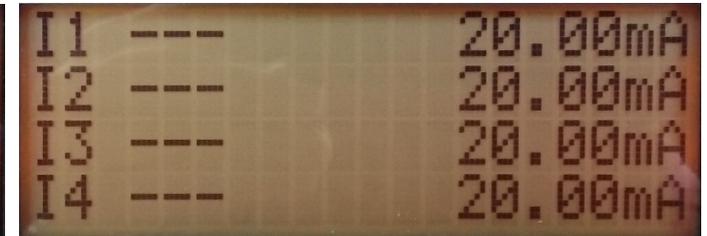
Mamos has one large display to present results, but also to notify user with important information, current work phase, status of analogue outputs, potential errors, etc.



Warming up will last for another 14 min. 45 sec.
Current time 10:47:57
The next measurement will be performed from place A (for twin split configuration)



Screen with results. From mamos PC program user can individually define what values will be presented on screen. It is possible to define 2 screens (8 different values).



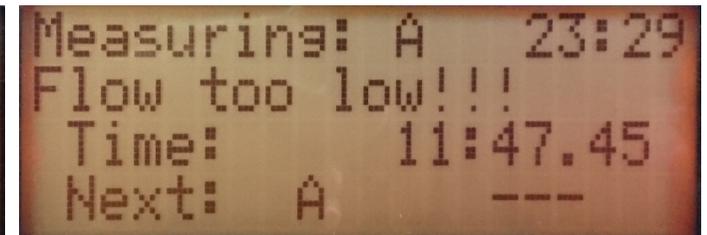
Screen with status of current analogue outputs.



Screen with status of voltage analogue outputs.



Screen with status of relays, digital inputs and PWM output.



Mamos is in measurement phase (from gas source A), but flow through the analyser is below threshold value, and mamos reports an error: *Flow too low!!!* (See chapter 6.5)

Mamos switches through its screens automatically. User can go to the screen of interest using LCD button  located in the bottom of analyser's below display.

2.1.4. Work knob



Since 2017 work knob is a standard equipment of every mammos analyser. It ease the performance of service maintenance or random check of analyser's work. Knob allows to manually select analyser's work phase and it overrides automatic selection.

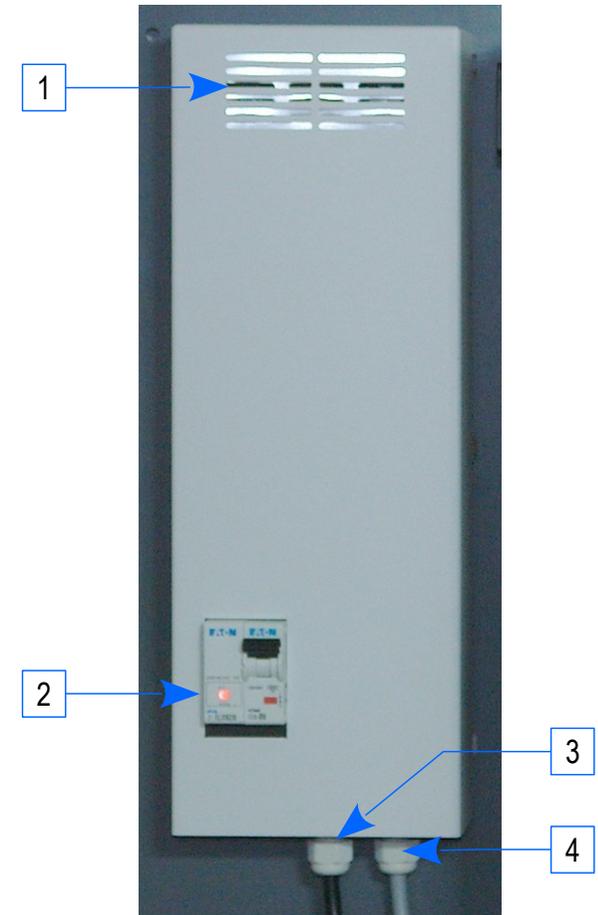
More information on selected work modes can be found in chapter 5. Available selections:

-  Service mode (for madur internal use)
- **AUTO** Analyser works according to currently selected program settings
-  Ventilation
- **zzz** Standby - 5.1.6
- **A** Enabled Measurements from channel A
- **A+** Enabled channel A including auxiliary channel (available only when analyser is equipped with AUX channel)
- **B** Enabled measurement from channel B (available only for analyser in Twin-split configuration)
- **B+** Enabled channel B including auxiliary channel (available only when analyser is in Twin-split configuration and is equipped with AUX channel)

2.1.5. SMPS – switched mode power supply

Madur provides power supply module that converts mains (either 230 VAC or 115 VAC) to 24VDC required by mamos. **SMPS** provides not only for the analyser but also for gas dryer and for heated hose steering relay. In case of Split configuration and Twin-split configuration, every remote MD3 dryer is equipped with its own SMPS module.

1. SMPS cover
2. Power switch with fuse – depending on version there are 1÷2 fuses (analyser + MD3 dryer, heated hose)
3. Mains cable
4. Supply cable – depending on version there are 1÷3 supply cables (for: analyser, MD3 dryer, heated hose)



2.1.6. MD2 gas dryer

The basic version of gas dryer. It is recommended for low-demanding applications, e.g. for laboratory use, or other, where humidity and dust / soot pollution is low.

Also recommended in measurement of gases, that are difficult to be affected by water presence, e.g. O₂, CO, CO₂.

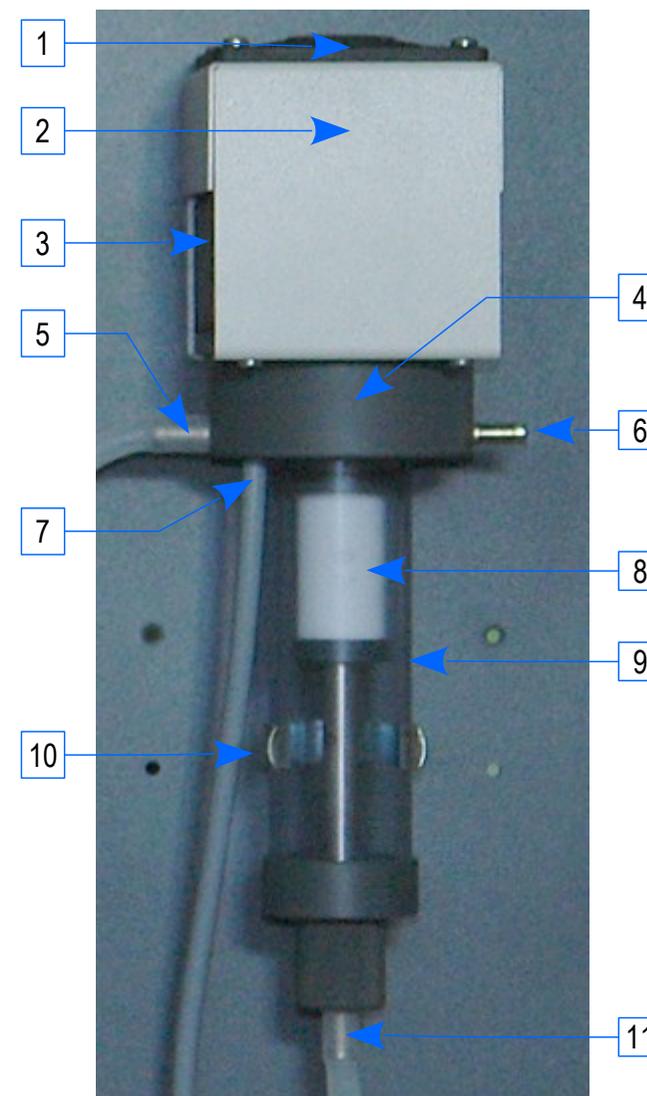
MD2 is a condensation type of gas dryer. Vapour in the gas stream is forced to condense by rapid cooling down of the gas. Condensate is then removed with the help of peristaltic pump. Cooling down of the gas is done with peltier module. Cold side of peltier module is in contact with gas, the heat from the hot side is removed with radiator supported with the fan.

Gas dryer should be able to cool down the gas below its dew point. MD2 dryer is able to keep the cooling temperature about 20°C below the ambient temperature (if possible MD2 dryer will try to keep circa 5÷6°C).

Gas dryer's fan is enabled when analyser is energised. It is forbidden to disable the fan, as it will damage the peltier module.

MD2 dryer is not equipped with its own peristaltic pump – removal of the condensate is provided by the peristaltic pump installed inside the mamos analyser.

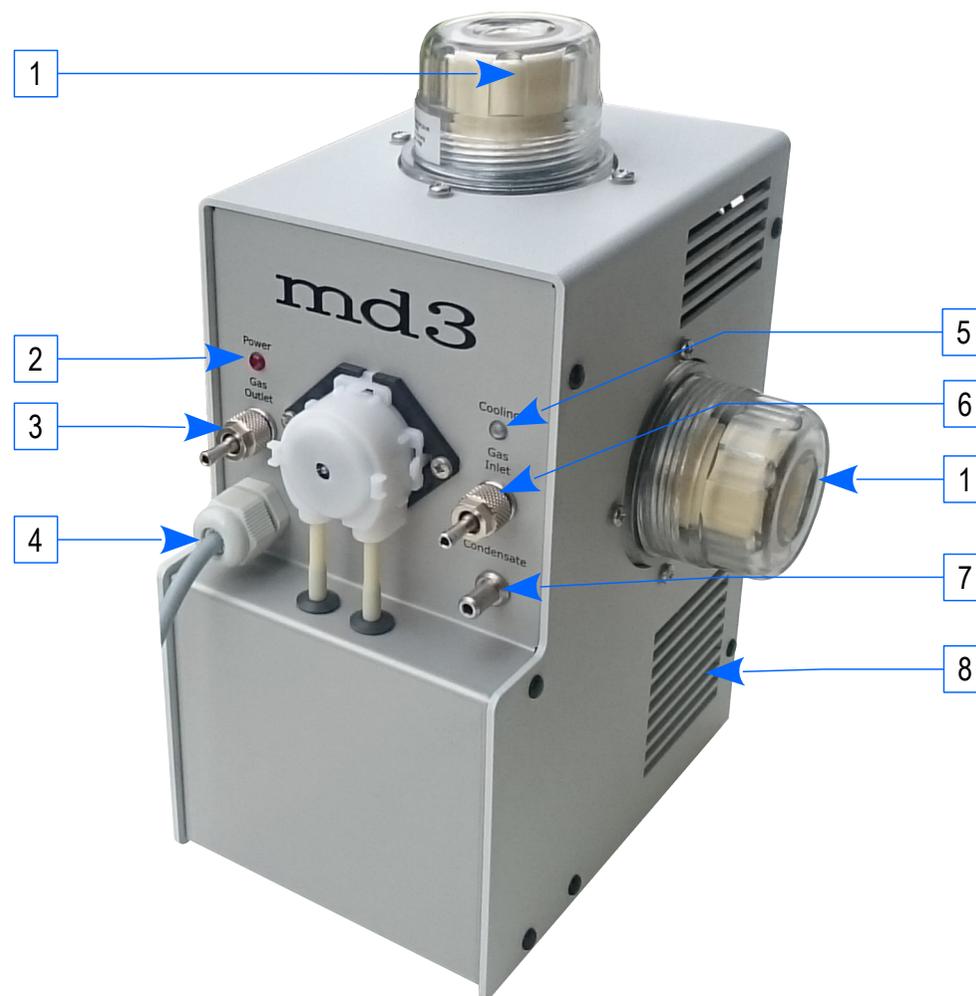
- | | |
|---|---|
| 1. Fan for cooling peltier's radiator | 7. Electric cable from analyser (supply and steering signals) |
| 2. Radiator's cover | 8. PE filter (by default V-FELM051) |
| 3. Peltier's radiator | 9. Condensate trap (made of PVC) |
| 4. Gas chamber where gas is cooled | 10. Spring holder |
| 5. Gas outlet (dried gas to the analyser) | 11. Condensate outlet (to PVC condensate bag) |
| 6. Gas inlet (wet gas from process) | |



2.1.7. MD3 gas dryer

MD3 dryer is more efficient conditioning unit in comparison to MD2 (MD3 cooling capability is about 30°C below ambient temperature). It is advised to be used in all industrial applications, like combustion process control, where humidity and pollution level is significant. It is also advised to pair MD3 dryer with other optional equipment: Heated line, Heated filter, Stationary gas probe with filter and blow-back option.

