Total Carbon Analyzer

TCA 08

User's Manual

Version 1.1.0.9

March 2021

Aerosol d.o.o., Ljubljana, Slovenia

Total Carbon Analyzer ® Model TCA 08 User's Manual

Version 1.1.0.9, March 2021

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1. GENERAL INTRODUCTION

Figure 1. The Total Carbon Analyzer®, Model TCA08

Magee Scientific and Aerosol Co. are pleased to announce the Model TCA08 Total Carbon Aerosol Analyzer®. The TCA 08 measures the Total Carbon content of ambient aerosols in an instrument package that is specifically designed for simple, robust operation in all settings. The TCA 08 has been developed with input from the research and monitoring communities and is designed for reliable operation under all conditions ranging from state-of-the-art research to routine air-quality monitoring.

2. SAFETY NOTES and WARNING LABELS

CAUTION!

READ THIS CHAPTER VERY CAREFULLY BEFORE OPERATING THE INSTRUMENT.

Instrument operation

Read this User's manual BEFORE operating the instrument. INCORRECT instrument operation can be DANGEROUS for the operator.

Instrument moving, mounting and transportation

The TCA 08 is intended for use in rack mount installations, or bench-top placement. The instrument can be also installed into a rack cabinet using slide rails. When moving the instrument, be sure to hold the instrument by its handles, both front and rear. When transporting or shipping the instrument, always use the original box and packaging.

Unauthorized instrument access and operation

The instrument must be protected against unqualified use. Operation by unauthorized or untrained persons can be dangerous. The instrument must only be operated by personnel who have received training and have appropriate qualifications, technical skills and practical experience.

Instrument service and repair

UNAUTHORIZED instrument service and repair procedures are NOT ALLOWED and will void the Manufacturer's Warranty. The instrument must be serviced only by authorized persons. Contact your authorized representative if you have any problems with the instrument. Check the instrument regularly for technical safety.

Electrical Power Supply cord

Use ONLY the power supply cord specified and supplied by the manufacturer, to connect the instrument to the main electrical power supply. Supply cords which are not specified or provided by the manufacturer or authorized distributor must NOT be used.

CHECK the main electrical power supply cord ANNUALLY. If the supply cable is DAMAGED, stop using the equipment and contact the manufacturer or your distributor.

Fire and explosion

This instrument is NOT "Intrinsically Safe" against risk of explosion in flammable atmospheres. NEVER install the instrument in explosion-risk areas and never use the equipment near flammable substances.

Instrument overheating

ALWAYS ensure that the instrument has adequate ventilation so that it can operate under its specified operating ambient conditions. NEVER install the instrument in spaces with limited air circulation.

Hot surfaces – Measurement chambers

The two measurement chambers are located behind the instrument's front panel door and are NOT intended to be accessed by the USER under NORMAL instrument operation. HOT SURFACES of the measurement chambers of the instrument are clearly marked with a hot surface caution LABEL. INJURIES could occur from coming in contact with hot surfaces. ALWAYS allow enough time for the hot surfaces to cool down before performing any service or maintenance procedure on the instrument or the measurement chambers.

Always wait at least 1 hour after the instrument has been switched OFF, before performing any service or maintenance procedure on the instrument or on the measurement chambers.

Protection provided by the equipment

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Electromagnetic compatibility

This is a Class A equipment. Therefore, it is intended for use in an industrial environment. There may be potential difficulties in ensuring electromagnetic compatibility in other environments, due to conducted as well as radiated disturbances.

3. WARRANTY

Limited warranty statement: TOTAL CARBON ANALYZER TCA08

Version 2016-01

Aerosol d.o.o., (Seller), warrants that the Product will operate or perform in conformance with Seller's published specifications and be free from defects in material and workmanship, when subjected to normal, proper and intended usage by properly trained personnel, for the period of time set forth in the product documentation, published specifications or package inserts. If a period of time is not specified in Seller's product documentation, published specifications or package inserts, the Warranty Period shall be one (1) year from the date of shipment to Buyer for new equipment and ninety (90) days for all other products except consumables. Seller agrees during the Warranty Period, to repair or replace, at Seller's option, defective Products so as to cause the same to operate in conformance with said published specifications; provided that (a) Buyer shall promptly notify Seller in writing upon the discovery of any defect, which notice shall include the product model and serial number (if applicable) and details of the warranty claim; (b) after Seller's review, Seller will provide Buyer with service data and/or a Return Material Authorization ("RMA"); and (c) then, if applicable, Buyer may return the defective Products to Seller with all costs prepaid by Buyer. Replacement parts may be new or refurbished, at the election of Seller. All replaced parts shall become the property of Seller. Shipment to Buyer of repaired or replacement Products shall be made in accordance with the Delivery provisions of the Seller's Terms and Conditions of Sale. Consumables, including but not limited to filters, and other such expendable items, are expressly excluded from the warranty. Notwithstanding the foregoing, Products supplied by Seller that are obtained by Seller from an original manufacturer or third-party supplier are not warranted by Seller, but Seller agrees to assign to Buyer any warranty rights in such Product that Seller may have from the original manufacturer or third party supplier, to the extent such assignment is allowed by such original manufacturer or third party supplier.

In no event shall Seller have any obligation to make repairs, replacements or corrections required, in whole or in part, as the result of (i) normal wear and tear, (ii) accident, disaster or event of force majeure, (iii) misuse, fault or negligence of or by Buyer, (iv) use of the

Products in a manner for which they were not designed, (v) causes external to the Products such as, but not limited to, power failure or electrical power surges, (vi) improper storage and handling of the Products or (vii) use of the Products in combination with equipment or software not supplied by Seller. Specifically, this Warranty does not cover repairs of the Products that are required as the result of (viii) exposure to weather or rain, or the passage of water through the Product's air sampling and handling systems, (ix) exposure to excessive dust, (x) transportation in improper packaging and (xi) damage due to internal condensation of water, if the Product is sampling outdoor air with a very high humidity, and the Product is in a room with excessively cold air-conditioning with a temperature below the condensation point of the outdoor sample air, leading to condensing of water inside the Product.

If Seller determines that Products for which Buyer has requested warranty services are not covered by the warranty hereunder, Buyer shall pay or reimburse Seller for all costs of investigating and responding to such request at Seller's then prevailing time and materials rates. If Seller provides repair services or replacement parts that are not covered by the warranty provided in this warranty, Buyer shall pay Seller therefor at Seller's then prevailing time and materials rates.

ANY INSTALLATION, MAINTENANCE, REPAIR, SERVICE, RELOCATION OR ALTERATION TO OR OF, OR OTHER TAMPERING WITH, THE PRODUCTS PERFORMED BY ANY PERSON OR ENTITY OTHER THAN SELLER WITHOUT SELLER'S PRIOR WRITTEN APPROVAL, OR ANY USE OF REPLACEMENT PARTS NOT SUPPLIED BY SELLER, SHALL IMMEDIATELY VOID AND CANCEL ALL WARRANTIES WITH RESPECT TO THE AFFECTED PRODUCTS. THE OBLIGATIONS CREATED BY THIS WARRANTY STATEMENT TO REPAIR OR REPLACE A DEFECTIVE PRODUCT SHALL BE THE SOLE REMEDY OF BUYER IN THE EVENT OF A DEFECTIVE PRODUCT. EXCEPT AS EXPRESSLY PROVIDED IN THIS WARRANTY STATEMENT, SELLER DISCLAIMS ALL OTHER WARRANTIES, WHETHER EXPRESS OR IMPLIED, ORAL OR WRITTEN, WITH RESPECT TO THE PRODUCTS, INCLUDING WITHOUT LIMITATION ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. SELLER DOES NOT WARRANT THAT THE PRODUCTS ARE ERROR-FREE OR WILL ACCOMPLISH ANY PARTICULAR RESULT.

4. PACKING LIST

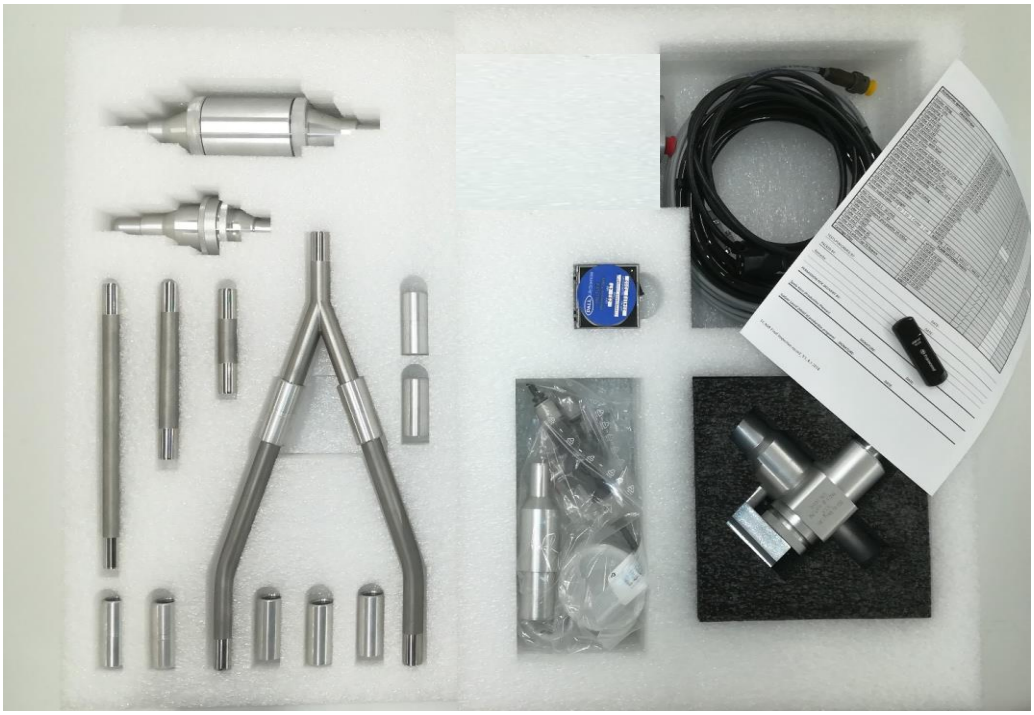


Figure 2. TCA08 accessories.

DESCRIPTION	CODE	QTY.
Divider 40 deg	TCA08 0 03 001	1
Divider Tube	TCA08 0 03 002	2
Coupling A	TCA08 8 03 003	4
Coupling B	TCA08 8 03 004	4
Tube 14x2-90	TCA08 0 03 005	1
Tube 14x2-152	TCA08 0 03 006	1
Tube 14x2-242	TCA08 0 03 007	1
VOC DENUDER KIT	TCA08 8 23 000	1
VOC Denuder, with Shell	TCA08 5 01 004	1
In-Line Filter Holder, 47mm	TCA08 8 24 000	1
Sharp-Cut Cyclone Inlet,	TCA08 5 01 005	1

2.5 µm at 16.7 LPM flow									
Sharp-Cut Cyclone Inlet Adapter - Kit					TCA08 8 25 000				1
Quartz Filters, 47 mm - Pack of 25 pcs.					TCA08 5 01 006				1
Tweezers					DRI-1201				1
Null modem cable – LI-840A					/				1
Protective Cap					TCA08 0 03 013				1
Silencer 1/4 NPT					TCA08 5 01 026				1
Insect and Water Trap Assembly					M9556				1
USB stick with manual					USBTS8G				1
Push-to-connect tool					AET 0 11 001				1
TetraCal TCA Adapter - Kit					TCA08 8 26 000				1
Static Dissipative Polyurethane Tubing					M4997				3 meters
1/8 MPT - 1/4 stem straight					M4916				1
1/4 stem - 1/4 Hose straight					M4968				2
3/8 stem - 1/4 MPT					M4973				1
3/8 stem - 1/4 Hose straight					M4979				1
Power supply cable	EU	US	CHINA	UK	B88F306	M6115	M6117	M6118	1

5. INTRODUCTION

5.1 TCA08 Total Carbon Analyzer

The **TCA08 Total Carbon Analyzer** instrument uses a thermal method for total carbon (TC) determination. The instrument collects a sample of atmospheric aerosols on a 47-mm diameter quartz fiber filter enclosed in a small stainless-steel chamber, at a controlled sampling flow rate. The sampling time is 1 h (default) but may be pre-set from 20 minutes to 24 hours. The instrument has two parallel sampling and analysis channels, with air flow controlled by ball valves. While one channel is collecting its sample for the next time-base period, the other channel is analyzing the sample collected during the previous period.

After collection on the filter, alloy wires heat the sample almost instantaneously in a small flow of 'analytical carrier gas' – which is actually ambient air. This produces complete combustion of all carbonaceous compounds into CO_2, creating a short-duration but large-amplitude pulse of CO_2 which passes to a sensitive detector. Since the amount of CO_2 produced is large compared to the internal volume of the system, the transient concentration of CO_2 greatly exceeds the carrier-gas (ambient-air) baseline for the brief duration of the pulse. This means that ambient air – rather than specialized gas supplies - may be used as the carrier. The CO_2 concentration over baseline is accurately measured and integrated to give the Total Carbon content of the sample.

The system calibration may be verified by analyzing samples containing known masses of carbon - either locally prepared, or 'dry' standards provided by the manufacturer. Operational maintenance is minimal: the quartz fiber sampling filters are exchanged typically once per month, and the 'VOC Denuder' is replaced typically every one to two months.

<u>The design principles of the Model TCA08 include:</u>

- **Two identical flow channels** for sampling and analysis
- Sample is collected on a **47 mm quartz fiber filter**
- Combustion chamber is made of **stainless steel**

- **Continuous operation** is provided by alternating (sample collection) and (analysis) between two channels.
- The collected sample is **flash heated** to convert all carbon to CO_2
- **Filtered ambient air** is used as the analytical carrier gas
- Large pulse of CO_2 in carrier gas flow is integrated over ambient baseline to determine **TOTAL CARBON** content of the sample

5.2 The TC-BC method

Carbonaceous aerosols are extremely diverse and are frequently the largest and most important fraction of fine particulate matter mass ($PM_{2.5}$). They impact air quality, visibility, climate forcing, cloud nucleation, the planetary radiation balance, and public health. The carbonaceous fractions are frequently separated into organic carbon (OC) and elemental carbon (EC) based on their volatility using thermal-optical methods.

The newly developed TC-BC online method combines an **optical method** for measuring black carbon (BC) by the Model AE33 Aethalometer®; with a **thermal method** for total carbon (TC) determination by the TCA08 Total Carbon Analyzer. This "TC-BC" method determines the organic carbon (OC) fraction of carbonaceous aerosols as OC = TC - b·BC, where the parameter b relates the optical measurement of BC to the thermal measurement of elemental carbon (EC). Since the thermal separation of EC from OC varies according to regions, locations, seasons and especially the thermal protocols used for analysis: the factor b may be variable. The default value of b is 1. However, the Total Carbon analysis avoids these uncertainties and yields a scientifically-robust result.

The "TC-BC" method offers high time resolution data – interpreted as "EC/OC" - from an instrument package that is rugged, reliable, and does not require specialized gas supplies.

5.3 Functional description of the Total Carbon Analyzer instrument

The TCA08 is based on modular design composed of interconnected subsystems. This optimizes construction, performance, maintenance and safety.

CHASSIS

The instrument chassis is made from heavy-gauge sheet metal to protect the internal components. It is grounded electrically through the power supply cable. The chassis dimensions fit a standard "19-inch" rack.

REAR PANEL COVER

The rear panel cover of the instrument supports the electrical and airflow connectors.

POWER CONNECTOR

The power receptacle accepts the standard 'IEC-520' connector. This is commonly available with EU, US, UK, China and Australasia type plugs. The receptacle includes an EMC filter, fuse, and the main ON/OFF switch.

COOLING FANS

Two system cooling fans are mounted on the rear panel and provide airflow through the instrument's electronics. The speed of the fans is controlled automatically according to the measured internal temperature. Two fans are mounted on the sides of the analytical zone to cool the combustion chambers at the end of the analysis cycle.

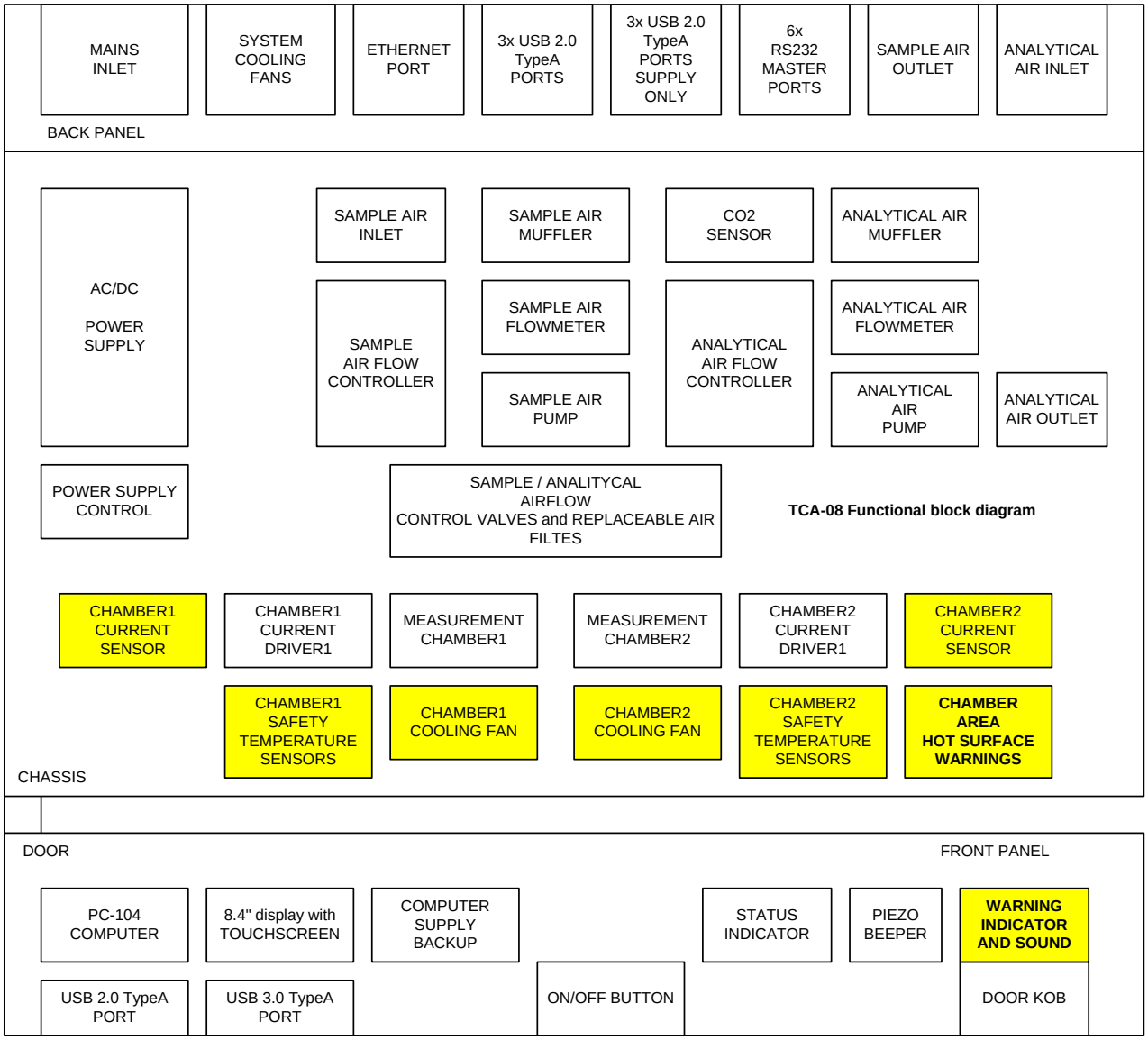


Figure 3. TCA 08 functional block diagram

ETHERNET PORT

An Ethernet (RJ45) port on the rear panel allows the TCA 08 to be connected to communication networks.

