# Model 633
# Aethalometer®
# Black Carbon Monitor

## User Manual

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# 1 INTRODUCTION

## 1.1 Description

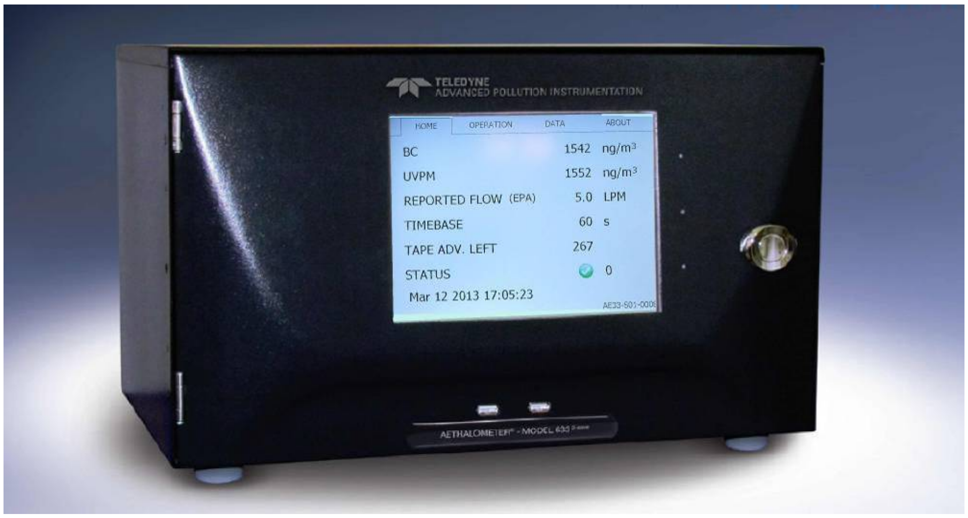


**Figure 1. The Aethalometer® Model 633.**

The Model 633 represents the "Next Generation" version of the real-time Aethalometer rack-mount instrument to measure Black Carbon (BC) particles in air. Please refer to the original Magee Scientific Aethalometer manual for a full description and background information on the method (http://mageesci.com/images/stories/docs/Aethalometer_book_2005.07.03.pdf).

The Model 633 Aethalometer incorporates scientific and technical advances designed to offer improved measurement performance versus previous versions of the Aethalometer and other BC instruments, user features, communications and interface, and the ability to perform routine performance tests to verify correct operation. Most importantly, the instrument incorporates the patented DualSpot™ measurement method. This provides two significant advantages: elimination of the changes in response due to 'aerosol loading' effects; and a real-time calculation of the 'loading compensation' parameter which offers insights into aerosol optical properties, and has been interpreted in models of aerosol origins and aging.

The Model 633 Aethalometer 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 compliance monitoring.

The leading innovations incorporated into the Model 633 include:

- The DualSpot™ measurement method, which solves the effects common to all filter-based real-time monitors, in which the instrumental response factor shows a dependence on the loading of material on the filter.
- Features for automatic ‘dynamic zero’ testing under a flow of internally-generated clean air; ‘span’ testing of the response of the optical sources and detectors; calibration of the response of the internal mass flow meters, if an external standard flow calibrator is connected; and validation of the photometric response by use of a kit of ‘Neutral Density’ optical filters whose properties may be traced to reference standards.
- User and communications interfaces, permitting remote monitoring of operation; data retrieval; performance of internal tests; and reporting of ‘state-of-health’ parameters.
- Modular construction designed for ease of routine maintenance service.

In addition to the above features, the Model 633 Aethalometer offers real-time aerosol absorption analysis at up to seven optical wavelengths, with rapid time resolution to 1 second even in multiple-wavelength mode. This permits the measurement of optically-absorbing aerosols – ‘Black’ Carbon and ‘Brown’ Carbon components of particulate matter – in applications including routine monitoring of ambient air quality for regulatory purposes; measurements of the concentration of BC in urban, suburban, regional, rural and remote locations; source testing; and laboratory-based research.

### 1.1.1 ‘DualSpot™’ Technology

The Model 633 Aethalometer uses the patented DualSpot™ method to compensate for the ‘spot loading effect’; and also to provide a real-time output of the ‘loading compensation’ parameter, which may provide additional information about the physical and chemical properties of the aerosol.

The 'spot loading effect' is a variable phenomenon which appears as a gradual reduction of instrumental response as the aerosol deposit density of the filter tape increases from zero to the predetermined limit of 'Maximum Attenuation' (Gundel 1984, Weingartner 2003, Arnott 2005, Virkkula 2007, Kanaya 2008). When the filter tape advances to a fresh spot, the data undergoes a discontinuous jump from its previous lower value, calculated when the spot was heavily loaded; to a higher value, calculated from collection on a fresh spot at zero loading. In the Aethalometer the reduction of data at increasing loadings is well described by a linear function of attenuation, but its magnitude cannot be predicted: some aerosols in some locations in some seasons may show a small or zero 'loading effect'; while under other conditions, the effect may be larger and noticeable. Empirically, it is found that fresher aerosols closer to their combustion sources will show a larger 'spot loading effect'; while well-aged aerosols under atmospheric conditions of high chemical activity and oxidative processing may show an almost zero effect. The effect is revealed statistically by processing data collected over a large number of tape advances, representing many data points collected at loadings ('ATN values') ranging from zero to the preset maximum. The data is collected into bins according to loading (attenuation, ATN). If there is a systematic reduction of the calculated result as a function of loading, the data will show a clear negative slope, with the intercept representing the 'zero loading' value. Figure 2 illustrates two datasets from urban locations with loading effects either present or not.

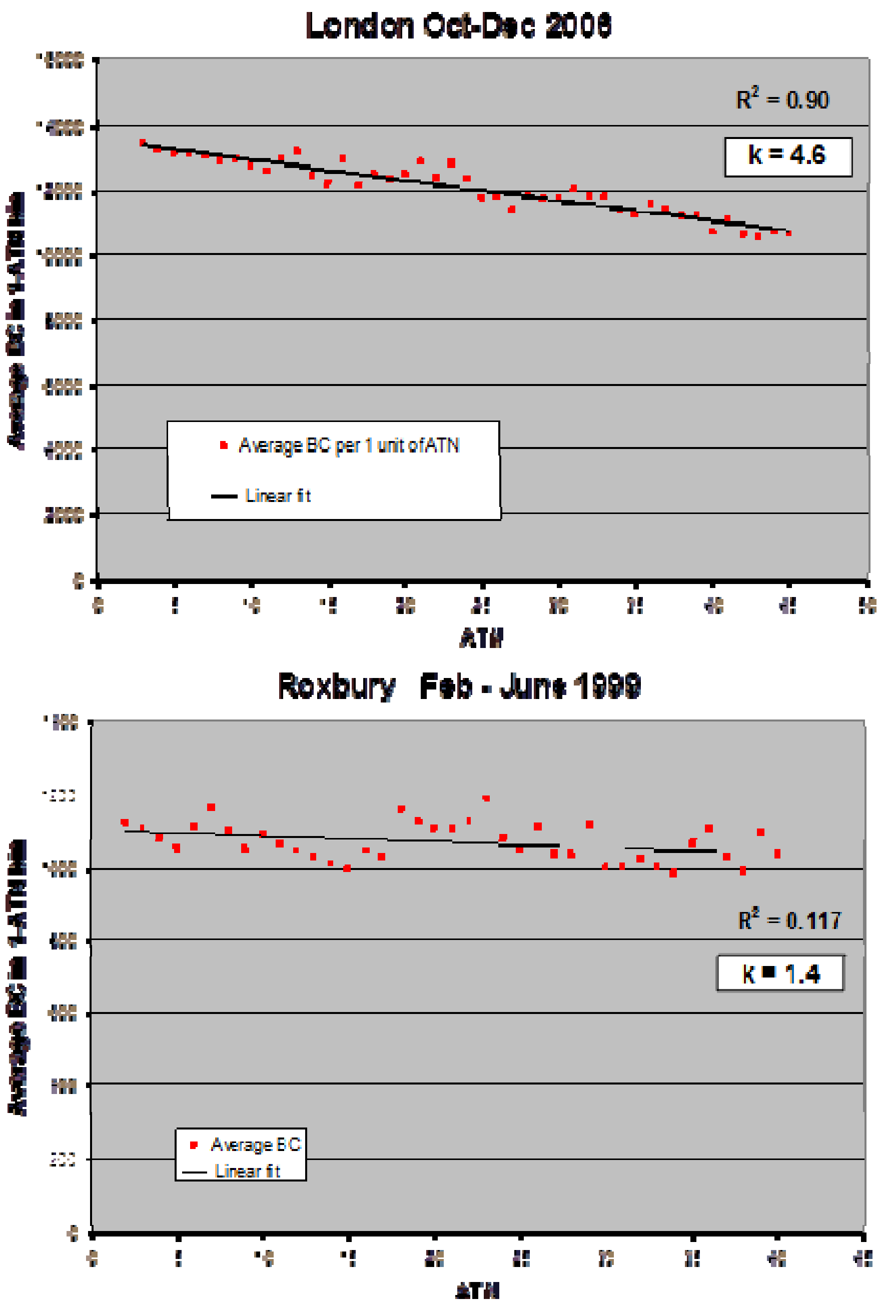


**Figure 2. Aethalometer data sorted and averaged according to loading (attenuation, ATN) on spot – roadside location in London, UK (top); urban site in Boston (Roxbury), USA (bottom).**

The London data show a systematic reduction at increasing loadings; while the Boston data do not. This demonstrates that any method intended to compensate for the 'spot loading effect' must be auto-adaptive and able to adjust dynamically to different situations. An instrument based on firmware with a fixed 'loading non-linearity' parameter will not operate correctly at all locations. The 'loading non-linearity' parameter must be measured.

It is clear that the effect, when present, is linear with loading ('ATN'). This can be represented as:

BC (reported) = BC (zero loading) * { 1 - k • ATN }

where BC (zero loading) is the desired ambient BC value that would be obtained in the absence of any loading effect; and k is the 'loading compensation parameter' (similar to Virkkula, 2007).

The analysis of a large number of datasets from a wide variety of locations shows that this relationship is linear in all cases studied; but with different values of k. It is therefore possible to eliminate the 'loading effect' of k by making two simultaneous identical measurements BC1 and BC2 at different degrees of loading ATN1 and ATN2.

