AethLabs

microAeth® Model AE51

Operating Manual

www.aethlabs.com

San Francisco, California

Contents

1. Introduction

1.1 Serial Number

The model and serial number are located on the back panel. Record the serial number in the space provided below. Refer to these numbers whenever you call for service.

Model No.: microAeth® Model AE51
Serial number: _____

1.2 Overview

Real-time Aerosol Black Carbon Personal Exposure Measurement Device
- Pocket-size, lightweight Aethalometer (250 g)
- Fast response: 1 sec measurement time base
- Ultra low power consumption: Up to 24 hour run time on one charge
- Onboard data processing, logging and diagnostics
- Flexible sampling options and wide dynamic range
- Filter strips for accurate sample tracking

The microAeth Model AE51 is designed specifically for investigation of personal exposure to carbonaceous particles found in ambient air. The instrument is based on Aethalometer technology that is widely used for studying indoor or outdoor air quality, and for the mobile mapping of the air quality impacts of localized sources. The instrument provides high quality, short time resolved data essential for assessing the real-time concentration of Black Carbon aerosols in a micro-environment.

The package includes:
- microAeth Model AE51 Personal Exposure Monitor
- Self-powered, single LED source (880nm-IR) , user-defined time base measurement, flow rate range of 50-150 mL/min with internal active mass flow measurement and control
- Sample collected and analyzed on a filter strip consisting of a T60 Teflon coated borosilicate glass fiber media housed in a protective casing
- USB-based power charger with AC adapter (100-500mA) for internal 5VDC lithium ion battery.
- USB charging / interconnect cable
- Flexible conductive sample tubing (1 m)
- Hose barb adapters
- Pack of 5 sample filter strips
- CD containing
  - microAethCOM communications software and USB driver
  - Operating Manual
- Quick Start Guide (hard copy)

For further information on this instrument or Black Carbon measurement, please contact:

AethLabs
San Francisco, California
www.aethlabs.com

1.3 Instrument Diagram

Figure 2: Filter strip slot

Figure 1: microAeth front panel

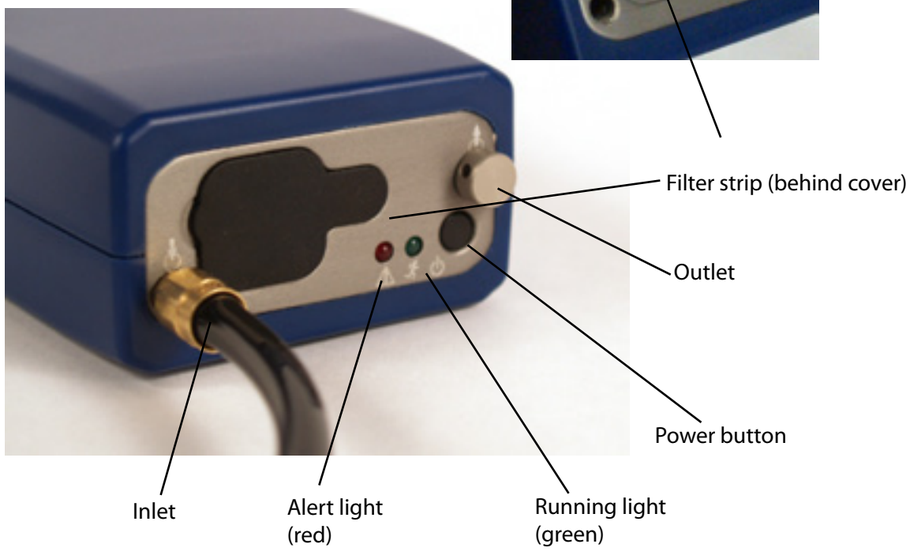


Figure 3: microAeth rear panel

1.4 Technical Specifications

microAeth® Model AE51

Measurement Principle
Real-time analysis by measuring the rate of change in absorption of transmitted light due to continuous collection of aerosol deposit on filter. Measurement at 880 nm interpreted as concentration of Black Carbon ('BC').

Measurement Range
0-1 mg BC/m^3, filter life time dependent on concentration and flow rate setting:
avg. 5 µg BC/m^3 for 24 hours @ 100 mL/min
avg. 100 µg BC/m^3 for 3 hours @ 50 mL/min
avg. 1 mg BC/m^3 for 15 min @ 50 mL/min

Measurement Resolution
0.001 µg BC/m^3

Measurement Precision
±0.1 µg BC/m^3, 1 min avg., 150 mL/min flow rate

Measurement Timebase (User setting)
1 second, 1 minute or 5 minute

Flow Rate (User setting)
Internal pump provides 50, 100, or 150 mL/min, monitored by mass flow meter and stabilized by closed-loop control.

Sampling
3 mm spot created on filter strip containing insert of T60 Teflon-coated borosilicate glass fiber filter material. PM2.5 size selective inlet available.

Consumables
Filter strip: 1 filter strip per sampling event, typically one per day.

Data Storage
4 MB internal flash memory, providing up to 1 month data storage when operating on a 5 minute timebase, and 1 week when operating on a 1 minute timebase.

Communications
USB connectivity to Windows®-based PC with microAethCOM, or data stream via digital output through mini USB port (command protocols can be supplied).

Data Output
Internal data files are uploaded to microAethCOM PC software and stored on local disk.

PC Software
microAethCOM software is included. Provides visual interface including real-time BC mass concentration values. Facilitates settings configuration, calibration routines, downloading data, and uploading new instrument firmware.

Dimensions
4.6 in (117 mm) L x 2.6 in (66 mm) W x 1.5 in (38 mm) D

Weight
Approximately 0.62 lbs (280 g).

Power
Internal rechargeable lithium-ion battery.

Power Supply Adapter
Input: 100~240 VAC 50/60 Hz 0.2 A
Output: 5VDC / 0.5A

Charging Time
4 hours to full charge (using AC adapter, instrument turned off).

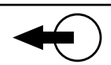
Total Run Time (single battery charge)
Minimum 24 hours @ 5 minute time base at 100 mL/min flow rate.

Operation Environment
0 ~ 40 °C operating, non-condensing.

Please note: Specifications are subject to change without notice.

1.5 Symbols and Cautions

1.5.1 Explanation of instrument operation symbols marked on the microAeth

	Operation indicator lamp
	Charging indicator lamp
	Aerosol inlet
	Aerosol outlet
	System alert
	Filter strip (note that arrow point indicates the orientation of the upstream face of the filter strip)
	On/Off
	USB device

1.5.2 Warnings

Caution: to reduce the risk of electric shock, do not remove product covering. No users-serviceable parts inside. Refer servicing to qualified service personnel.

NOTE:

This "bolt of lightning" symbol indicates uninsulated material within your unit may cause an electrical shock. Please do not remove product covering.

This symbol is intended to alert the user to the presence of important operating and maintenance (servicing) instructions in the literature accompanying the appliance.

1.5.3 Important Safeguards

Please read these safety instructions completely before operating the instrument, and keep this manual for future reference. Carefully observe all warnings, precautions and instructions on the instrument, or as described in the operating manual and product literature.

1.5.3.1 Use

1.5.3.1.1 Power Source

The microAeth should be operated only from the type of power source indicated in the instrument specifications. If you are not sure of the type of electrical power supplied to your home, consult your dealer or local power company. For those sets designed to operate from battery power, or other sources, refer to the operating instructions. The AC power/charger adapter plug is designed to fit into the power outlet only one way. Also, the connections on both ends of the USB interface cable are designed to be inserted into the AC power/charger adapter or the microAeth only one way. These are safety features. If you are unable to insert the AC plug fully into the outlet, try reversing the plug. If the plug should still fail to fit, contact AethLabs.