USB PORTS

Six USB 2.0 Type A connectors are provided on the rear panel to support USB based devices such as external sensors. Three of these are configured as USB power supply (5 volt) outlets only, without data communication.

RS232 PORTS

Six RS232 'COM port' connectors are provided on the rear panel to allow connections to external devices such as sensors or data-loggers. These RS232 ports are configured as 'transmitters': a "null modem" may be required when connecting to certain other devices, including the Model AE33 Aethalometer®.

SAMPLE AIR INLET and OUTLET

Sample air enters the instrument through the two inlets located on the top panel of the instrument; and is discharged through the sample air outlet connector on the rear panel. Instrument-specific tubing connectors are required for the air sample inlet: the discharge air outlet is a standard NTP 1/4" threaded socket. All airflow connectors are supplied with the instrument.

ANALYTICAL CARRIER-GAS AIR INLET

Ambient air for the analytical carrier-gas flow enters the instrument through a standard NTP 1/8" threaded socket connector on the rear panel of the instrument. This air stream is filtered and buffered in an internal volume. After passing through the CO_2 sensor, the analytical carrier-gas stream is discharged within the interior of the instrument at a low flow rate.

AC/DC POWER SUPPLY

The main power supply converts the incoming AC voltage to the low DC voltages which power the instrument's internal elements. There are no high voltages present on any other internal component. The power supply accepts all inputs in the range of 100 to 240 v AC, 50/60 Hz. The power supply module includes a temperature-activated cooling fan.

FRONT PANEL DOOR

The front panel of the instrument functions as the access door to the analytical area, and also contains the computer and touch-screen display. The door is secured by a turn knob, and

must be closed for the analysis to proceed. A sensor on the chassis detects the "Door Open" condition, and puts a warning on the display screen.

ON/OFF BUTTON

The display screen enclosure includes a power ON/OFF button located on the lower left side. See 8.5 for details.

EMBEDDED COMPUTERS: SOFTWARE AND FIRMWARE

High-level control and the user interface of the instrument are implemented by software on the main computer which is integrated into the front panel door. Within the instrument, specific functions on specific electronic boards are controlled by local microprocessors which are loaded with firmware. Both software and firmware may be uploaded and upgraded via the front-panel USB ports.

COMPUTER POWER BACKUP

A low-capacity local backup provides sufficient power to the embedded computer to permit an orderly shutdown in the event of brownout or interruption of the main AC line power.

DISPLAY and TOUCHSCREEN

The 8.4" SVGA display and the touchscreen are the main user interfaces of the instrument. Through this interface the operator can perform all necessary operations to setup, control and monitor the operation of the instrument.

PIEZO BEEPER

A piezo beeper provides audible feedback in conjunction with the user interface operations.

USB PORTS

Two USB Type-A ports on the front panel door can be used to connect an USB keyboard, a mouse or a data stick.

STATUS INDICATOR

An LED on the front panel provides a quick operational status indicator. This may show green – normal, correct operation; yellow – continuing operation but with warnings or attention required; or red - an error has been detected and the instrument is stopped.

SAMPLING AND ANALYSIS CHAMBERS

Two chambers are located in the operational area behind the front panel doors. They are made from stainless steel, and contain metal heating elements. They support the quartz fiber filters which are used to collect the sample. They operate in alternating modes: while one chamber is collecting a sample, the other is performing the combustion analysis of its previously-collected sample. At the end of the timebase cycle, the modes interchange. The analytical chambers include sliding air-seal couplers to allow vertical movement for exchanging quartz-fiber filters; flash heating elements both above and below the sample; and a thermocouple probe to measure the combustion temperature. The analytical chambers may be removed completely for exchange or service.

COMBUSTION ELEMENT VOLTAGE DRIVERS AND CURRENT SENSORS

After the aerosol sample is collected on the filter, alloy elements in the chamber heat it almost instantaneously to full combustion in a small flow of "analytic carrier gas", i.e. filtered ambient air. The heating elements are powered by a low-voltage, high-current source. Voltage and current sensors monitor the performance of the elements. A thermocouple monitors the temperature in each chamber.

Figure 4. TCA 08 measurement chamber with lower and upper heating modules.

CHAMBER SAFETY TEMPERATURE SENSORS and CHAMBER COOLING FANS

Since the heating elements reach high temperatures in order to fully combust the aerosol sample, an independent safety temperature monitoring system prevents accidental overheating of the operational area.

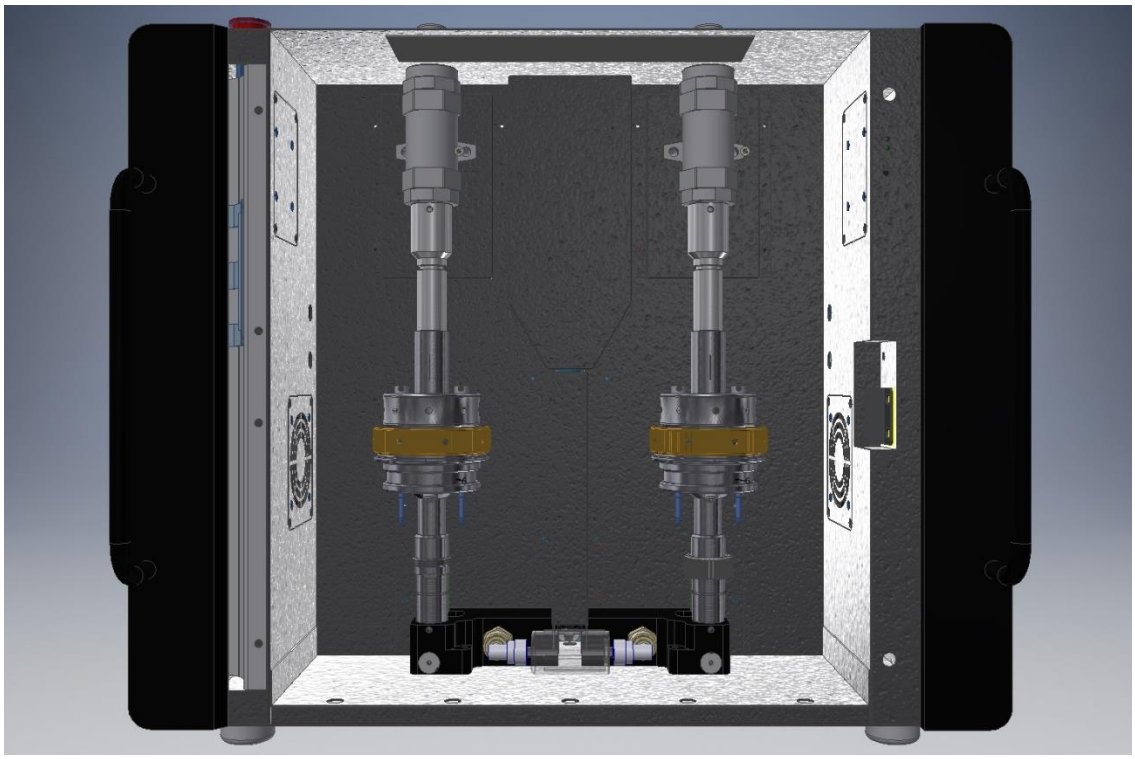


Figure 5. TCA 08 sampling and analysis chambers located behind the front panel door

WARNING INDICATOR and SOUND; HOT SURFACE WARNINGS

When the door is opened to access the operational area, both visible and audible warnings are activated since hot surfaces may be present. Additionally, a clearly visible HOT SURFACES label is affixed between the two chambers.

Please wait at least 1 hour after the instrument is switched OFF before performing any service or maintenance procedure on the instrument or on the measurement chambers.

SAMPLING AIR PUMP, FLOWMETER and FLOW CONTROL

The main pump draws the sample air through the quartz filters which are housed in the measurement chambers. Its motor speed (and hence its sampling flow rate) is controlled by a closed loop with feedback from an air mass flow sensor.

ANALYTICAL CARRIER GAS AIR PUMP, FLOWMETER and FLOW CONTROL

The 'analytical carrier gas flow' pump draws a low flowrate of ambient air first through a "CarbonCap" filter to remove organic vapors; next through the combustion chamber; and finally, to the CO_2 sensor. Its motor speed (and hence its flow rate) is controlled by a closed loop with feedback from an air mass flow sensor.

SAMPLE AND ANALYTICAL AIRFLOW CONTROL VALVES and FILTERS

The airflow control solenoid valves and ball valves switch the sample and analytical carrier flow between the two measurement channels. The 'analytical carrier gas' air filters are located in the operational area behind the front panel door and must be replaced periodically.

CO_2 GAS ANALYZER MODULE

TCA08 determines the CO_2 concentrations with a CO_2 analyzer – a high performance, non-dispersive infrared gas analyzer designed to be used for a wide range of applications. The life expectancy of the analyzer´s source is typically >20,000 hours or >2 year of continuous operation, but this will vary depending upon the number or warm-up cycles, vibration, and other factors (please see also chapter 9 -Maintenance and Service).

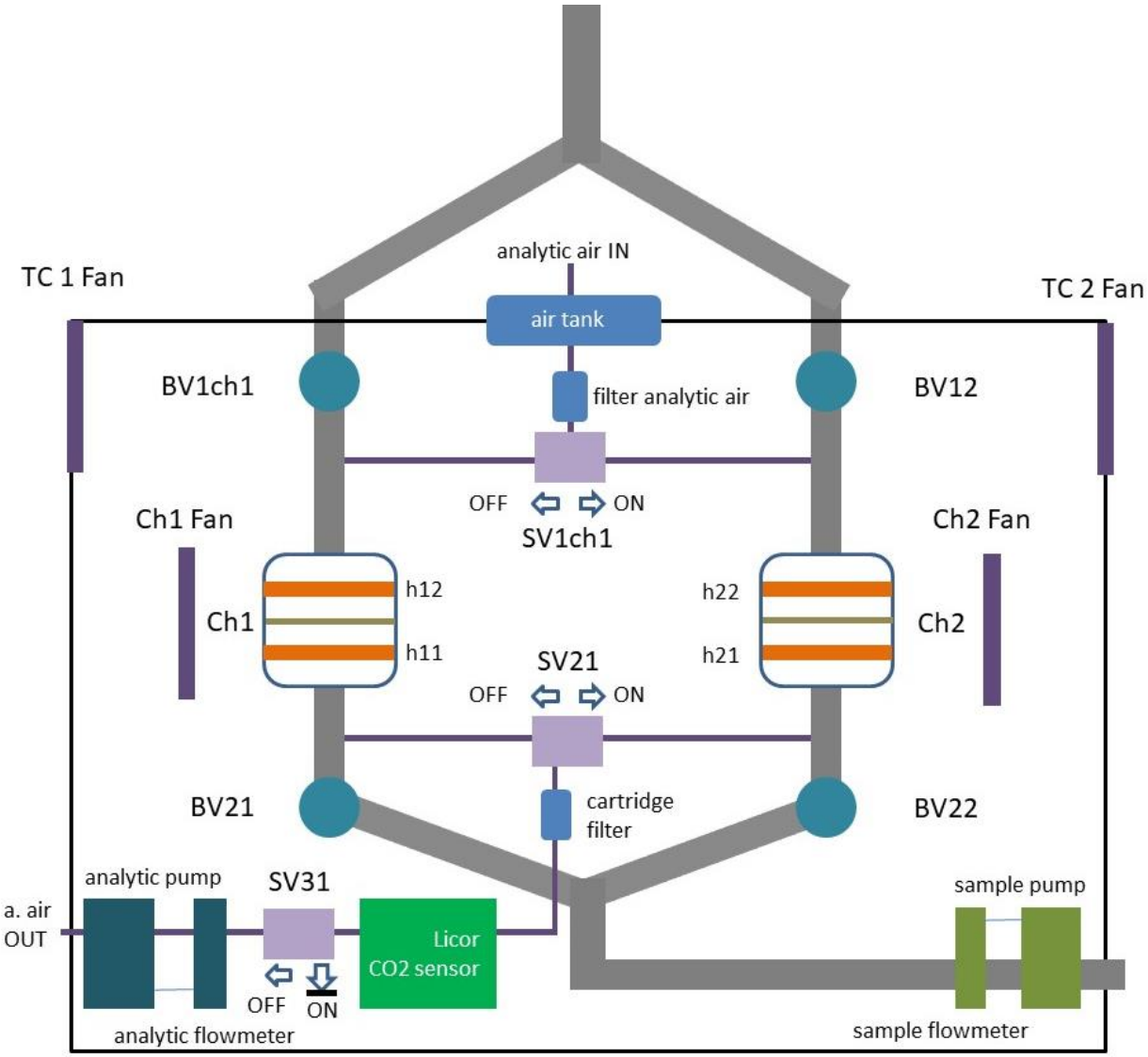


Figure 6. TCA 08 air flow diagram

5.4 Technical specification

Operation:

- Supply voltage: 100-240 V~, 50/60 Hz. Fuse: T10AH 250 V~
- Rated power: 1500 W
- TC measurement sensitivity: 0.5 C µg/m^3 at 60 min Sample time base and 16.7 LPM Sample Airflow
- TC sampling time: 60 min (default), 20 min to 24 h
- Standard Sample air flow: 16,7 LPM
- Standard Analytical carrier air flow: 0,5 LPM

Insulation and protection:

- Degree of protection against electric shock: All accessible external connections or terminals (including USB ports, RS232 ports or Ethernet port) are protected with REINFORCED INSULATION.
- Transient overvoltage: OVERVOLTAGE CATEGORY II
- Pollution degree: 2

Environmental operating conditions:

- For indoor installations only
- IPX protection: IPX0
- Operational altitude: up to 3000 m
- Operational temperature range: 10 °C – 35 °C
- Operational relative humidity range: 30 % - 80 %, non-condensing

Mechanical specification:

- Chassis material: sheet metal
- Front plate material: aluminum plate
- Dimensions: standard 19”/9U, rack mount
- Weight: approx. 35 kg

Input / output connections:

Airflow:

- Sampling air inlet: custom metal tubing, internal diameter 14 mm, external diameter 18 mm – standard TCA 08 accessory
- Sampling air outlet: standard NPT 1/4" threaded connector
- Analytical carrier air inlet: standard NPT 1/8" threaded connector

Communication:

- 1x USB 3.0 type A – front panel
- 1x USB 2.0 type A – front panel
- 3x USB 2.0 type A (5 VDC / 500 mA) – rear panel
- 3x USB 2.0 type A, no USB data D+, D- lines, supply only (5 VDC /500 mA) – rear panel
- 6x RS232 master ports – rear panel
- 1x Ethernet – rear panel

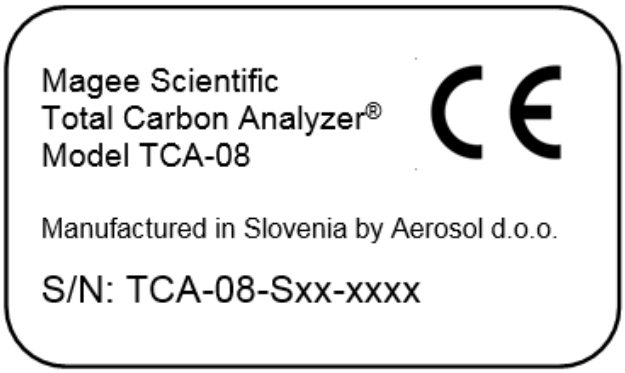
User interface:

- Display: 8.4" SVGA with LED backlight
- Basic interface: Touch-screen
- Optional control: keyboard and/or mouse
- Visible indicator: Green, Yellow or Red status LED
- Audible indicator: Piezo buzzer

6. INSTRUMENT IDENTIFICATION, CONNECTORS and MARKINGS

6.1 Instrument identification

The instrument is identified with the following label:



6.2 Front panel

The On/Off power button is identified with the IEC 5009 symbol »I/O«. It is located on the lower left corner of the front panel. The USB 2.0 Type A connectors are located on the lower right corner of the front panel.

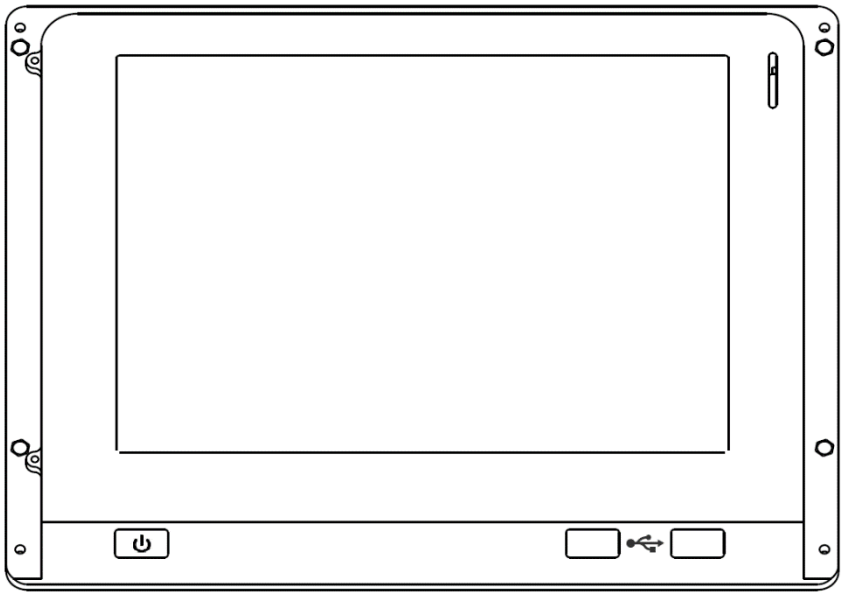
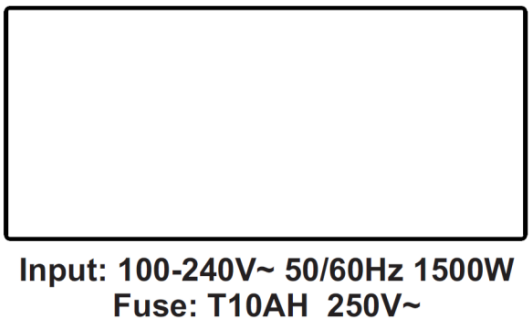


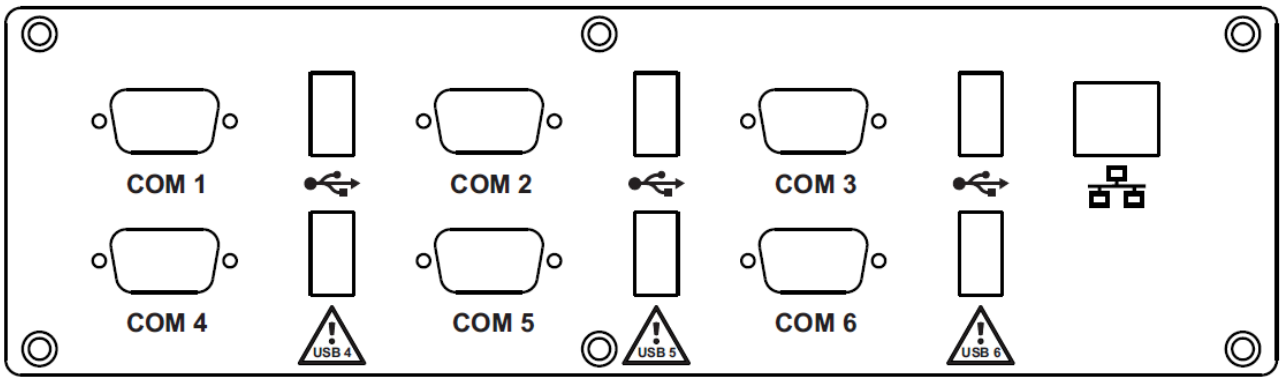
Figure 7. Front panel with touch LCD, USB 2.0 and USB 3.0 Type A connector and On/Off power button.