BC1 = BC * { 1 - k • ATN1 }
BC2 = BC * { 1 - k • ATN2 }

From these two linear equations we may calculate the 'loading compensation parameter' k; and the desired value of BC compensated back to zero loading.

The Model 633 Aethalometer analyzes the Black Carbon component of aerosols on two parallel spots drawn from the same input stream, but collected at different rates of accumulation, i.e. at different values of ATN. By combining the data according to the above equations, the Model 633 yields the value of BC extrapolated back to 'zero loading'; as well as a real-time output of the 'loading compensation parameter' k which provides insights into the aerosol nature and composition. This process is performed in real time for all wavelengths: examination of the 'k' values as a function of wavelength provides further information about the aerosol composition. An example of this is shown for extreme concentrations of black carbon (Figure 3).

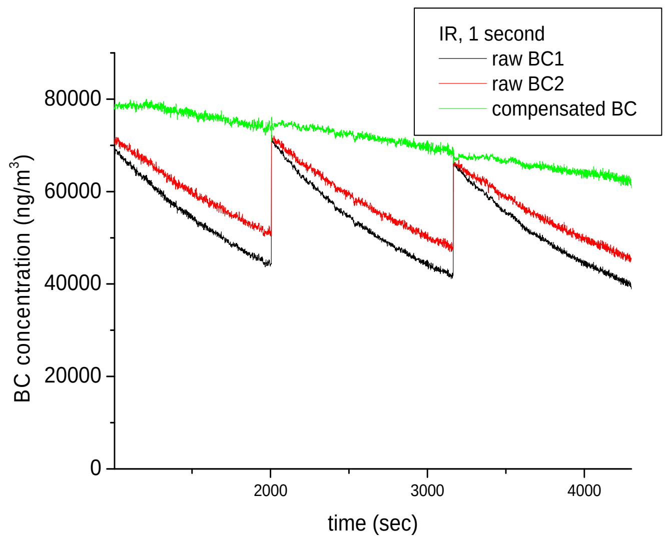


**Figure 3. The time-series of 633 raw and compensated BC concentrations with 1 second timebase – note the extreme concentrations and loading effects.**

### 1.1.2 Automatic Zero and Span

The Model 633 Aethalometer is capable of automatically checking the 'zero-air' response of the instrument under dynamic operating conditions. This test is implemented by back-flushing the inlet connection with an excess flow of internally-filtered air and circulating the filtered air in the instrument. The data reported during this period are analyzed for the mean value and the point-to-point variation. The mean value should be close to zero under ideal conditions; any positive value greater than zero represents the leakage of BC-containing room air into the instrument's analytical zone. The point-to-point variation represents the instrument's measurement noise level under actual operating conditions of actual flow – i.e., a 'dynamic' test. The point-to-point variation for the wavelength 370 nm at the time-base set to one second is about 125 ng/m3, which translates to a couple of ng/m3 at 1 minute time resolution (Figure 4).

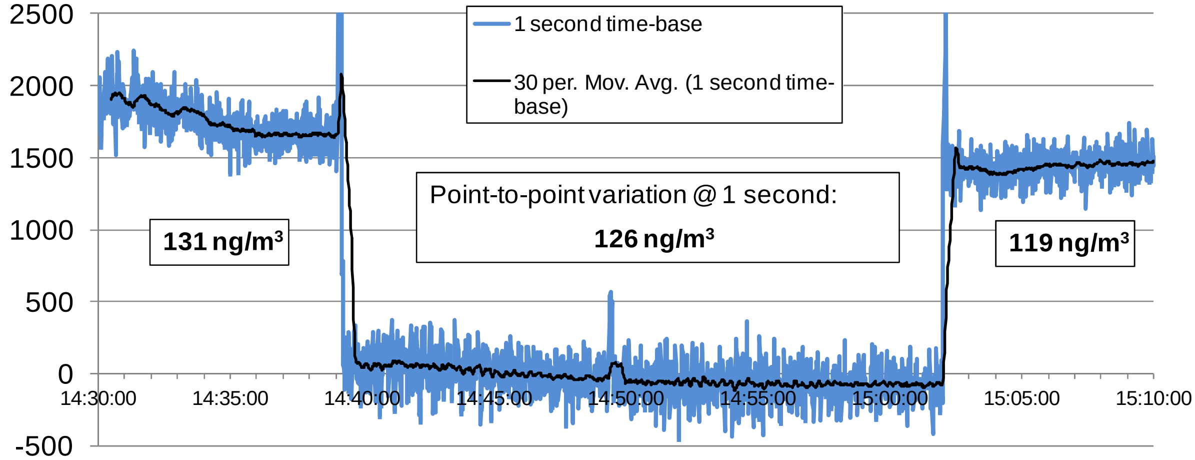


**Figure 4. 'Zero-air' check – the Model 633 Aethalometer switches from sampling ambient air to filtered air – 1 second time resolution point-to-point variation is very stable.**

The response of the optical detectors of the Model 633 Aethalometer may be verified using a standard kit of Neutral Density optical filters. These are glass elements with a range of known and stable optical absorptions, from light to dark, which are traceable from manufacturing records back to primary standards. When these are inserted into the Model 633 Aethalometer, its photodetectors will give a certain output signal. The stability and reproducibility of the relationship between optical signal and ND Filter density from one validation test to another; and the comparison with the original factory values; is a measure of the consistency of performance of the instrument's optics.

### 1.1.3 User and Communications Interfaces

The Model 633 Aethalometer incorporates the following user, data and communications features:

- 21-cm (8.25") color graphics touch-screen for data display and local user interface;
- USB ports for insertion of a memory stick for local data download;
- USB ports for connection of a keyboard, if necessary for initial setup of parameters, such as station identification;
- RS-232 COM ports for data transmission from auxiliary instruments or to the digital datalogger;

(Ethernet port installed for future software implementation).

### 1.1.4 Modular Construction

The Model 633 Aethalometer is constructed with a modular design, so that sub-units may be easily serviced. The only item requiring attention in routine use is cleaning of the optical insert to remove accumulated dust or other contamination which may be brought in with the sample air stream. The optical chamber is attached with a bayonet fitting for quick removal; easy cleaning; and reliable re-assembly. The entire instrument is hermetically sealed to reduce the entry of dust.

## 1.2 Technical Specifications

| |
|---|
| Operation:<br>• Supply voltage: 100-240 V~, 50/60 Hz<br>• Max power consumption: 90W<br>• Measurement wavelengths: 370, 470, 525, 590, 660, 880 and 940 nm<br>• Air flow: adjustable 2, 3, 4 and 5 LPM |
| Environmental operating conditions:<br>• Indoor use<br>• Altitude: up to 3000 m with internal pump, other configurations possible<br>• Temperature range: 10 – 40 degrees Celsius (instrument)<br>• Relative humidity range: non-condensing |
| Mechanical specification:<br>• Chassis material: sheet metal<br>• Front plate material: plastic<br>• Dimensions: standard 19”/6U, rack mount<br>• Weight: approx. 20 kg |
| Connectors:<br>• Sampling air: inlet / outlet type – ¼” NTPF<br>• Communication: 3x USB type A, 3x RS-232 COM, 1x Ethernet |
| User interface:<br>• 8.4” SVGA display with LED backlight<br>• Basic control: touch-screen<br>• Optional control: standard PC keyboard and mouse<br>• Red, Yellow, Red status LEDs |
| Data storage capacity: 10+ years, at 1-minute intervals |

## 1.3 Functional Description

The Model 633 features modular design and is composed of several subsystems which are so interconnected that most simple and safe handling of the instrument is possible. Presented here are a functional block diagram followed by a flow diagram.

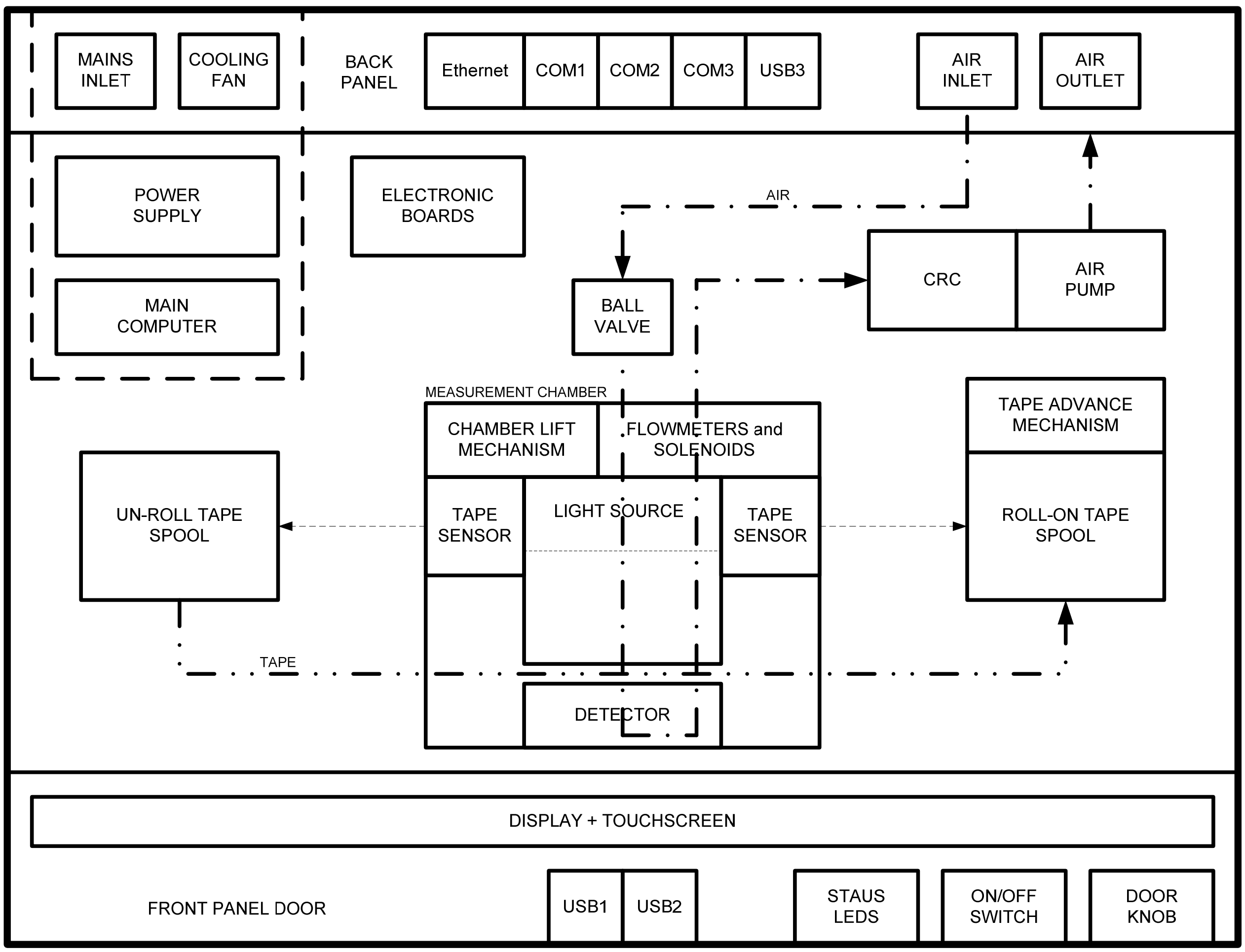


**Figure 5. Model 633 functional block diagram**

**ENCLOSURE**

The Model 633 enclosure is very robust and made from sheet metal. The enclosure mechanically protects the delicate inner measurement parts. The dimensions of the enclosure meet the rack mount standard for the instrumentation.