1. Fibreglass filter
2. Power LED
3. Gas outlet (dried gas to analyser) (Błąd: Nie znaleziono źródła odwołania)
4. Supply cable (to SMPS)
5. Peltier status LED – informs if peltier module is enabled or not. During normal work, this LED is flashing.
6. Gas inlet (wet gas from process) (Błąd: Nie znaleziono źródła odwołania)
7. Condensate outlet (to the PVC bag)
8. Peltier fan and radiator – to remove heat from peltier's hot side.



2.1.8. Nafion gas dryer

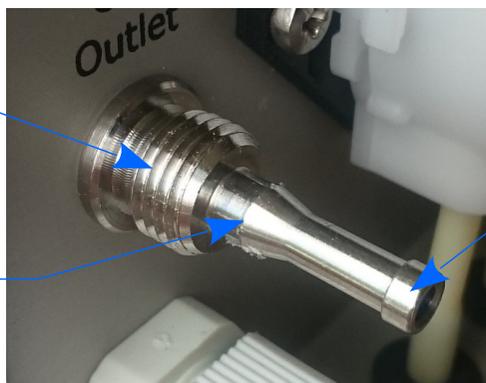
Madur also offers permeation dryer, with **Nafion®** tubing. In permeation conditioner, gas is not being cooled to evoke condensation and gas sample has no contact with condensate (like it happens with peltier dryers). Nafion removes water by absorption as water-of-hydration – water particles are removed from gas stream when they are still in gaseous form – this type of dryer is recommend for measurement of water-soluble gases, like chlorine (Cl₂), hydrogen chloride (HCl) or hydrogen fluoride (HF). Despite that ammonia (NH₃) is also water-soluble gas, nafion dryer is not recommended to use in case of its measurement. Ammonia presents an exposed hydroxyl group (-OH), and therefore it also migrates through nafion membrane, like water does.

2.1.9. Dual-mode gas port



Gas ports in mamos, both in gas dryer and analyser are dual-mode, i.e. user can establish

1. Standard gas connection using 3x2mm silicon tube
2. Pressure secure connection using 4x2mm PTFE tube and secure it with provided nut [4]
3. Nut to secure PTFE tube



- 4. Thread
- 5. Barb for 4x2mm PTFE tube
- 6. Barb for 3x2mm silicone tube



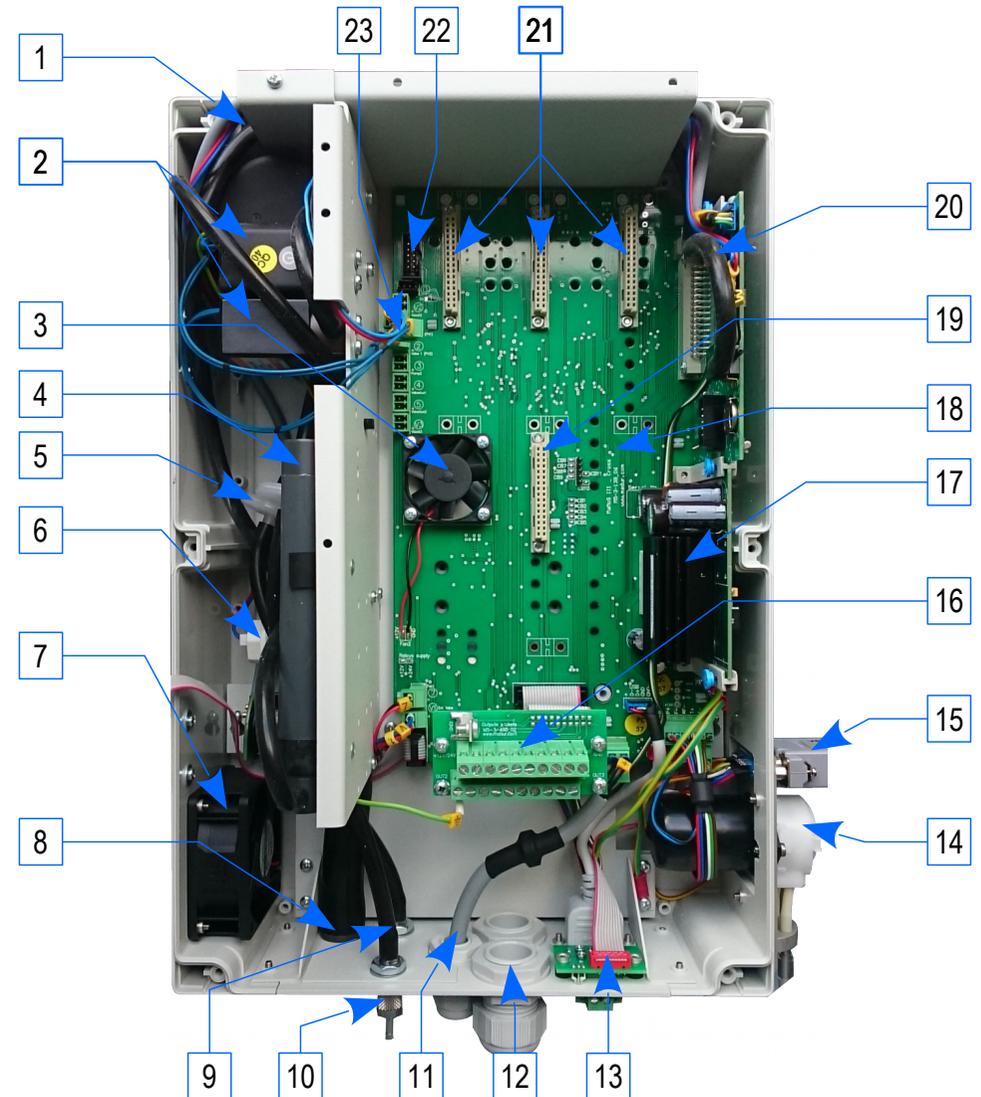
In High-pressure configuration, gas outlet is different than in standard version of mamos analyser. It is, similar to the dual-mode gas port. It allows to use standard silicone hose or PTFE tubing secured with a nut. This type of gas port allows for a secure, air-tight connection with a process (for both inlet and outlet).

- 7. Gas inlet
- 8. Gas outlet (with secure nut removed)
- 9. Standard dual-mode gas port

Matching hoses for hi-press gas port:
 PTFE tube: 8x6mm
 silicone tube: 5x1,5mm

2.2. Inside mamos analyser

- 1 Diaphragm Gas pump
- 2 Set of two solenoid valves for ventilation (2.2.3)
- 3 Main board fan – for uniform redistribution of heat within gas sensors chamber
- 4 Gas damper (to smooth the gas flow)
- 5 Gas filters
- 6 Battery of electrochemical sensors
- 7 Main fan
- 8 Gas outlet
- 9 Inlet of fresh air for ventilation
- 10 Gas inlet (from gas dryer)
- 11 24 VDC supply cable (provided form SMPS)
- 12 Cables pass
- 13 Communication interfaces (USB, RS485, LAN – depends on version)
- 14 Peristaltic pump (2.2.4) for condensate removal (for mamos with MD2 gas dryer)
- 15 Communication cable for MD2 dryer
- 16 Electric terminals – analogue outputs, digital outputs, relays (optional)
- 17 Power supply PCB – redistributes 24VDC from SMPS to other voltages necessary in analyser
- 18 Main (cross) board – is responsible to transmit (cross) signals between different modules
- 19 Extensions slot:
 - for galvanic isolated analogue outputs
 - voltage to current analogue output converter (8x current outputs)
 - others
- 20 CPU board – brain of the analyser. Also allows to connect 4 electrochemical sensors (oxygen + 3 different toxic gases), temperature, pressure sensors.
- 21 NDIR sensors slots
- 22 Data-logger module connector
- 23 Pump, valves connectors



2.2.1. Gas sensors

Mamos can be equipped with one to several (depending on the configuration, even up to eight) gas sensors. Depending on the gas, measurement range, application and other, sensors may be one of four types:

- **electrochemical** sensors: O₂, CO, NO, NO₂, SO₂, H₂S, H₂, HCl, NH₃ (for measurement of dry gas only), Cl₂, others
- **NDIR** (non dispersive infra red): CO₂, CO, C_xH_y, CH₄, N₂O, CHF₃, SO₂
- **PID** (photo-ionic detector): **VOC = volatile organic compounds**.
- **TCD** (thermal conductivity detector): H₂, He.

The most common and standard sensors and their ranges are described on madur's [webpage](#). Though, it is not feasible to predict and describe all configurations of gas sensors and eliminate their possible divergences, and if the required gas sensor and /or concentration was not listed on our webpage, we encourage to contact our sales team for assistance.

2.2.2. Gas pump



SP620 EC-BL - main gas pump in mamos analyser. This **diaphragm pump** is equipped with **brush-less motor**, that in comparison to a pump with traditional motor, is much more resistant to work in dusty environment. By default pump efficiency is set to give 1,5 l/min flow.

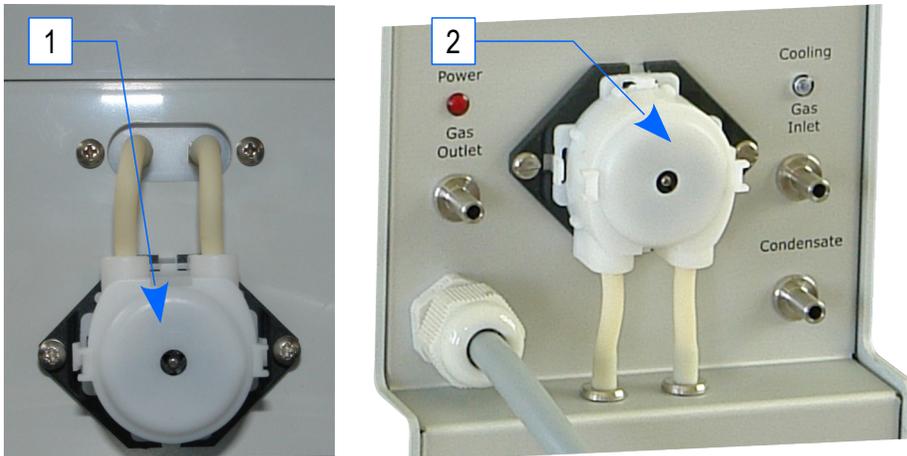
Mamos is equipped with flow control, and if this will drop below certain (adjustable from PC program – by default 0,5 l/min) level, mamos will report the flow error.

2.2.3. Ventilation valve



Gas sensors (of all types) for proper work require periodical ventilation with ambient air. Our on-line analyser handles ventilations automatically. Due to scheduled plan, analyser switches to source of fresh air with help of a solenoid valve. Since August 2015, 3-way solenoid valve was replaced with a pair of shut-off valves. In this, new configuration, one of the valves is always energised, while the other one is resting – this provides more stable heat distribution of mamos components.