Do not try to disassemble the front panel door. It contains delicate electronics – the computer, SVGA display and touch-screen.

6.3 Rear panel

The AC line power receptacle is on the rear panel, and includes a switch, a fuse and a spare fuse (type: T10AH 250V~). Connect the power supply cord and switch ON the instrument.

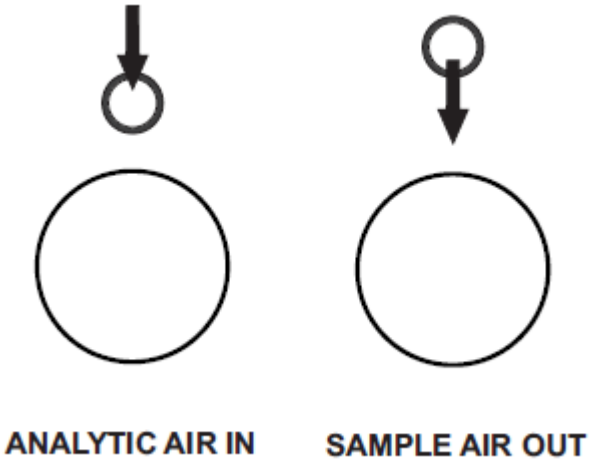




The rear panel also provides the following communication connectors: 3x USB 2.0 Type-A marked with USB symbols, 3x USB 2.0 supply only marked with warning symbols, 6x RS232 master connectors marked with COM symbols, and one Ethernet connector marked with the networking symbol. The maximum current that may be supplied by the USB ports is 500 mA and is protected with a 500 mA PTC fuse. The USB 2.0 ports identified with warning symbols are intended for 5 VDC supply only. No data lines are connected to these three ports.

Analytical carrier air inlet: standard NPT 1/8" threaded connector

Sampling air outlet: standard NPT 1/4" threaded connector



Do not remove the rear panel!

7. INSTRUMENT INSTALLATION

7.1 Unpacking the system

Take standard accessories (See Section 10, Standard Accessories) and the TCA08 instrument out of the box. Place the instrument on an even surface or mount it in a rack. Keep the back of the instrument accessible. The minimum overall height requirement of the TCA08, with its default sampling line system, is 1.2 m before any connection to an external stack (See Fig. 9).

Remember to remove protective caps on the airflow ports before operation!

Figure 8. Remember to remove protective caps on the airflow ports before operation.

7.2 Connecting and installing the sampling airflow line

Using TCA TUBES KIT TCA08-TUB and DENUDER-01 DEN-001 (See Section 7, Standard Accessories) assemble the Total Carbon Analyzer with the standard sampling line system. Use a tube-to-tube coupling to connect the system to an external sampling inlet line. Make sure that any penetrations of the building surfaces are leak proof. Use the PM2.5 size selective inlet on the sample air entry.

To minimize particle loss by kinetic deposition in the tubing, use large-radius bends. For reference, follow **EN 12341:2014 standard: "Standard gravimetric measurement method for the determination of the PM10 and PM2.5 mass concentration of suspended particulate matter".**

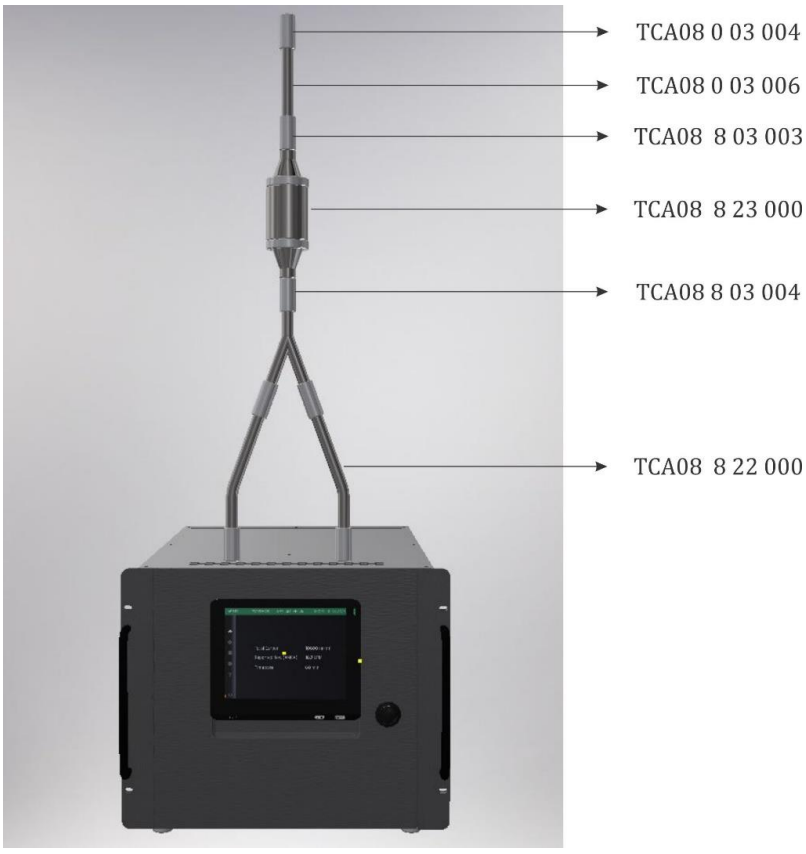


Figure 9. Total Carbon Analyzer with default sampling line system (See Section 10, Standard accessories). Couplings TCA08 8 03 004 are used to detach TCA from the fixed sampling system to perform flow verification/calibration or to perform denuder efficiency test.

Figure 10. Tube couplers TCA08 8 03 003 and TCA08 8 03 004 are used to connect different parts of the sampling system. TCA08 8 03 004 coupler can move freely along the sampling tubes and is used for disassembly of the sampling system. (See Section 10, Standard accessories).

The Sample Air outlet can either be connected to a discharge tube to the outside air; or directly into the room. If discharging directly into the room, we recommend attaching a muffler to reduce the pump pulsation noise.

7.3 Connecting and installing the carrier-gas 'analytical air' inlet line

The instrument is supplied with several meters of black tubing for the 'analytical air' carrier gas inlet. Thread the supplied fitting onto the Analytical Air Inlet port on the rear panel of the TCA08. Fit the supplied barbed connector to the end of the black tubing and insert the connector into the fitting on the rear part of the instrument. Use the "Insect and Water Trap" in the tubing next to the rear panel. Avoid routing the tubing near the direct outlet from HVAC systems. Lead the tubing to an inlet point in ambient air on the outside of the measurement station. Shield the inlet to be very sure that RAIN cannot enter the tube inlet end.

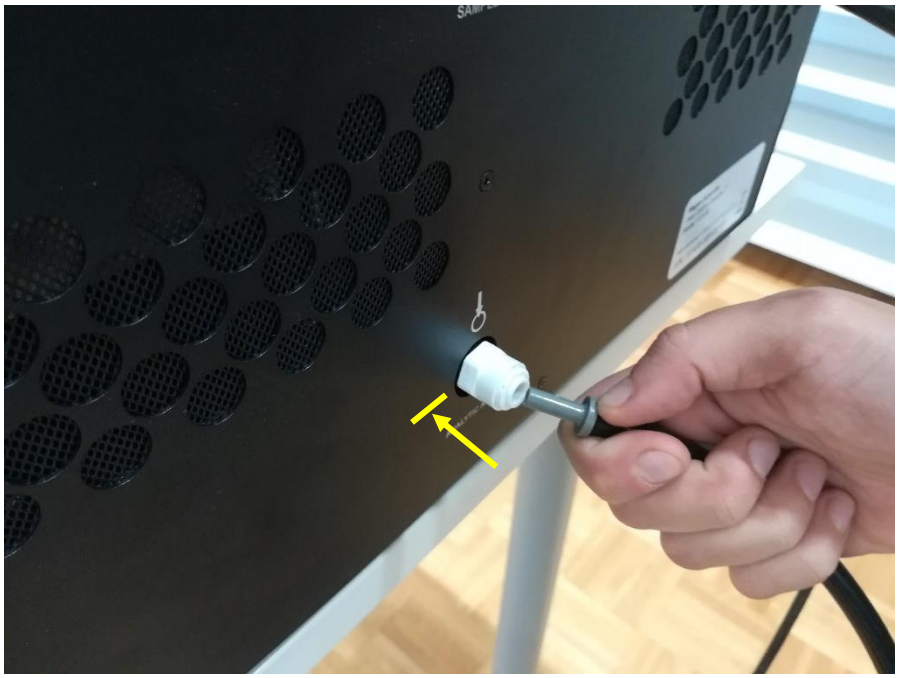


Figure 11. Fit the supplied barbed connector to the end of the black tubing and insert the connector into the 'Analytic Air' fitting on the rear panel of the instrument.

7.4 Recommended 'standard' TCA08 installation (sample line with PM2.5 inlet, carrier-gas line, meteorological sensor)

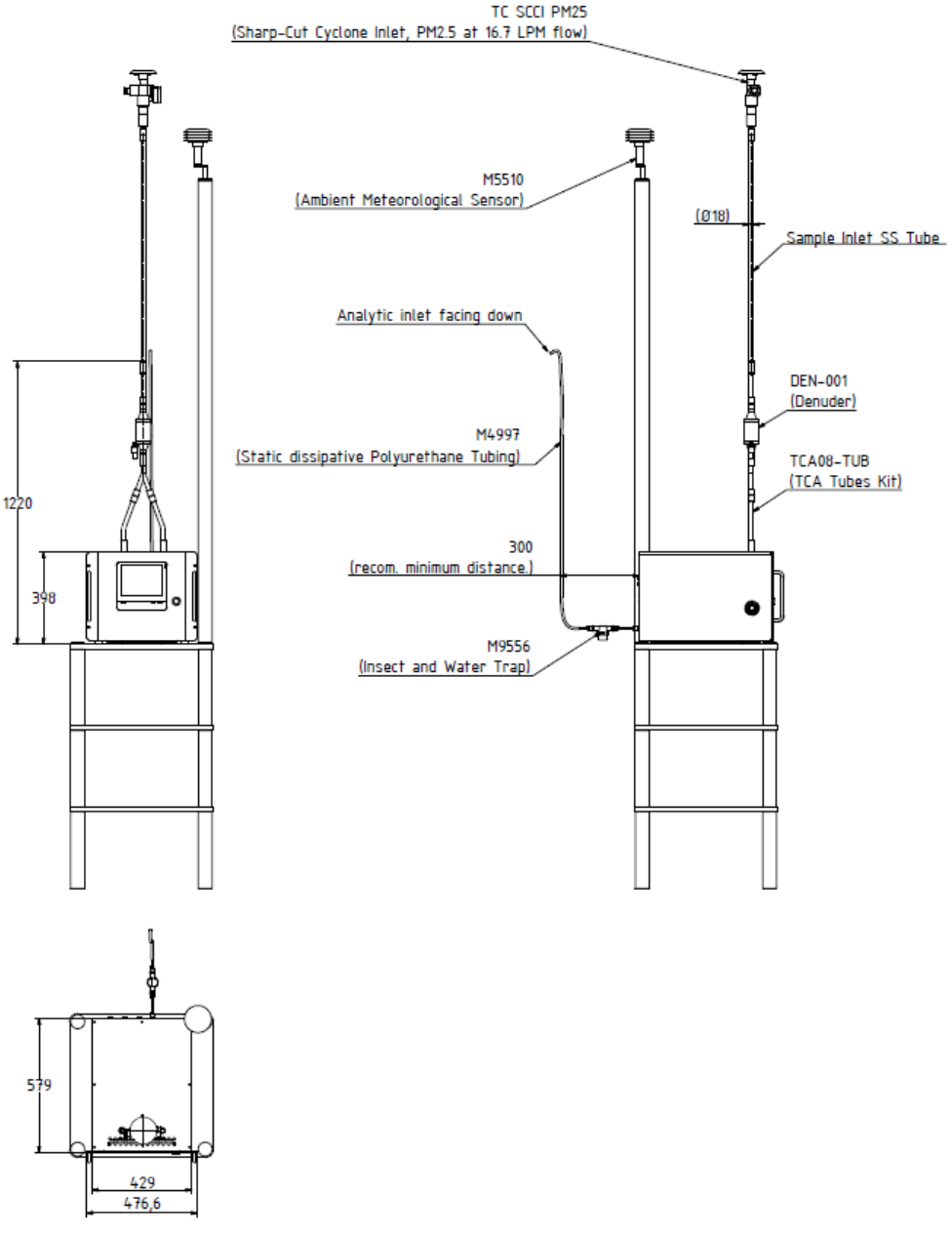


Figure 12. Recommended 'standard' TCA08 installation.

7.5 Example of customized TCA installation (sample line with PM2.5 inlet, carrier-gas line, meteorological sensor)

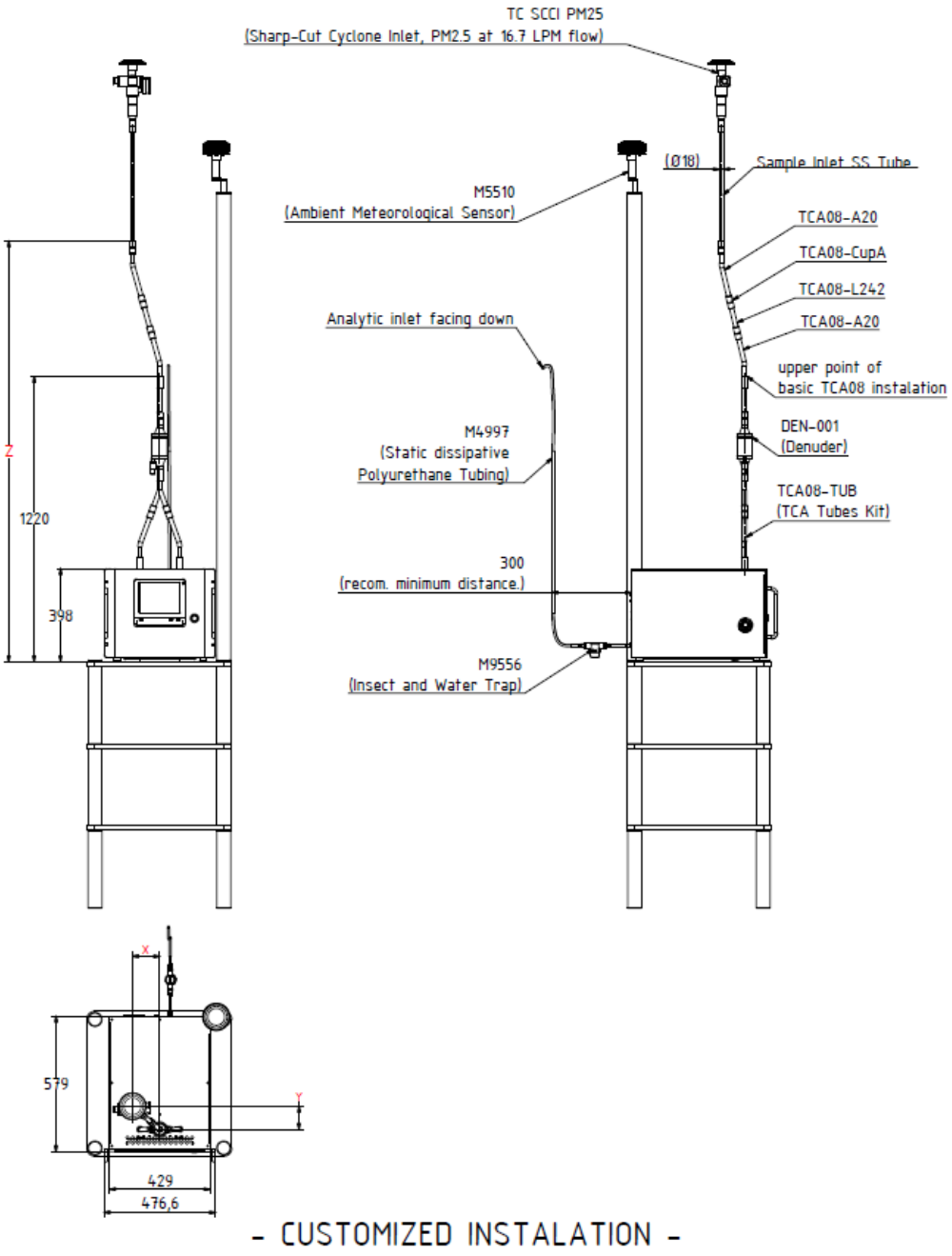


Figure 13. Example of customized TCA08 installation.

7.6 Switching the TCA08 ON

Connect the TCA08 instrument to AC power and turn on the main switch in the power receptacle.

Figure 14. Power on switch: rear panel

Upon start-up, the instrument will initialize the TCA software in "standby mode" and the following home screen will appear:

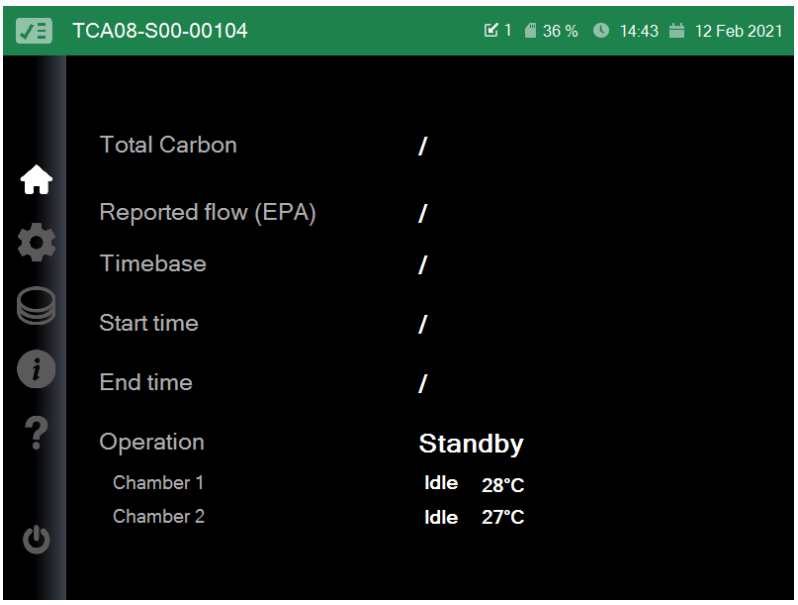


Figure 15. Home screen in standby mode.