**POWER SUPPLY**

The power supply module is composed of the mains inlet, the power supply electronics and the cooling fan. Since the power supply electronics heats up, it is mechanically integrated in a separated and thermally sealed area.

**MAINS INLET**

The mains inlet accepts standard EU, US or UK supply cords. It is composed of the inlet itself, the EMC filter, the main fuse and the primary ON/OFF switch. The switch is a part of the power supply module.

**COOLING FAN**

The cooling fan is also a part of the power supply module. The control electronics measures the temperature of the power supply area and switches on and off the cooling fan.

**MAIN COMPUTER**

The main computer processor also generates quite a lot of heat. It is integrated in the power supply area so it can be cooled down together with the power supply electronics. The highest level control software and the user interface are implemented on the main, PC based computer.

**ELECTRONIC BOARDS**

The system features modular design so the electronics is composed of various electronics boards which mechanically fit together with other mechanical modules. The low level control firmware is implemented with microcontrollers, which are located on separate electronic boards so parallel real time data processing is possible.

**ETHERNET CONNECTOR**

The Ethernet connector allows the connection of the Model 633 measurement system to Ethernet based communication networks.

**COM1, COM2, COM3 CONNECTORS**

The COM connectors allow the connection of the system to RS232 based devices, like external sensors or dataloggers.

**USB CONNECTOR (rear panel)**

The USB connector allows the connection of the system to USB based devices, like external sensors or data processing units.

**AIR INLET and OUTLET CONNECTORS**

The air inlet and outlet connector allows the connection of the instrument to external airflow system. The measured air enters the instrument through the inlet connector and leaves the instrument through the outlet connector.

**BALL VALVE**

The ball valve is an electrically actuated valve which is connected directly to the inlet connector and connects or separates the instrument from the external air system.

**CRC**

The CRC (also called muffler) is a filter used to decrease the noise in the airflow which is created by mechanical rotation of the pump.

**AIR PUMP**

The air pump pumps the measured air through the inlet connector, directly to the measurement chamber. It is one of the main components in the system.

**FLOWMETERS**

Two flow meters measure the airflow in different points in the system. One of them is used also in the air flow regulation loop.

**SOLENOID VALVES**

Three solenoid valves are used to switch the airflow through different airflow paths when the instrument is set in different operating modes like measure, tape advance or similar.

**CHAMBER LIFT MECHANISM**

The chamber lift mechanism allows the measurement chamber to be lifted manually or electromechanically. During tape advance the automated chamber lift procedure is invoked. During tape replacement the manual chamber lift procedure can be engaged. The manual chamber lift mechanism features also a special locking mechanism which simplifies the tape replacement or chamber cleaning procedure. The main electronic components of the chamber lift mechanism are the stepper motor and the chamber lift position sensor.

**TAPE ADVANCE MECHANISM**

The advance mechanism allows the instrument to perform automatic tape advances during measurements. The main electronic parts of the tape advance mechanism are a stepper motor and the two tape sensors.

**ROLL-ON and UN-ROLL TAPE SPOOLS**

The roll-on and the un-roll tape spools hold the measurement tape. During automated tape advance the tape unrolls from the un-roll spool and rolls on the roll-on spool. If the un-roll spool is empty, the event is detected automatically thanks to the tape sensors. The tape replacement procedure must be performed manually by the operator. The measurement tape is one of the main parts of the system.

**TAPE SENSORS**

The two tape sensors are used by the instrument software to detect the amount of tape on the un-roll and roll-on spools.

**LIGHT SOURCE**

The light source integrates groups of LEDs of different light wavelengths. It is one of the main parts of the system.

**DETECTOR**

The detector detects what amount of light passes through the measurement tape. A special algorithm is used to calculate the black carbon concentration using the information from the detector and the flow meter.

**FRONT PANEL DOOR**

The front panel door can be opened which allows the access to the instrument for tape replacement or chamber cleaning.

**DISPLAY and TOUCH-SCREEN**

The display and the touch-screen are the main user interfaces of the instrument. Using this interface the operator can perform all necessary operations for proper functioning of the instrument.

**USB CONNECTORS (front panel)**

The two USB ports on the front panel door can be used to connect a keyboard, mouse or a USB key for data download or data upload.

**STATUS LEDS**

The red, yellow and green status LEDs show the correct or incorrect operation of the instrument. This status is replicated on the screen with the Status Condition (see, 4.2 Instrument Status).

**DOOR KNOB**

The door knob is used to open the front panel door.

**ON/OFF SWITCH**

The secondary ON/OFF switch is located behind the front door. It is electrically connected in series with the primary ON/OFF switch, which is located at the back of the instrument, next to the mains inlet. (Both switches must be set to ON to power up the instrument, but either one can be set to OFF to power down the instrument).

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## 2 SAFETY NOTES and 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.

**Unauthorised instrument access and operation**

The instrument must be protected against unqualified use. UNAUTHORISED instrument access and operation can be dangerous. The instrument can only be operated by persons who can ensure proper handling due to their qualification, technical skills and practical experience.

**Electric shock**

CHECK the mains power supply cord ANNUALLY. If the supply cable is DAMAGED, stop using the equipment and contact your authorized representative.

**Fire and explosion**

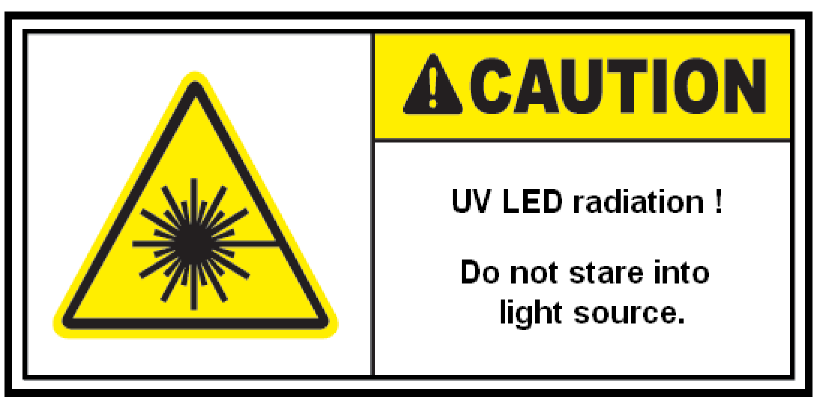
NEVER install the instrument in explosion-risk areas and never use the equipment near flammable substances.

**Instrument overheating**

ALWAYS assure the instrument operates under proper operating ambient conditions. NEVER install the instrument in spaces with limited air circulation.

**UV radiation**

633 light source contains an ultraviolet (UV) light emitting diode (LED). The LED radiates UV and visible light during operation. Precautions must be taken to prevent looking directly at the UV light with unprotected eyes. NEVER touch or look directly into the Model 633 light source!



### Instrument service and repair

UNAUTHORISED instrument service and repair procedures are NOT ALLOWED. The instrument can only be serviced, repaired or modified by authorized persons. Please contact your authorized representative if you have any problems with the instrument. Please make sure to have the equipment checked regularly for technical safety.


**Moving parts**

During AUTOMATIC tape advance procedure, the measurement chamber is lifted by a motorized chamber lift mechanism. To prevent any injuries to your fingers, NEVER squeeze your hands or fingers into ANY mechanical apertures, DURING automated tape advance procedure.

During MANUAL chamber lift procedure ALWAYS use the chamber lift locking mechanism. To prevent any injuries to your hands or fingers, NEVER squeeze your hands or fingers into ANY mechanical apertures, BEFORE manually lifting the chamber.

During filter tape replacement procedure, precaution must be taken, to prevent unintentional injuries to your hands or fingers.

# 3. INSTRUMENT INSTALLATION

## 3.1 Unpacking the system

Take the instrument out of the box and place it on an even surface. Keep the back of the instrument accessible.

**<u>Remember to remove protective caps on the inlet and exhaust ports before operation!</u>**

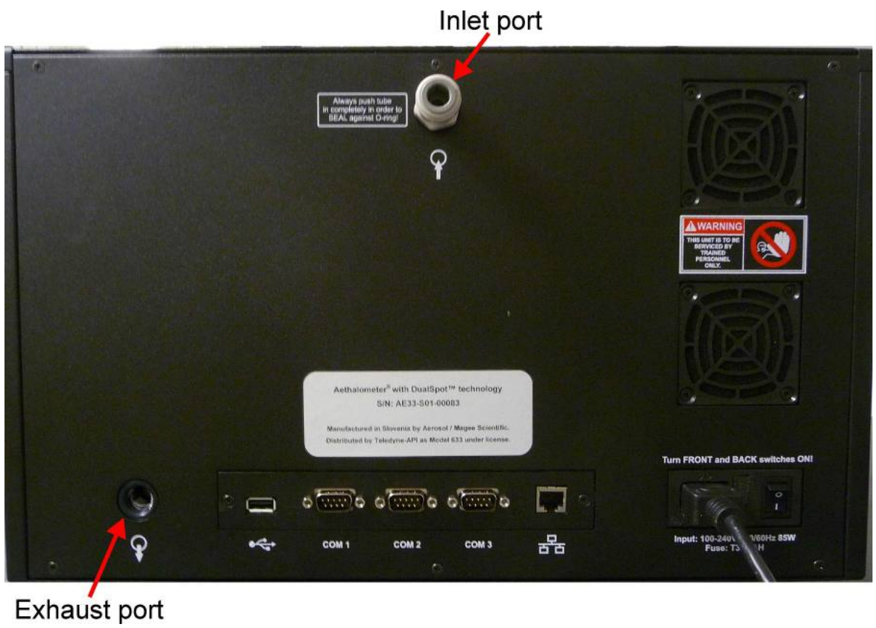



**Figure 6. Remove protective caps on the rear panel of the instrument before switching it on!**

## 3.2 The sampling line

The instrument is supplied with several meters of black conductive sample line tubing designed to minimize electrostatic particle losses in the sampling system. Keep the sampling line as short as possible. Do not attempt to substitute the sampling tubing with tubing from a different material. If substituting the supplied tubing with tubing from other material, please consult the instrument supplier for details.