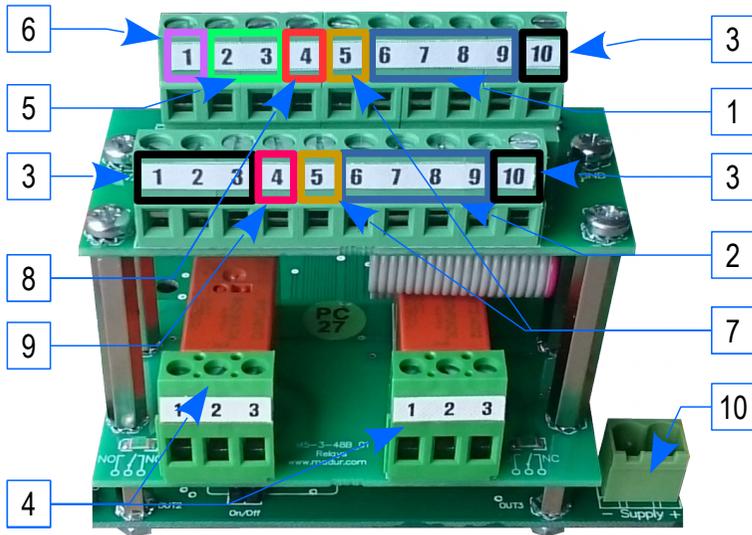
2.2.4. Condensate pump



Peltier element in the gas dryer rapidly cools the gas in order to force the condensation in a very specific place of the gas path, i.e. gas dryer chiller. Directly from the chiller condensate is removed outside (to PVC condensate bag) with help of [peristaltic pump](#). Depending on the version of analyser peristaltic pump is located in different positions:

1. In analyser equipped with MD2 dryer, pump is installed inside the analyser (right wall, in the bottom).
2. If mamos works with MD3 dryer, pump is integrated with dryer

2.2.5. Electric terminals

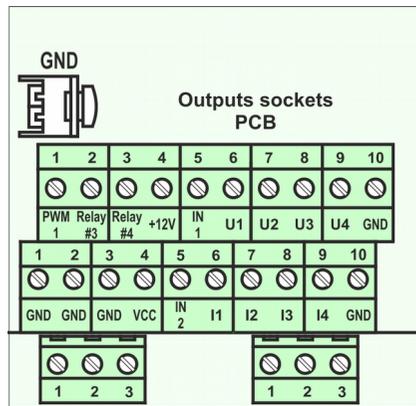


By default mamoS is equipped with analogue outputs:

1. 4x voltage U1÷U4 (0-10V or 0÷5V)
 2. 4x current I1÷I4 (4÷20mA or 0÷20mA)
- Optionally, voltage outputs can be converted to current ones with optional expansion board – in this scenario mamoS has 8x current analogue outputs marked I1÷I8. For proper connection of analogue outputs (and other mamoS connectors) please refer to description shown in the picture below, on the left. Same terminal map is provided in every analyser in a form of sticker inside mamoS casing.
3. GND pins for analogue outputs, PWM and digital inputs. GND pins must be shared (more than one cable can be connected to one GND pin)

Other available outputs:

4. Relay #1, Relay #2 – **SPDT** relays – optional equipment (as an optional board installed below the analogue outputs board).
Relays can switch voltages up to 230V and current below 2A.
Relays' actions are fully programmable via analyser's PC software (please refer to PC program manual)
5. Relay #3, Relay #4 – **open drain** outputs that work in similar way to relays.
Max 500mA current-carrying capacity, Max 24VDC voltage
Relay #3 is programmable as Relays #1 and #2.
Relay #4 is controllable only via MODBUS.
Both Relay #3 and Relay#4 outputs are mamoS standard option.
6. PWM – **pulse width modulation** output (standard option). As in case of open drain outputs, current-carrying capacity of PWM output is max 500mA. Modulation of the pulse is done only via MODBUS.
7. Digital inputs IN1 and IN2 (standard option) – allow to restart / terminate mamoS measurement cycle.
They can also be used in order to control any of Relays #1, #2, #3.



Cross PCB



24VDC



Extra voltage outputs for user convenience (each with max current-carrying capacity: 250mA)

8. +12VDC
9. VCC (= +5VDC)
10. Next to the analogue outputs/ relays module, on the cross board, there is power supply connector 24VDC – connected directly to SMPS – switched mode power supply.

2.2.6. Communication interfaces

Mamos uses **serial communication (UART)** – this allows to use RS485 (previously RS232) interfaces. Other available interfaces (USB, Ethernet) use special signal converters.

By default mamos is equipped with a few communication interfaces:

1. USB – allows to communicate with PC via mamos software (with USB-B cable). This connector is present in every mamos analyser.

USB signals are converted to serial communication with FTDI chip, therefore **USB drivers** are required to work with mamos via USB cable. Drivers install virtual COM port in PC. More details and installation guide can be found in a separate manual concerning mamos PC software.

USB port has the highest priority – this means it will disable other ports (RS485, Ethernet) when USB connection is initialised (USB cable must be connected to both mamos and PC)

2. RS485 allows to connect up to 15 mamos devices. Connector provides two terminals – to be able to continue ring topology (to connect the next mamos device).

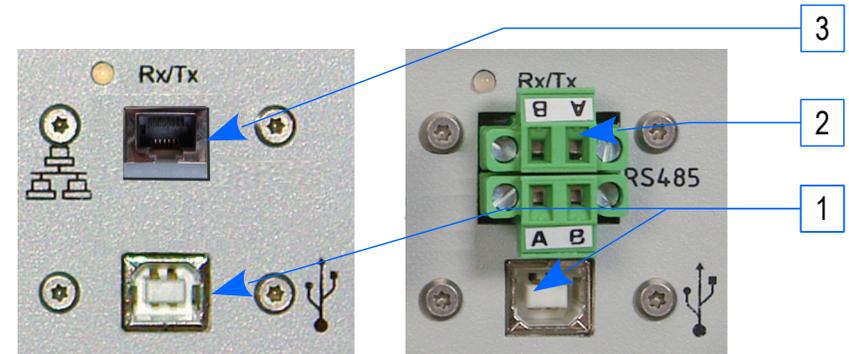
RS485 can be replaced with:

3. Ethernet connector – allows to connect mamos with PC over LAN network. As in case of USB connection, this also “translates” ethernet signals to serial communication. LAN module requires additional installation in PC – instructions may be found in a separate manual.

In the bottom part of analyser (in lid) there is yet another connector for MODBUS RTU communication with PLC's. MODBUS communication is independent from PC communication – it is possible to simultaneously communicate with mamos from PC (using madur protocols, via USB, RS485 or LAN) and at the same time with PLC via MODBUS. MODBUS communication is described in details in a separate manual.

2.3. Optional equipment

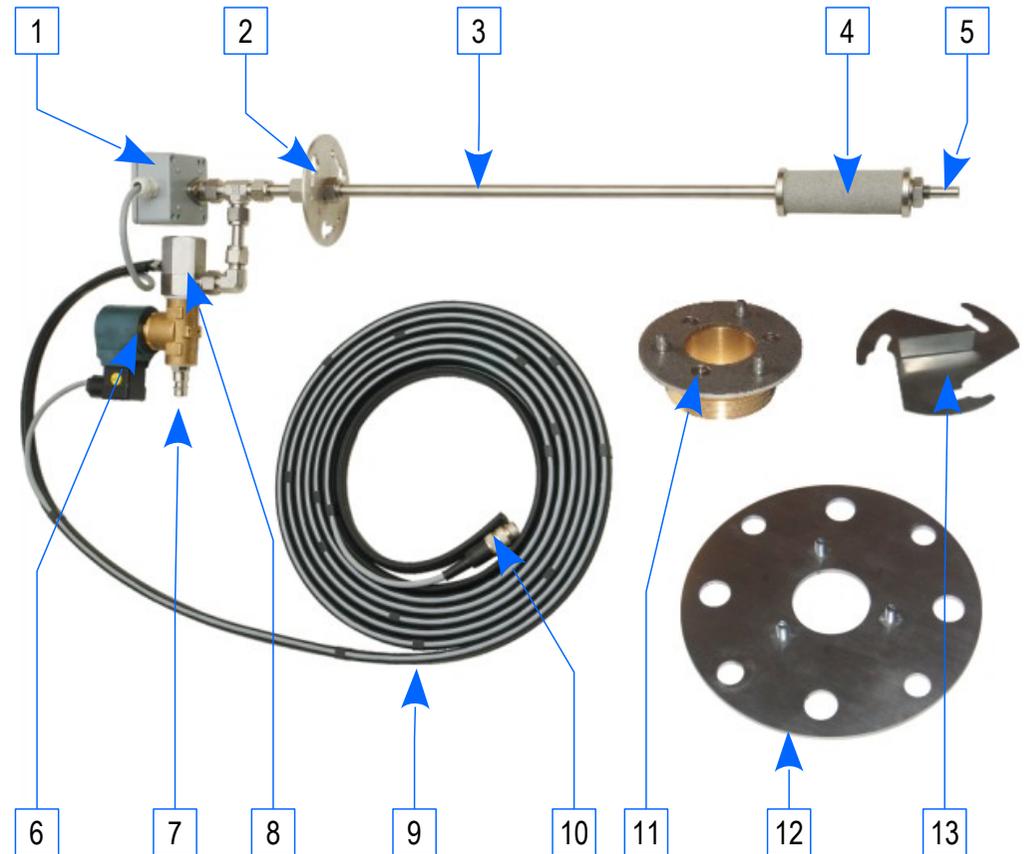
One of the greatest strength of mamos analyser is its modularity, and therefore possibility to adapt to a very specific working conditions and different customers' requirements. Mamos modularity concerns selection of gas dryer, configuration of gas sensors, but also additional equipment, like heated lines, IP55 cabinets, etc.



2.3.1. Stationary gas probe

Stationary gas probe is the first element of the sample collecting system. It is permanently installed in sample extraction point, e.g. on stack, chimney, etc. Like mamos analyser it has modular construction and can be adjusted to ones needs. Picture shows elements of the probe – options that can be ordered:

1. Box where **Thermocouple's** cold junction is located – concerns optional gas temperature measurement
2. Immersion depth regulator – allows to adjust how deep the probe is inserted into a stack.
3. Probe pipe.
4. Optional gas filter. length 90mm, diameter 30mm. Available materials:
 - Siperm R (sintered stainless steel) – working temperature 500° (peak 650°C), pore size ~70µm
 - corundum (Al₂O₃) – working temperature 1000°C (peak 1100°C), pore size ~20µm
5. Thermocouple's tip (hot joint) – concerns optional gas temperature measurement
6. Compressed air pilot valve – enables the source of compressed air for cleaning of gas filter (4). This electro-valve is triggered directly from mamos, it is synchronised with ventilation of gas sensors. Burst of compressed air cleans the filter from soot and dust particles.



7. Quick-coupler for compressed air. For proper cleaning of gas filter (4), it is advised to provide compressed air pressurised to 6÷8 bar (87÷116 PSI)
8. Pneumatic valve. When solenoid valve (6) enables compressed air, it is important that its burst gets only to the filter and not into the analyser. Pneumatic valve closes the gas path between probe and analyser and opens path for compressed air between filter and compressor.
9. Gas-electric cable. Madur provides 3m gas-electric cable, but for the sake of measurement performance it is advised to adjust this cable length to the absolute minimum (in order to avoid unwanted condensation between probe and gas dryer). If the distance between probe and dryer is longer than 3m, a heated hose must be used. One should consider the use of the heated line even at distances <3m. Electric cable transfers signal from temperature sensors (T_{gas} and T_{amb}) to analyser. It is also used for sending the signal to shut-off valve (6).
10. Electric plug

11. M64 adapter
12. ANSI flange adapter. Double standard DN50 and 2"
13. Blank. If probe is removed for maintenance actions. Probe adapter can be closed (so the process gas is kept inside) with help of this blank

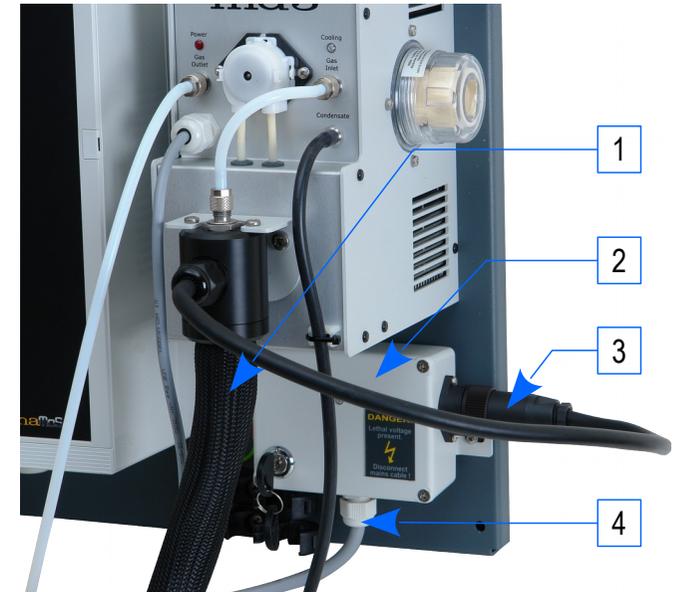
2.3.2. Heated line

Mamos is ex-situ type of analyser, this means that sample is extracted from the process with the Gas pump. Measured processes, like combustion process, are usually hot and wet. Extracted gas sample cools rapidly, and when its temperature drops below the process' dew point, a condensation occurs. Unattended condensation must be avoided for a few reasons:

- solution of measured gases with water – measured compounds are lost and therefore measurement is falsified (decreased results)
- in a consequence of chemical reaction of gases with water, strong acids and/or bases are formed. As highly caustic substances, those can damage elements of gas path (even though the gas path elements are made with very resistive materials, like stainless steel, PTFE, PVC)
- condensed water in larger volumes (more than single droplets), when sucked by gas pump will not be managed by gas dryer – it will enter to gas analyser, onto gas sensors, causing sensor contamination and/or damage.
- If ambient temperature drops below zero, water in the gas tube may froze and clog the path

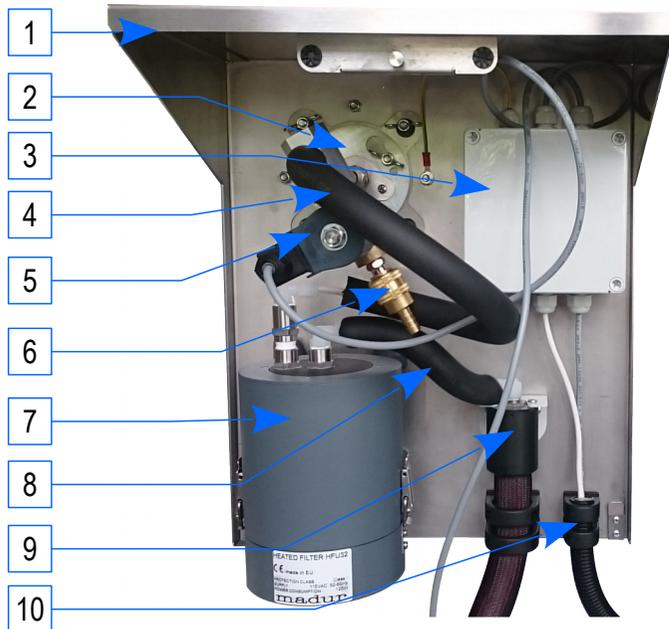
Heated hose objective is to keep the gas temperature above the dew point to avoid situations described above. Madur offers hoses of various lengths (3, 5, 8, 10m and more) and supply voltages (115VAC and 230VAC). Hoses may differ in construction, depended on e.g. hose length or application which it will serve for. Though, the purpose and work principle are the same.

1. Heated hose (version in soft braid)
2. Heated hose driver – controls and regulates the heated hose temperature, that is set to 120°C with regulation hysteresis of 2°C
3. Control and supply cable for hose
4. Supply cable 115VAC / 230VAC for hose and 24VDC for driver

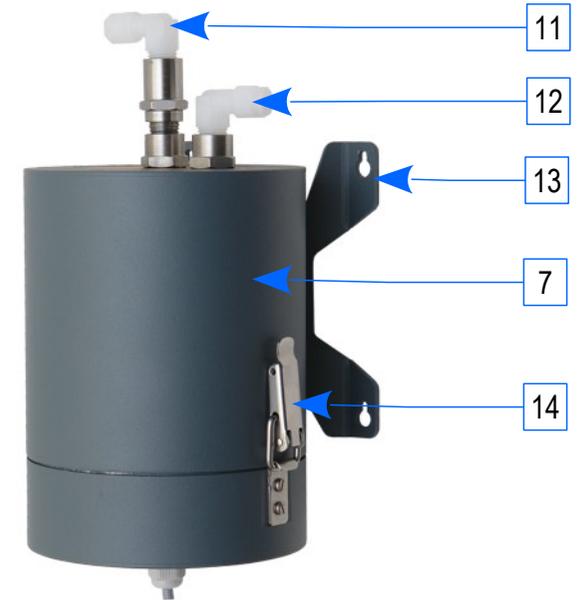


2.3.3. Heated filter

In applications where gas is heavily polluted with dust and soot, filter installed on the probe may be insufficient. In such cases, or in applications where gas temperature exceeds working temperature of probe's filter, it is advised to use additional filter installed in between gas probe and heated hose. External filter also must be heated to prevent condensation (otherwise water with filtered material would create muddy, tacky substance). Filter's temperature is set to 120°C with 2°C hysteresis. If mamos analyser is delivered with a complete set of accessories for sample collection, i.e. probe, heated filter and heated line, the accessories are installed in special stainless steel housing. Filter is delivered with additional stainless steel inlet – replacement of filter is fast and simple, thanks to quick release mechanism (14). Replaced filter may be then cleaned with compressed air, detergents, etc. and prepared for another swap.



1. Stainless steel housing
2. Gas probe
3. Controller box – supply for heated filter, thermocouple signal from probe, trigger for probe's filter
4. Insulated gas connection between probe and filter
5. Electromagnetic pilot valve
6. Pneumatic connection for compressed air
7. Heated filter
8. Insulated gas connection between filter and heated hose
9. Heated hose
10. Electric cable (from mamos) – thermocouple signal and triggering cleaning of probe's filter.



11. Filter's inlet port (from probe)
12. Filter's outlet port (to heated hose)
13. Filter's hanger
14. Filter's quick release

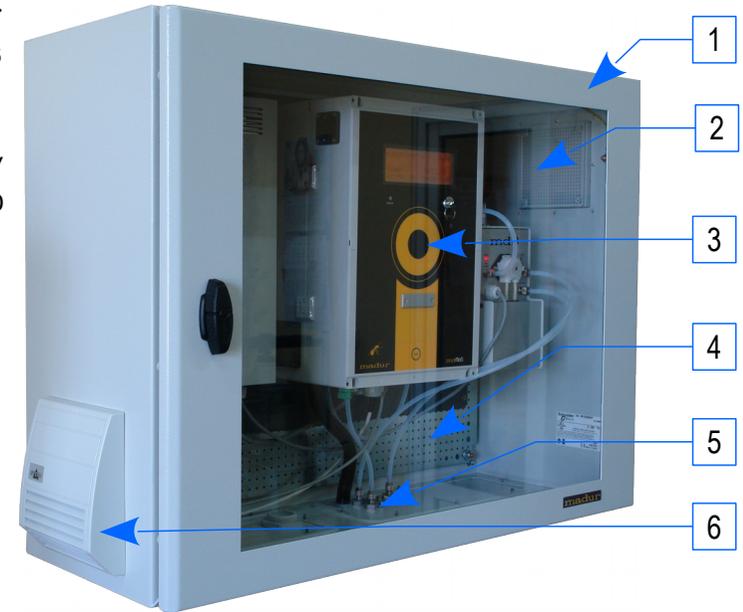
2.3.4. IP55 cabinet

Whenever it is necessary to install mamos analyser outdoors, it must be protected against harsh weather conditions. Madur offers **IP55** cabinet for mamos and its accessories. Because mamos components generates heat, cabinet must be ventilated.

IP55 cabinet provides protection: against dust (*Ingress of dust is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment*) and water (*Water projected by a nozzle (6.3 mm) against enclosure from any direction shall have no harmful effects*). IP55 is equivalent to NEMA 12.

1. IP55 cabinet
2. Fan guard – outlet
3. Mamos with accessories in compact configuration
4. Montage panel
5. Gas and electric ports
6. Fan guard with IP55 fan – inlet

Cabinet should be installed out of direct sunlight. Ambient temperature range for proper work is 0°±35°C. If temperature is out of this range cabinet should be additionally equipped with air conditioning module.

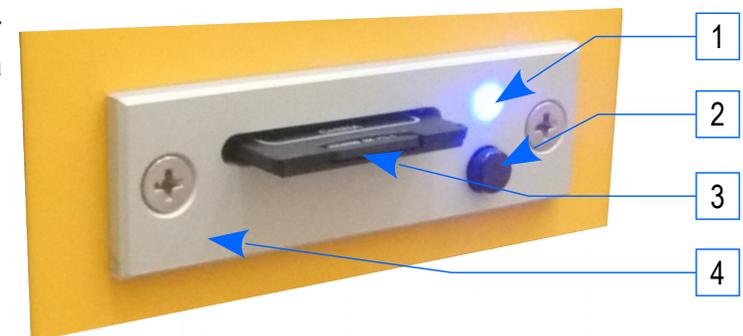


2.3.5. Data-logger

Mamos can present results as analogue signals (current or voltage signals), also in digital form (RS232 with PC or MODBUS with PLC communication). Additionally, results can be saved in binary form to files stored on SD card via optional equipment: data-logger.

1. Status LED
2. Control button
3. SD card
4. Data-logger module

Data-logger is plug and play equipment and can be easily added at any point of device lifetime.



Mamos uses FAT-16 file system format with cluster size 64kB – this limits the size of SD card to 4GB. Bigger SD cards (including SDHC) are possible to use, but FAT-16 will limit their size also to 4GB. Mamos stores files in root folder only – maximum limit of files in root folder in FAT-16 is 512 = this is the max limit for automated storage. User can manually create sub-folders and move files there.

Single “package” of results is 512 bytes. Package contains results from every sensor and also every calculated value. Single file can store 10.000 packages = max. size of file is 5MB. After 10.000 limit is reached, mamos creates new file. The file name is the next number from the device's internal counter (for example 0000012.mrp) which counts the number of files created by the monitor – therefore there is a risk of overwriting a file if the same SD card is being used in different analysers (it is advised to move already stored files to a new folder, e.g. named with device serial number).

Minimal interval between data storage is 10 seconds. By default the interval is set to 30 sec.

Due to the aforesaid, mamos can store: 10 (seconds interval) x 10.000 (packages in one file) x 512 (files in root directory) = 51.200.000 seconds of storage, i.e. >592 days → almost 1 year and 8 months of constant, unattended storage.

Because data is stored in binary form, those files must be “translated” to more understandable form. This is possible with help of mamos PC program, that can convert binary data to CSV file, that then can be edited in Excel-like applications.

2.3.5.1. Control button

It is not advised to remove SD card from data-logger when records takes place – file is not terminated properly and cannot be read. It is also possible that FAT-16 system will be corrupted. In this situation SD card must be reformatted and all previously stored data is lost.

To terminate storage of results, short press the control button. Mamos will properly close the currently opened file – LED is quickly flashing (see below). LED will go OFF when it is safe to remove the card.

If card is not removed from slot, after 10 seconds mamos will initialise the card again in order to resume storage.

2.3.5.2. Format SD card

Control button also allows to format SD card. In order to perform formatting:

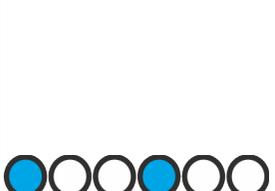
1. Press and hold control button
2. Insert SD card to data-logger
3. When Status LED starts flashing, release control button

4. After SD card is formatted, data-logging will proceed.

Alternatively, card may be formatted in PC using external programs. Important settings: format type FAT-16, cluster size 64kB.

2.3.5.3. Status LED

LED on data-logger informs user about work status, potential errors, and when SD card can be removed from slot.

	LED OFF	<ul style="list-style-type: none"> • No SD card in data-logger • Control button was pressed – records has been stopped – it is OK to remove the card from the slot.
	LED ON	<ul style="list-style-type: none"> • Data-logging – measurement results are being stored to SD card. Data-logging interval can be set in mamos PC program.
	LED quickly flashing (10x per second)	<ul style="list-style-type: none"> • Initialisation of SD card that was just inserted. Initialisation lasts for about 5 seconds, during which card parameters are being read • File has reached 10.000 records and a new file is being created • Formatting of SD card • Control button was pressed – records being stopped – please wait before removing the SD card from the slot
	LED slowly flashing (1x per second)	<ul style="list-style-type: none"> • Data-logger ERROR. Possible reasons: <ul style="list-style-type: none"> ◦ incorrect file format (other than FAT-16) ◦ card is not formatted ◦ limit of 512 files in root directory has been reached ◦ SD card is write-protected ◦ SD card malfunction ◦ others • Possible solutions: <ul style="list-style-type: none"> ◦ Format SD card in mamos ◦ Format SD card in mamos ◦ Move some files to e.g. a sub-folder ◦ Remove write-protection ◦ Change SD card to another one
	LED seldom flashing (1x per 3 seconds)	<ul style="list-style-type: none"> • SD card is in data-logger, but recording has been disabled from PC program (Off stage)

2.4. Differential pressure sensor

By default, mamos is equipped with differential pressure sensor that is used for controlling the flow through the analyser.