Before starting measurements, it is ESSENTIAL to perform the following Standard Operating Procedures (See Section 8.1, User interface and settings):

- Quartz filter change procedure
- Sample/Analytic flow verification

The instrument requires proper ventilation for cooling purposes. NEVER install the instrument in spaces with limited air circulation.

ALWAYS position or install the instrument so that it is EASY to reach the main electrical power on/off switch and supply cord on the back of the instrument.

8 USER INTERFACE, SETTINGS and OPERATION

8.1 User interface and settings

On each screen, the user can navigate the interface by pressing the icons on the left side of the screen. Status, instrument serial number, external devices, used storage, time and date are shown in the uppermost Status line. The General Status of the instrument is shown by the color of this line, and the LED indicator next to it: (**Green** = OK; **Yellow** = warning, check status; **Red** = error).

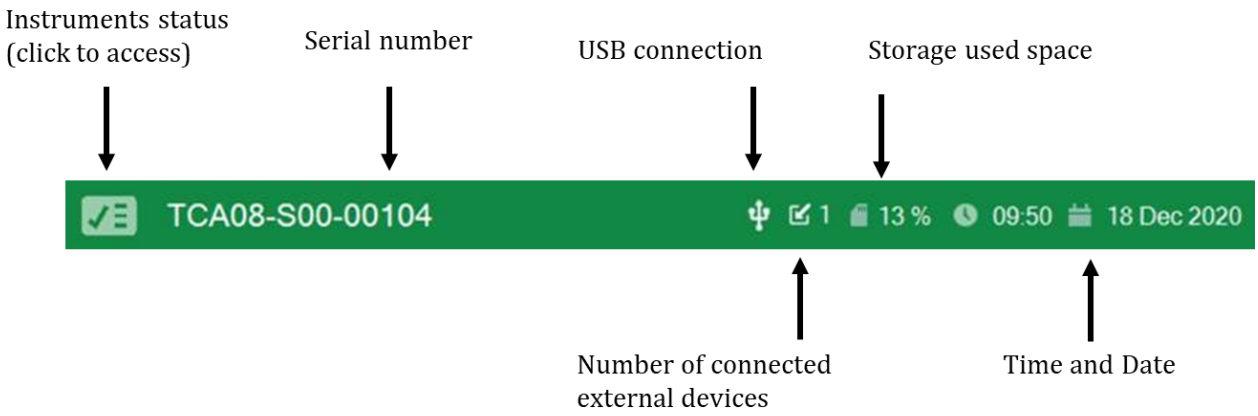


Figure 16. Status line

The HOME SCREEN shows:

- Total Carbon concentration
- Measured flow
- Sample timebase setting,
- Start time of the sampling for the measured Total Carbon Concentration
- End time of the sampling for the measured Total Carbon Concentration
- General operation status (Standby or Online) with status and temperature for each chamber. A full display of the instrument status is provided by pressing the **status icon** in the upper left corner of the home screen.

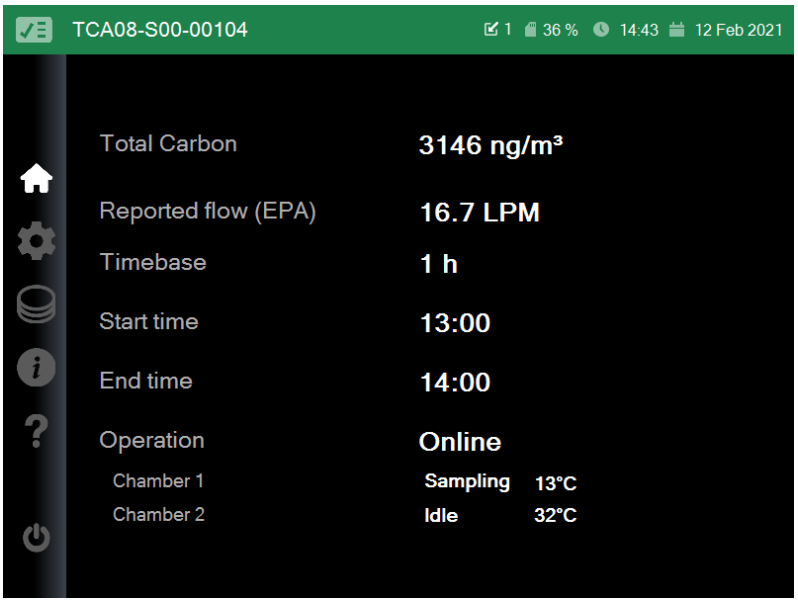


Figure 17. Home screen, online measurement

The OPERATION SCREEN has seven sub-tabs:

GENERAL, ADVANCED, TEST & PROCEDURES, EXTERNAL DEVICES, MANUAL CONTROLS, LOG, SOFTWARE UPDATES.

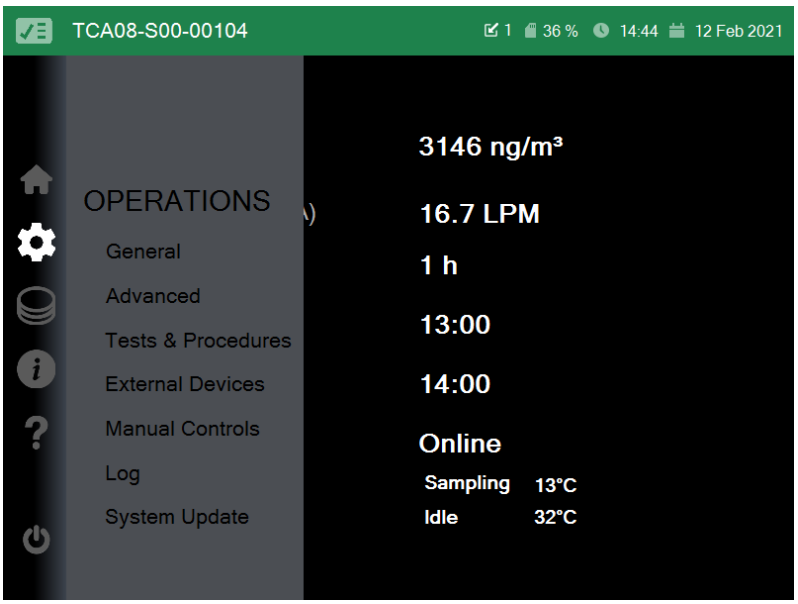


Figure 18. Operations menu

- The GENERAL screen provides access to general settings:

- Sample timebase,
- Reporting standard for Sample flow,
- EC/BC ratio *b,*
- Calibration constants for Chamber 1 and Chamber 2

and to START the ONLINE measurement.

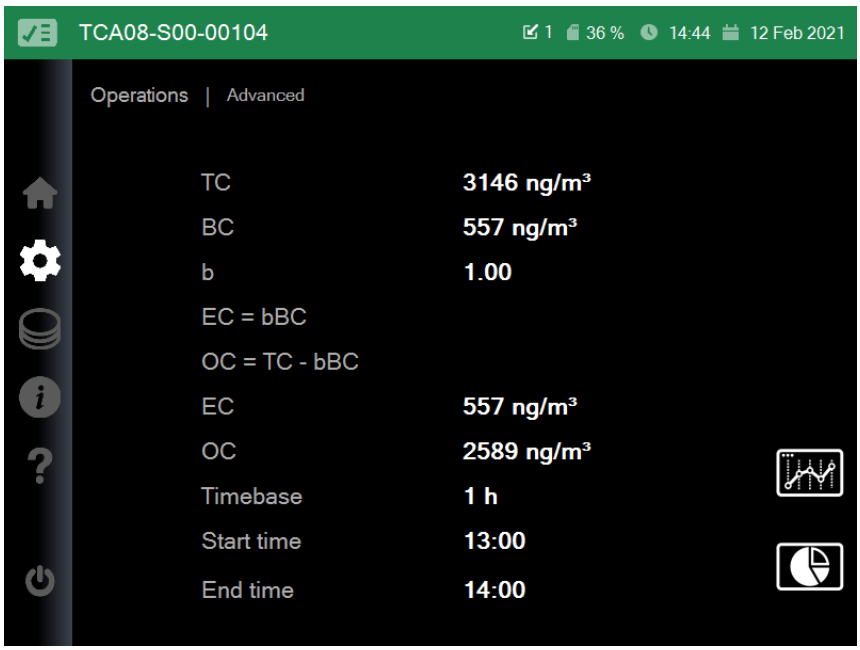


Figure 19. User interface, Operations - General

- The ADVANCED screen shows the TC, BC, EC and OC data if an AE33 is connected to the TCA as an external device. The parameter b can be changed before starting the ONLINE measurement.

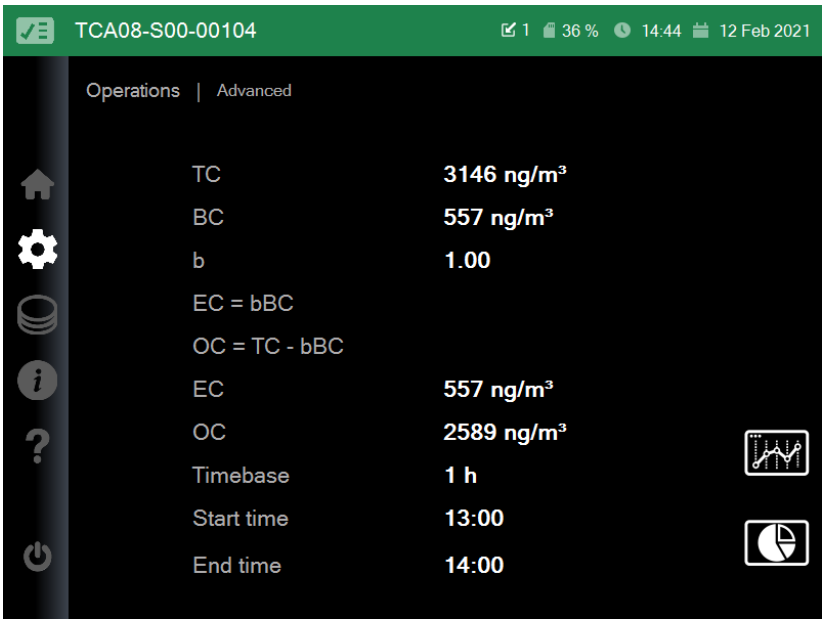


Figure 20. User interface, Operations - Advanced

By pressing on the GRAPH and PIE CHART icon on the lower right part of the ADVANCED screen, an OC, EC, TC timeseries and OC/EC ratio for the last 24h or last 7 days can be accessed.

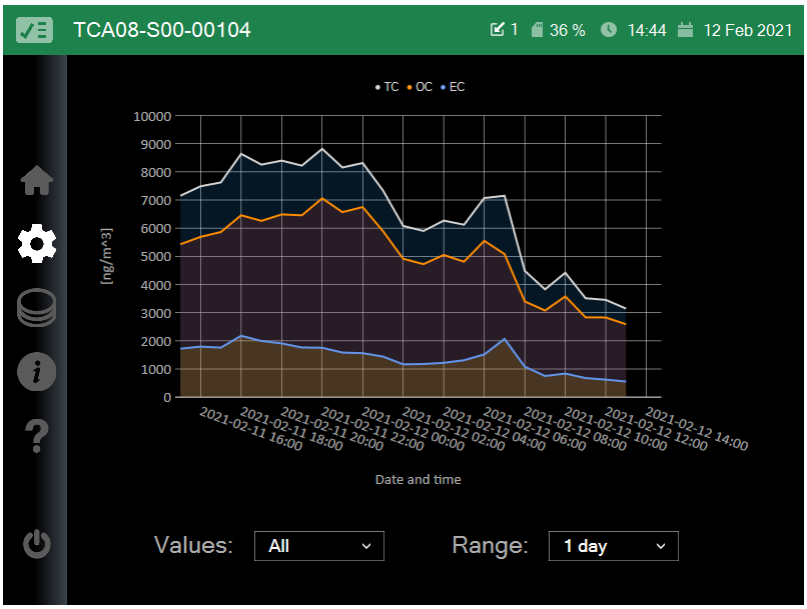


Figure 21. OC, EC and TC timeseries.

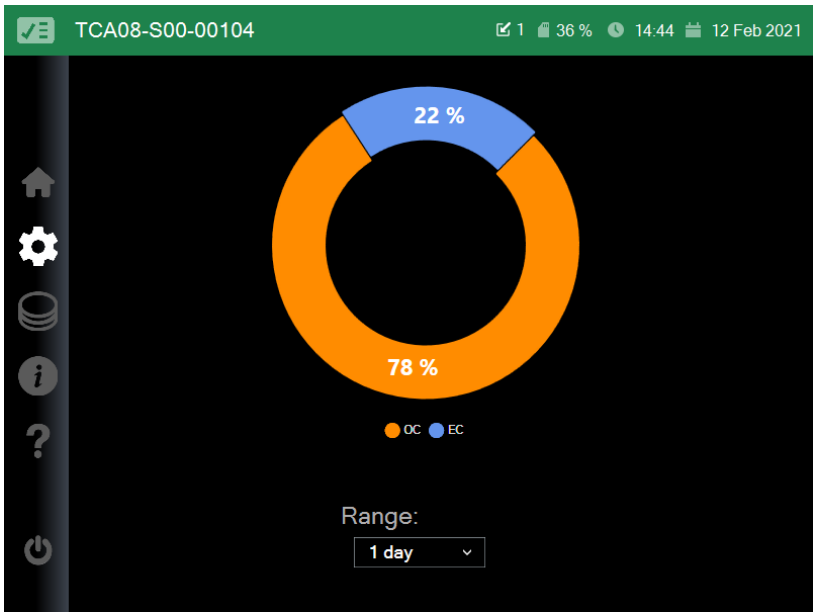


Figure 22. OC/EC ratio.

- The TEST & PROCEDURES screen provides control of the following tests and procedures:

  - Leakage test
  - Flow verification
  - Zero verification
  - Denuder test
  - Temperature probe verification
  - Quartz filter change
  - Flow calibration
  - Clean chambers
  - Offline analysis
  - Temperature probe calibration

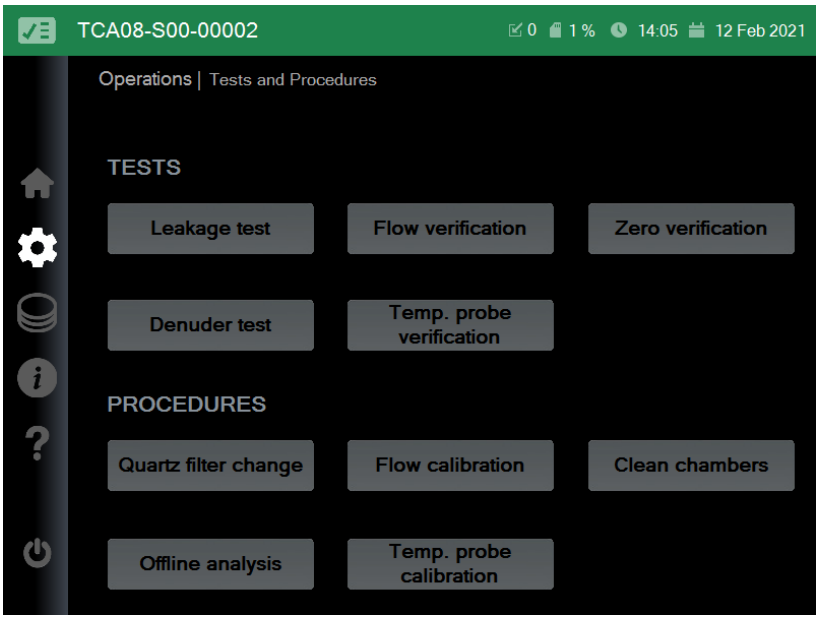


Figure 23. User interface, Operations – Test & Procedures

- The EXTERNAL DEVICES screen controls the connection of equipment to the COM ports. Up to six external devices are supported by the TCA08. Before use, the connection with the selected device should be enabled using "External device" in the OPERATION menu. Select the device connected to the specified COM port and click "Connect". The TCA08 will try to connect to the device every few seconds. When the external device is connected successfully, its icon will change from a "cross" to a "check" ("tick") mark. Currently, the TCA08 supports following external devices:

  - **Aethalometer AE33** [Ext. device ID = 2]

  - **AMES_TPR159** [1] – Temperature, Humidity (Relative Humidity) & Pressure Sensor, used for flow reporting at ambient conditions.
    Data line: *T* [°C], *RH* [%], *p* [hPa]

  - **Gill_GMX200** [17] - Ultrasonic wind speed & direction sensor, used for logging wind conditions on a 1 second timebase.
    Data line: WS [m/s], WD [°], corrected WD [°], status

  - **Gill_GMX300** [18] - Temperature, Humidity (Relative humidity & Dew point) & Pressure Sensor, used for flow reporting at ambient conditions.
    Data line: T [°C], RH [%], p [bar], DP T [°C], status

  - **Gill_GMX500** [19] - Compact weather station – provides Temperature, Humidity (Relative humidity & Dew point) & Pressure Sensor, wind speed and direction.
    Data line: Temperature [°C], relative humidity [%], pressure [bar], dewpoint temperature [°C], wind speed [m/s], wind direction [°], corrected wind direction [°], status

  - **AE33+ MET** [3] - If only one (1) MET station is available for both instruments (TCA08 and AE33), connect it to the AE33. In the TCA08 menu select Operation / External device select AE33+MET. NOTE: AMES_TPR159, Gill_GMX200, Gill_GMX300, Gill_GMX500 are all automatically recognized by TCA08 as MET stations, when connected to the AE33.
    However, Gill_GMX200 (only wind sensor) cannot be used for ambient flow reporting standard.

    A common data line is set for all AE33+MET combinations:
    Data line: Met Ext. Device ID, BC6_AE33 [ng/m^3], Status_AE33 [ ] , Timebase_AE33 [s], Temperature [°C], relative humidity [%], pressure [bar], dewpoint temperature [°C], wind speed [m/s], wind direction [°], corrected wind direction [°], status_Gill200, status_Gill300, status_Gill500.

Met Ext. Device ID:

- 1 – Ames
- 2 – Gill GMX200
- 4 – Gill GMX300
- 8 – Gill GMX500
- 3 – Ames_Gill GMX200,
- 6 – Gill GMX300_Gill GMX200

"NaN" value is used if no data is available at corresponding position. If connection between AE33 and MET sensor is lost, last collected MET data is repeated in the following AE33+MET data lines (External device warning is shown on TCA08). For more information on GILL sensors status (MaxiMet), please go to: http://www.gillinstruments.com/data/manuals/manuals.htm.

- **TCA_DataProtocol** [4] - the port is enabled for communication with data-logger or PC. See section 8.2 for details.
- **Bayern Hessen data-logger protocol** [5] See section 8.3 for details.