When installing the sample line, try to avoid sharp bends or long horizontal runs with the sample tubing as either of these conditions can promote particle losses in the sample tube. Insulate the sample lines inside the instrument shelter and avoid exposing them to direct exhaust from the HVAC unit – this can lead to condensation inside the sample line tubing and can damage the instruments and interfere with the measurement.

1. Thread the supplied fitting onto the Sample Inlet port on the rear panel of the Aethalometer (Figure 7, top). Use Teflon tape on the thread.
2. Fit the supplied barbed connector into the end of the black conductive sample tubing (Figure 7, left).
3. Insert the connector into the fitting on the rear panel of the instrument (Figure 7, right).

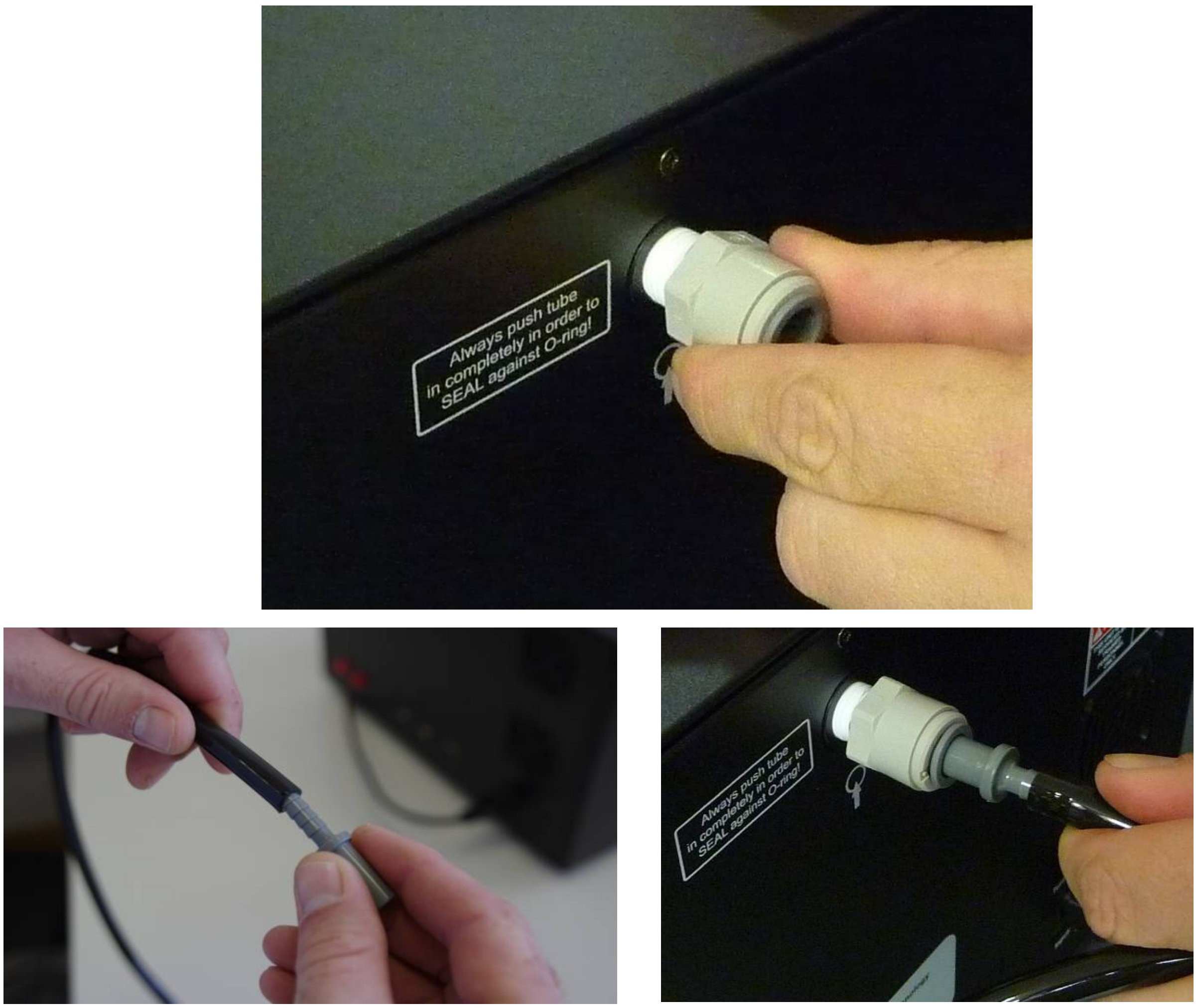



**Figure 7. Connecting the sampling line.**

Connect the other end of the sample line tubing to the sampling manifold or to the inlet on the outside of the measurement station. Make sure that any openings in the station walls or ceiling is leak-proof. If not using a size selective inlet, please make sure to keep the end of the tubing inverted so rain cannot enter. A funnel on the sampling end of the inverted sample line tubing with the opening covered by a mesh screen is recommended. Alternatively, the optional insect screen can be installed near the sampling end of the tubing. The inlet should be unobstructed, securely fixed and placed at an appropriate distance from the roof or walls of the station. Please consult the appropriate national and international technical standards for particulate matter sampling and analysis for details.

### 3.3 Powering on the Aethalometer

Connect instrument to AC power and turn on. The instrument has two power-on switches – one on the rear panel (Figure 8, top) and another on the front inside the door on the right (Figure 8, bottom). Set both switches to the ON position.

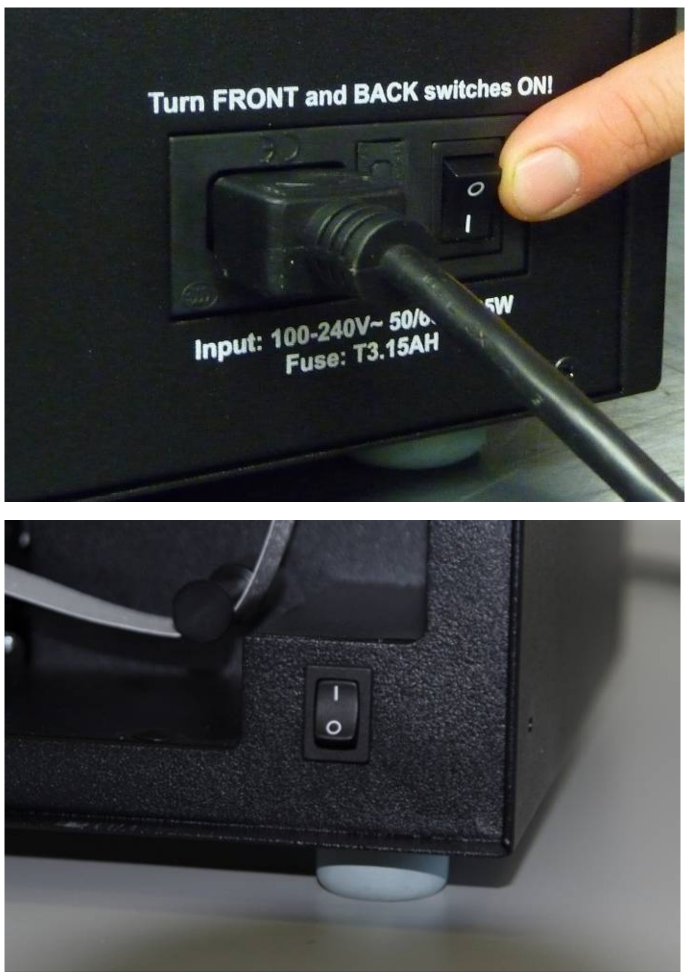



**Figure 8. Power on switches: rear panel (top photo) and front inside the door on the right (bottom photo).**

Upon start-up, the instrument will proceed through an initialization period which can take up to 5 minutes (Figure 9). Various subunits are tested during this period and test results are indicated by green check boxes for each step. The instrument will automatically begin measurements as quickly as initialization is complete, if the touch screen display remains untouched during the process.