Optionally, it is possible to order additional differential pressure sensor – in this case additional gas ports are installed.

This additional pressure sensor can be used for measurement of:

- Flow velocity in stack – measurement is performed with a help of [Pitot tube](#) – it is indirect measurement: flow is calculated based on the difference between static pressure (connected to Differential pressure port (-)) and total pressure (connected to Differential pressure port (+)). Mamos can use both L-type and S-type tubes. Additionally S-type tube can be equipped with air-compressed cleaning system (similar to one introduced to Stationary gas probe)
- [Draught](#) – pressure difference in stack due to [Stack effect](#).

3. POSSIBLE WORKING CONFIGURATIONS

Yet another example of mamos modularity is how the analyser can be installed. Below we present the most popular configurations.

3.1. Compact configurations



The most popular of mamos configurations. All necessary equipment (analyser, dryer, SMPS) are gathered on one mounting plate. This configuration is advised in applications where installation of analyser is possible right next to the sample collection point, and position of analyser is in convenience of maintenance crew.

3.2. Split configuration



Wherever it is not possible or convenient to install the analyser right next to the sample collection point, split configuration of mamos analyser comes in handy. Analyser module is separated from the dryer. Each module has its own SMPS and can work independently. In split configuration gas dryer is installed very near the collection point, to ensure that gas is conditioned (i.e. dried and filtered) as close of the source as possible, to avoid unwanted condensation. Dry and clean gas sample is then supplied to the analyser, that is installed meters away from collection point. In applications where collection point is remote from the location of the analyser, this type of configuration allows to reduce the length the heated line and therefore to reduce the costs of entire installation.

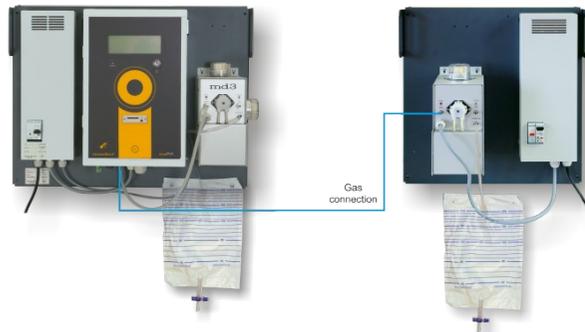
Example of use: gas dryer is installed high at the stack (dozens of meters above the ground), analyser is installed at ground level where maintenance crew can easily monitor combustion parameters, and from where analogue signals can be connected to users PLCs.

3.3. Twin-split configuration



Twin-split configuration is a variation of the split configuration, but this one allows to measure from two different locations. It consists of mamos and two gas dryers (every module with its own SMPS). Collection points are conventionally named A and B. Measurements are taken in turns, i.e.: measurement place A, ventilation, measurement place B, ventilation, measurement place A, and so on. Mamos informs the user, from where the measurements are taken: on screen, LED status diodes (installed for corresponding device configuration), if necessary on relays and MODBUS registers.

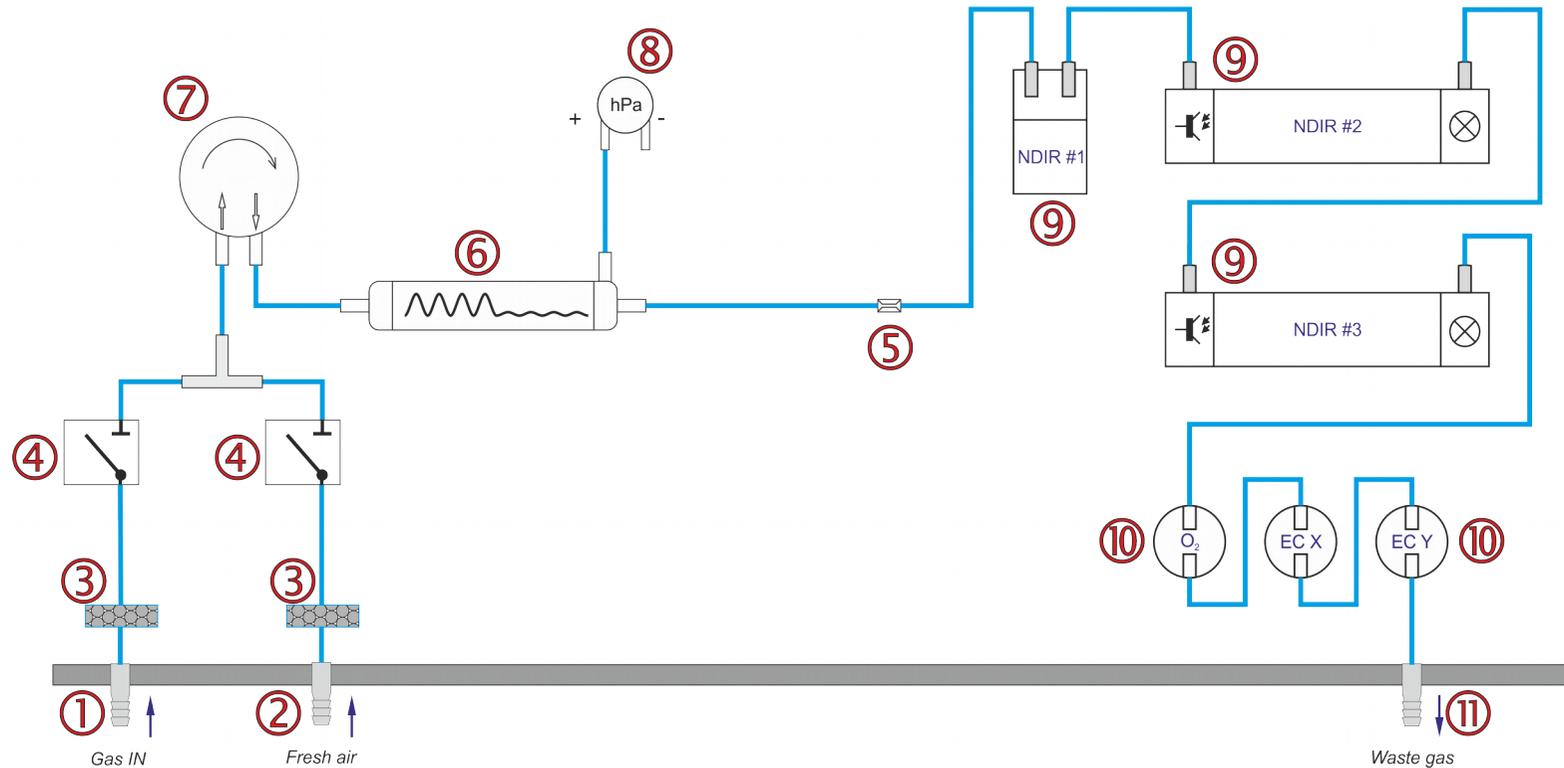
3.3.1. Twin-split configuration with one remote dryer



Yet another twin-split configuration that is a combination of compact and split configurations. Mamos is set to work in twin-split mode (measures in turns from places A and B), the difference is that one of the collection points is located right next to the installation of mamos in compact configuration.

4. GAS CHANNEL

4.1. Single gas channel, basic configuration



- | | | |
|---|--|---|
| 1. Gas inlet (from the gas dryer) (Błąd: Nie znaleziono źródła odwołania) | 4. Set of two solenoid valves for ventilation (2.2.3) | 8. Differential pressure sensor that controls flow through the analyser |
| 2. Fresh air inlet (ventilation) (Błąd: Nie znaleziono źródła odwołania) | 5. Nozzle (to dam the gas in order to control flow with pressure sensor) | 9. NDIR sensors |
| 3. Internal filters | 6. Gas dumper | 10. Battery of electrochemical sensors |
| | 7. Diaphragm Gas pump | 11. Gas outlet |

4.2. AUX gas channel

AUX channel is depicted in orange rectangle:

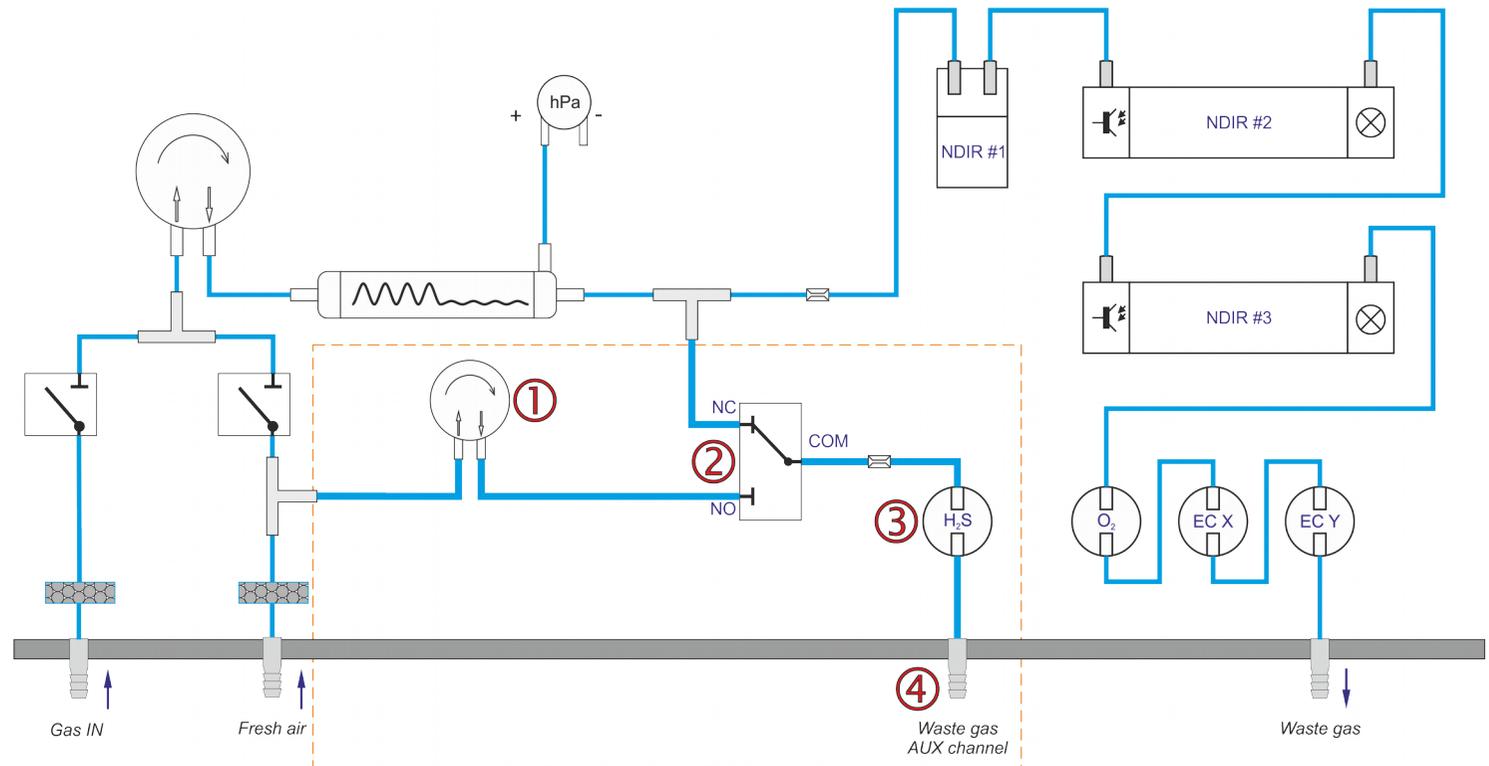
1. Purging pump
2. Additional 3-way valve
3. AUX sensors
4. Waste outlet from AUX channel

Some electrochemical sensors are more sensitive than others.

Mamos often works in applications where there is a risk that sensors will be exposed to concentration higher than their range and therefore could be damaged.

For these two cases mamos can be equipped with additional (AUXiliary) gas channel, where those sensitive sensors are installed.