1.5.3.1.2 Object and Liquid Entry

Never push objects of any kind into the AC power/charger adapter or into the microAeth (except for the filter ticket) through openings as they may touch dangerous voltage points or short out parts that could result in a fire or electric shock. Never spill liquid of any kind on the microAeth or its electrical accessories. This instrument should not be exposed to rain or moisture, and objects filled with liquids, such as vases, should not be placed on this instrument.

1.5.3.1.3 Accessories

Do not use accessories not recommended by the manufacturer, as they may cause hazards.

1.5.3.2 Service

1.5.3.2.1 Servicing

Use extra care when servicing the instrument yourself as opening or removing covers exposes sensitive internal hardware to potential damage. Refer to all service documentation and trained, authorized service personnel for assistance.

1.5.3.2.2 Replacement Parts

Only genuine AethLabs parts should be used in the microAeth. Only trained, authorized service personnel should make repairs or install replacement parts.

1.5.4 Other Warnings

Replacement of the microAeth battery must be performed by trained, authorized service personnel, otherwise, fire or injury may result. Do not expose the microAeth or its batteries to sources of excessive heat such as sunshine or fire.

Lithium-Ion batteries are recyclable. You can help preserve our environment by returning your used rechargeable batteries to the collection and recycling location nearest you.

Caution: Do not handle damaged or leaking Lithium-Ion batteries.

2. Configuration and Operation

NOTE: Please read the Operating Tips and Troubleshooting section 2.4.4.7 and the Quick Start Guide before using the instrument for the first time.

2.1 Overview

The AethLabs microAeth® Model AE51 is a high sensitivity, miniature, portable instrument designed for measuring the optically-absorbing Black Carbon ('BC') component of aerosol particles. The instrument is based on the well-established Aethalometer principle used for over 30 years in laboratory-sized analyzers.

The microAeth draws an air sample at a flow rate of between 50 and 150 mL/min through a 3 mm diameter portion of filter media. Optical transmission through the 'Sensing' spot is measured by a stabilized 880 nm LED light source and photo diode detector. The absorbance ('Attenuation, ATN') of the spot is measured relative to an adjacent 'Reference' portion of the filter once per timebase period. The gradual accumulation of optically-absorbing particles leads to a gradual increase in ATN from one period to the next. The air flow rate through the spot is measured by a mass flow sensor which is also used to stabilize the pump. The electronics and microprocessor measure and store the data each period to determine the increment during each timebase. This is then converted to a mass concentration of BC expressed in nanograms per cubic meter (ng/m^3) using the known optical absorbance per unit mass of Black Carbon material.

The instrument's operating parameters are set up by an external software application (microAethCOM) and uploaded to the microAeth by a USB interface cable. Operation is completely automatic after the instrument is switched on. During operation, the microprocessor performs the optical measurements, measures and stabilizes the air flow, calculates the BC mass concentration and records data to internal non-volatile memory. The data may be downloaded at a later time by the same external software package.

The microAeth derives its power from an internal rechargeable battery. The same USB interface cable serves to recharge the battery from either the USB port of a connected external computer, or an AC power supply. The instrument will operate for 6 to 24 hours on a single charge, depending on operational settings.

Figure 4: microAeth USB Port

Figure 5: USB to AC-USB wall adapter

2.2 Power

The power switch is located by the side of instrument. There are two options for recharging:

1. USB to PC-USB port (500mA): 4 hours to full charge
2. USB to AC-USB wall adapter (500mA): 4 hours to full charge.

The instrument uses a USB-based power charger (100-500mA) for internal 5VDC lithium ion battery. The yellow charging light illuminates when the microAeth is connected to an external power source and is recharging the battery. When the battery is fully charged, the yellow light turns off.

2.3 Filter Media

2.3.1 General

The sample collection and analysis is performed on a filter strip, consisting of a small section of filter material held between and supported by a specially designed filter holder to create the filter strip assembly. As the aerosol sample is drawn through the filter media by the instrument's integrated, internal sample pump, the aerosol sample collects gradually on the filter medium to create a gray spot 3 mm in diameter. The microAeth determines the attenuation of the source light as the accumulated black carbon increases the optical density of the filter spot. After the optical density reaches a certain level, the filter strip must be replaced to maintain measurement integrity.

To maintain a leak-free sample path, the filter strip is clamped between two halves of the spring-loaded sampling head. A release button opens the clamp to allow the filter strip to be inserted and removed. A locating pin in the head engages in a matching hole in the filter strip holder to ensure correct placement.

2.3.2 Filter Strip Installation and Removal

Figure 6: Inserting filter strip while depressing filter release button.

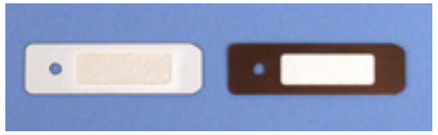


Figure 8: Front (left) and back of filter strip. Sample collects on front (white) side.

Figure 7: Bottom of microAeth with filter strip release button.

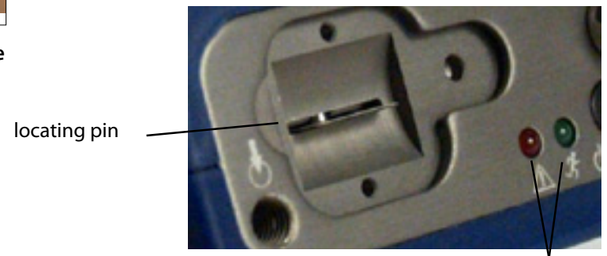


Figure 9: Filter strip locating pin.

IMPORTANT NOTE: Whenever the filter strip is exchanged, the microAeth should be turned off to prevent dust or debris from being drawn into the inlet and analysis chamber.

IMPORTANT NOTE: Always insert and remove the filter strip in good lighting. Always check carefully that the locating pin is engaged in the matching hole.

1. Hold the microAeth in your left hand so that the filter chamber release button is on the bottom of the enclosure (Figure 6) (all of the icons will be right side up) and the filter strip slot is facing you.
2. Press and hold the release button with your left thumb until the locating pin retracts into the upper surface of the analysis chamber filter slot. Then pull out the filter strip.
3. Pick up the new filter strip in your right hand so that the plastic (white) side is facing up.
4. Carefully slide the filter strip into the slot by pressing it gently on the lower side of the analysis chamber opening until the locating hole in the filter strip is aligned with the locating pin.
5. Release the release button and verify the locating pin has registered properly in the filter strip locating hole. If you gently lift the filter strip up, you should be able to see the pin has passed through the locating hole (Figure 9).

2.4 Software Installation and Operation

The microAethCOM software application is designed to install and operate on a PC using Windows® XP; Service Pack 1, 2, and 3 are supported. All software components are included in a file named **microAethCOM_Setup.exe** which is located on the CD included in the instrument accessory package.

NOTE: Internet access may be required during installation of the microAethCOM PC software. Many current computers with MS Windows® operating systems do not have the support software libraries installed (found in a program called ".NET Framework") which are necessary to support the microAethCOM software set up routine. The SETUP routine will automatically detect and install, if necessary, the appropriate software libraries. If an internet connection exists, the installer will attempt to download the software from the internet.

2.4.1 Installation of microAethCOM communications software

1. **Do not connect the microAeth to the USB port on the computer until instructed by the setup installer software routine!**
2. Make sure that your computer can access the internet before beginning the installation.
3. Locate **Setup.exe** on the included CD or obtain the setup file from AethLabs.
4. Copy **Setup.exe** onto your computer desktop.
5. Double click **Setup.exe**. The installer will prompt you through the setup (Figure 11).
   NOTE: The installer first checks for the necessary prerequisite Windows software. If the software is not found, the installer will access the file via the internet.
6. After all prerequisite software has been installed, the installer will continue and install microAethCOM to your computer.
   NOTE: During the installation process, the user will be prompted for the location of the main file folder named 'AethLabs'. This file folder will be the location for the microAethCOM software program. A shortcut to this program will be automatically placed on the PC desktop and in the Quick Launch bar (if enabled). A second prompt will request the file destination of the AethLabs 'data' file. This file folder will become the destination for the downloaded data file from the microAeth and will be automatically named the serial number of the instrument. The actual microAeth instrument data file will be established upon the first data download from the device.