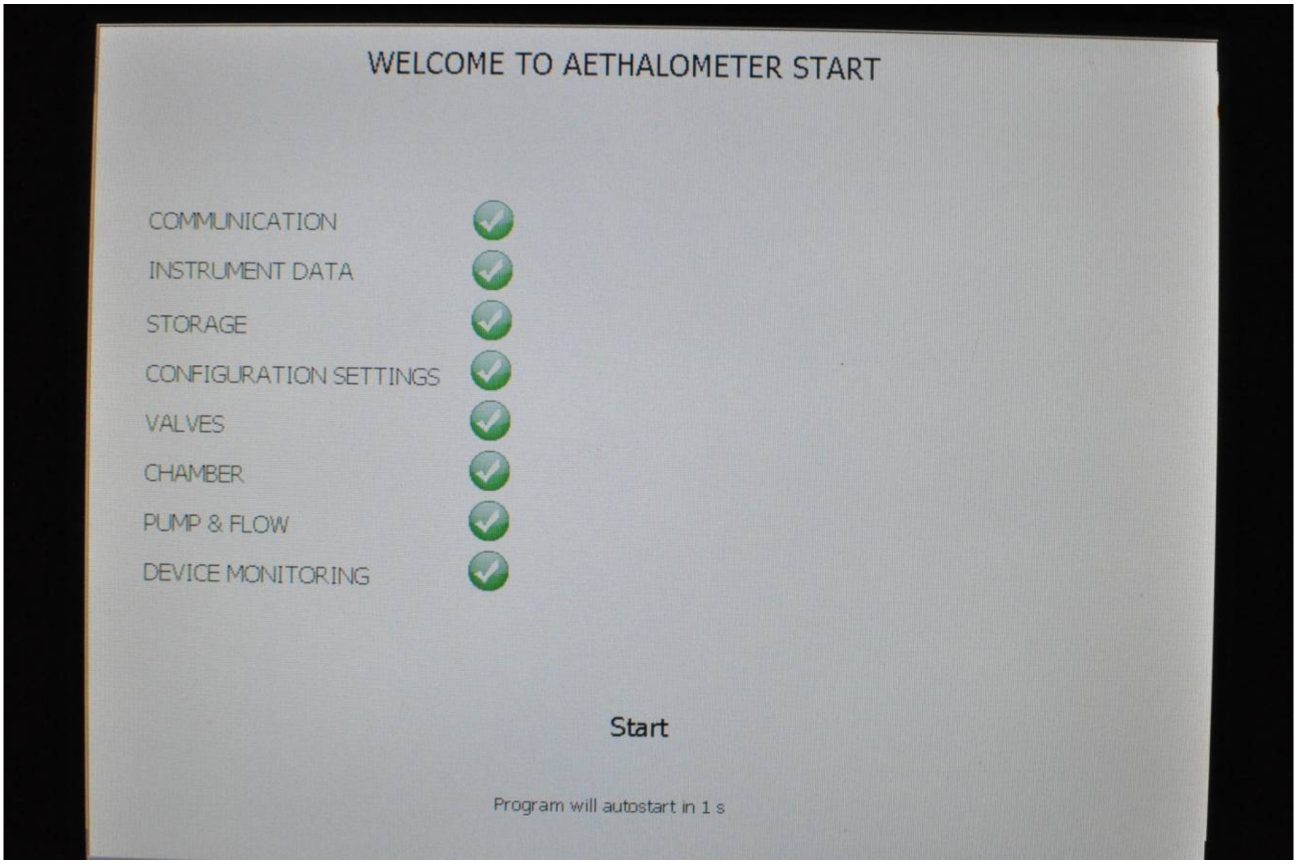


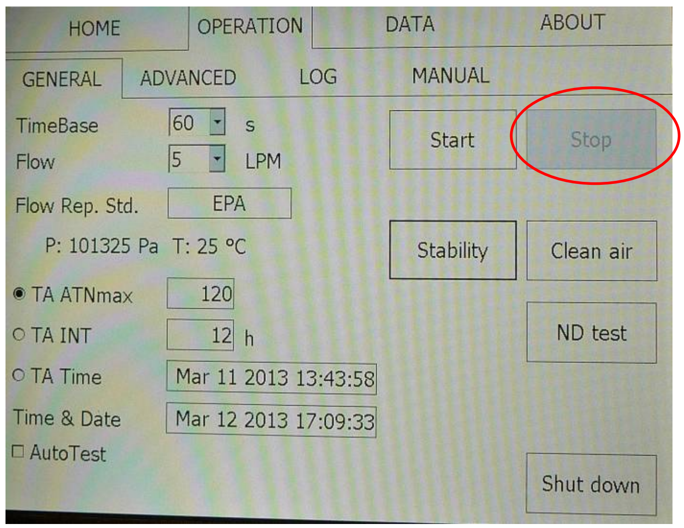

**Figure 9. The initialization screen with test results.**

Note that the green spot with a checkmark in its center means that the corresponding system is functioning properly. If there is any kind of error, either a red spot with an x-mark or a yellow spot with an exclamation mark will appear; in that case, please contact Technical Support.

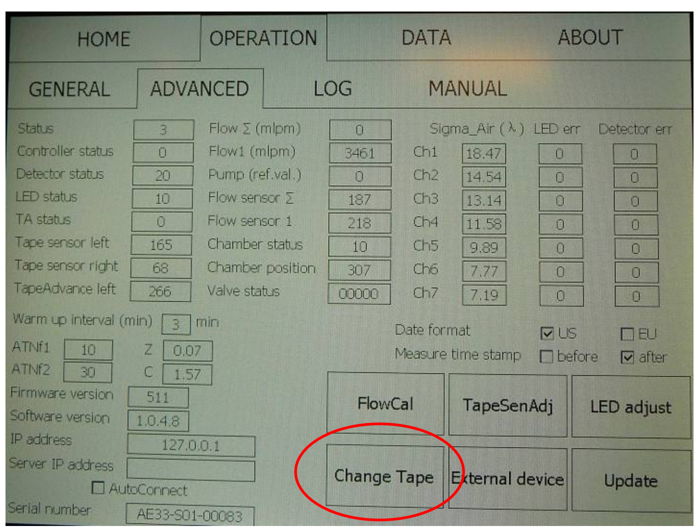
## 3.4 Filter tape installation

In the “Operation / General” menu (Section 4 provides information about the user interface) press “Stop” to stop measurements. (If the instrument is powered OFF for this procedure, see Section 3.4 Manually lifting/lowering chamber optical head). Press “Change Tape” and follow instructions – you will need a fresh roll of filter tape and some adhesive tape. For details, please see below.

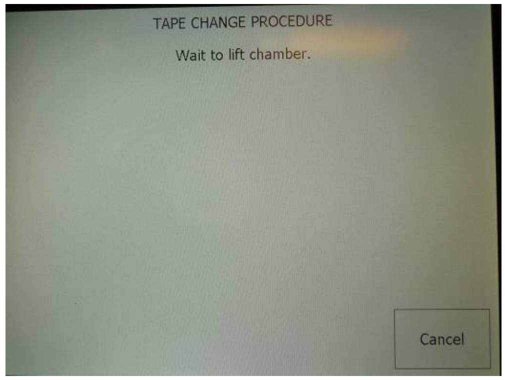
In the Operation / General menu press Stop to stop measurements, then in the Operation / Advanced menu press “Change Tape”

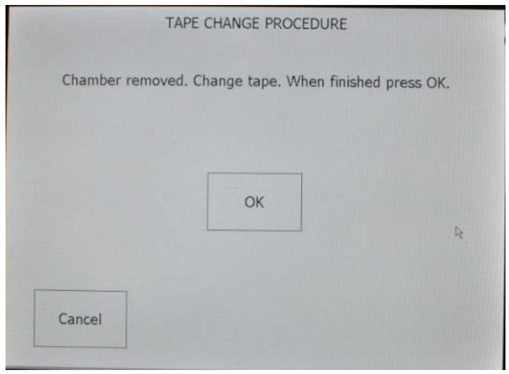



In the Operation / Advanced menu press “Change Tape”



The first “Tape Change Procedure” screen is displayed while the chamber lifts, then the second “Tape change Procedure” screen is displayed with a prompt to change tape.



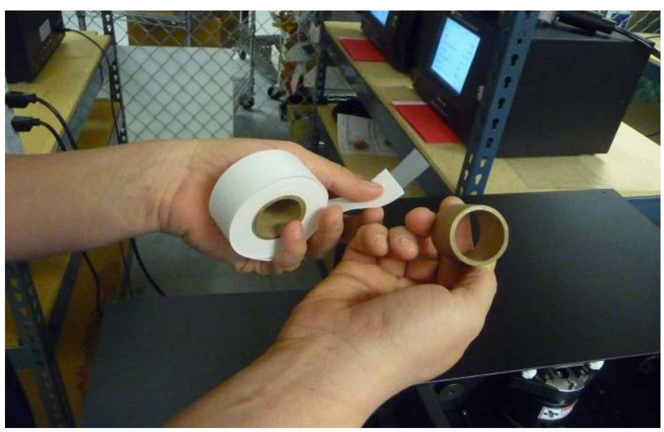

Start changing filter tape: First remove the transparent tape retention disk on the left …

… then on the right.

Slide tape from beneath the optical chamber and remove the used tape.

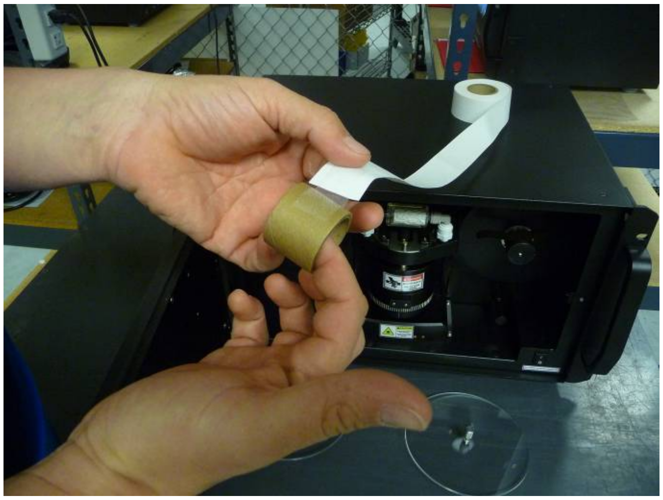
Keep the empty roll for use with new, replacement tape.

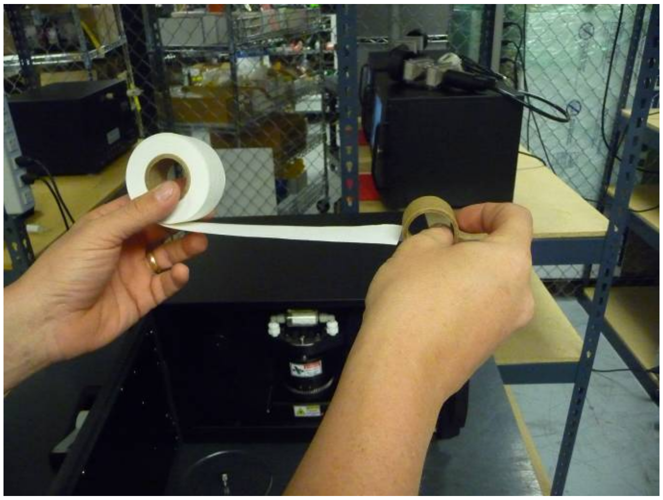
Using transparent tape, attach end of new tape to empty roll.



Center carefully for even alignment.

Tape direction is from bottom, left to right.