AUX channel can be disabled by mamos with electromagnetic valve [2]. Then, sensors in AUX channel [3] are ventilated with ambient air, with help of the purging pump [1]. Simultaneously sensors in the main channel are still measuring.

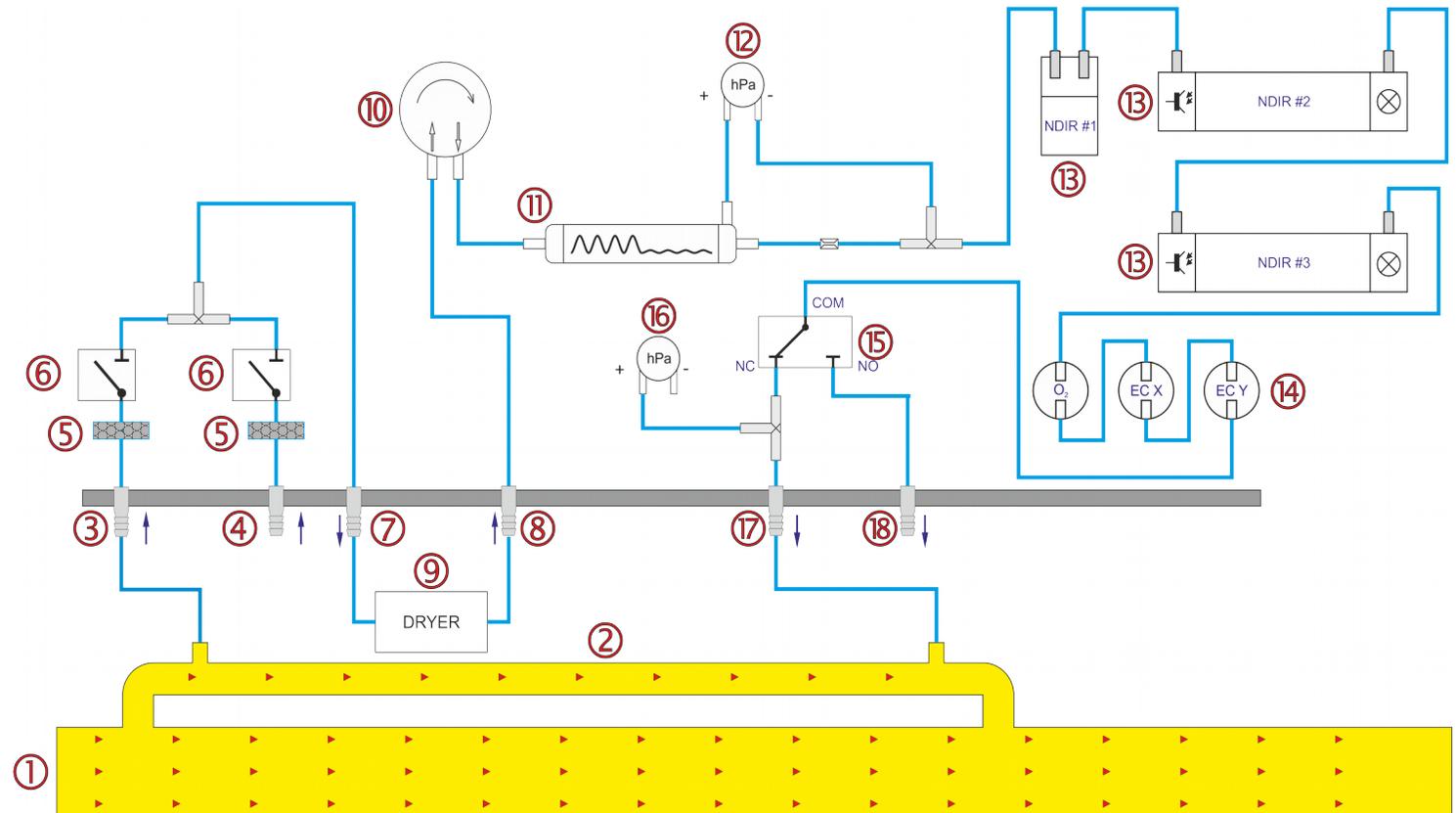


AUX channel can be disabled under one of two conditions:

- timer switch – sensors in AUX channel are performing measurements only for the first moments of the measurement phase (this time is adjustable in mamos PC software). After AUX time is over, AUX channel is being disabled. This setting is typical for H₂S sensor in BIO gas applications.
- range switch – sensors in AUX channel are measuring only until concentration on a triggering sensor is within acceptable range. If range on triggering sensor is exceeded, the AUX channel is disabled (until concentration returns to the acceptable limit). This setting is typical in combustion process applications – where high CO concentrations can be expected – potentially harmful to CO sensor, but also others, like H₂ sensor (that shows high cross-sensitivity to CO gas). Triggering sensor and range can be set via mamos PC program.

4.3. High-pressure configuration

1. Process under pressure
2. Bypass in process from where gas sample is extracted / returned
3. Gas inlet (from process)
4. Inlet of fresh air
5. Internal filters
6. Pair of cut-off valves for ventilation
7. Gas outlet (to gas dryer)
8. Gas inlet (from gas dryer)
9. Gas dryer
10. Main gas pump
11. Gas damper
12. Differential pressure sensor (controls flow through analyser)
13. NDIR sensors
14. Electrochemical cells
15. 3-way valve for ventilation (to prevent air being returned to process)
16. Differential pressure sensor – controls pressure in process
17. Gas outlet – return to process after measurement
18. Ventilation gas outlet



Mamos can work in applications where it is necessary not to disturb the balance of the measured process – this concerns e.g. process under pressure, or when measured gas must not be released to the atmosphere. In such cases, mamos construction is prepared accordingly, i.e. all gas ports are screw-secured (on PTFE tubes), all internal gas links are secured against disconnection.

Mamos controls the pressure of the process against atmospheric pressure [16]. In case the pressure exceeds safe level (safe for mamos components like gas sensors, etc.) electromagnetic valves shut-off from process and appropriate error is reported.

In this construction, gas collected from process [1] is returned there after being measured [17]. During ventilation, process is also undisturbed, because ventilation outlet [18] is separated, and mamos switches additional valve [15] to release ventilation air to atmosphere.

Measured process can be of maximal pressure (relative to atmosphere) = 0,8 bar (11,6 psig) – this is possible for NDIR sensors and O₂ partial-pressure sensor (MOX-1). In case analyser equipped mainly with electrochemical cells (that usually do not stand well changes of pressure) the maximal process pressure can be 0,1 bar (1,45 psig). Possible overpressure is always established versus the analyser's configuration.

The diagram above, shows another, non-standard feature, i.e. in case where mamos is installed in humid ambient conditions (tropics) it may be necessary to dry not only the process gas but also the gas used for ventilation. In this scenario, gas dryer [9] is installed after solenoid valves [6]

5. WORK MODES

Mamos analyser can be adjusted to a specific application also in terms of work time regime. Measurements can be performed continuously, or at a very specific moment of a day. They can be also triggered by user (user's process) via digital input.

5.1. Work phases

Each of the work mode is performed in cycles, where there are specific work phases. Phases that are crucial for proper work of analyser non-adjustable, predefined by madur, other phases may be adjusted according to requirements of measured process.

5.1.1. Initial phases

Initial phases are essential for proper work of analyser, cannot be omitted nor modified. They exists only at the very beginning, after the analyser has been powered on.

5.1.1.1. Warming up

Warming phase occurs right after analyser is powered on. Device performs initial tests of its status and waits for the system temperature to stabilise. During this phase no usable measurements are performed. Time for Warming phase is fixed to 15 minutes.

5.1.1.2. *FirstZeroing*

FirstZeroing phase is the final stage of Warming phase, where sensors are being prepared for work and are ventilated with ambient air, and their signals are zeroed. FirstZero time is fixed to 2 minutes.

5.1.2. **Ventilation**

Ventilation starts each measurement cycle. During Ventilation sensors are provided with neutral gas and perform zeroing. During this phase no usable measurements are performed, but sensors measure and mamos shows their results on the display. Ventilation time is set in the PC program. By default it is set to 15 minutes. It is advised not to set it below 5 min.

REMARK: The first work cycle that occurs after the initial phases (after sensor is powered on) does not start with Ventilation phase but at once with the Measurement phase. It is because zeroing of sensor was just performed during the FirstZeroing phase.

5.1.3. **Infusion**

The Infusion phase precedes directly the Measurements. During infusion, mamos is supplied with measurement gas and performs measurements but due to the delay caused by the gas course and the sensors' reaction time the measurement results can be underrated. Duration of infusion is constant and equals 1 minute.

5.1.4. **Measurement**

Measurement is the main phase for every work cycle. It occurs right after the Ventilation. During this phase, sensors are provided with the measured gas and performs usable measurements. Results are presented on display. Time of the Measurement phase depends on the selected work mode and can last from a dozen of minutes up to 31 days. This time is adjustable from PC program. By default it is set to 4 hours.

Valves, pump control and analogue outputs act as they were programmed to behave during Measurement phase in PC program.

5.1.5. AUX channel

If the analyser is equipped with AUX gas channel, and it is time-triggered, it is possible to adjust (via PC program) the duration of measurements of sensors installed there. AUX phase is usually shorter than Measurement phase (but it is possible that both phases are of the same duration)

5.1.6. Prestandby and Standby

Prestandby and a follow-up Standby phases occur after every Measurement phase if the Measurement phase has finished, but a new work cycle has not yet started. Those phases may not occur at all. Purpose of Prestandby phase is to ventilate gas channel and remove any residues of measured gas. This phase last for two minutes and is not adjustable.

Standby occurs directly after Prestandby and is when analyser simply rest. Standby time is not defined, mamos stays in this phase until a new work cycle begins.

5.2. Work modes

Mamos can work according to several predefined programs. Those automatic programs are called work modes. There are several to select from.

5.2.1. Cyclic measurements

Cyclic mode is a simple-one-day mode, i.e. it occurs identically each day, and consists of the consequent same work cycles. Cyclic measurements mode has the following parameters (every of those is adjustable from the PC program):

Code	Description	Default madur setting	Additional information
H1	Moment of the first zeroing	00:00:00	The first cycle starts each day at midnight. The beginning of the new cycle has a higher priority than any current cycle phase. This means that if the beginning of the new cycle occurs before the current cycle finishes the current phase will be interrupted and the device will start a new cycle.
TV	Duration of Ventilation phase	00:15:00	15 minutes
TM	Duration of Measurement phase	01:45:00	1 hour 45 minutes
TA	Duration of measurement in AUX channel	00:15:00	15 minutes. Time-triggered AUX channel is enabled for the first 15 minutes of the Measurement phase. Afterwards, AUX channel is being disabled and sensors are purged with ambient air. For the rest of Measurement phase (1h30min) only the sensors in the main channel performs measurements.
TC	Duration of the entire Work Cycle	02:00:00	2 hours. If (TC > TM + TV) then stand-by phase occurs. In case of default settings stand-by nor pre-stand-by do not occur.