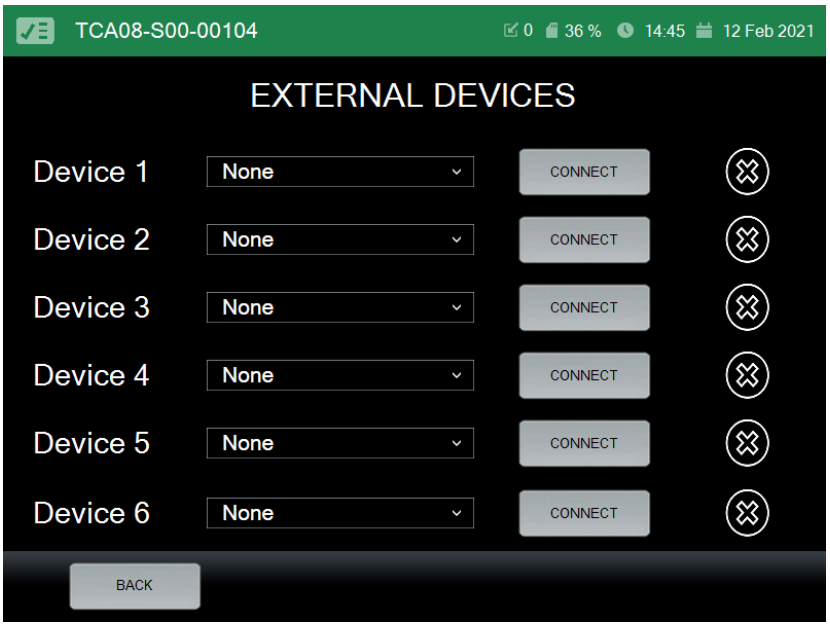


Figure 24. User interface, Operations – External devices

To connect the AE33 Aethalometer to the TCA08, be sure to use a "null modem" type COM cable. In the AEE33 menu screen 'Operation / Advanced / External Device', specify 'Datalogger_AE33_protocol' for the COM port which is used. **AE33 software version 1.4.4.0 or greater is required.** . Check the AE33 software version on its

'Operation/Advanced' screen. Download the most recent AE33 software from the site http://group.mageesci.com/.

- The MANUAL CONTROLS screen provides access to basic commands to operate hardware (solenoids, pumps, ball valves).

USE OF MANUAL CONTROLS IS LIMITED TO TRAINED PERSONEL ONLY! TAMPERING WITH THESE SETTINGS CAN RESULT IN HARDWARE FAILURE!

- The LOG screen shows the operational reports of status, parameter changes, data download.
- The UPDATE screen is used for software/firmware update. See section 8.8 for details.

The DATABASE main menu button is used for data export and storage management. For data export insert a USB memory stick in either of the front USB ports. (Note: the rear-panel ports are intended for external devices, and mouse or keyboard: and not for data transfer). Select the Tables you wish to export; choose the date range; and press EXPORT.

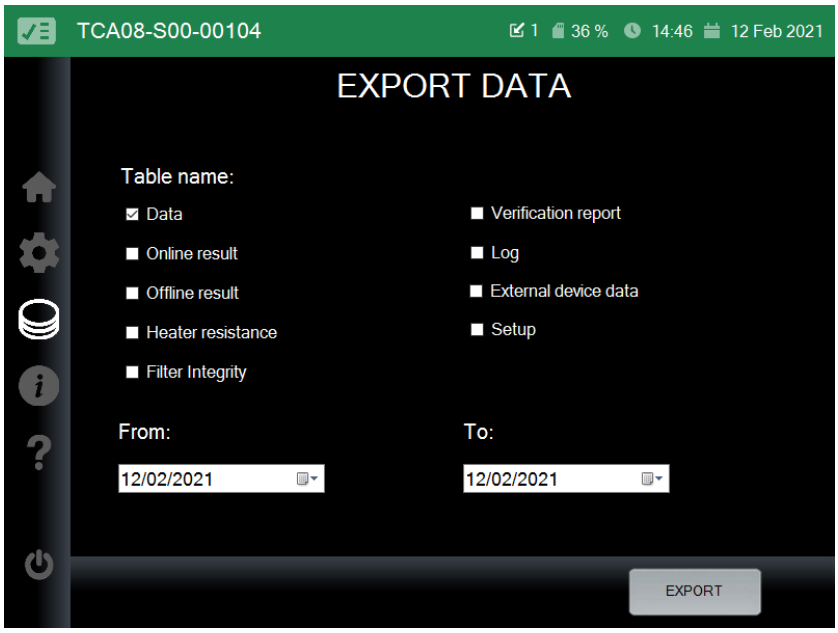


Figure 25. User interface, Export data

In the Storage menu, old DATA rows can be deleted. Select the date range and press the DELETE button. Only 1-sec data will be deleted (Data table), Online result, Offline result, Heater resistance, Filter integrity, Verification report, Log, External device data and Setup tables will stay intact. To export Database to USB stick, insert a USB memory stick in either of the front USB ports and press EXPORT DB TO USB.

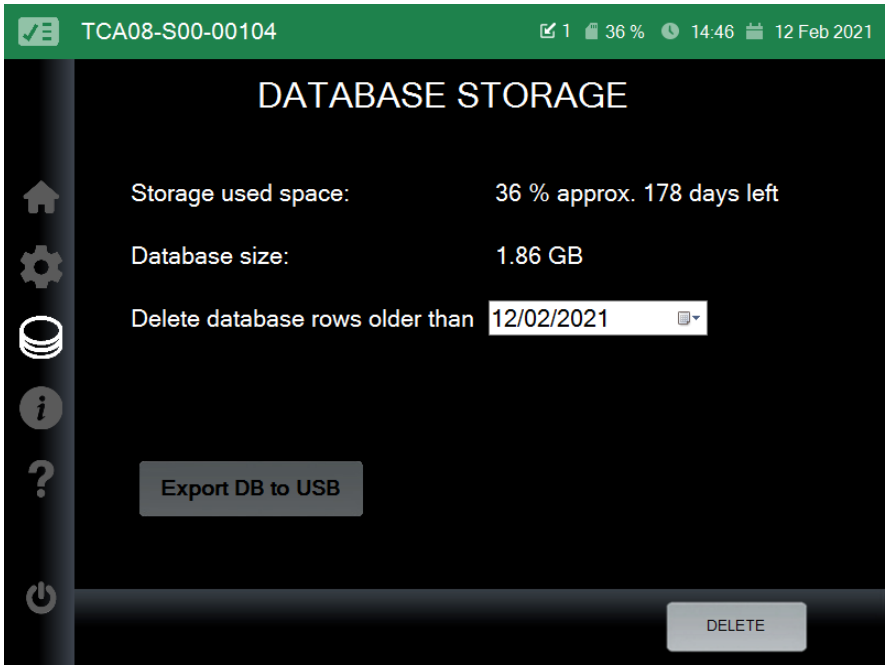
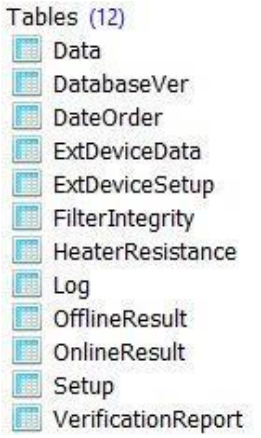


Figure 26. TCA08 storage management menu.

The TCA data is stored in an SQLite database. Internal measurement data is stored on a 1-sec timebase. The results of the analysis are stored in an online and offline table. Each time a configuration of the instrument is changed (for example sample time, or chamber calibration constants), a new setup file is created which is then used in a new online or offline measurement cycle. The database is structured as follows:



The exported filename is constructed as "TableName_Date_Time.csv" (ex. Data_23-10-2018_15-53.csv).

Examples of exported files:

Data:

ID,TimeStamp,SetupID,Timebase,G0_Status,G1_Status,G2_Status,G3_Status,G4_Status,G5_Status,G6_Status,Ch1_Status,Ch1_SampleID,Ch2_Status,Ch2_SampleID,MainBoardStatus,Ch1BoardStatus,Ch2BoardStatus,SensorBoardStatus,FlowS,setFlowS,FlowS_RAW,SamplePumpSpeed,FlowA,setFlowA,FlowA_RAW,AnalyticPumpSpeed,Solenoid1,Solenoid2,Solenoid5,BallValve1,BallValve2,BallValve3,BallValve4,Ch1_Temp,Ch2_Temp,Ch1_Voltage1,setCh1Voltage1,Ch1_Current1,Ch1_Voltage2,setCh1Voltage2,Ch1_Current2,Ch2_Voltage1,setCh2Voltage1,Ch2_Current1,Ch2_Voltage2,setCh2Voltage2,Ch2_Current2,Ch1_SafetyTemp,Ch2_SafetyTemp,SafetyTempInt,Fan1,Fan2,Fan3,Fan4,LicorTemp,LicorPressure,LicorCO2,LicorCO2abs,LicorH2O,LicorH2Oabs,LicorH2Odewpoint,LicorVoltage

1602383,2018-11-16 23:59:59.073,11,20,1,2,1,4,0,0,1,Standby,866,Standby,867,N,n,n,n,16.6347,0,635,255,0,0,203,0,0,0,0,C,C,O,O,100,31,0,0,0,0,0,0,0,0,0,0,0,0,34,33,34,60,0,40,40,51.4907,99.3099,842.182,0.1488839,11.8919,0.07915366,9.36399,11.90369

OnlineResult:

ID,SampleID,StartTimeUTC,EndTimeUTC,StartTimeLocal,EndTimeLocal,TCcounts,TCmass,TCconc,AE33_BC6,AE33_ValidData,AE33_b,OC,EC,
CO2,Volume,Chamber,SetupID, a1,b1,c1,d1,e1,f1,a2,b2,c2,d2,e2,f2

1,3,2018-09-05 09:20:00,2018-09-05 09:40:00,2018-09-05 11:20:00,2018-09-05 11:40:00,1618.25,18529.02,58708,0,0,1,0,0,678.83,315.61,1,4,734.11151923016,0.007605128934671236,-0.0008426029126914941,1.2467680585602101e-5,-5.7904734574089255e-8,8.278151418589865e-11,721.7721108681338,0.07058174812424729,-0.0033522482678232687,4.1361800378848836e-5,-1.7473727839550791e-7,2.3652177675724055e-10

OfflineResult

ID,SampleID,SampleName,StartTimeUTC,StartTimeLocal,TCcounts,TCmass,TCconc,PunchArea,DryingTime,Chamber,SetupID,a1,b1,c1,d1,e1,f1,a2,b2,c2,d2,e2,f2

39,695,5_arso_20170215mm,2018-01-12 12:36:19,2018-01-12 13:36:19,17520.1621,214100,189335,1.1308,0,1,25,653.0881745453704,2.070347518278751,-0.015783676941518294,5.743388472621944e-5,-9.85991925184398e-8,6.435298788574163e-11,-1921.268617466437,20.638064759183404,-

Setup

ID,TimeStamp,SerialNumber,SetFlowS,SetFlowA,Area,FlowFormulaA,FlowFormulaB,FlowFormulaC,FlowFormulaD,FlowFormulaE,FlowFormulaF,CCch1,CCch2,SlopeTempCh1,InterceptTempCh1,SlopeTempCh2,InterceptTempCh2,SampleTime,C0,C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,P11,P12,P13,P21,P22,P23,A0,A2,A3,FlowRepStd,Temp,Pressure,SoftwareVersion,FirmwareVersion,AE33_b,TimeZone,DST,TimeProtocol,BHparamID,FilterIntegrity_threshold

1,2017-09-26 14:19:05,TCA-08-S00-00000,16.7,0.5,4.91,7.31204978640517e-5,-0.0357400687309517,10.0655216405797,9.76321196119687e-7,-4.46034050051914e-6,0.0185413211101763,11.45,11.45,1,0,1,0,60,300,3,12,57,3,495,3,12,57,3,180,265,265,220,265,265,220,100,50,100,1,25,101.325,0.1.0.0,301,1,UTC,1,0,0,0.45

ONLINE DATA FILE description:

ID,	Unique database identifier
SampleID,	Number that represents sample and its analysis data

StartTimeUTC,	Start time of the sampling for the measured Total Carbon Concentration (UTC)
EndTimeUTC,	End time of the sampling for the measured Total Carbon Concentration (UTC)
StartTimeLocal,	Start time of the sampling for the measured Total Carbon Concentration (Local time)
EndTimeLocal,	End time of the sampling for the measured Total Carbon Concentration (Local time)
TCcounts,	Integral of the CO2 signal (ppm)
TCmass,	TC counts multiplied by a Carbon Constant CCCh1 or CCCh2 (ng)
TCconc,	TC mass divided by a volume of sampled air
BC6_AE33,	Averaged Black Carbon value (measured at 880 nm with connected AE33) – same sample timebase as TCA08
AE33_ValidData	Fraction of the AE33 data (in %) which is valid within the TCA08's sample timebase. Please see AE33 user manual to determine which status values represent valid data.
AE33_b	Parameter b: EC = bBC
OC	OC = TC-bBC
EC	EC = bBC
CO2	Average ambient CO2 value (ppm)
Volume,	Volume of sampled air
Chamber,	Chamber in which measurement was done
SetupID,	Configuration of the instrument for this measurement
a1,b1,c1,d1,e1,f1,a2,b2,c2,d2,e2,f2	Polynomial constants which describe CO2 background within first and second heating time

<u>OFFLINE TABLE</u> description

ID,	Unique database identifier

SampleID,	Number that represents sample and its analysis data
SampleName,	Sample name (set by user)
StartTimeUTC,	Start time of the offline analysis (UTC)
StartTimeLocal,	Start time of the offline analysis (Local)
TCcounts,	Integral of the CO2 signal (ppm)
TCmass,	TC counts multiplied by a Carbon Constant CCCh1 or CCCh2 (ng)
TCconc,	TC mass divided by a filter punch area (ng/cm^2)
PunchArea,	Filter punch area (set by user, cm^2)
DryingTime,	Drying time before the offline analysis (s). Analytic pump is running, heaters are turned off.
Chamber,	Chamber in which measurement was done
SetupID,	Configuration of the instrument for this measurement
a1,b1,c1,d1,e1,f1,a2,b2,c2,d2,e2,f2	Polynomial constants which describe CO2 background within first and second heating time

SETUP REPORT description

ID,	Unique database identifier
TimeStamp	Date/Time of Setup record creation
SerialNumber	Instrument serial number
SetFlowS	Set Sample Flow (constant value of 16,7 LPM)
SetFlowA,	Set Analytic Flow (constant value of 0.5 LPM)
Area,	Active filter area determined by lower heater size (constant value of 3.91 cm2)
FlowFormulaA, FlowFormulaB, FlowFormulaC,	Calibration curve for sample flowmeter
FlowFormulaD, FlowFormulaE,FlowFormulaF,	Calibration curve for analytic flowmeter
CCch1,CCch2	Calibration Chamber constants
SampleTime,	Sample timebase
C0,C1,C2,C3,C4,C5,C6,C7,C8,C9,C10	Thermal protocol constants

P11, P12, P13, P21, P22, P23,	Heater powers (W) during thermal analysis
A0, A2, A3,	Analysis constants (see Analysis procedure)
FlowRepStd,	Flow reporting standard ID
Temp,	Manual flow reporting standard: Temperature
Pressure,	Manual flow reporting standard: Pressure
AE33_b	EC/BC ratio *b* defined by user
FilteryIntegrity_Treshold	Limit value for filter integrity test
TimeZone	Region of the globe that observes a uniform standard
time	
DST	Adjust for daylight saving time automatically
TimeProtocol	Automatic/Manual time settings

VERIFICATION TABLE description

ID,	Unique database identifier
TimeStamp	Date/Time of Setup record creation
ReportType,	Analytic Flow = 1; Sample Flow = 2; Carbon Constant = 3; Zero Verification = 4; Temperature Verification = 5
Report	Report result

The ABOUT screen shows the current software and firmware version.

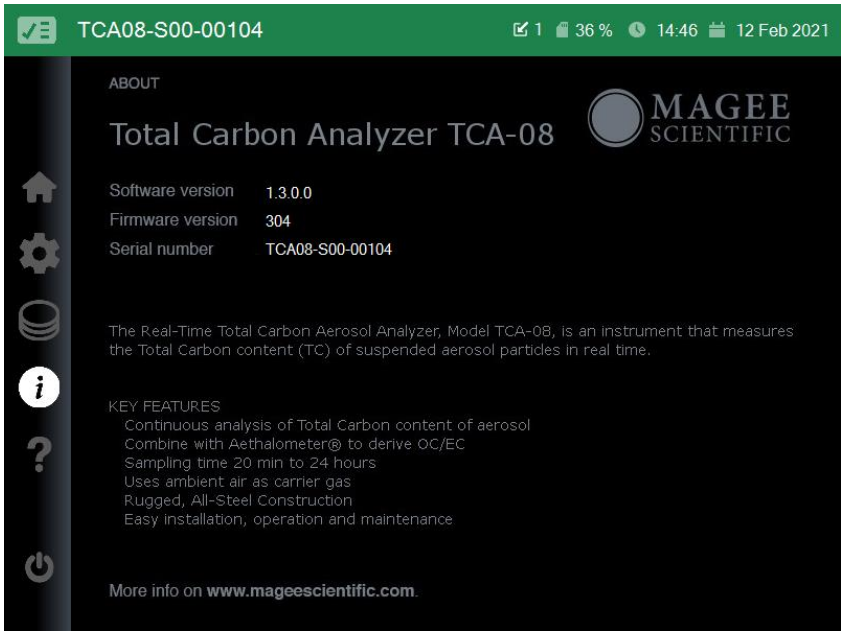


Figure 27. User interface, About.

8.2 Connecting to External Datalogger or PC

Connect with a crossover cable (or standard serial cable with null modem adapter) from the PC / Datalogger to the serial port of the instrument on the rear panel.

Establish communications using the following values:

BaudRate = 115200

DataBits = 8

StopBits = 1 (IO.Ports.StopBits.One)

Parity = None (IO.Ports.Parity.None)

Handshake = None (IO.Ports.Handshake.None)

Serial commands for communication with TCA 08 are specified as follows:

Header	Command	Table ID	From	To	Terminator
$TCA:	STREAM, ID, INFO, LAST, END	Table name or 0-7	''Day Hour'' or ID	''Day Hour'' or ID	CR

All commands finish with Carriage Return (CR). When using STREAM and LAST command, Table number or Table name can be used for Table ID:

Table name	Table number
DATA	0
DATABASEVER	1
EXTDEVICEDATA	2
EXTDEVICESETUP	3
FILTERINTEGRITY	4
HEATERRESISTANCE	5
LOG	6
OFFLINERESULT	7
ONLINERESULT	8
Setup	9
VerificationReport	10

There are 5 possible commands for TCA_DataProtocol: STREAM, ID, INFO, LAST, END.