A Windows Security Warning dialog box (Figure 12) may be displayed if Windows doesn't recognize the origin of this executable program. If displayed, click **Run** to continue.

After the program is installed, the user will click **Finish** on the installation wizard screen and connect the microAeth instrument to the PC using the supplied USB cable. This will complete the installation of the driver and microAethCOM software.

NOTE: In order to be recognized by the microAethCOM software application, the microAeth must be turned on with a filter strip installed and connected by USB cable to the PC.

Locate the microAethCOM PC software application or use the application shortcut which was installed on the PC desktop and double click. The application will open the program to the main screen which contains a box displaying the serial number of the microAeth connected to the computer (Figure 13). This indicates that the software is running correctly and is connected to the microAeth.

2.4.2 Best Use Practices Recommendations

The small size and light weight of the microAeth® Model AE51 allow it to be used to gather data in a wide range of operational scenarios, not always possible using larger instruments. Optimization of performance across this breadth of applications requires an understanding of perational settings, precautions, and maintenance procedures. The following recommendations provide general guidelines.

1. Always use a new filter strip for each measurement period.

2. Leave the microAeth connected to the wall charger when not in use, to be sure the battery is always fully charged and ready for use.

3. Instrumental noise contributes a random perturbation to the 'ideal' BC data. Its magnitude is inversely proportional to the operational parameters of timebase and flow rate. These parameters should be set to values appropriate to the measurement requirements and scenario.

4. If the data exhibits noise that is unacceptable relative to the BC level being measured, the noise may be reduced proportionally by taking the arthmetic average of successive data values.

5. Data collected on a rapid timebase is useful for identifying transient events of rapidly changing BC concentration. Data collected on a 1 second timebase will almost always require some subsequent smoothing and averaging. The 1 second timebase should be considered as a 'Data Acquisition Mode'.

6. Vibration and impact may contribute transient changes to the light signal measurements. These changes will appear as noise on the data, which may be amplified if the instrument is operating at the shortest timebase setting.

7. The instrument's sample chamber should be kept clean and free of contamination in order to minimize electronic noise and the possible effects of vibration and impact.

8. Minimize transitions between environments of substantially different humidity. Avoid placement near the vents of cycling air conditioning systems.

2.4.2.1 Instrument Settings: Measurement TimeBase and Flow Rate

The microAeth can aquire data on three timebase settings: 1, 60, and 300 seconds. Its pump can operate at three sampling flow rate settings: 20, 100, 150 mLPM. The choice of these parameters affects the operation and data as follows:

Battery Run Time on Single Charge: affected by flow rate setting.
NOTE: battery life will gradually diminish after many cycles (~ 1 year use)

50 mLPM: > 26 hours
100 mLPM: > 24 hours
150 mLPM: at least 20 hours

Individual Data Point Noise: primarily affected by timebase setting.

1 second: 5 ~ 10 ug/m³
1 minute: 0.1 ug/m³
5 minutes: < 0.05 ug/m³

Effects of Contamination, Vibration, and Impact: primarily affected by timebase setting.

1 second: very large
1 minute: moderate
5 minutes: least effect

2.4.2.2 Recommended Settings of microAeth Model AE51 for Different Scenarios

Different Black Carbon measurement scenarios require different operational settings for optimim performance. The 1 second timebase setting is a 'Data Acquisition Mode' intended for subsequent processing, and should **NOT** be used for routine monitoring. Data collected on a 1 second timebase should always be smoothed or averaged over longer periods, in order to optimize the signal-to-noise ratio at the desired time resolution.

	1 second	1 minute	5 minute
50 mLPM	**'Data Acquisition Mode'** for measurements of immediate emissions and impacts at highest concentrations.	Personal Exposure Monitoring in locations of high BC. Occupational Exposure.	Epidemiology. Area monitoring in locations of high BC concentration. Longest battery & filter life. Lowest acoustic noise.
100 mLPM	**'Data Acquisition Mode'** for measurements of emissions and impacts in typical urban and traffic environments.	**Most Common Setting for General Applications.** Personal Exposure Monitoring. Traffic impact measurements. High time resolution ambient monitoring.	Epidemiology. Area monitoring. Long battery & filter life.
150 mLPM	**'Data Acquisition Mode'** for higher time resolution at lower BC concentrations.	High time resolution ambient monitoring in locations of low BC concentration.	Monitoring in locations of low BC concentration. Lowest data noise.

2.4.2.3 Contamination, Maintenance, and Cleaning of Sample Chamber

If a loose particle of contamination enters the microAeth's sample chamber or the instrument experiences vibration or impact, the data will be degraded. Shaking or tapping a "dirty" instrument will create data excursions that are far larger than those of a "clean" unit. These effects are amplified greatly at the shorest (1 second) timebase setting. Our recommendations for cleaning are based upon the likelihood of contamination and the nature of use.

Contamination Probability for Various Use Scenarios

Sampling Scenario	Contamination Probability
Dry, dusty environment	High
Occupational settings with combustion exhaust	High
Exposure to "oily" smokes such as biomass-burning plumes, 2-cycle engine exhaust	High
Presence of suspended fluff, fibers, pollen	High
Immediate vicinity of traffic and roadways	Medium
Outdoor urban environments	Medium
Outdoor rural environments (without dust, fluff, pollen)	Low
Residential indoor environments	Low

Cleaning Maintenance Recommendations (hours of operation)

	High	Medium	Low
Mobile sampling with impacts: on person or in vehicle	100	200	400
Mobile sampling on cushioned support	150	300	500
Fixed sampling, moved from place to place during operation	500	800	1200
Fixed sampling , not moved during operation	800	1200	2000

2.4.3 Configuration of Instrument Operating Parameters

All instrument parameters are configured through the microAethCOM user interface. The various parameters are accessed through the 'File' menu button on the tool bar.

Before starting a test, it is recommended that the user verify all parameter settings before beginning a sampling run. A description of each operating parameter and its configuration is described below.

The first item in the 'File' menu is 'Device Settings' (Figure 14). Click on 'File' 'Device Settings' to open a dialog box (Figure 15) that allows the user to examine the currently programmed set of operating parameters. The software also allows the user to modify any of the operating parameters. Parameters of most common use are:

2.4.3.1 microAeth Internal Clock Date and Time

Press the shortcut button to synchronize the microAeth internal date and time to the current PC date and time. If other date/time values are desired, enter the new date and time in the box and press enter. **NOTE:** It is very important to confirm the Date / Time of the PC prior to synchronizing to the microAeth. Once confirmed, it is good operating practice to always synchronize the date and time when configuring the microAeth before starting a new sample session.

2.4.3.2 Sampling Flow Rate

A drop-down box allows the user to select the flow rate from 50 to 150 mL per minute. We recommend using lower flows in areas with high BC concentrations, and higher flow rates when maximum sensitivity is required in areas of low BC concentration. A lower flow rate should also be selected for longer run times and extended battery life.

2.4.3.3 Sampling Timebase

A drop-down box allows the user to select the analysis timebase period. We recommend 60 seconds for most 'human exposure' or 'ambient monitoring' use. Faster timebases will result in higher noise on each measurement point, and are most useful either for direct source monitoring (tailpipe analysis) or for other applications requiring extremely rapid data. A 5 minute timebase can be used to extend battery life and run time.