H1 and TC parameters set the beginning time for each cycle during the day. With the default settings for TC, TV, TM there are 12 cycles a day, starting at the following times:

H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H1
Day 1 00:00:00	Day 1 02:00:00	Day 1 04:00:00	Day 1 06:00:00	Day 1 08:00:00	Day 1 10:00:00	Day 1 12:00:00	Day 1 14:00:00	Day 1 16:00:00	Day 1 18:00:00	Day 1 20:00:00	Day 1 22:00:00	Day 2 00:00:00

Cyclic mode – behaviour of the analyser after turning on

TC – Full cycle time

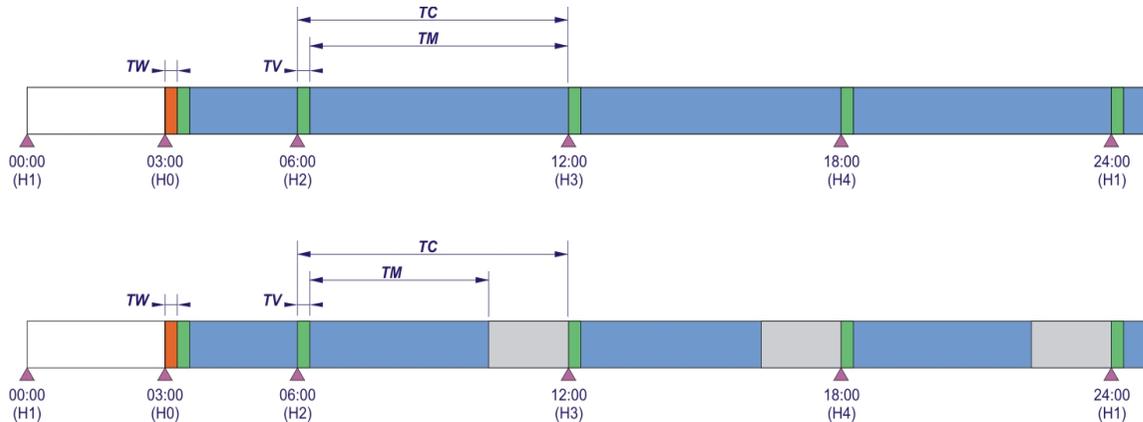
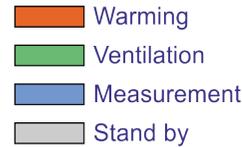
TM – Measurement time

TW – Warming time

TV – Ventilation time

H0 – moment when analyser was powered on

H1÷H4 – beginning of the following work cycles



The device set in the cyclic work mode executes the initial phases, i.e. Warming and FirstZeroing – and then proceeds directly to the Measurements. Duration of the first cycle is asynchronous to all the following, normally planned cycles. The synchronization executes with the second cycle.

In the diagram, a device with settings: TC=6h, TV=15m, TM=5h45min, was turned on at 3 o'clock (H0). The first measurements are shorter, as they are interrupted with the next, planned cycle H2 (starting with ventilation phase).

Afterwards, device works as it is planned: →H2→H3→H4→H1→H2...

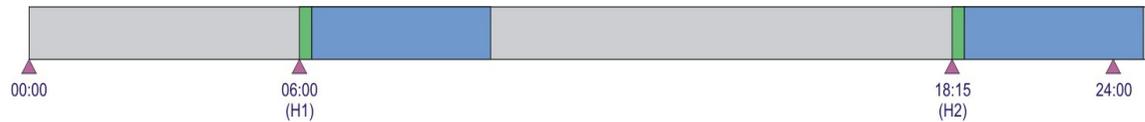
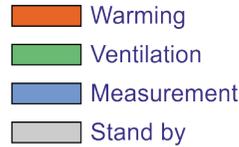
If the measurements together with the ventilation phase are shorter than a single cycle length (TC > TV + TM), then the analyser awaits the following cycle in Standby phase.

Cyclic mode – unit's behaviour at midnight

The lasting cycle will not be interrupted at midnight. The current cycle will normally be finished and the device will move on to the Standby phase awaiting the H1 moment. If the H1 (first zeroing) moment comes while the previous cycle lasts, the current cycle will be interrupted and a new cycle will begin.

5.2.2. Measurements according to scheduler

- TC – Full cycle time
- TM – Measurement time
- TW – Warming time
- TV – Ventilation time
- H0 – moment when analyser was powered on
- H1 ÷ H4 – beginning of the following work cycles



Measurements according to scheduler is also a 24-hour mode (repeats every 24-hours) and contains of the maximum of 24 measurement cycles. Each of the cycle's beginning point is defined individually.

Example on left, shows two work cycles: H1 begins at 6:00, H2 begins at 18:15. Because $(TC < TV + TM)$ analyser goes into standby mode in between cycles.

Behaviour of analyser after turning on



Analyser is turned on H0, in between scheduled cycles H1 and H2. Device begins its work with the initial phases (Warming and FirstZeroing) and then proceeds with the measurements. Analyser synchronises its work (to the scheduler) with the beginning of the first programmed work cycle (H2).

Behaviour of analyser after midnight

The lasting cycle will not be interrupted at midnight. The current cycle will normally be finished and the device will move on to the Standby phase awaiting the first planned cycle (H1 or next if H1 is inactive). If the H1 (or next if H1 is inactive) moment comes while the previous cycle lasts, the current cycle will be interrupted and a new cycle will begin.

5.2.3. Measurements triggered by digital input

TC – Full cycle time

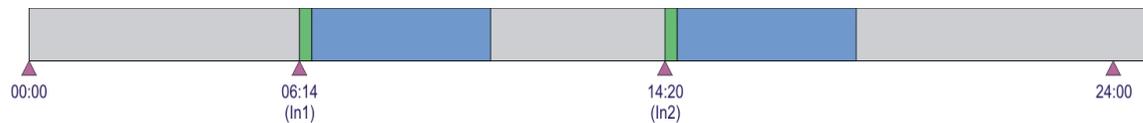
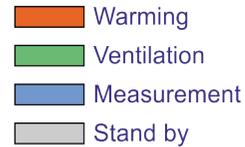
TM – Measurement time

TW – Warming time

TV – Ventilation time

H0 – moment when analyser was powered on

H1 ÷ H4 – beginning of the following work cycles



For the measurements triggered by a digital input (available at Electric terminals) there are no predefined beginning points of the cycles. The beginning of each of the cycles is triggered from the outside with help of any of the digital inputs In1..In2.

The rising slope appearing on the active input is the trigger. The disconnected (floating) input is treated as remaining in a high state.

At 6:14 (In1) and 14:20 (In2). After the In1 measurement cycle has finished the analyser moved on to Standby phase awaiting the In2 signal which triggers another measurement cycle beginning.

Behaviour of analyser after turning on



After the device, set to Measurements triggered by a digital input mode, is turned on it performs the initial phases, that is Warming and FirstZeroing and then proceeds directly to Measurement.

As shown above the first cycle after the start-up is performed even though there was no triggering signal. After the first cycle has finished the device moves on to Standby phase and awaits for the triggering signal.

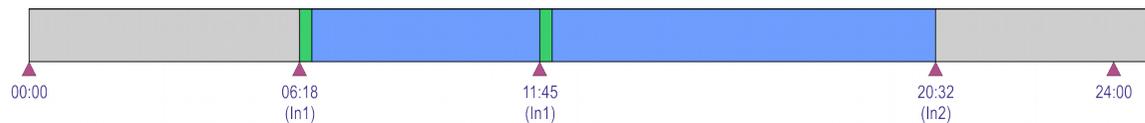
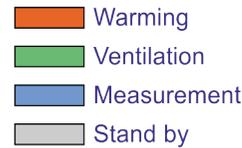
In example above a new cycle was triggered at 7:10 (In1) and another one at 8:25 (In2). The first cycle H0 (after the turn on) has been interrupted by a signal from In1. In1 cycle has been discontinued when signal from In2 appeared.

Behaviour of analyser after midnight

Midnight does not interrupt the current cycle. The current cycle is normally finished and the device proceeds to Standby phase awaiting the triggering signal from any of the active inputs.

5.2.3.1. Measurements controlled by external process

TC – Full cycle time = 00:00:00
 TM – Measurement time = 00:00:00
 TV – Ventilation time = 00:15:00
 IN1 = Restart measurement cycle
 IN2 = Terminate measurement cycle



Work mode Measurements triggered with digital input allows the user's system to take the full control over mamos work. i.e. mamos receives information when to start the cycle (by sending signal to digital input IN1). Cycle will start with Ventilation and then go to Measurement. Measurements will last until:

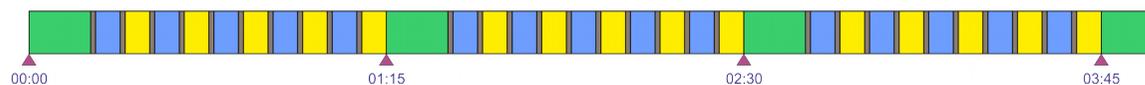
- they are restarted with digital input IN1 (to refresh sensors with ambient air)
- they are terminated with signal from digital input IN2 – mamos then goes into standby and awaits another signal from IN1 to initiate Ventilation + Measurements

This mode allows (in theory) to perform measurements for the indefinite time. Though, for the sake of measurement accuracy, it is advised to perform ventilations and zeroings as often as possible.

5.2.4. Flip-Flop for Twin-Split configuration

TC – Full cycle time = 1h 15 min
 TM – Measurement time = 5 (=TM_A = TM_B)
 TV – Ventilation time = 15 min
 TI – Infusion time = 60 sec

$$TC = N \times (TM_A + TM_B + 2x TI) + TV$$



This work mode is available only for a device in Twin-split configuration. In its behaviour, it is similar to a Cyclic work mode – analyser continuously performs measurements. The main difference is that Ventilation is performed every N-measurements (depended on the set times). In the example on the left, Ventilation occurs every 10 Measurement phases. Measurements switches (flip-flops) from gas source A to B. Each Measurement phase is preceded with infusion (non-adjustable 60 sec). This mode does not have stand-by phase.

5.2.5. Long-term, monthly-cyclic mode

Monthly-cyclic mode has a length of the cycle equal to the length of the calendar month. This means the analyser's sensors are zeroed once a month, and then a continuous measurement proceeds (until the next zeroing).

Monthly-cyclic mode has the below parameters (all of them set via PC program):

- The First zeroing date (DD/MM/YY) – defines the calendar date the first zeroing is to be performed. The date indicates the number of day when the monthly zeroing is to be performed.
- The First zeroing moment – it is the exact hour (with the accuracy of 1s – hh:mm:ss) the monthly zeroing is to be performed
- The length of the Ventilation phase (TV)

The date of the first zeroing indicates when exactly (the day of the month) the zeroing is to be performed. If the number of the days in a month is smaller than the number of the day the zeroing is to be performed on, the zeroing will be performed on the last day of the month. That means, that whenever the date of the first zeroing is set to the 30th of January, the zeroing in February will be performed on the 28th.

After the device set to Monthly mode is turned on, it performs the initial phases, that is Warming and FirstZeroing and then proceeds directly to Measurement. It remains in the measurement phase until another zeroing comes.

5.2.6. Long-term mode with adjustable length (1-30 days)

The Long-term mode with adjustable length is similar to monthly-cyclic mode, however the cycle length does not equal the calendar month length but it is a set number of days (1..30).

Example:

The sensor works in the adjustable monthly mode. The date/ hour of the first zeroing is 4:00, the 1st of September. The cycle length is 7 days. As the 1st of November 2014 was Monday the sensor will perform zeroing each Monday at 4:00.

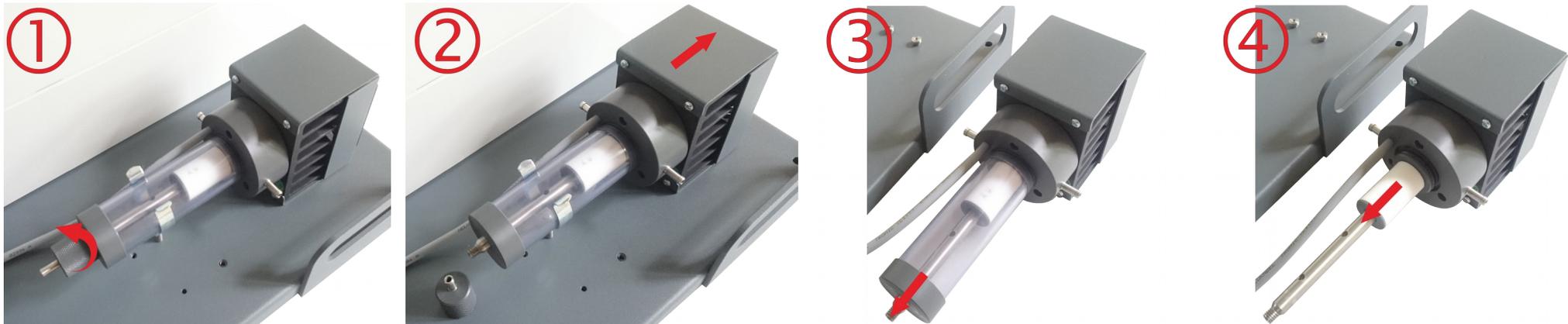
After the device set to Long-term adjustable mode is turned on, it performs the initial phases, that is Warming and FirstZeroing and then proceeds directly to Measurement. It remains in the measurement phase until the another zeroing comes.