STREAM

Acquire data from selected DB Table between two dates or two DB table ID fields. If "To" date or ID field is left out, streaming will continue until END command is used.
Examples:
$TCA:STREAM Data ''2018-05-02 12:00:00'' ''2018-05-04 12:00:00'' CR
$TCA:STREAM Data 1200000 1230000 CR
$TCA:STREAM 0 1200000 1230000 CR
$TCA:STREAM 0 ''2018-05-02 12:00:00'' ''2018-05-04 12:00:00'' CR
$TCA:STREAM 0 1200000 CR

ID

Acquire first Data table ID after "From" date field and last Data table ID before "To" date field. ID command is used for faster Data table date range determination with Data Table row ID.
Example:
$TCA:ID Data ''2018-05-02 12:00:00'' ''2018-05-04 12:00:00'' CR

INFO

Acquire general instrument information:

- Instrument name
- Model number
- Serial number
- Firmware version
- Software version
- UTC timestamp

Example:
$TCA:INFO CR

LAST

Acquire last selected DB table row.

Example:
$TCA:LAST SETUP CR

END

Ends STREAM command if running.

Example:
$TCA:END CR

8.3 BH protocol

The instrument supports data acquisition using the BH protocol. The basic command is: <STX>DA<address><ETX><BCC> or <STX>DA<ETX><BCC>.
This command initiates a data transfer from the instrument. The address is optional and can be set on the 'Operation / General" screen as "BH param. ID", after BH protocol is selected as an external device.
The instrument responds to a valid command in the following format:
<STX>MD07<SP><address><SP><value><SP><opStatus><SP><errStatus><SP>0000000000<SP>…
….
<address>><SP><value><SP><opStatus><SP><errStatus><SP>0000000000<SP><ETX><BCC><CR
><LF>

<address>
is the instrument address.
<value>
TCconc
BC6_AE33
AE33_b
OC
EC
AE33_valid data*
Volume
<opStatus>
is the operation status G0 (See 8.4 for details):
00000000 –Standby,
00000001 – Online meas.,
00000010 – Offline meas.,
00000100 – calibration,
00001000 – verification,
00010000 – Change quartz,
00100000 – Initializing standby,

01000000 – Safety stop,

10000000 – Critical stop

<errStatus>

Covers different warnings and errors (See 8.4 for details):

00000000 – no error,

00000001 – Filter warning,

00000010 – Leakage warning G3/4=,2,4,

00000100 – Safety stop G3/4=8,16,32,64,

00001000 – Flow warnings (analytical,sample).

00010000 – External device,

00100000 – Door

8.4 Instrument Status

The General Status of the instrument is shown by the colour of the top line of the screen display, and the LED indicator next to it: (**Green** = OK; **Yellow** = warning, check status; **Red** = error). The detailed **Status Code** can be observed by pressing the Status icon on the far left of the status line. The Status Code of the instrument is a combination of seven groups of sub-status values (8 bits) in the following order:

G0_G1_G2_G3_G4_G5_G6,

where each of the seven groups represent:

G0: TCA operation (G0=0, standby)

G1: Chamber 1 operation status (G1=0, Ch1 = idle)

G2: Chamber 2 operation status (G2=0, Ch2 = idle)

G3: Chamber 1 warning and errors status

G4: Chamber 2 warning and errors status

G5: Common warnings, errors and information

G6: Network & Ext Device status.

bit	**0**	G0	G1	G2
0	**1**	Online meas.	Sample	Sample
1	**2**	Offline meas.	Analysis	Analysis
2	**4**	Calibration	Clean	Clean
3	**8**	Verification	Leakage	Leakage
4	**16**	Change quartz	Denuder	Denuder
5	**32**	Initializing standby	Zero	Zero
6	**64**	Safety stop	Temperature	Temperature
7	**128**	Critical stop		

bit	**0**	G3	G4
0	**1**	Voltage Timeout ***e***	Voltage Timeout ***e***
1	**2**	Leakage ***w***	Leakage ***w***
2	**4**	Filter Integrity Failed ***w***	Filter Integrity Failed ***w***
3	**8**	Heater Error ***e***	Heater Error ***e***
4	**16**	Overcurrent ***e***	Overcurrent ***e***
5	**32**	Voltage set error ***e***	Voltage set error ***e***
6	**64**	Temperature sensor not connected ***e***	Temperature sensor not connected ***e***
7	**128**	Ball Valve error ***e***	Ball Valve error ***e***

bit	**0**	G5	G6
0	**1**	Door Open ***w***	Network detected
1	**2**	Analytical flow ***w***	Database ***e***
2	**4**	Sample flow ***w***	Setup ***e***
3	**8**	Cooling fan ***w***	External device ***w***
4	**16**	CO2 Error e	Storage ***w***
5	**32**		Internal communication ***e***
6	**64**		
7	**128**		

When the status flag is type of ***e*** (error), the instrument stops. When the status flag is type of ***w*** (warning), the instrument keeps on running but needs technical attention. The overall status of each group G0 to G6 can be a combination (sum) of statuses.

Warnings:

- Leakage warning: TCA detected leakage in Chamber 1 or 2 with Leakage test (See Section 9.2 Leakage test). Inspect the chambers and repeat the leakage test again.
- Filter Integrity Failed: TCA detected that one of the filters in Chamber 1 or 2 might be broken. Stop the measurement and change the broken filter (See Section 9.1 Quartz filter change procedure). Additionally, a pop-up window WARNING is shown on the screen when filter integrity status occurs.
- Door open: TCA door is open.

IMPORTANT:

If the temperature in one of the chambers is above 50°C and the door is open, the following screen will be displayed, along with an audible alert and a red LED flashing on the upper right side of the opened door frame:

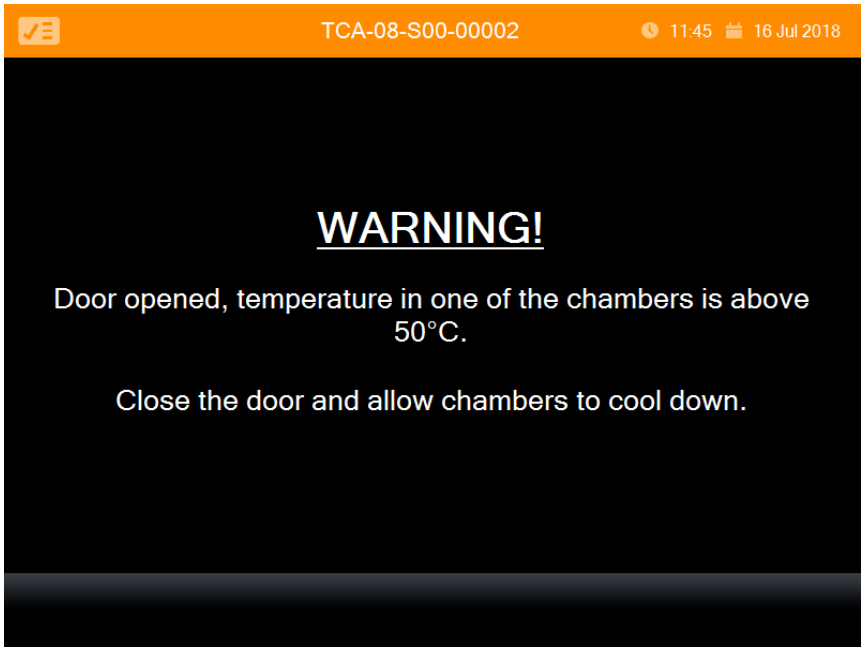


Figure 28. Warning screen when the door is opened and the temperature in one of the chambers is above 50° C.

Immediately close the door and allow chambers to cool down!

- External device: (1) External device is connected but there is no data transfer or external device data is out of bounds. (2) AE33 connected, but AE33 flow reporting standard differs from TCA08 flow reporting standard.
- Analytic flow: Average analytic flow was lower than set flow limit in the last analysis. Make sure the analytical air inlet tubing is not blocked.
- Sample flow: Average sample flow was lower than set flow limit in the last sampling. Make sure the sample air inlet tubing is not blocked.
- Cooling fan: One of the chamber cooling fan is not working. Check the fan for blockage or disconnection.

- Storage: Number of Data rows is reaching the internal memory limit. Delete older Data rows by using commands in the Storage menu. We recommend to backup the database before deleting the rows.

Errors:

- Voltage timeout: Voltage driver for one of the heating modules in Chamber 1 or Chamber 2 was turned on longer than limit time value. Instrument will stop the measurement, reset and try to continue with measurement. If this error occurs 3 times, instrument will not continue with the measurement (G0=64, safety stop).
- Heater error: Instrument detected that the heating wire in one of the heating modules in Chamber 1 or Chamber 2 is broken or has a loose contact with the voltage supply pin. Instrument will stop the measurement and turn on status G0=64, safety stop.
- Overcurrent: Measured current in one of the heating modules in Chamber 1 or Chamber 2 is higher than limit current value. Instrument will stop the measurement, reset and try to continue with measurement. If this error occurs 3 times, instrument will not continue with the measurement (G0=64, safety stop).
- Voltage Set Error: Set voltage value for one of the heating modules in Chamber 1 or Chamber 2 is higher than limit voltage value. Instrument will stop the measurement, reset and try to continue with measurement. If error occurs 3 times, instrument will not continue with the measurement (G0=64, safety stop).
- Thermocouple temperature sensor failure: Sensor in Chamber 1 or Chamber 2 is not connected or broken. Instrument will stop the measurement, reset and try to continue with measurement. If this error occurs 3 times, instrument will not continue with the measurement (G0=64, safety stop)

Please wait at least 1 hour after the instrument shows "Temperature sensor not connected" (G3=64 or G4=64) status before performing any service or maintenance procedure on the instrument or on the measurement chambers. This is a safety measure against possible high temperatures.

- Ball Valve Error: One of the Ball Valves in the sampling channels 1 or 2 has reported an error. Instrument will stop the measurement, reset and try to continue with measurement. If this error occurs 3 times, instrument will not continue with the measurement (G0=64, safety stop).
- Database: Storage CF card is missing.
- Setup: One of the values in the setup table in the database is out of bounds. Instrument will turn on status G0=64, safety stop.

- Internal communication: Error in internal communication. Instrument will turn on status G0=64, safety stop.
- CO2 Error: CO_2 sensors ppm values exceed operating range. CO_2 sensor needs to be serviced.

8.5 Instrument Reset

If the instrument is in status G0=64 (safety stop), it must be restarted before it can be used again. Please follow these instructions below:

- Press the Power ON/OFF icon on the lower left side of the startup screen. The following message is displayed (Figure 29).

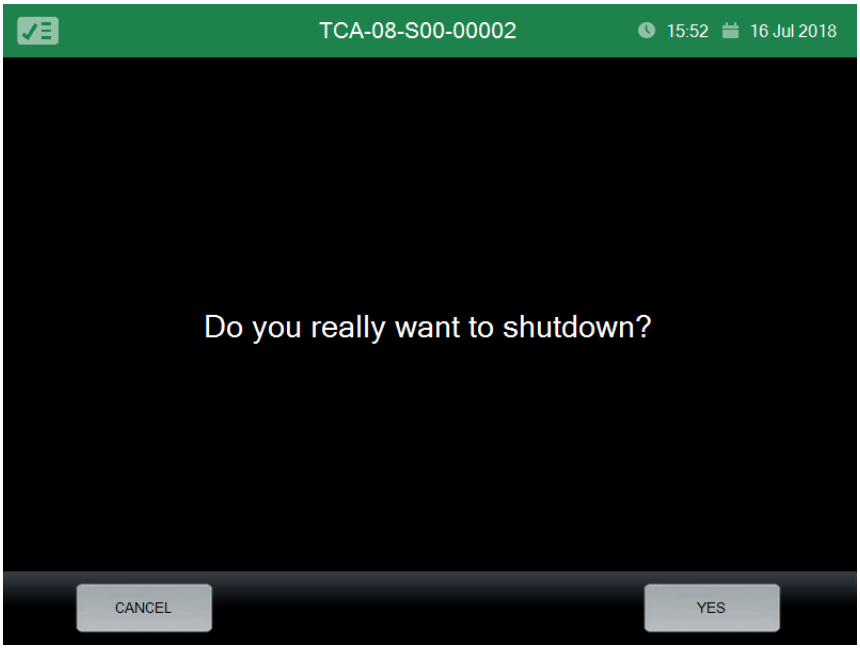


Figure 29. Shut down screen.

- Press YES and wait for the instrument to turn OFF.
- Wait for 10 seconds.
- Press and hold the Power ON/OFF button for 3 seconds again. After a long beep, the instrument will turn ON again.

Figure 30. Power ON/OFF button is located below the screen on the left side.

8.6 Instrument emergency stop

The TCA-08 instrument can be stopped at any time by pressing and holding the Power ON/OFF button for 3 seconds. The button is located below the screen on the left side (Figure 30). To turn on the instrument again, wait for 10 seconds and press and hold the Power ON/OFF button for 3 seconds again. After a long beep, the instrument will turn on.

8.7 Set Date/Time

- Stop the measurement and wait for TCA Standby status (G0=0).
- Press the Date/Time icon in the top green status line and adjust Date/Time and time zone (Figure 31). If the TCA is connected to the internet, Date/Time and time zone can be adjusted automatically.
- Press set and save new settings.

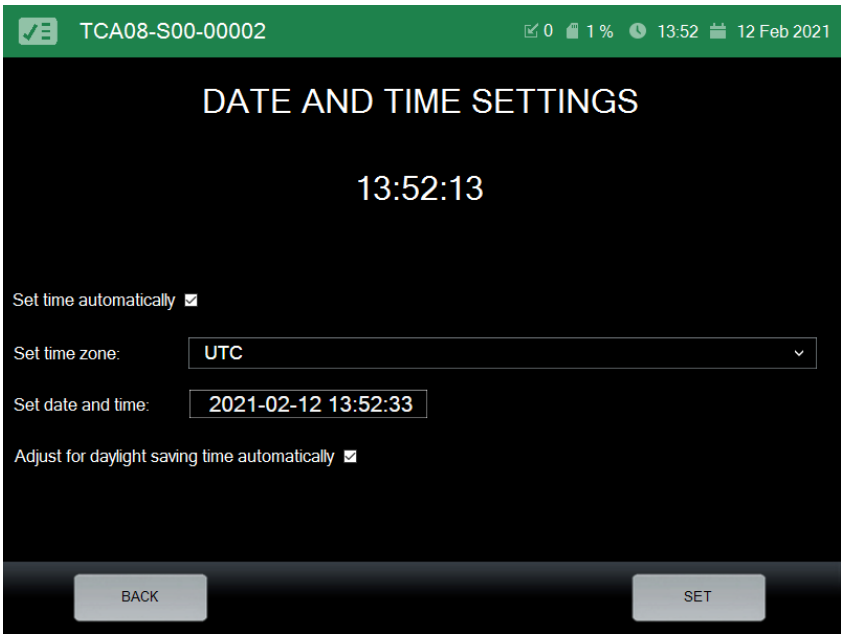


Figure 31. Date and Time settings

8.8 System update

Take a USB memory drive and copy the following files to its root directory:

TC.exe (software),

TCCH304.hex, TCSE304.hex, TCMA304.hex (firmware):

- Stop the measurement and wait for TCA Standby status (G0=0).
- Insert the USB key into the front USB slot. Wait 10 seconds.
- Go to "OPERATIONS/System update" menu.
- Choose "Software" update.
- Wait until the TCA08 finishes the upgrade. At the end of the upgrade, instrument will restart. This can take up to 15 minutes!
- Choose "Firmware" update.
- Wait until the TCA08 finishes the upgrade. At the end of the upgrade, instrument will restart. This can take up to 5 minutes!
- Check the "OPERATIONS/About" to verify the software and firmware version numbers.

Important: Preform software update before firmware update!

9. MAINTENANCE and SERVICE

The two measurement chambers are located behind the instrument's front panel door and are not intended to be accessed by the user under normal instrument operation. HOT SURFACES of the measurement chambers of the instrument are clearly marked with a hot surface caution label. INJURIES could occur from coming in contact with hot surfaces. ALWAYS allow enough time for the hot surfaces to cool down before performing any service or maintenance procedure on the instrument or the measurement chambers.

Please wait at least 1 hour after the instrument is switched OFF before performing any service or maintenance procedure on the instrument or on the measurement chambers.

The TCA 08 is a sophisticated and complex instrument and requires regular maintenance. We recommend the following schedule:

Cleaning with dry cloth	**as needed**
Verify Sample inlet flow	**once / month**
Inspect the sample line tubing	**once / month**
Inspect and clean the size selective (PM2.5) inlet	**once / month**
Verify date/time	**once / month**
Quartz filter change procedure	**once / month**
Zero verification and Denuder efficiency test	**once / month**
Flow verification (analytic /sample flow), calibrate if necessary	**twice / year**
Change analytic air filter	**twice / year**
Change cartridge filter	**once / year**
Verification of TCA 08 with ambient filter punches, calibrate if necessary	**once / year or after any major maintenance or modification of the system**
Change heating modules	**once / year**
Leakage test	**each time a chamber is opened**
Replacement of CO_2 analyzer	**once/2 years**

9.1 Quartz filter change procedure

Always use the "Quartz filter change procedure" when changing the filter. This ensures that the instrument will automatically check for leakage and pre-condition the filters before the first heating cycle. Failure to do so may result in a premature filter integrity failure after the first heating cycle.

Stop measurements, wait for chambers to cool down and follow instructions. You will need two fresh 47 mm quartz filters, and a pair of tweezers. Use only TCA08 5 01 006 quartz filters (see Section 10).

- Make sure that the sampling protection caps are removed (if the instrument is being set up for the first time at this location).
- STOP the measurements.
- Wait for the chambers to cool down before you open the door. A warning will be shown on the screen together with an audible beep, if the door is opened when the temperatures in either chamber is above 50°C.
- Go to OPERATION tab and select "Quartz filter change" procedure.
- Rotate the locking screw ring on Chamber 1 to unscrew it in an anti-clockwise direction until the upper half of the chamber can be slid upwards on the inlet tube

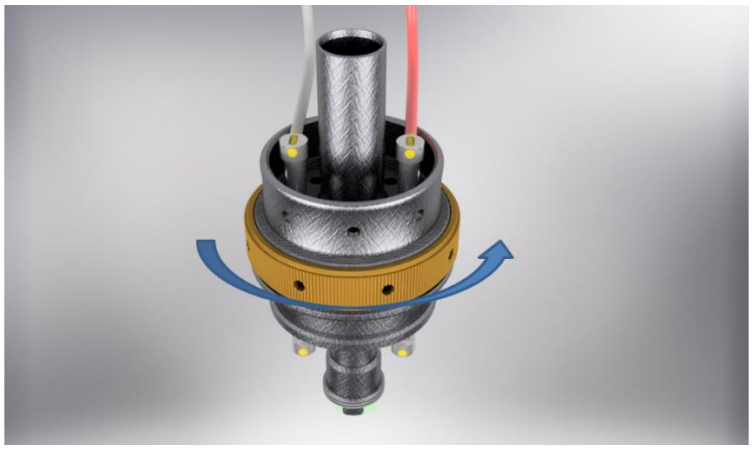


Figure 32. Rotate the threaded clamping ring on Chamber 1 in a counter-clockwise direction until you can slide the upper part of the chamber upwards on the tube.

- Remove the old filter using tweezers and carefully install a new filter. Make sure it is positioned centrally on the lower chamber half (See Figure 33).

Figure 33. Remove the old filter using tweezers, and carefully install a new filter.