2.4.3.4 Set Shut Down Mode

The microAeth is designed for applications that include being carried or worn by a person. Consequently, the electronics are consciously designed to minimize the risk of the instrument being accidentally turned off while in use, by un-intentional presses of the power button.

Power On: Press and hold the power button. Instrument will start up; red and green indicators will light and then start flashing slowly; after about 1 minute, measurements will begin as indicated by very short flashes of the green indicator.

Power Off: There are 2 modes:

1. **USB Cable from PC running microAethCOM**
   We recommend this for normal use. Attach the USB cable; launch the PC-based software program; download the data. Verify the data is stored to file. Erase the microAeth's internal memory; then use command 'Shut down microAeth'. The microAeth will shut down; recharge power through USB cable, to be ready for next use.

2. **Power Button Sequence**
   The power button must be pressed and released three times in succession, before the microAeth will shut down. The sequence is coordinated by a simultaneous beep and red LED indicator light. Each cycle takes about 1 second:

- Press the power button and hold it
- When you hear/see the first 'beep/flash' (usually one or two seconds), release the button quickly
- When you hear/see the next 'beep/flash' (1 second) - -
- Press the power button and hold it
- When you hear/see the first 'beep/flash' (1 second), release the button quickly
- When you hear/see the next 'beep/flash' (1 second) - -
- Press the power button and hold it
- When you hear/see the first 'beep/flash' (1 second), release the button quickly

The microAeth will then shut down.

The sequence can be described that the 'beep/flash' instructs you to change the button. The sequence is fast - one second between beeps:

Press /flash/ Release /flash/ Press /flash/ Release /flash/ Press /flash/ Release
/beep/ /beep/ /beep/ /beep/ /beep/

NOTE:
- The unit can not be shut down using the instrument Power button while connected to the PC through the USB cable.
- Any time an operating parameter or group of operating parameters have been changed, the configuration setting must be transferred to the microAeth by clicking on the control button shown to the left of each setting's drop down box, or by clicking on **Set All Parameters** control button on the bottom of the Settings screen.
- It is a good practice to close the microAethCOM software program before disconnecting the microAeth from the PC.

VERY IMPORTANT: You must turn off and restart the microAeth after disconnecting from the PC and beginning a new sampling event.

2.4.3.5 Operating Mode

The operating mode function permits the user to configure data storage and streaming options.

Store to Flash
Data are stored to internal memory only.

Flash and Streaming
Data are stored to internal memory and output through USB port for display in the RealTime Graph and RealTime Data Table.

2.4.3.6 Auto PowerOFF and Delayed PowerON

These configuration functions allow the microAeth to turn off automatically at a desired future time and date or turn on at a future date and time.

Auto PowerOFF
Click the check box to enable this feature, then set the time and date as desired.

Delayed PowerON
Click the check box to enable this feature, then set the time and date as desired. If this function is used, shut down the microAeth and disconnect it from the computer after all other parameters have been configured. The monitor will wake up at the desired time.

After the desired functions are set for either PowerOFF or PowerON, click **Set wake up/sleep settings** to send the configuration settings to the microAeth.

After uploading the desired Delayed OFF / Delayed PowerON settings:
- Close the 'Settings' screen; then click on **File** , **Shutdown microAeth**
- Disconnect USB cable from microAeth.
- Turn on microAeth. (Unit will signal that it has turned on by emitting three (3) short beeps and a long flash of the GREEN LED. If the unit starts properly, it will beep and briefly illuminate the GREEN LED but the pump will not start.)

NOTE: The Automatic PowerOFF setting must be at least two (2) minutes ahead of the actual PowerON time, otherwise, the Automatic PowerOFF feature will be canceled.

2.4.3.7 Sound Notifications

The audible notifications issued by the microAeth can be turned on or off if desired by clicking the Sound Notifications **ON** check box.

NOTE: The following sound notifications cannot be turned off:
- Error sound at Power ON. This is a sequence of three, short "beeps"
- Data collection started. This is a longer chirp sound
- OK sound at Power ON. This is a longer "bebebebeep"

2.4.4 Advanced Settings

There are three primary functions that can be accessed through the Advanced Settings menu (Figure 16)(accessible from the microAethCOM main screen):

2.4.4.1 Show Graph

This function is used to open a graph of data that is stored on your computer.
1. Clicking on **Show Graph** will open a file menu to allow the data file to be chosen.
2. Choose the desired microAeth *.dat file and click open to display the desired data set.
3. There are several user selectable control features embedded in the graphing routine allowing the user to change the focus on the data.

2.4.4.2 RealTime Graph

If the microAeth is operating in the "Flash and Streaming" mode, clicking on the menu choice will open up the real time graph screen and begin displaying the BC concentration as it is calculated. Data will be updated according to the instruments current time base setting. Each new data point represents the most recent time base measurement. Multiple graphs can be displayed at once, but any new data will only be registered to the most recently opened graph.

2.4.4.3 Sigma Value

This function allows the user to modify the sigma value parameter. The sigma value represents the conversion of particle absorption to Black Carbon mass. The function is password protected (password is 10107) as it is a critical component to the overall BC measurement. This value should only be changed by trained personnel with an understanding of the implications this presents to the measurement data. Please consult AethLabs for discussion.

2.4.5 Instrument Preparation and Operation

Before first placing the microAethalometer into service, connect the microAeth USB cable to the AC Power/ Charging Adapter and allow the instrument to recharge overnight. During this charging period, make sure instrument is turned **OFF**.

Using the instrument generally consists of the following steps:

1. Charge the internal battery (if required)
2. Prepare the instrument for sampling
    a. Install new filter strip (if required)
    b. Turn instrument on, connect to PC running microAethCOM
    c. Erase internal memory (if needed)
    d. Configure / upload operating parameters
    e. Turn instrument off using microAethCOM
3. Start sampling - turn instrument on
4. Stop sampling - turn instrument off
5. Recover data
    a. Turn instrument on
    b. Connect to PC
    c. Download data using microAethCOM
    d. Turn instrument off
    e. Replace filter ticket (if required)
    f. Recharge internal battery

IMPORTANT NOTES:

1. Whenever the instrument is turned on, a filter strip should be used to prevent dust from being pulled into the analysis chamber.
2. Always turn the instrument off before replacing the filter strip.
3. Only exchange the filter strip when the instrument is turned off.

2.4.5.1 Preparation for Sampling

1. Turn the instrument off and recharge the battery, if required.
2. After the battery has been charged, remove used filter strip, if present, following the instructions in section 2.3.2.
3. After removing the filter strip, continue pressing the release button and visually check the insertion slot to make sure it is clear of any debris or filter material (“fluff”), etc. Carefully use forceps or blow gently to clear, if needed.
4. Insert a new filter strip according to section 2.3.2. The instrument is now ready to run.

2.4.5.2 Operation

1. Install the microAeth in the desired sampling position and turn the power on.
2. To end the sample session, switch the microAeth off according to the instructions shown in Section 2.4.3.4. This closes the data file.

Sampling automatically begins as soon as the power is turned on. Sampling will continue until the unit is turned off, either manually or automatically if the battery gets too low.

As soon as sampling starts, a new data file is opened and data storage begins as the unit starts measuring. Data storage and sampling will continue until the unit is switched off.

When the unit is turned off Black Carbon measurements and data collection ends and the data file is closed. When the microAeth is running, status indicator lamps located on each end panel of the microAeth provides information regarding the instrument operating status.

VERY IMPORTANT NOTE: It is important to disconnect, turn off, and restart the microAeth following any changes which are made to the Instrument Device Settings from the microAethCOM software application. Do NOT change any instrument parameters or query the microAeth during a sampling run. Any communication between the microAeth and the microAethCOM software will result in the closing of any active sampling session.

To restart data collection, the microAeth must be disconnected from the PC, turned off and then restarted.