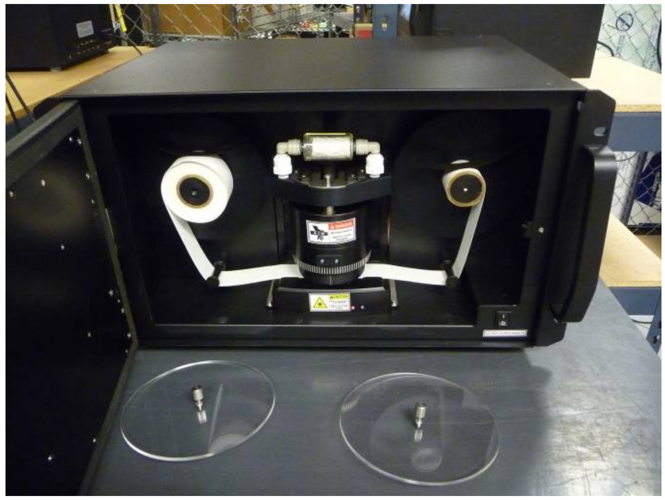


Insert the new tape roll on the left side of the chamber and run the tape under the left guide-arm.

Slide the tape under the optical head,

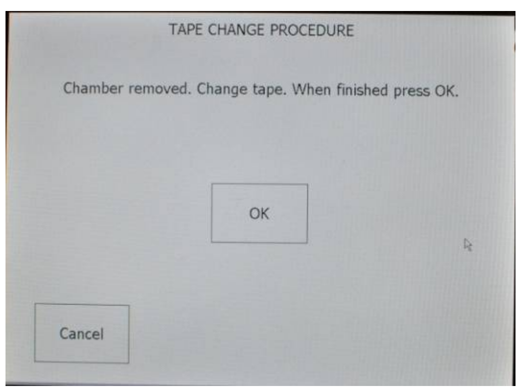
then run it under the right guide-arm and install the empty roll on the right. There may be some slack in the tape.

Ensure the tape is taut between the two sides.

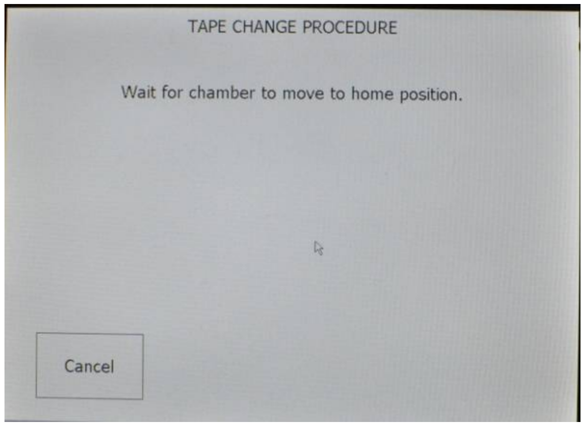


Replace the transparent tape retention disks.

Close the door and press OK on the display screen.



The next "Tape Change Procedure" screen prompts you to wait for the chamber to return to home position.




The next screen provides notice when the tape change procedure is finished. Press OK.

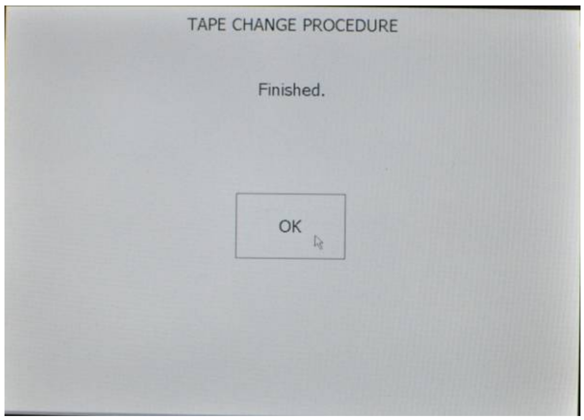


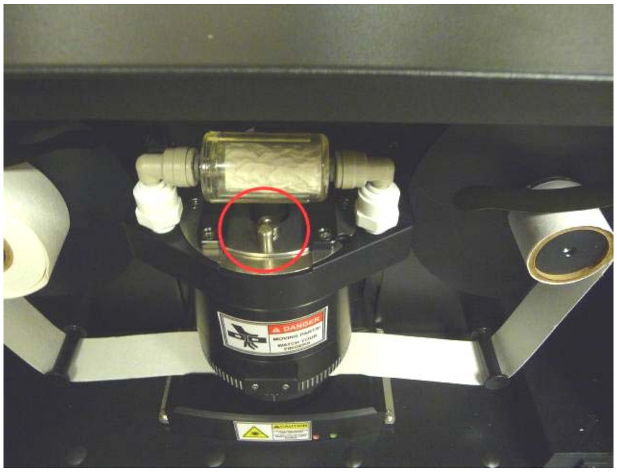

**Figure 10. Changing filter tape**

## 3.4 Manually lifting/lowering chamber optical head

In case the instrument is turned off, the chamber can be lifted manually, as follows:

(Stop measurements first: Operation>General>Stop).

Note the retention pin at the top of the chamber optical head.



Grasp the optical head securely in both hands with fingers at bottom and thumbs on top, pressing retention pin down and raising optical head up.

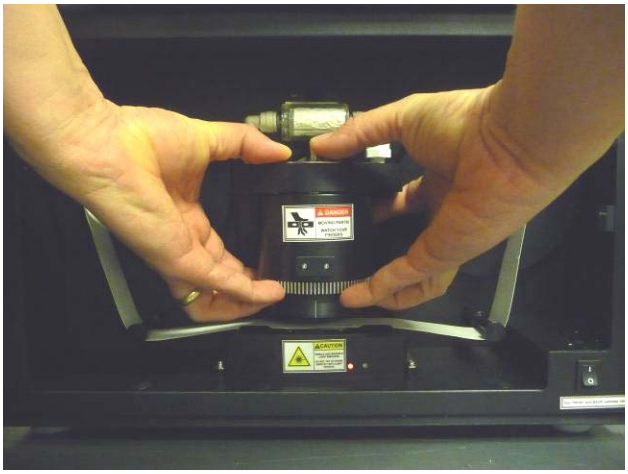


**Figure 11. Manually Lifting the Chamber Optical Head**

**ATTENTION! – If the chamber is lifted while instrument is operating (STOP button not pressed), it is not possible to restart the measurement without cycling the instrument power. (Flip both power switches to OFF; then flip each to ON).**

# 4 USER INTERFACE, SETTINGS and OPERATION

## 4.1 User interface and settings

There are four 1st level menu tabs in the touch-screen user interface: HOME, OPERATION, DATA, and ABOUT (Figure 12), described as follows:

- **HOME** with the following parameters:
  - BC - the measured values for Black Carbon (measured at 880 nm)
  - UVPM - UV particulate matter (calculated at 370 nm)
  - REPORTED FLOW - measured flow (in LPM)
  - TIMEBASE - timebase setting (in seconds)
  - TAPE ADV. LEFT - the amount of remaining tape (in )
  - STATUS – instrument status: green (all OK), yellow (check status), and red (stopped) with a Status Condition (see, 4.2 Instrument Status),
  - Bottom of HOME screen shows date and time.

  *Note: The BC and UVPM values will typically be similar, but not exactly the same. If aromatic compounds are present in the sampled air (such as when sampling fresh wood-smoke, for example), the UVPM concentration will exceed the BC mass concentration value significantly, depending upon the amount and type of organic material present.*

- **OPERATION** with four sub-tabs: GENERAL, ADVANCED, LOG and MANUAL.

  **GENERAL** where one can change the settings:
  - Flow (LPM) *(see Note below on flow-reporting standard)*
  - TimeBase (seconds)
  - select one of three radio buttons:
    - TA ATNmax - maximum attenuation at which the Aethalometer advances tape
    - TA INT - the time interval at which the Aethalometer advances tape (hours)
    - TA Time - the time at which the Aethalometer advances tape
  - Start, Stop, Stability, Clean air, and Change Tape buttons

  **ADVANCED** with all parameters which can be set in the Aethalometer.

  **LOG** with the last operational reports of status, parameter changes, data download.

  **MANUAL** with basic commands, to operate hardware (solenoids, pump, chamber, TA)

  *Note: flow-reporting standard: These are the pressure and temperature which the instrument uses to report flow and sample volume. By choosing to report mass flow, (101325 Pa, 21.11 C) are used to convert the measured mass flow to reported volumetric flow at these conditions (these are values used by the flow meter in the Model 633). These values can be substituted for any other (pressure, Temp) values,* *should you want the flow to be reported at 0 C, or 25 C for example. Optionally, you can chose volumetric flow at ambient conditions to be reported. To do that you need an optional weather station accessory kit available from Teledyne API (part number DU0000200). This external device is connected to one of the rear RS-232 COM ports, please see below (Section 4.6 External devices).*

- **DATA** with two sub-tabs: TABLE and EXPORT.
  **TABLE** where raw measurement values are reported, BC concentration calculated from each individual spot (BC1, BC2), and the compensated BC concentration. All three concentrations have the unit ng/m³.
  **EXPORT** with selection data to be copied to USB

- **ABOUT** – features and contact information.