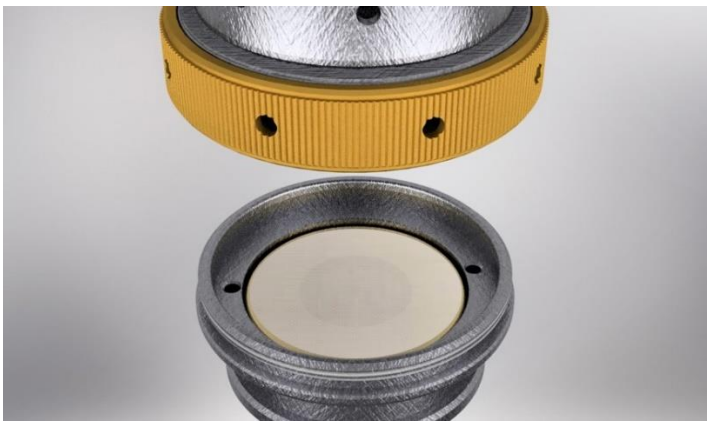


Figure 34. Make sure the new filter is positioned centrally.

- Slide the upper half of the chamber back down, and check that its two locating pins have inserted into the matching holes in the lower chamber half.
- Rotate the locking screw ring in a clockwise direction until the chamber is closed and the quartz filter is firmly compressed between the upper and lower halves.
- Repeat the same procedure for chamber 2.
- Press “Finished”. The instrument will start the leakage test for both chambers.

At the conclusion of the leakage test, the instrument will start the "fresh filter preparation procedure". In each chamber, air flow will run for 2 minutes to condition the filter before the first heating cycle. This procedure extends the operational lifetime of the quartz filters.

9.2 Leakage test

The Leakage Test is a fully automated procedure to check for leakage in (1) chamber 1 flow line (chamber 1, cartridge filter, CO_2 detector) and in (2) chamber 2 flow line (See flow scheme in Fig. 4). Leakage values below 0.5 % are acceptable.

9.3 Manual analytic/sample flow calibration

For manual calibration, an external flow-meter and a connecting adapter is needed. Please note the units and conditions at which your flow-meter reports flow, and take care to convert these to the flow at the appropriate standard temperature and pressure conditions specified in the TCA. Before starting an analytic/sample flow calibration, perform the Leakage Test. If the Leakage Test result is acceptable, flow calibration is needed in only one chamber.

- Stop measurement
- Go to OPERATION tab and select Calibrate Flow
- By sliding lower tube coupler TCA08 8 03 004 down, and upper coupler up, the TCA 08 can be detached from its upper inlet stack (see Fig. 34).
- Connect the external flowmeter to the sample inlet.

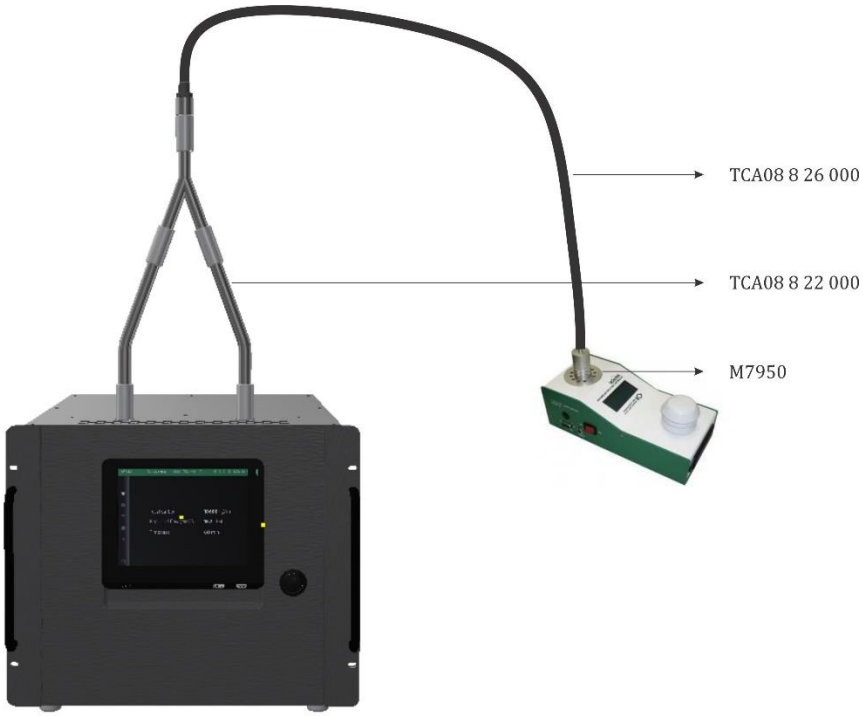


Figure 35. Connect TetraCal flowmeter (M7950) to the TCA08 sample line with TetraCal adapter kit (TCA08 8 26 000).

- Press NEXT.
- Select Analytic or Sample flow calibration. Press Next.
- Select chamber and press OK
- Input measured flow and flowmeter reporting conditions (pressure, temperature) and press OK (repeat for 3 different flows).

9.4 Sample/Analytic flow meter verification

The Sample/Analytic flow verification routine is used to check if the internal flow meters need calibration. No instrument settings are changed during the flow verification routine.

9.5 Cleaning Procedure

The Cleaning Procedure will clean a filter in Ch1 or Ch2 chamber by performing one thermal analysis cycle. No data result is given after this procedure.

9.6 Zero Verification

Cleaning procedure should be done prior to Zero verification!

The Zero Verification test will perform one thermal analysis cycle in Ch1 or Ch2. At the end, the measured TC mass will be shown as the result in ng. Values between -500 µg and 500 ng TC are acceptable in terms of the reported mass of carbon on a "clean" filter.

9.7 Offline analysis

The TCA08 can be used for the "offline" thermal analysis of aerosol samples previously collected on quartz fiber filters. These may be inserted as a punch, on a top of the installed cleaned 47-mm filter.

- Stop measurement
- Perform the Cleaning procedure and Zero Verification for the chamber in which you wish to perform offline analysis (See Sections 9.5 and 9.6)
- Wait for the chambers to cool down before you open the door. Make sure that the chamber temperature is close to room temperature before you insert a sample for analysis: this prevents volatilization of any material on the sample.
- Rotate the locking screw ring on the chamber to unscrew it in an anti-clockwise direction until the upper half of the chamber can be slid upwards on the inlet tube. Please see Figure 32.
- Using tweezers, insert a punch of the sample-containing filter and put it on top of the 47 mm quartz filter that was cleaned using Cleaning Procedure. Please see Figure 36.
- Go to OPERATION/Tests&Procedures tab and select Offline analysis

Figure 36. Using tweezers insert punch of ambient filter and put it on the 47 mm quartz filter that was cleaned using Cleaning procedure.

- On this screen, enter the Sample Name and Punch Area (in cm^2). Select in which chamber you want to preform offline analysis and select drying time (time in seconds before offline analysis will start, analytic flow will be turned on). Please see Figure 37.
- Press Start. When the procedure finishes TC mass (in ng) and TC concentration (in ng/cm^2) will be shown on screen.

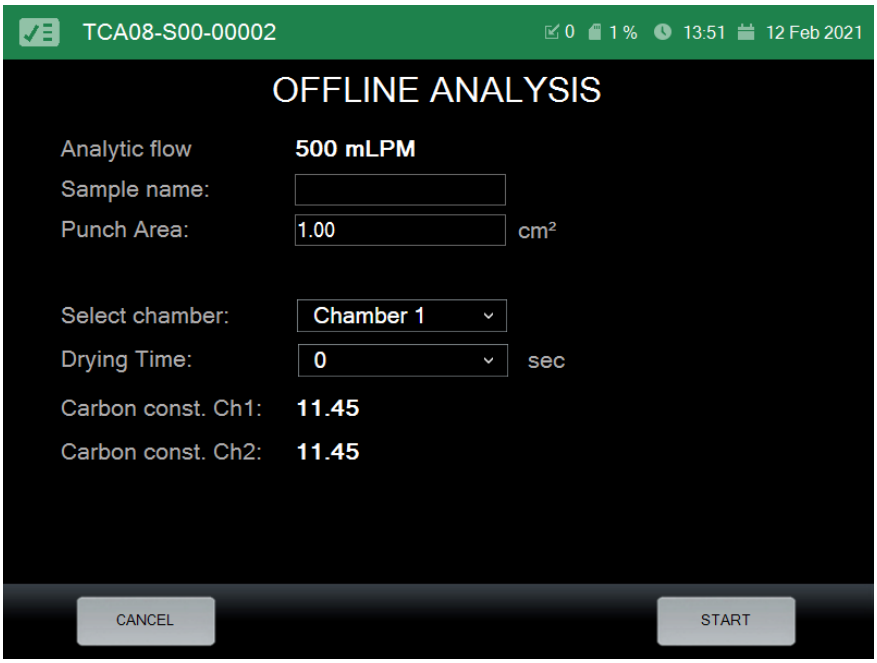
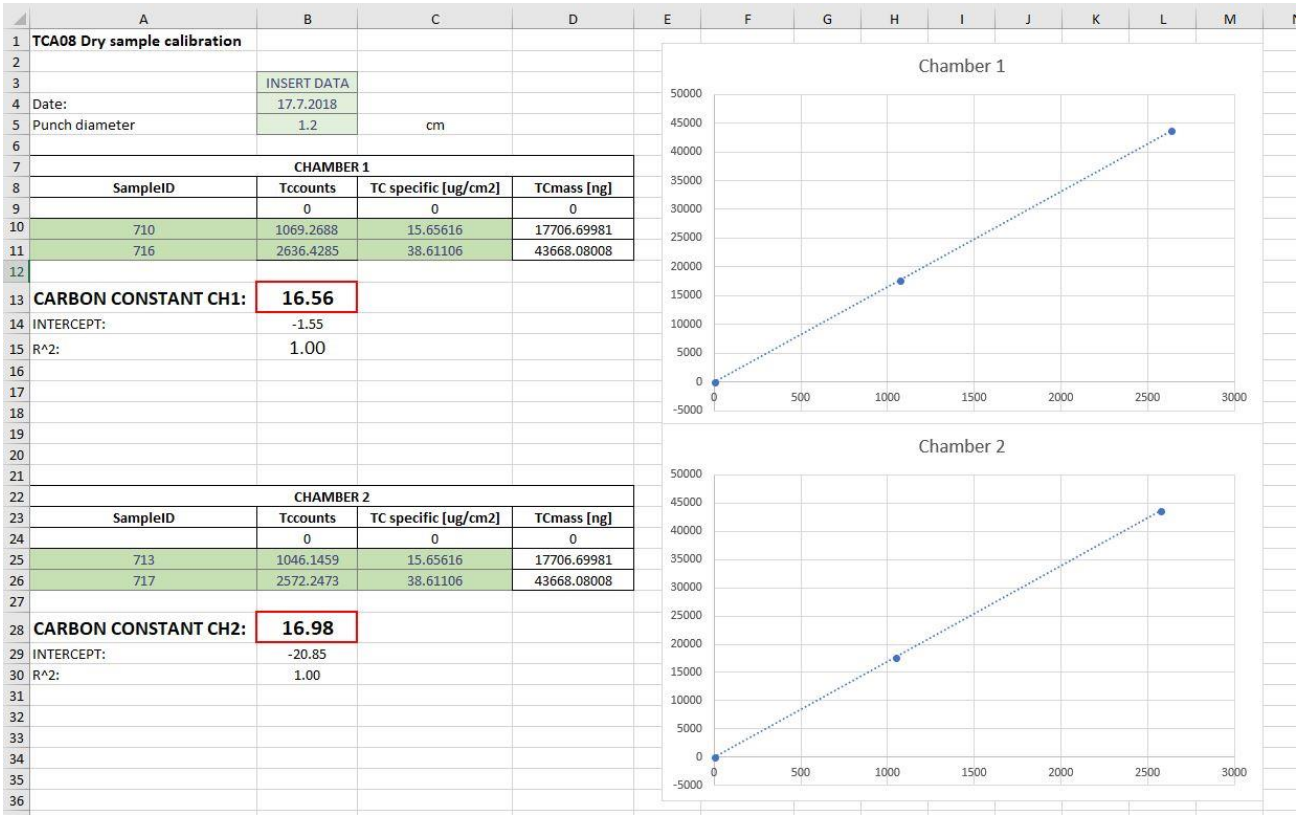


Figure 37. Offline analysis

9.8 Carbon Calibration

Calibration of the carbon detector response is performed by using punches of dry ambient filters that were measured with calibrated OC/EC/TC instrument. Perform Offline procedure (See Section 9.7) for a blank (cleaned filter) and two different punches of ambient filters for each chamber. The concentration range of the filter punches should be similar to the ambient concentration levels. In the database, select the OfflineResult table and locate the 'TC counts' column. Compare these values to the measured TC content from the OC/EC instrument. See Figure 38. The slope of the linear fit is the Carbon Calibration value.

New carbon calibration values can be saved using the Operations/General screen (Figure 19.) Press on the old value of the Carbon Constant Ch1 and insert a new one. Repeat for Carbon constant Ch2. Press Start Online measurement and confirm new settings. This will also change the carbon constants in Offline Analysis menu (Figure 37).



	A	B	C	D
1	**TCA08 Dry sample calibration**			
2				
3		INSERT DATA		
4	Date:	17.7.2018		
5	Punch diameter	1.2	cm	
6				
7		**CHAMBER 1**		
8	**SampleID**	**Tccounts**	**TC specific [ug/cm2]**	**TCmass [ng]**
9		0	0	0
10	710	1069.2688	15.65616	17706.69981
11	716	2636.4285	38.61106	43668.08008
12				
13	**CARBON CONSTANT CH1:**	**16.56**		
14	INTERCEPT:	-1.55		
15	R^2:	1.00		
16				
17				
18				
19				
20				
21				
22		**CHAMBER 2**		
23	**SampleID**	**Tccounts**	**TC specific [ug/cm2]**	**TCmass [ng]**
24		0	0	0
25	713	1046.1459	15.65616	17706.69981
26	717	2572.2473	38.61106	43668.08008
27				
28	**CARBON CONSTANT CH2:**	**16.98**		
29	INTERCEPT:	-20.85		
30	R^2:	1.00		
31				
32				
33				
34				
35				
36				

Figure 38. Example of the Dry Sample calibration data.

CAUTION – if the calibration constants appear to have changed substantially (> 10%); or if the correlation coefficient (R^2) of the calibration results is lower than 0.9; we recommend that you repeat the Calibration procedure to verify the new values. Changing the Carbon Calibration constants changes the proportional response of the entire instrument.

9.9 Denuder efficiency test

Carbonaceous species in the gas phase (i.e. organic carbonaceous vapours) can be adsorbed by quartz fibre filters and will affect the result as a positive sampling artefact. The TCA08 instrument uses a honeycomb charcoal denuder to remove gas-phase OC at the 16.7 LPM sampling flow. This ensures that its analysis represents the TC content of aerosols only. The denuder efficiency slowly decreases as the denuder active surfaces become saturated with OC gas molecules. We recommend that the denuder should be replaced with a fresh one every month of active TCA operation or when its efficiency drops below 70 %. Furthermore, in environments with high VOC concentrations, two denuder honeycombs in series are

recommended. For more details, the reader can refer to section "2.3 Positive and negative sampling artifacts in the TCA08 Total Carbon Analyzer" of article by Rigler et al.: Atmos. Meas. Tech., 13, 4333–4351, 2020: https://doi.org/10.5194/amt-13-4333-2020.

The Denuder Efficiency Test provides a quantitative method to determine the efficiency of the denuder. For this test, the In-Line Filter Holder TCA08 8 24 000 and a TCA tube section TCA08 0 03 007 are needed. Insert a fresh quartz filter (TCA08 5 01 006) in the In-Line Filter Holder (Figure 39) and assemble TCA08 sampling system as shown in Figure 40. Connect the In-Line Filter Holder to the external sampling system.

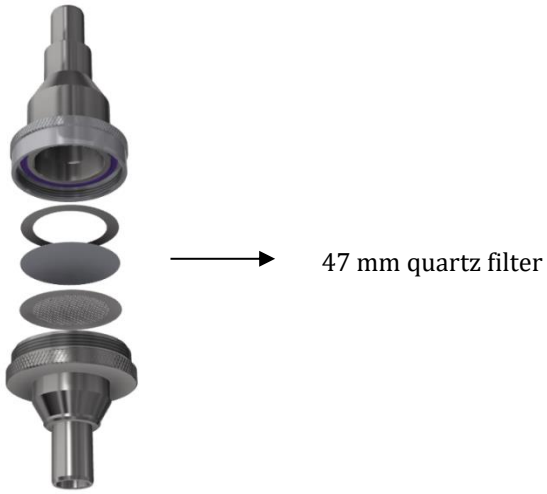


Figure 39. In-Line Filter HolderTCA08 9 24 000 assembly

- Go to OPERATION tab and select Denuder Efficiency Test.
- Use the same settings as for the online measurement press start Online.

The denuder efficiency is obtained as

$$E_{\mathrm{D}} = \left[\frac{1}{n}\sum_n \frac{\mathrm{TC}_{\mathrm{F},n} - \mathrm{TC}_{\mathrm{F+D},n}}{\mathrm{TC}_{\mathrm{F},n}}\right] \cdot 100,$$

where $\mathrm{TC}_{\mathrm{F+D},n}$ is n-th Total Carbon content measured in chamber 1, where sample stream goes through filter above divider and denuder and $\mathrm{TC}_{\mathrm{F},n}$ is n-th Total Carbon content

measured in chamber 2, where sample stream goes only through filter above divider. Constant gaseous OC concentration approximation through *n* measurements is used for calculation. At least two measurements are recommended in each chamber.

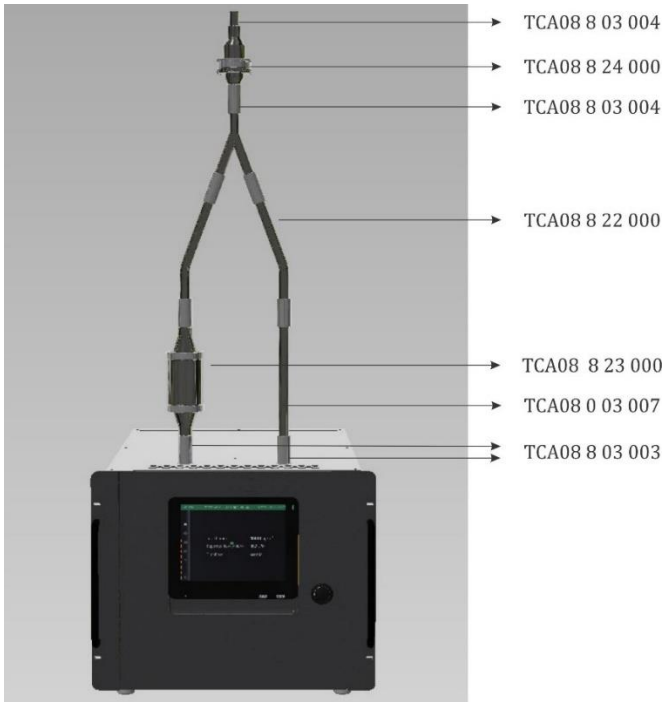


Figure 40. TCA08 denuder efficiency test assembly. Place denuder above chamber 1.