5.2.7. Restrictions when using long-term work modes

Long-term work modes, especially with long cycle times, result in long interval between zeroings. This lowers the measurements' accuracy. In order to obtain high measurement accuracy, it is advised to avoid long-term work modes (= perform zeroings of gas sensors as often as it is possible).

6. BASIC SERVICE OPERATIONS

6.1. Replacement of filter inlet in MD2 gas dryer





1. Unscrew the bottom part of the filter
2. Gently slide the dryer upwards and remove it from the spring holder
3. Pull down the PVC cover
4. Pull down the filter inlet
5. Remove the centering pad from the filter.
6. Install a new filter inlet and assemble the filter in the reverse order.

Madur code for MD2 filter:

- V-FELM051 (5 μ m pore size)
- V-FELM201 (20 μ m pore size)

6.2. Replacement of filter inlet in MD3 gas dryer



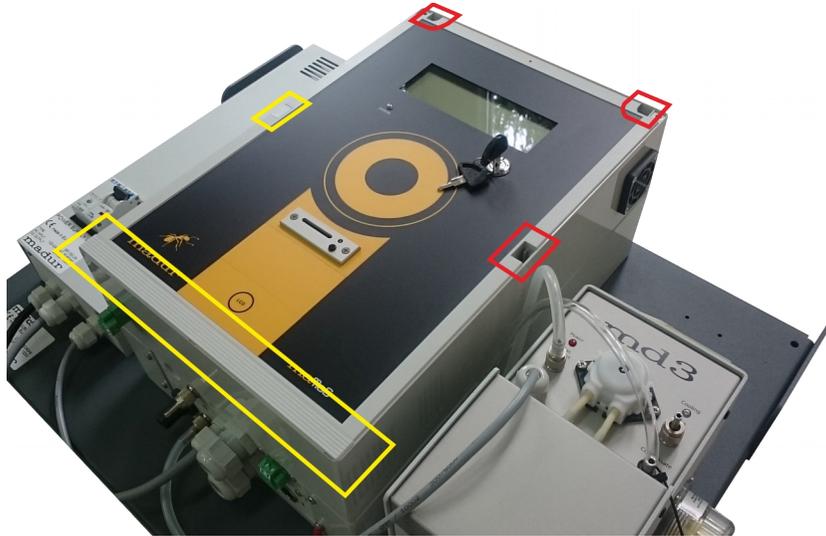
To replace the filter the user should:

1. Twist off the filter's cover.
2. Replace the filter's inlet.

Madur code for MD3 filter:

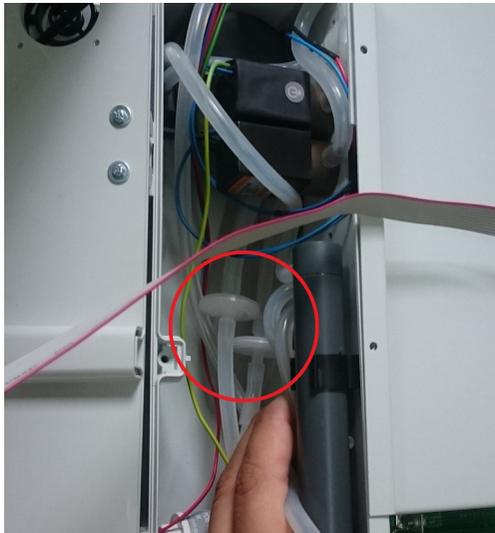
- 614Z0010B (2 μ m pore size)
- 614Z0010C (1 μ m pore size)

6.3. Replacement of hydrophobic filters in gas analyser



Hydrophobic filters protect mamos strategic elements (gas sensors, pump, valve, etc.) against dust and humidity. Gas sample, before entering the analyser should be appropriately conditioned, i.e. dried and cleaned. Though, those hydrophobic filters may in time catch some pollution, and therefore should be periodically checked and, if necessary replaced.

Hydrophobic filters may also be clogged with water (one of the reasons for “Flow too low” error) – this most likely suggest that the conditioning system for the analyser is not selected appropriately to a given application. In this situation it is suggested to use heated lines, more efficient gas dryer (or add the second stage dryer), etc.

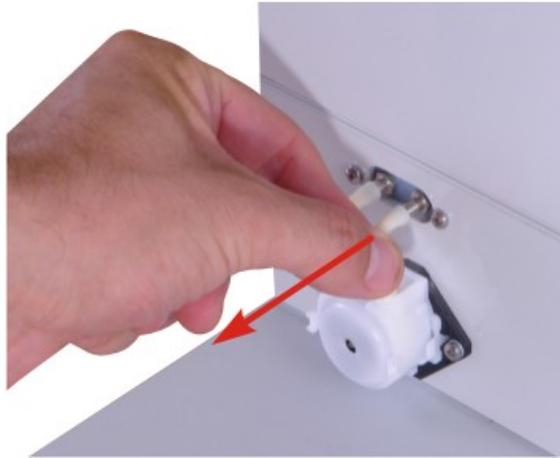


To replace filters:

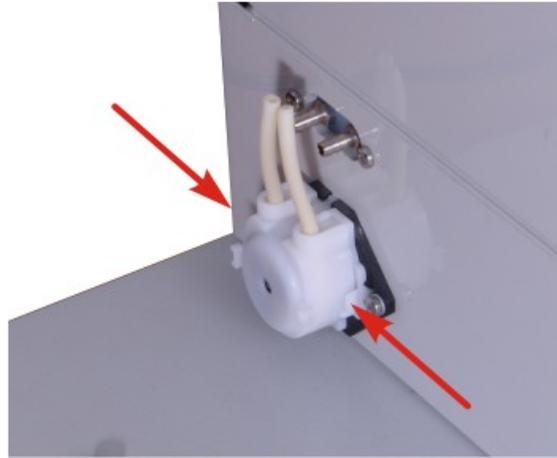
1. Remove the 4x blanks protecting the screws
2. Unscrew 6x Pozidriv PZ2 screws 
3. Open the analysers lid
4. Filters are located inside the analyser on the left side (between electrochemical sensors and ventilation valve)
5. Replace filters for both gas path and ventilation path

madur code for hydrophobic filter: 614Z0009A

6.4. Replacement of peristaltic pump's hose



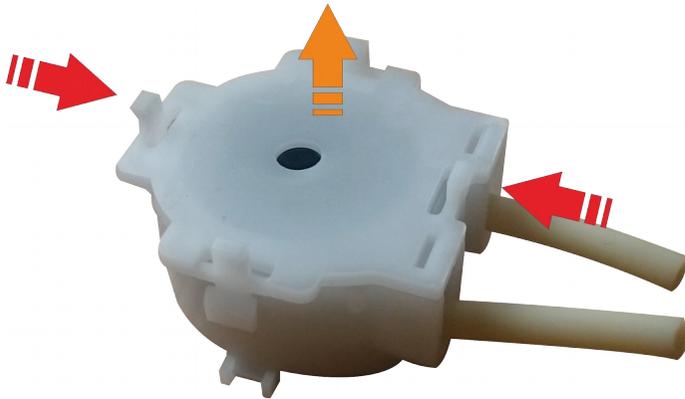
Disconnect hose from its ports



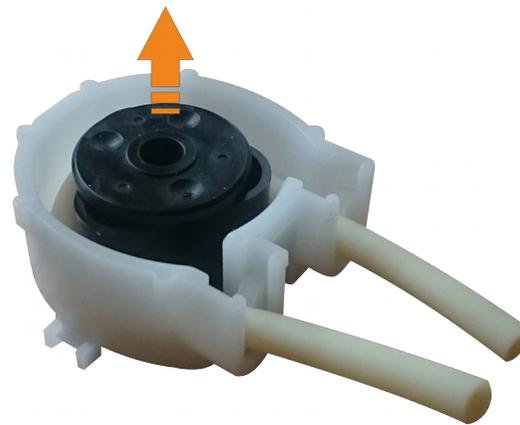
Squeeze the head of the pump as indicated with arrows (horizontal clamps)



Pull the pump's head



Squeeze the cover's vertical clamps and pull the cover



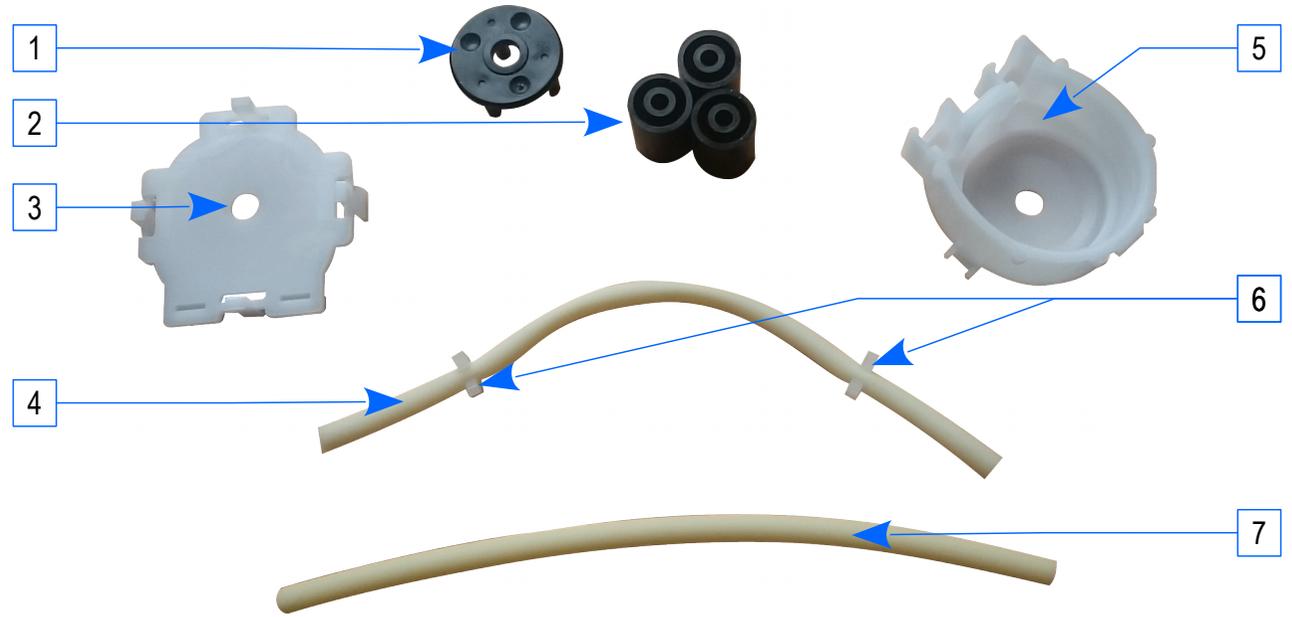
Remove the centering pad



Remove pump's rollers



Remove used tubing from pump's body



- 1. Centering pad
- 2. Rollers
- 3. Pump's cover
- 4. Used tubing

- 5. Pump's body
- 6. Tubing's holders
- 7. New Flidprene tubing 2,0x4,0mm (madur stock code: 613N2040B)

Pump should be assembled in the reverse order.

6.5. Troubleshooting in case of “Flow too low” error

As mentioned, mamos analyser is equipped with differential pressure sensor that measures flow through the analyser. By default analyser’s main pump is adjusted to give flow 90 l/h. Flow threshold value is set by default to 30 l/h – this means that if the flow drops below threshold value, mamos will report an error. There are several reasons of such situation. Proceed with the following steps to recognise the source of the problem, after each of the step verify if the “Flow too low” error still exists:

1. Replace gas filters in MD2 / MD3 dryer – filters must be replaced on regular basis, process gas always contains pollution that in time will clog gas filters to the point that gas flow will drastically decrease.
2. Verify if the gas pump in analyser is working correctly – disconnect the entire gas path from analyser (disconnect tubing from gas dryer). If problem persists, this means that either pump is malfunctioned or its settings are incorrect
3. Verify each of the elements of the gas path, starting from the components that are the closest to the analyser – disconnect the gas path before each of the components. Clogged element can be identified when “Flow too low” exists after the element, but not before it.
4. Finally, check if the hydrophobic filters in analyser are clogged – please see chapter 6.3
5. If none of the aforementioned brings a solution, please contact madur service team: service@madur.com