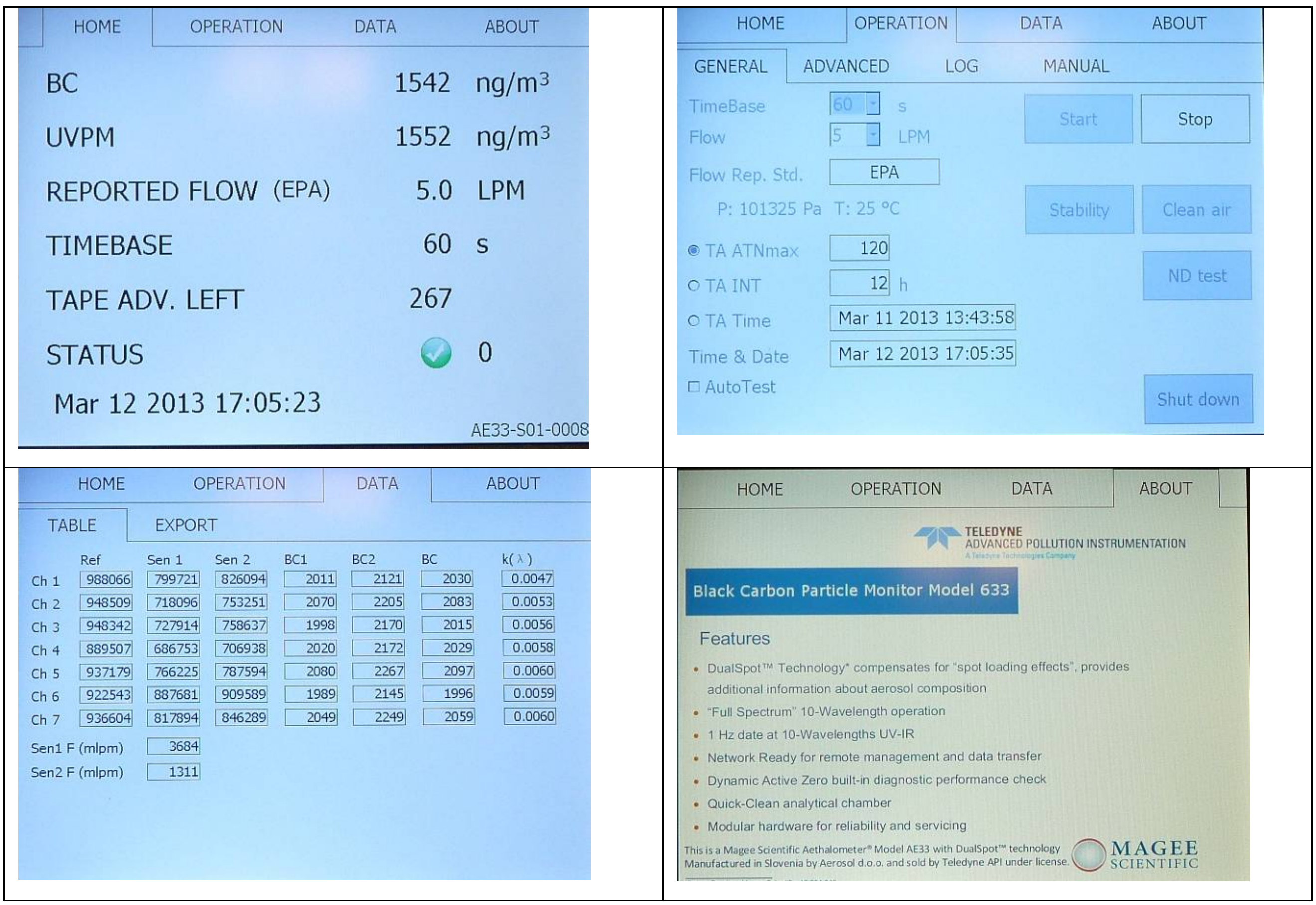



**Figure 12. The Aethalometer HOME, OPERATION, DATA and ABOUT screens, clock-wise from top left.**

## 4.2 Instrument Status

The instrument's current status condition is displayed in decimal format on the front panel HOME screen and in the Status column of the data download. The status condition relates to various subcomponents of the instrument, e.g., Detector, Flow, LED, etc. The decimal number represents a sum of all of the status conditions occurring at any given time. (Multiple status conditions are interpreted using subtraction of the largest possible Status Condition value using the table below.

**Table 1. Status Conditions and Descriptions.**

| Parameter | Status Condition | Description |
|---|---|---|
| Detector | 0 | measuring |
| | 1 | not measuring (due to either tape advance, fast calibration in progress) |
| | 2 | calibrating (LED, Flow, Tape Sensors) |
| | 3 | stopped |
| Flow | | flow OK |
| | 4 | flow low/high by more than 0.25 LPM |
| | 8 | Flow check status history |
| | 12 | Flow L/H and check status history |
| LED | | LEDs OK |
| | 16 | calibrating |
| | 32 | calibration error in one or more channels (at least one channel OK) |
| | 48 | led error (all channels calibration error, COM error) |
| Tape Advance | | tape advance OK |
| | 128 | tape warning (less than 10 spots left) |
| | 256 | tape last warning (card box visible, less than 5 spots left) |
| | 384 | tape error (tape not moving, end of tape) |
| Tests | | No test |
| | 1024 | Stability test |
| | 2048 | Clean air test |
| | 3072 | Change tape |

When Status Condition 3 is encountered, the Aethalometer stops. In all other statuses, it continues to operate with a warning, and the data is flagged accordingly. The status is represented by one value, which can point to one parameter or a combination of parameters.

### Single Status Condition

If the value displayed matches a value in the Status Condition column, it indicates only one parameter and its description.

Examples:

- **Status = 0**, all OK -> front panel LED's GREEN
- **Status = 1**, all OK, tape advancing -> blinking GREEN LED
- **Status = 128**, machine is running, tape advance warning flag is set -> YELLOW

### Multiple Status Conditions

If the Status displayed does not match a value in the table, it means that there are multiple parameters whose Status Conditions are added together, forming a sum that must be broken down by subtraction: find the largest value in the Status Condition column that does not exceed the Status value, and subtract it from the sum. Then Find the next largest value in the Status Condition column that does not exceed the remainder, and subtract again. Continue finding the next largest number and subtracting it until the remainder matches a value in the Status Condition column.

Examples:

- **Status = 289**, which breaks down as follows: 289 – 256 = 33; 33 – 32 = 1; therefore, the Status Conditions are 256, 32, and 1. which mean -> machine is not measuring (1), LED calibration had errors in 1 or more (but not all) channels (32), and less than 5 tape advances are left (256)
- **Status = 145**, which breaks down as follows: 145 – 128 = 17; 17 – 16 = 1; therefore, the Status Conditions are 128, 17, and 1. which mean -> machine is not measuring (1), LED calibration is in process (16), and less than 10 tape advances are left (128)

## 4.3 Downloading and Viewing Data

To download data, insert the USB stick in either of the **front** USB ports. Do not use the rear ports as they are intended for the mouse and keyboard only and not for data transfer (surge protection).

Go to the “Data / Export” menu and press “Export to USB”. The data will be stored in a text file with a header. The file name is:

AE33_S*ss*- *nnnnn_yyyymmdd*.dat

where *ss* is the production series number, *nnnnn* is the serial number, and *yyyymmdd* is the date, for example 20120901 means 1 Sept 2012.
Please make sure that the transfer is finished before removing the USB stick from the USB port on the Aethalometer. You can now transfer the data file to a personal computer as any other file, making note, where you saved it, and open it in your favorite data processing application.

**Data file structure and description of the fields**

### Header:

Date(yyyy/MM/dd); Time(hh:mm:ss); Timebase; RefCh1; Sen1Ch1; Sen2Ch1; RefCh2; Sen1Ch2; Sen2Ch2; RefCh3; Sen1Ch3; Sen2Ch3; RefCh4; Sen1Ch4; Sen2Ch4; RefCh5; Sen1Ch5; Sen2Ch5; RefCh6; Sen1Ch6; Sen2Ch6; RefCh7; Sen1Ch7; Sen2Ch7; Flow1; Flow2; FlowC; Pressure (Pa); Temperature (°C); RH (%); ContTemp; SupplyTemp; Status; ContStatus; DetectStatus; LedStatus; ValveStatus; LedTemp; BC11; BC12; BC1; BC21; BC22; BC2; BC31; BC32; BC3; BC41; BC42; BC4; BC51; BC52; BC5; BC61; BC62; BC6; BC71; BC72; BC7; K1; K2; K3; K4; K5; K6; K7; TapeAdvCount; ID_com1; ID_com2; ID_com3; fields_i

### Data line:

2012/09/21 00:34:00 60 890416 524323 709193 823296 573862 756304 884844 619592 789142 822391 673266 816066 792706 686925 828401 738101 718325 841075 789053 722690 833686 3325 1674 4999 101325 21.11 -1 30 40 0 0 10 10 00000 0 1150 1290 1242 1166 1248 1215 1150 1231 1190 1146 1196 1175 1214 1195 1234 1144 1114 1139 1180 1225 1174 0.00133 0.00095 0.00092 0.00080 0.00057 -0.00024 -0.00025 12 0 2 0 21.1

**Data field description:**

- *Date(yyyy/MM/dd)*: date.

- *Time(hh:mm:ss)*: time.

- *Timebase*: timebase – units in seconds.

- *Ref1, Sen1Ch1, Sen2Ch1…:* are the raw signal Reference (Ref), Sense 1 ( Sen1) and Sense 2 ( Sen2) values form which the BC concentrations are calculated for channel 1 (Ch1), that is wavelength 370 nm. BC11 is the uncompensated BC calculated from the spot 1 for channel 1. BC1 is the final results the BC calculated form measurements for channel 1 (370 nm).
- *Flow1; Flow2; FlowC:* Measured flow in ml/min. Flow 1 is flow through the spot 1, Flow_C is common (total flow) through the optical chamber, Flow_2 is the difference between these two.
- *Pressure (Pa); Temperature (°C); RH (%)*: These are the pressure and temperature which the instrument uses to report flow. By chosing to report mass flow, (101325 Pa, 21.11 C) are used to convert the measured mass flow to reported volumetric flow at these conditions (these are values used by the flow meter in the AE33). These values can be substituted for any other (pressure, Temp) values, should you want the flow to be reported at 0 C, or 25 C for example. Optionally, you can choose volumetric flow at ambient conditions to be reported. To do that you need an optional weather station accessory for the (pressure, Temp) measurement. We offer this separately (PN DU00000200). This external device is connected to the COM ports, please see below.
- *ContTemp; SupplyTemp*: control and power supply board temperatures
- *Status; ContStatus; DetectStatus; LedStatus; ValveStatus; LedTemp*: status codes for the instrument, reported in the , please see manual, chapter 5.2. and the subcomponents: controller, detector LED board; valve status (each valve can be on or off); LED board temperature
- *BC11; BC12; BC1; BC21; BC22; BC2; BC31; BC32; BC3; BC41; BC42; BC4; BC51; BC52; BC5; BC61; BC62; BC6; BC71; BC72; BC7*: BC11 is the uncompensated BC calculated from the spot 1 for channel 1. BC1 is the final results the BC calculated form measurements for channel 1 (370 nm).