9.10 Temperature calibration

The External Thermocouple Kit TCA08 8 01 500 is required for the Temperature Calibration procedure. The calibration is done at two temperatures: (1) room temperature (T_{min}) and (2) maximum combustion temperature (T_{max}), and is interpolated linearly.

- Stop measurement
- Wait for the chambers to cool down. Make sure that the chamber temperature is close to room temperature before you start with calibration: this assures the correct value of T_{min}.
- Go to the OPERATION tab screen and select Temp. Probe Calibration. Follow instructions on the screen.
- Rotate the locking screw ring on Chamber to unscrew it in an anti-clockwise direction until the upper half of the chamber can be slid upwards on the inlet tube. Please see Figure 32.

- Remove the old filter using tweezers.
- Remove the calibration temperature protection plug. See Figure 41.

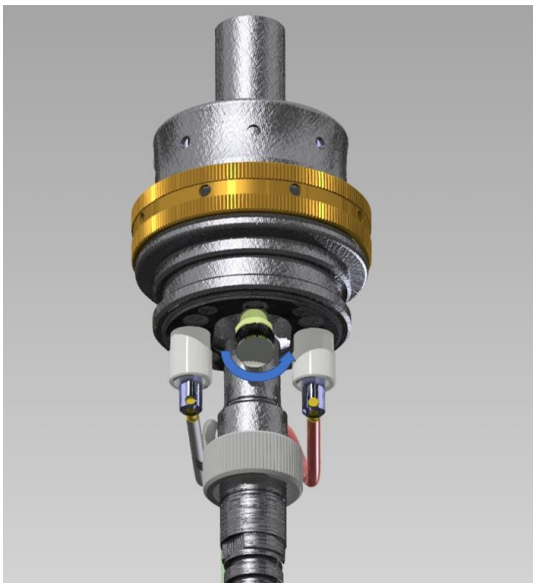


Figure 41. Remove calibration temperature protection plug.

- Insert the calibration temperature probe TCA08 9 01 500 and carefully push it towards the chamber until it reaches the end position. Tighten the nut to secure the probe in place. (Figure 42). **Make sure that the temperature calibration probe is not in contact with the heating wire. Slightly bend the probe if necessary.** Please see Figure 43.
- Carefully install a new filter. Make sure it fits centrally onto the lower chamber half.
- Slide the upper half of the chamber back down and check that its two locating pins have inserted into the matching holes in the lower chamber half. Rotate the locking screw ring in a clockwise direction until the chamber is closed and the quartz filter is firmly compressed between the upper and lower halves.

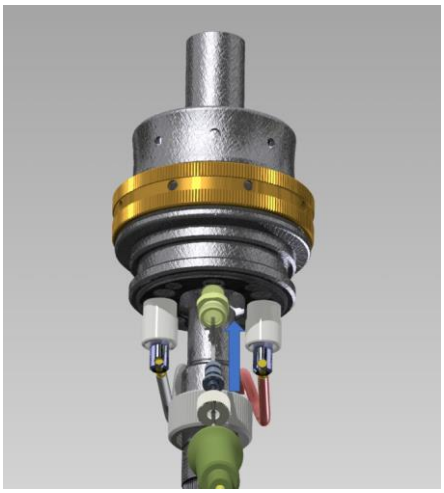


Figure 42. Insert calibration temperature probe and carefully push it towards the chamber until your reach end position.

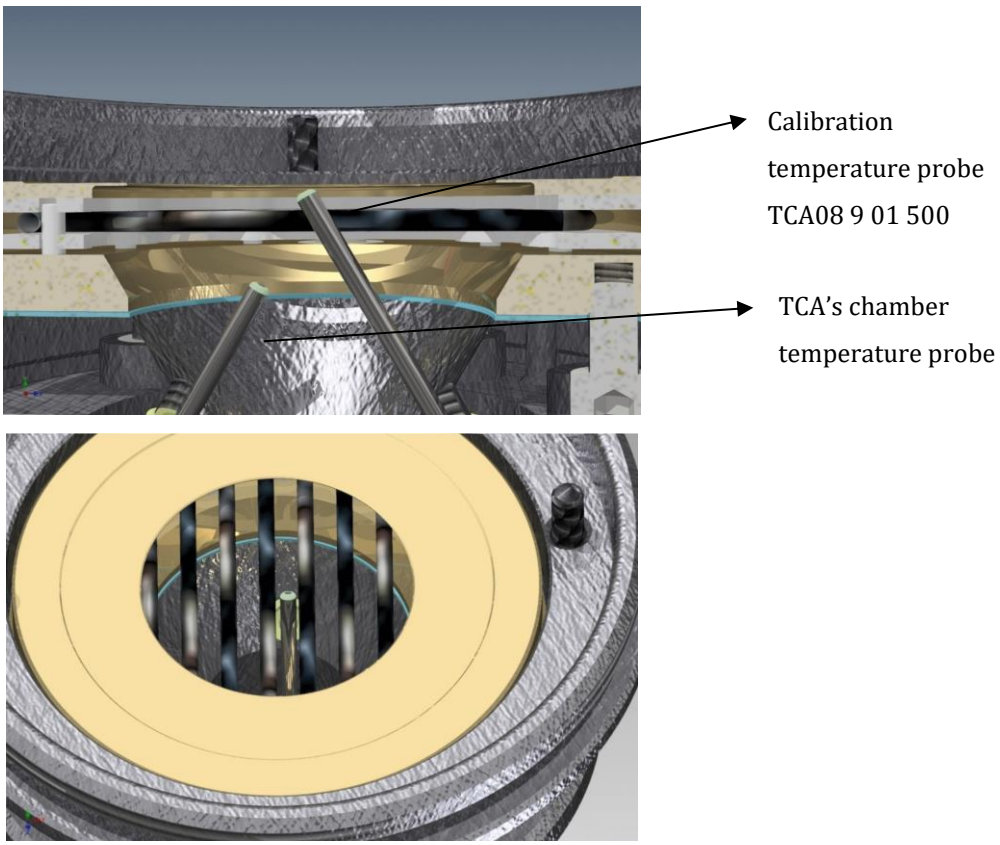


Figure 43. Make sure that temperature calibration probe is not in contact with the heating wire. Slightly bend the probe if necessary.

- Slide the upper half of the chamber back down and check that its two locating pins have inserted into the matching holes in the lower chamber half. Rotate the locking screw ring

in a clockwise direction until the chamber is closed and the quartz filter is firmly compressed between the upper and lower halves.

- **<u>Make sure to select MIN/MAX setting on handheld thermometer TCA08 5 01 010.</u>** (Figure 44). At the end of the temperature calibration protocol, you will be asked to input the MAX temperature measured with your probe.

Figure 44. Make sure to select MIN/MAX setting on your calibration probe.

- Enter the MIN temperature shown on your handheld thermometer (T_{min}).
- Wait for the temperature calibration protocol to finish.
- Enter the MAX temperature shown on your handheld thermometer (T_{max}).

9.11 Temperature verification

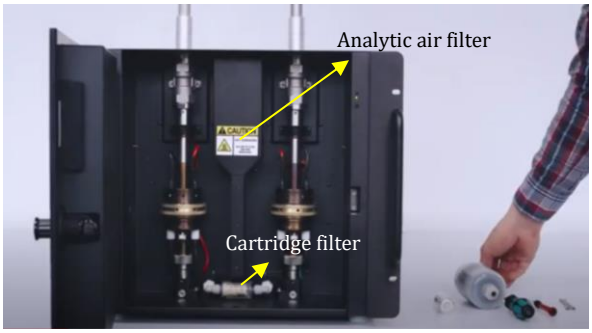
The Temperature verification routine is used to check if the chamber temperature probes need calibration. No instrument settings are changed during the Temperature verification routine.

9.12 Replacement of the Analytic air filter and the cartridge filter

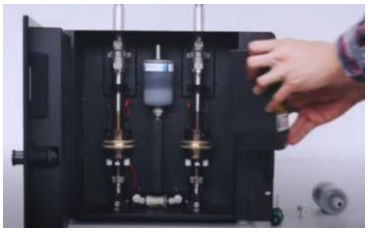
- Stop with the measurement
- Wait for the chambers to cool down.

To change the air filters in the TCA08 you will need a set of new Analytic air filter (PN TCA08 9 03 002) and a new cartridge filter (PN M8072) and a set of tools (long crossed PH1 screwdriver and push to connect tool – AET 0 11 001).

Start with the Analytic air filter replacement procedure:



- Unscrew the Analytic Air filter cover (2 crossed screws on each side in the right figure).



- Remove the cover by pushing it upwards (left figure), release the grip adapters of the analytic air filter by using push to connect tool (middle figure) and disconnect the analytic air filter from the tube (right figure). Install the new analytic filter in reverse order.

Now continue with the cartridge filter replacement procedure.


Release the grip adapter of the cartridge filter with push to connect tool (left figure). Once the filter is removed from the TCA08, repeat the same also for the elbow connectors on the

left and right side of the cartridge filter (right figure). Take the new cartridge filter and repeat the procedure in reverse order.

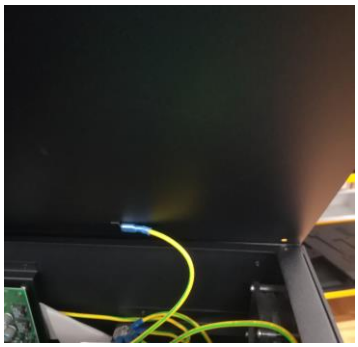
Finally install the new cartridge filter by pressing elbow connectors firmly down into the sockets. Pay attention to proper orientation of the air flow arrow on the filter, pointing from the right to the left (indicated with the yellow circle below).

9.13 CO_2 analyzer replacement procedure

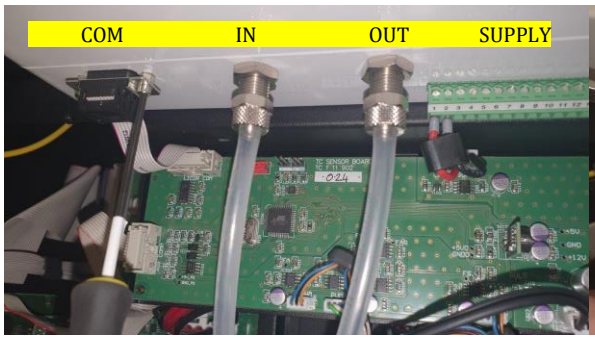
In case of CO2 analyzer failure or regular maintenance please proceed as follows:

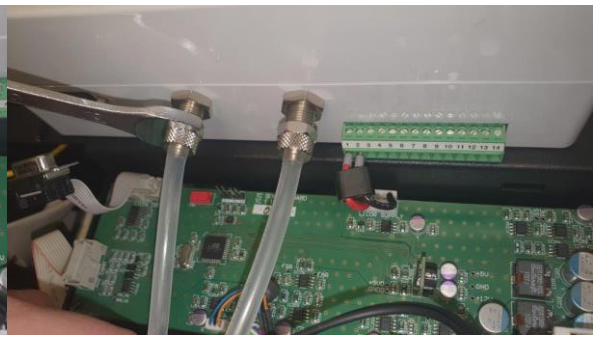
- Stop with the measurement
- Wait for the chambers to cool down and then TURN OFF the instrument on the rear panel.
- Tools needed (12/13 mm wrench, metric allen key 3 mm, imperial allen key for screws UNC#4/40 – for COM cable release):

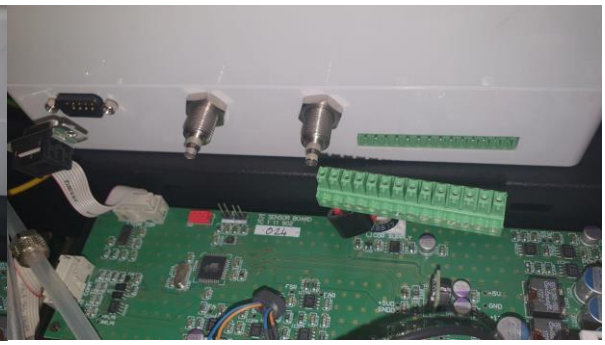
- Remove the top cover of the instrument (screws indicated with red in the left figure below). Disconnect grounding wire from the top cover (right figure below).

- Remove connectors from the CO_2 analyzer (COM, IN, OUT, and SUPPLY):

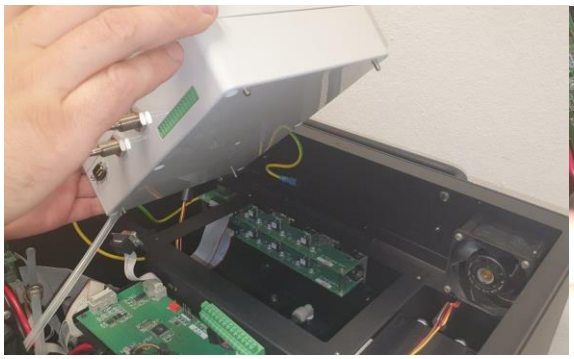


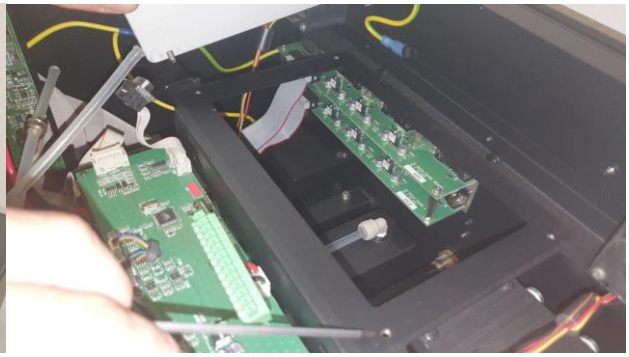




- Unscrew 4 screws indicated below in yellow

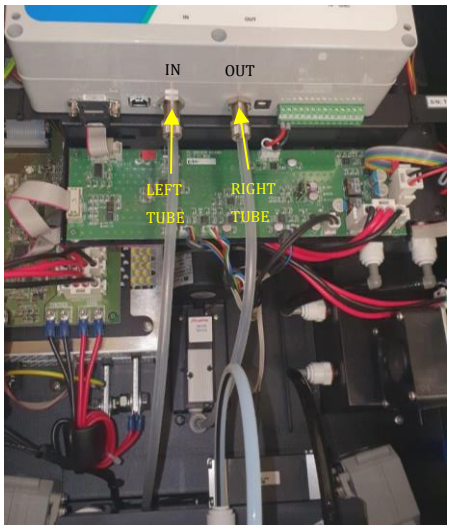
Remove the CO_2 analyzer from the instrument housing and exchange it with the new one. Pay attention to screw holes on the housing to properly position the new CO_2 analyzer (right figure below).





Install the new CO_2 analyzer in reverse order. Afterwards it is highly recommended to repeat the carbon calibration procedure (for more details please see section 9.8).

IMPORTANT: PAY ATTENTION TO INSTALL CORRECT TUBES on the IN or OUT CONNECTOR (looking from the front panel of the instrument, the LEFT tube must fit on IN and the RIGHT tube must fit on OUT) – FIGURE BELOW!!



10 STANDARD ACCESSORIES

Product NO	Pcs	Description	Picture
TCA TUBES KIT TCA08 8 22 000			
TCA08 0 03 001	**1**	Divider 40deg	 
TCA08 0 03 002	**1**	Divider Tube	
TCA08 8 03 003	**4**	Tube coupling A	
TCA08 8 03 004	**4**	Tube coupling B	
TCA08 0 03 005	**1**	Tube 14x2-90	
TCA08 0 03 006	**1**	Tube 14x2-152	
TCA08 0 03 007	**1**	Tube 14x2-242	
ORVMQ 18x2,5	**32**	O-ring 18x2,5 VMQ 70ShA	
VOC DENUDER KIT TCA08 8 23 000			
DE01 0 01 001	**1**	Main Tube	
DE01 0 01 002	**2**	Diffuser Tube	
DE01 0 01 003	**2**	Nut M60x1,5	
DE01 0 01 004	**1**	DE Ring	
TCA08 5 01 004	**2**	VOC Denuder – Activated	
ORVMQ 46x3	**2**	Carbon Element, with Shell	
		O-ring 46x3	
In-Line Filter Holder, 47mm TCA08 8 24 000			
FS02 0 01 001	**1**	Inlet Diffuser	
AEFH 0 01 002	**1**	Nut M54x1,5	
AEFH 0 01 003	**1**	slide Washer d51/44	
FS02 0 01 004	**1**	Outlet Tube	
AEFH 0 01 005	**1**	Slide Ring	
AEFH 0 01 007	**1**	Support mesh	
	1		

OR278 40x3,5		O-ring 40x3,5	
Sharp-Cut Cyclone Inlet TCA08 5 01 005 TCA08 8 25 000			
TA08 5 01 005 TCA08 0 03 003 TCA08 0 03 012 TCA08 0 03 013 ORVMQ 18x2,5	**1** **1** **1** **1** **4**	Sharp-Cut Cyclone Inlet, 2.5 µm at 16.7 LPM flow Tube coupling A Inlet Reducer Protective Cap O-ring 18x2,5	
External Thermopile Kit TCA08 8 01 500			
TCA08 5 01 010 TCA08 9 01 500	**1** **1**	Handheld Termometer Thermopile with Fitting	
OTHER ACCESSORIES			
TCA08 9 03 002	**1**	Whatman 6704-7500 ‘CarboCap’ 75 Capsule Filter	
M8072	**1**	Cartridge Filter	

TCA08 5 01 006	**1**	Quartz Filters, 47 mm, 25 pcs	
M5530-A	**1**	Meteorological Sensor GMX300 (T, RH, P, DewPoint): 10 m cable included	
M5550-A	**1**	Compact weather station GMX500 (T, RH, P, DewPoint wind): 10 m cable included	
M5520-A	**1**	Wind sensor GMX200: 10 m data cable included	
M9556	**1**	Insect and water Trap	
TCA08 8 26 000	**1**	TetraCal TCA Adapter - Kit	
AET 0 11 001	**1**	Push-to-connect tool	

DRI-1201	**1**	Tweezers	
M4997	**3m**	Static Dissipative Polyurethane Tubing	
M4916	**1**	3/8 stem F - 1/4 MPT	
M4968	**2**	1/4 stem - 1/4 hose straight	
M4973	**1**	3/8 stem - 1/4 MPT	
M4979	**1**	3/8 stem - 1/4 Hose straight	
OTHER TC ACCESSORIES/PARTS - OPTIONAL			
TCA08 0 03 008	**1**	Tube 14x2-2000 *2 m long sampling tube*	
TCA08 0 03 009	**1**	Tube 14x2-500 *0.5 m long sampling tube*	
TCA08 0 03 014	**1**	Tube 14x2-elbow45 *45º sampling tube elbow*	
TCA08 0 03 010	**1**	Tube 14x2-elbow90 *90º sampling tube elbow*	

M7950	**1**	BGI TetraCal (0.1 - 30 LPM)	

11 TECHNICAL SUPPORT and CONTACT INFORMATION

Please contact the service department through our web sites (Service & Support):

www.mageesci.com

www.aerosol.eu

Please include the serial number of the instrument and a sample of recent data in the communication. Please **always** send us the raw files **exactly** as downloaded from the instrument.

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The distributor responsible for your country is:


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