Figure 9 shows the two LED status indicator lights that indicate if the instrument is running and the remaining charge capacity of the battery. The green light will flash periodically to indicate the instrument is running properly. When this light turns to flashing red, the battery charge is low (less than 20%) and the unit should be switched off and recharged soon or immediately connected to an AC power source using the supplied AC power/charger adapter and USB cable.

2.4.5.3 Downloading Measurement Data

1. Starting with the microAeth switched off, turn the microAeth on.
2. Connect the USB cable to the microAeth and to a computer where microAethCOM has been installed.
3. Start microAethCOM by locating the AethLabs main file folder or using the desktop shortcut.
4. Wait for the microAeth to establish communications with the software. Verify that the serial number is shown to the right of SN in the lower left hand portion of the microAethCOM main screen.
   NOTE: If the serial number is not displayed, the connection between the microAeth and the computer has not been established. Check that the cable is properly inserted in the microAethalometer USB port and the USB port on the computer. Simply unplugging and reconnecting the cable should be sufficient to enable the connection. You may need to chose an alternative USB port on the computer. USB recognition is usually indicated in the form of an audible alert from the PC. You may also need to restart the microAethCOM application if the first connection attempt is unsuccessful.
5. Once connected, click the **Get Data** button.
   NOTE: The data will be downloaded into the file folder which was set up during the original microAethCOM software installation. The default location is C:\Documents and Settings\”current user name”\My Documents\AethLabs\Data. The data folder in this directory is named **AE5X-SX-XXX-MMDD**.

6. After downloading the file, verify that the date, time and all data for the entire length of the sampling event have been stored to the file.
7. If the file download is successful and the file stored to the computer is ok, the memory can be erased, if desired. This is done by pressing **Erase All Data** from the microAethCOM PC applications main screen. A confirmation prompt will be initiated.
8. Prepare the microAeth as described in Section 2.4.3, above, for the next sampling event.
9. Turn the microAeth off by clicking on **File / Shutdown** and the microAeth should turn off.

2.4.5.4 Viewing and/or Analyzing Measurement Data

1. Data files are named by the microprocessor using the following naming convention: AE5X-SX-XXX-YYYYMMDD.dat, where xxx is the serial number of the instrument.
2. Data files are formatted such that they can be imported directly into Excel.

NOTE: If several data downloads are performed on the same day, in which the data was not erased between downloads, but gradually accumulated by being appended to the previous data, then each subsequent download file will have an increasing number of "-1-" sub-tags appended to the file name to distinguish later downloads from earlier ones.

2.4.5.5 Data File Structure

The data files are plain text with the extension '.dat'. The file consists of a header containing descriptive information; a line identifying the columns; and then a number of data lines with each item separated by a semicolon.

An example of the header is:

AethLabs
Device ID = AE51-S0-137-0905
Application version = 1.1.3.0
Flow = 101 mlpm
TimeBase = 1 s
Date(yyyy/MM/dd);Time;Ref;Sen;ATN;Flow (mL/min);Temp(C);Status;Battery(%);BC(ng/m³)

The first line of data does not contain the final BC calculation; all subsequent lines show this expressed in units of ng/m3 of BC. A typical excerpt of data lines is shown below:

2009/06/13;07:55:00;857837;575870;39.8532163971505;100;33;0;66;
2009/06/13;07:55:01;857655;575754;39.852143458633;101;33;0;66;-3620
2009/06/13;07:55:02;857703;575782;39.8528768881755;100;33;0;67;2500
2009/06/13;07:55:03;857547;575679;39.8525774349175;100;33;0;67;-1021
2009/06/13;07:55:04;857774;575829;39.8529919908042;99;33;0;67;1427
2009/06/13;07:55:05;857697;575771;39.8540878064019;100;33;0;67;3735
2009/06/13;07:55:06;857962;575954;39.8532013067173;101;33;0;67;-2991
2009/06/13;07:55:07;857710;575800;39.8505668838593;101;33;0;68;-8889
2009/06/13;07:55:08;857810;575865;39.8509371518125;100;33;0;68;1262
2009/06/13;07:55:09;857737;575797;39.8542357670399;100;33;0;68;11242

Important !
Always close the Application Program after downloading data; unplug the USB cable; and switch off the microAeth after every interaction session. This permits it to re-initialize for subsequent operation. If data is downloaded during the middle of a measurement session, the analysis and collection of data will not continue unless the power to the microAeth is cycled OFF and ON.

2.4.5.6 Status Indications

2.4.5.6.1 LED Status Indications

The microAeth has one LED located on the rear panel of the monitor and two LEDs located on the front panel.

The rear panel LED turns yellow when the microAeth is charging.

There are two LED indicators (GREEN and RED) located on the front end panel immediately to the left of the filter chamber. These lights indicate the instrument's current operating status. The GREEN LED generally indicates that the instrument is functioning properly and is or is not collecting data. The RED LED indicator generally indicates that the unit is not operating in a normal sampling state. The status indications signaled by the LEDs is given in the following table.

Run Modes		
Green	1 long blink "Beep" sound	Start of data storing to internal memory.
Green	1 blink every 3 sec	Acquiring data to internal memory.
Green	2 blinks every 3 sec	Acquiring data to internal memory and streaming.
Green	1 long blink every 1 or 5 min	Data write to internal memory (1, 5 min timebase only).
Status Warnings during Run Modes (see above)		
Green indicates Run Mode (see above), Red indicates Warning (see below)		
Red	1 blinks every 1 sec	Warning - Change filter strip
Red	2 blinks every 1 sec	Warning - Battery low
Red	3 blinks every 1 sec	Warning - Flow error
Stop Modes		
Red & Green	Red & Green - synchronous 1 blink every 1 sec	Startup - Beeping, Not collecting data until ready. Idle - No Beeping, Not collecting data, Restart Req'd
Red Only	Red - Repeating blink on/off sequence; on time is same as off time. Also emits one series of 3 triple beeps.	Critical hardware error: • Main supply voltage too high or too low • Light source current too high or too low • Light source feedback circuit error.

2.4.5.6.2 Data File Status Codes

Reported Status/Error Code in Data File	Reason/Indication
1	Battery Low
2	Flow out of range
4	Change filter ticket / Sense signal out of range
8	Optical signal feedback out of range
16	Power supply 5V out of range
32	LED current out of range
64	Flash memory full
128	Automatic shutdown occurred on configured schedule
0	OK - Instrument operating within specifications

NOTE: If more than one status error code is active simultaneously, the resulting code written to the data file is the sum of the error codes shown in the table above.
For example, if the battery is low (status code = 1) and the flow is out of range (status code = 2), the status code shown in the data file will be 3.

2.4.5.7 General Operating Tips

- Every time the microAeth's power is cycled a new measurement session starts.
- The GREEN LED blinks during normal operation.
- The GREEN LED will illuminate for several seconds each time data is written to internal memory (except in the 1 second timebase mode).
- After turning on the microAeth, there is a measurement delay of approximately 15 seconds before data collection begins. If the microAeth is operating using the 1 minute timebase setting, there is a delay of 1 minute and 15 seconds before the first data value is recorded.
- If the timebase is set to 1 second, internal memory can store approximately 20 hours of data.
- If the timebase is set to 1 minute, more than 4 days of data can be stored.
- When the battery is almost empty a beep every 30 sec is emitted and the RED LED will blink.
- When the battery is empty, the pump and LED are switched off and the data is no longer recorded.
- In the 'Device Settings' menu, you can synchronize the clock with your PC clock calendar, or you can manually adjust the time and date and synchronize with adjusted time settings.
- Before the microAeth is connected over USB to the microAethCOM software, it must be switched ON for application to connect. The microAeth must also have a minimum amount of battery power remaining in order to connect to the PC. If the battery is completely drained it will first be necessary to charge the device and attempt the configuration setup at a later time.
- If you want to download the data from the microAeth, press the 'Get Data' button and the application will download data from the device. DO NOT TURN OFF THE MICROAETH DURING DOWNLOAD. The application will create a directory whose name is the microAeth device's serial number. Inside the folder the files are labeled in the following format: »SerialNumber StartDate StartTime StartTime.DAT«.
- Every measurement session will have its own file.
- Any change to the device settings (flow, timebase, time) will stop the current measurement session. To start a new measurement session, the microAeth has to be shut down using either the function in the software or by disconnecting the USB cable from the computer and then pressing the power switch as described in the previous table. When the microAeth is turned back on, a new measurement session will start and a new data file will be created.
- Once the data is downloaded, you must turn OFF and then turn ON the microAeth to start measuring and storing data again.

2.4.6 Upgrading microAeth Operating System Firmware

Upgrading the microAeth operating system firmware requires three components:
- microAethCOM PC Software
- microAeth Flow Calibration software
- PSxxx.hex (xxx refers to the version number)

If any of the above software or files is needed, please contact AethLabs. Upgrading the firmware is accomplished in three major steps, as follows:

1. Download the microAeth Flow Calibration Parameters (Figure 17)
   a. Turn on the microAeth, then connect the USB cable
   b. Open the flow calibration software.
   c. Make sure communications are established (confirm message 'USB Connected' is displayed on lower left hand of screen).
   d. On right hand side of screen, click check box "Save to File" (Figure 17)
   e. Click the 'Read' button.
   f. A dialog box opens and allows you to save the flow calibration file to a file, UnitSerialNumber_Calibrationval.txt where UnitSerialNumber refers to the serial number of the connected instrument (Figure 18).
   g. Close microAeth Flow Calibration software application.

2. Install the new firmware.
   a. Open microAethCOM.
   b. With the microAeth turned off, connect the instrument to the computer via the USB cable.
   c. From the microAethCOM main menu, click on Advanced then Upgrade FW. A dialog box will open which will allow you to find and open the file named 'PSxxx.hex' where xxx refers to the version number (Figure 19).
   d. Open 'PSxxx.hex'.
   e. When prompted, press the power button within 5 sec.
   f. Wait for the microAeth to finish blinking which will be accompanied by a triple beep. The microAethCOM Log window will report "Flash OK! Remove USB cable!
   g. Close microAethCOM.

3. Upload Flow Calibration Parameters
   a. Turn on the microAeth then connect the instrument to the computer using the supplied USB cable.
   b. Open the microAeth Flow Calibration Software.
   c. Make sure communications are established (confirm message 'USB Connected' on lower left-hand corner of screen is displayed).
   d. On right hand side of screen, uncheck the box 'Save to File' (Figure 17)
   e. Click the 'Write' button.
   f. A dialog box opens and allows you to open the flow calibration file that had been stored in Step 1, above. Make sure to open the file specific to unit being upgraded.
   g. Select the proper file (UnitSerialNumber_Calibrationval.txt where UnitSerialNumber refers to the serial number of the connected instrument) and click Open. The software will upload the flow calibration parameters into the microAeth.
   h. When the upload is complete, the communications log box in the software (left-hand center of screen) will acknowledge that the calibration parameters have been successfully uploaded and saved to the firmware (Figure 20).
   i. Close microAeth Flow Calibration software application.

2.4.7 microAethCOM Software Screens

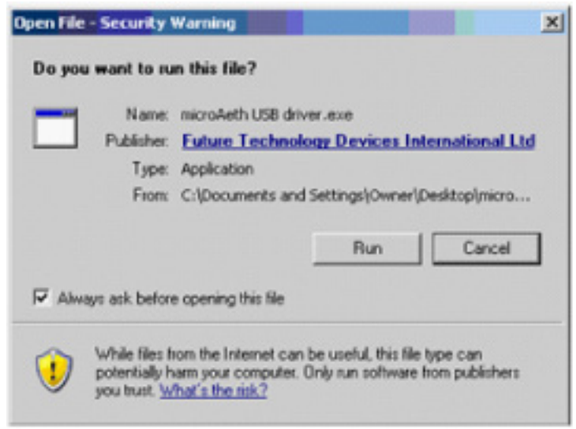


Figure 10: Warning message when installing driver software. Press 'Run'.

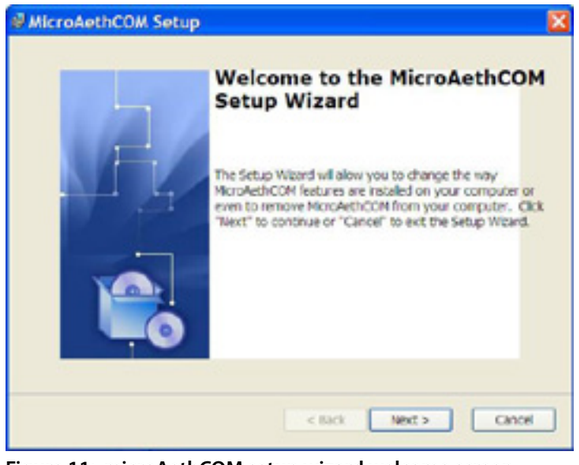


Figure 11: microAethCOM setup wizard welcome screen.

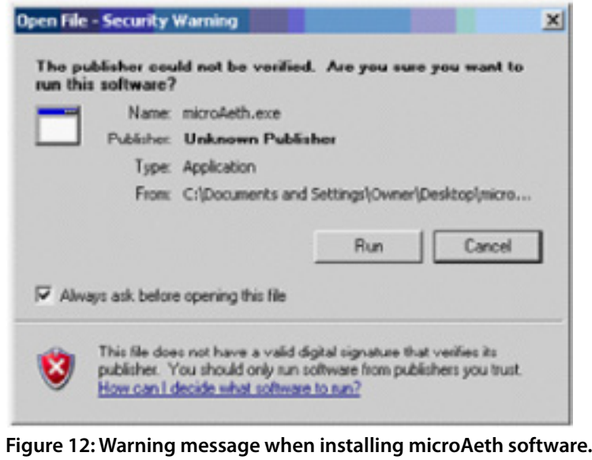


Figure 12: Warning message when installing microAeth software. Press 'Run'.

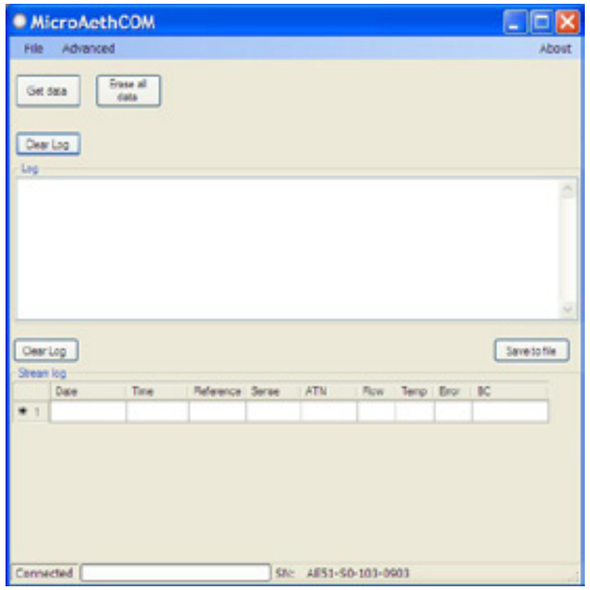


Figure 13: microAethCOM main screen.

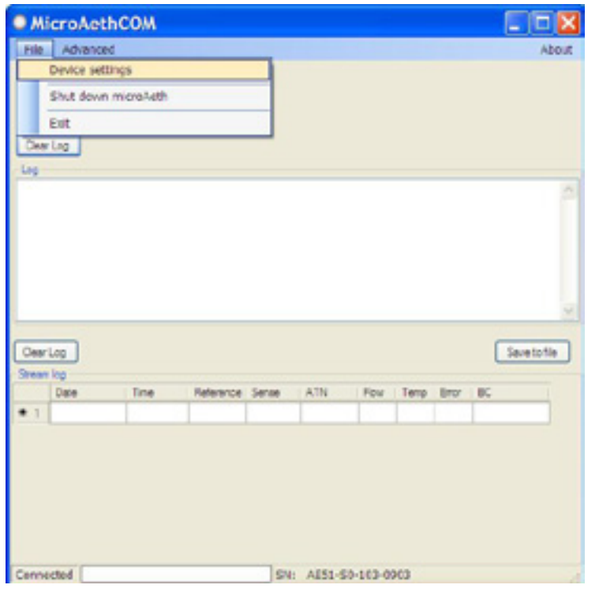


Figure 14: microAethCOM software Main Menu showing drop down menu displayed when 'File' is clicked.

Figure 15: 'Device Settings' interface

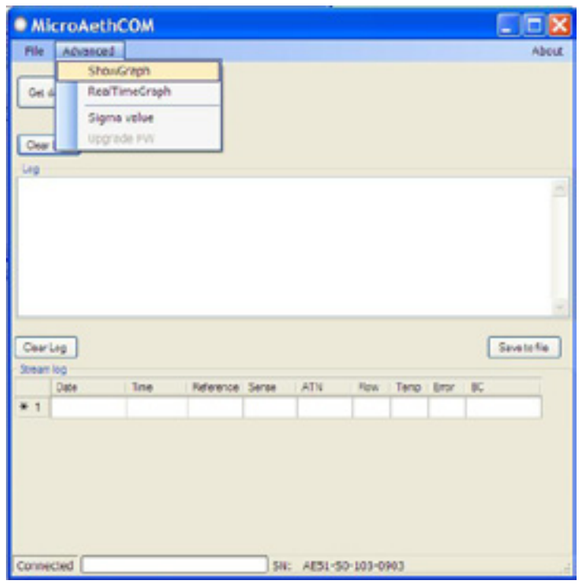


Figure 16: 'Advanced Settings' menu choices

Figure 17: microAeth Flow Calibration Software – Main Screen

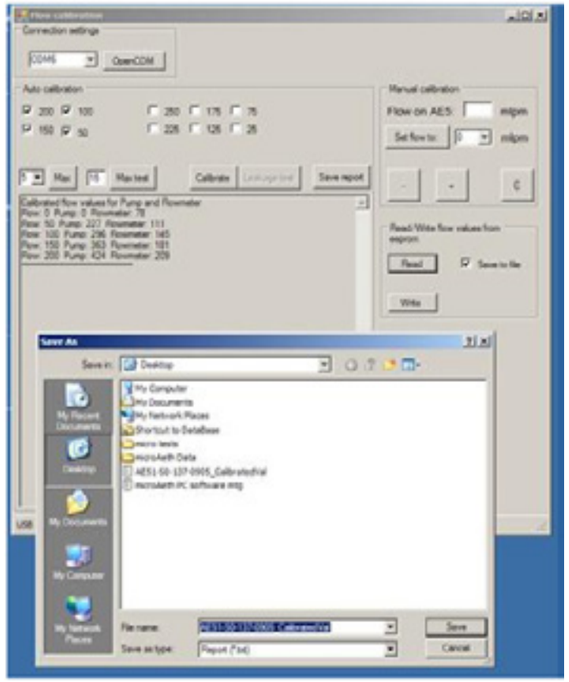


Figure 18: microAeth Flow Calibration Software – Main Screen with Save File Dialog window

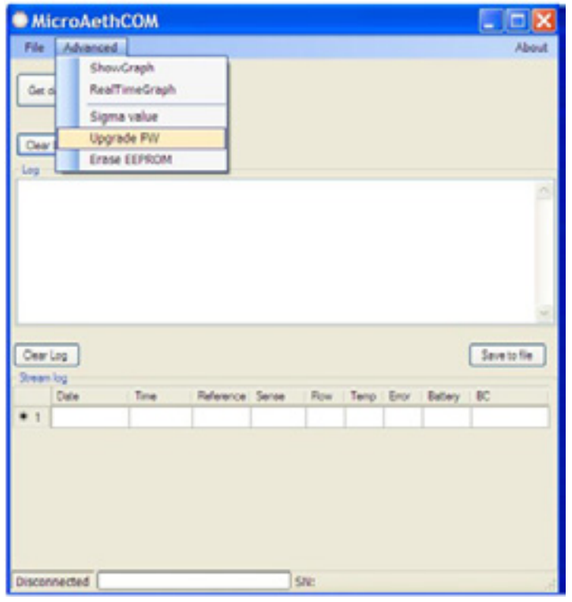


Figure 19: Upgrade Firmware Screen

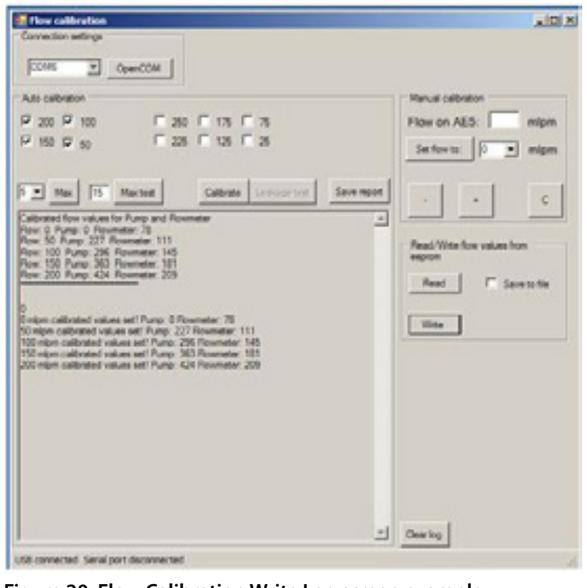


Figure 20: Flow Calibration Write Log screen example

2.5 Flow Calibration Procedure

Establish Connections

1. Connect the microAeth to the PC using the supplied USB cable.
2. Connect the external flow calibration (ie. BIOS 220L, TSI 440, etc.) device to the inlet port on the microAeth using acceptable diameter tubing.
   NOTE: It is important that the external flow calibration device is calibrated and operates in the range of 50 – 200 mL/min.
3. Be sure the flow rate is directed properly through the flow calibration device. This is typically labeled as the "suction" port on the external flow calibration device.
4. Power on the external flow calibration device.

microAeth Flow Calibration PC Software and Calibration Routine Instructions

5. Initiate Flow Calibration Software (AE5_Flow_Cal.exe) which is provided on the CD in the microAeth Model AE51 package.
6. The Connection settings and Auto Calibration is specifically designed for use with external flow calibration devices with RS-232 Serial output capability. This functionality is under development and will be available shortly.
7. For manual flow calibration, locate the Manual Calibration on the right hand side of the application window.
8. Using the drop down arrow, select the flow rate of 50 mL/min and press the **Set Flow to:** button
   a. The microAeth will respond by setting the pump speed to achieve approximately 50 mL/min.
   b. The Actual flow rate measured by the microAeth's internal flow sensor will be displayed in the box adjacent to "Flow on AE5:".
9. Using the **+** and **-** buttons, adjust the flow rate shown in the **Flow on AE5:** box to match the flow rate shown on the external flow device.
10. Once the flow rate stabilizes and matches within one mL/min, press the **C** button to calibrate.
11. Repeat steps 9-11 using the flow rate of 100 mL/min.
12. Repeat steps 9-11 using the flow rate of 150 mL/min.

Backing up Flow Calibration Values

13. Following the Calibration procedure, you can back up the Flow Calibration values using the **Read/Write flow values from eeprom** feature.
14. Select the checkbox **Save to File**.
15. Press the **Read** button
16. This will open a **Save As** dialog box where you can chose to save the "*.txt" file containing the flow calibration values.
17. Save the file in a secure place
18. The flow calibration values can be uploaded into the microAeth at a later point in the case of a firmware upgrade or loss of the eeprom flash memory. These values are not stored on the same flash memory drive used to store data and is NOT erased when you select **Erase All Data** button in the microAethCOM PC software application. Instructions for uploading the previous calibration values can be found in section 2.4.6.

2.6 microAeth Communication Protocol v. 1.1

Communication protocol is based on folowing syntax: **STX LEN DATA CRC ETX** where:

- STX is one byte 0x02 (HEX values)
- LEN is one byte lenght of DATA
- CRC is XOR function between LEN byte and DATA bytes
- ETX is one byte 0x03

Every string of DATA that microAethCOM PC software sends starts with »AE5X:« followed by one letter. Reply from microAeth is either Acknowledge (ACK - DATA = "AE5X:A"), or the same string PCCOM sent with following data.

Instruction are divided into 3 groups:

1. Instructions that are replied with **Acknowledge:**
   - Erase flash »AE5X:E« - Reply: ACK, after flash is erased another ACK is sent. (erasing should take 30 – 45 seconds)
   - Stop write »AE5X:S« (stops writing to flash)
   - Start write »AE5X:W« (Starts writing to flash)
   - Kill »AE5X:K« Shuts down microAeth

2. Instructions that are **read only**, we only read from microAeth, reply is same instruction as we sent plus additional data bytes :

- Battery »AE5X:B« - tells us a percentage of remaining battery Reply: »AE5X:B« + 1byte percentage
- Number of sessions »AE5X:N« - important for correctly reading flash (when microAeth is reading flash every end of session is followed by 32 bytes of 0xFF) Reply: AE5X:N + 1 byte (number of sectors) + 1byte (number of sessions)
- GPS »AE5X:G« - NOT YET IMPLEMENTED
- Flash ID »AE5X:I« Reply: +4bytes (Hex ID)
- Firmware version: »AE5X:V« Reply +2bytes (LSB,MSB)
- Error status: »AE5X:H« Reply +1byte (binary coded errors 8bits:
  - BATT_LOW_ERROR_FLAG 0 //1
  - FLOW_ERROR_FLAG 1 //2
  - SENSE_ERROR_FLAG 2 //4
  - PHOTODIODE_ERROR_FLAG 3 //8
  - SUPPLY_6V_ERROR_FLAG 4 //16
  - LED_CURRENT_ERROR_FLAG 5 //32
  - FLASHFULL_ERROR_FLAG 6 //64
  - AUTO_SHUTDOWN_FLAG 7 //128

3. Instructions that are **read/write**. If we **read,** reply is same as in second group of instructions. If we **write** to microAeth, we send an instruction followed by data bytes and we get an **acknowledge** reply:

- Date
  - Read date »AE5X:D« - Reply: 1 byte for year (+2000), 1byte for month, 1 byte for Day, 1byte for Day of week
  - Write date »AE5X:D + 1 byte for year (+2000), 1byte for month, 1 byte for Day, 1byte for Day of week« Reply: ACK

- Time
  - Read time »AE5X:T« - Reply: +1 byte Hours, 1 byte minutes, 1 byte seconds
  - Write time »AE5X:T + 1 byte Hours, 1 byte minutes, 1 byte seconds« Reply: ACK

- Flow
  - Read flow »AE5X:F« -Reply: 1byte (value * 25 = FLOW in mlpm)
  - Write flow »AE5X:F + 1 byte = FLOW / 25« Reply: ACK

- Running Mode
  - Read mode »AE5X:M« - Reply: +1byte (0x46 – Flash only, 0x42 – Flash and streaming)
  - Write mode »AE5X:M +1byte (0x46 – Flash only, 0x42 – Flash & streaming)«

- Power OFF/ON
  - Read Power ON/OFF »AE5X:O« - Reply: +1byte Power OFF enabled, +6 bytes Power OFF Date and Time (year + 2000, month, day, hour, minute, second) +1byte Power ON enabled, +6bytes Power ON Date and Time (year + 2000, month, day, hour, minute, second)
  - Write Power ON/OFF »AE5X: O +1byte Power OFF enabled, +6 bytes Power OFF Date and Time (year + 2000, month, day, hour, minute, second) +1byte Power ON enabled, +6bytes Power ON Date and Time (year + 2000, month, day, hour, minute, second)«

- TimeBase
  - Read Timebase »AE5X:X« - Reply: + 2byte (LSB, MSB)
  - Write Timebase »AE5X:X + 2byte (LSB, MSB)«

- ShutDown Mode
  - Read shutdownmode »AE5X:P« Reply: +1byte (»N«, »U«)
  - Write shutdownmode »AE5X:P + 1byte(»N«, »U«)«

- Sound notifications
  - Read sound notif. »AE5X:U« Reply: +1byte (0,100) – 0 (OFF), 100(ON)
  - Write sound notif. »AE5X:U +1byte(0,100)«

- Read/Write all settings: Differs which values are set and which we get from microAeth (some are Read only) This can be extended if we will add any new functions!
  - Read All Settings: »AE5X:J« Reply: + 31bytes (Date(3), Time(3), TimeBase(2), Flow(1), Batt(1), Sector(1), Session(1), OperatingMode(1), SoundNotif(1),Fwversion(2), ShutDownMode(1), SleepEnabled(1), SleepDateTime(6), WakeUpEnabled(1), WakeUpTime(6)).
  - Write All Settings: »AE5X:J + 25 bytes(Date(3), Time(3), Flow(1),OperatingMode(1),SoundNotif(1), ShutDownMode(1),), SleepEnabled(1), SleepDateTime(6), WakeUpEnabled(1), WakeUpTime(6)).

4. Special protocol

- Read flash »AE5X:R« As soon as command is sent micro starts sending back flash data line by line (32 bytes) every time 32 0xFF is sent session has ended. Before you send a read flash instruction it is necessary to send instruction for number of sessions. Last 32nd byte is CRC of previous 31 bytes! 32 bytes of Data (Reference1 – 3 bytes, Sense 1 – 3 bytes, Feedback – 3 bytes, Flow – 2 bytes, PCB Temperature – 1 byte, Date – 3 bytes, Time – 3 bytes, Status – 1 byte, Battery – 2 bytes, Reserved – 10 bytes, CRC – 1 byte).

- Streaming: After mode is set to streaming, the microAeth starts sending messsages: AE5X:M + bytes as in the reading flash protocol
  - 'Ref
  - Data(index)
  - Data(index + 1)
  - Data(index + 2)
  - 'Sen1
  - Data(index + 3)

- Data(index + 4)
- Data(index + 5)
- 'Sen2
- Data(index + 6)
- Data(index + 7)
- Data(index + 8)
- 'Flow
- Data(index + 9)
- Data(index + 10)
- 'PCB Temp
- Data(index + 11)
- 'Date
- Data(index + 12)
- Data(index + 13)
- Data(index + 14)
- 'Time
- Data(index + 15)
- Data(index + 16)
- Data(index + 17)
- 'Status
- Data(index + 18)
- 'Battery
- Data(index + 19)
- Data(index + 20)
- 'Reserved for GPS etc...
- Data(index + 21)
- Data(index + 22)
- Data(index + 23)
- Data(index + 24)
- Data(index + 25)
- Data(index + 26)
- Data(index + 27)
- Data(index + 28)
- Data(index + 29)
- Data(index + 30)