- *K1; K2; K3; K4; K5; K6; K7*: K_i are the compensation parameters for wavelengths i=1…7
- *TapeAdvCount*: TapeAdvCount – tape advances since start
- *ID_com1; ID_com2; ID_com3; fields_i:* ID_comi are the identifiers telling the Aethalometer which auxiliary device is connected to which serial port (necessary because of the different data structure). This is a 3 byte field:

0 2 0 21.1

means that the "Comet temperature probe" (instrument code 2) is connected to COM2. The temperature is 21.1 C. (This is not true for the temperature and pressure measurements to calculate volumetric flow using AMES_TPR159 sensor!)
If we connected additionally another aux instrument to COM1 the dataline would be (ID_comi: 5 2 0):

Date(yyyy/MM/dd); Time(hh:mm:ss); Timebase; RefCh1; Sen1Ch1; Sen2Ch1; RefCh2; Sen1Ch2; Sen2Ch2; RefCh3; Sen1Ch3; Sen2Ch3; RefCh4; Sen1Ch4; Sen2Ch4; RefCh5; Sen1Ch5; Sen2Ch5; RefCh6; Sen1Ch6; Sen2Ch6; RefCh7; Sen1Ch7; Sen2Ch7; Flow1; Flow2; FlowC; Pressure (Pa); Temperature (°C); RH (%); ContTemp; SupplyTemp; Status; ContStatus; DetectStatus; LedStatus; ValveStatus; LedTemp; BC11; BC12; BC1; BC21; BC22; BC2; BC31; BC32; BC3; BC41; BC42; BC4; BC51; BC52; BC5; BC61; BC62; BC6; BC71; BC72; BC7; K1; K2; K3; K4; K5; K6; K7; TapeAdvCount; ID_com1; ID_com2; ID_com3; fields_i

2012/09/21 00:34:00 60 890416 524323 709193 823296 573862 756304 884844 619592 789142 822391 673266 816066 792706 686925 828401 738101 718325 841075 789053 722690 833686 3325 1674 4999 101325 21.11 -1 30 40 0 0 10 10 00000 0 1150 1290 1242 1166 1248 1215 1150 1231 1190 1146 1196 1175 1214 1195 1234 1144 1114 1139 1180 1225 1174 0.00133 0.00095 0.00092 0.00080 0.00057 -0.00024 -0.00025 12 5 2 0 1090 45 20.0 21.1

where the aux instrument with the code 5 is a weather station reporting pressure (1090 mbar), RH (45%) and temperature (20.0). the temperature 21.1 is reported by the "Comet temperature probe" installed at a different location.

## 4.4 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 = IO.Ports.StopBits.One

.Parity = IO.Ports.Parity.None

.Handshake = IO.Ports.Handshake.None

.DtrEnable = True

.RtsEnable = True

## 4.5 Serial Commands for Communication with the Aethalometer

IMPORTANT NOTE: All commands finish with a Carriage Return [CR].

| | | | |
|---|---|---|---|
| $AE33:Dnnn | nnn number of lines of data requested | | Request nnn last measurements |
| $AE33:TyyyyMMddHHmmss | yyyy<br>MM<br>dd<br>HH<br>mm<br>ss | year<br>month<br>day<br>hour (24)<br>min<br>second | Synchronize time with the data-logger |

Command: $AE33:D1[CR] will return one data line (i.e. 1 byte -> value = 13 so all together there should be 9 bytes)

Please note these are all capital letters.

Example 1: $AE33:D120[CR] => 11 bytes; Output will be 120 lines of data.

Example 2: If you are using Hyper Terminal just write following command $AE33:D1 and press enter (this should add CR character at end of command).

Example 3: $AE33:T20120110120000[CR] will synchronize the time on the Aethalometer to 10 Jan 2012, noon.
Note: Hyper Terminal may experience problems when sending the string more than two consecutive identical numbers (111, for example).

## 4.6 External Devices

Several external devices are supported for data-logging using the Aethalometer. Before use the connection with the selected device should be enabled using “External device” button on the Operation/Advanced tab. Select the device connected to the certain COM port and click “Connect”. Aethalometer will try to connect to the device every few seconds. When connected the status will go green.

Supported devices:
- AMES_TPR159 – dedicated ambient temperature + pressure + relative humidity sensor used for flow reporting at ambient conditions
- Comet_T0310 – temperature sensor
- Vaisala_GMP343 – CO2 sensor
- TSI_4100 – mass flowmeter
- Remote_Access – the selected port is waiting for communication with the data-logger

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# 5 MAINTENANCE and SERVICE

The Aethalometer needs to be maintained regularly. We recommend the following schedule for regular maintainance.

| **Item** | **Frequency** |
|---|---|
| Sample inlet flow | Monthly |
| Inspect the sample line tubing | Monthly |
| Inspect and clean the size selective inlet (if present) | Monthly |
| Clean cyclone<br>(5.1 Cleaning the cyclone) | Weekly at first to gauge debris accumulation, then adjust as needed. |
| Verify time and date (if not set to update automatically)<br>(Time & Date in OPERATION>GENERAL page). | Monthly |
| Inspect optical chamber, clean if necessary<br>(Section 5.6 Cleaning the optical head) | Semi-annually<br>Site dependent, use educated judgement! |
| Check flow, calibrate if necessary<br>(Section 5.2 Leak test).<br>(For calibration: Section 5.3 Automatic flow meter calibration or Section 5.4 Manual flow meter calibration). | Semi-annually or as needed. |
| Change by-pass cartridge filter<br>(Section 5.7 Changing the bypass cartridge filter) | Annually or as needed. |
| Install a new filter tape roll<br>(Section 3.4 Filter tape installation) | As needed.<br>The instrument issues a warning. |
| Calibrate tape sensor<br>(Section 5.8 Calibrating the tape sensor) | When measurement chamber has been removed/replaced. |

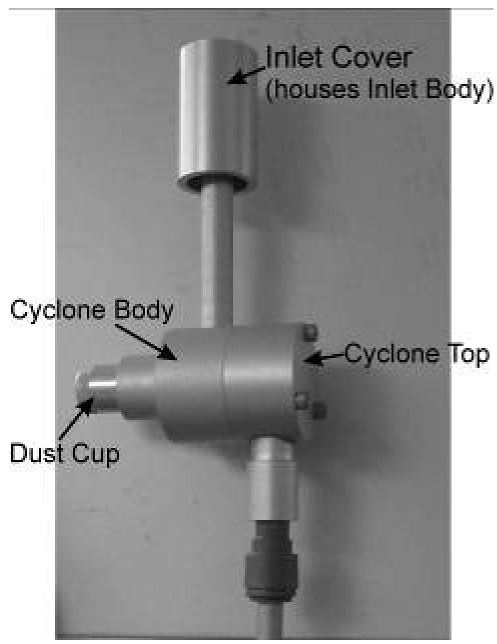
## 5.1 Cleaning the cyclone

Remove the cyclone and disassemble (shown in the following instructions), cleaning the various parts thoroughly. The recommended cleaning method is immersion in an ultrasonic cleaner with water and mild soap. However, wiping with a water-dampened and lint-free cloth is sufficient.

**IMPORTANT: Protracted soaking in soap/caustic solutions will damage the aluminum components.**
**Do not re-aerosolize hazardous materials when using compressed air for cleaning.**

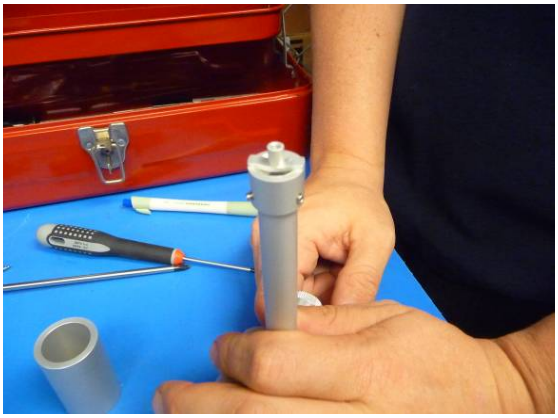
Cyclone cleaning procedure:

1. Remove cyclone assembly from instrument.

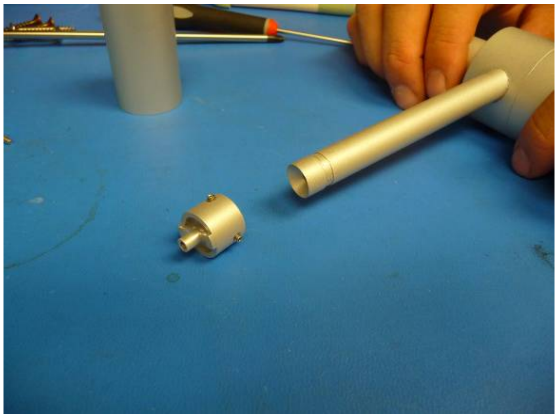



2. Remove inlet cover.

3. Loosen the three set screws that hold the inlet body in place.

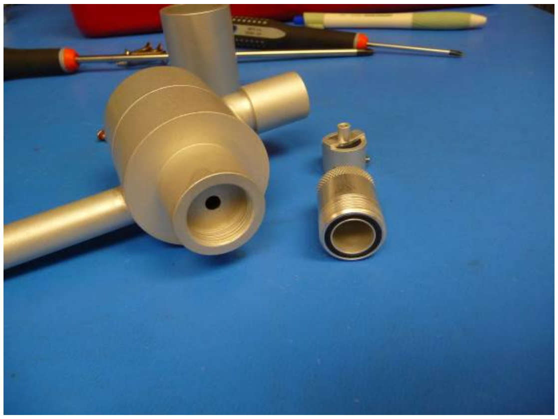


4. Remove inlet body.



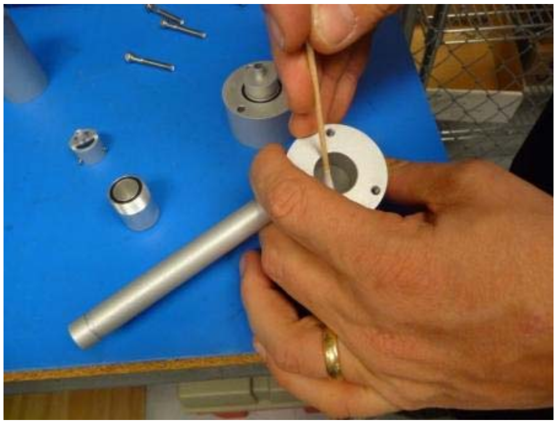
5. Remove dust cup.

6. Illustration shows inlet cover, inlet body and dust cup removed.



7. Remove allen cap screws from cyclone top.

8. Clean all parts and thoroughly dry; then reassemble in reverse order.



**5.2 Leak test**

Always conduct a leak test prior to running a flow meter calibration, whether automatic (section 5.2) or manual (section 5.3).

Leakage (ζ) is measured during instrument operation. It is calculated from the flow in (Fin) and flow out (Fout).

$$\zeta=1-(Fin/Fout)$$

Average leakage is 7% at 5 LPM. It can differ slightly from spot to spot and during the spot loading.

Flow measurement using a mass-flow meter (for example TSI4100)

1. Connect the flow meter to the input of the instrument.
2. Wait for a few seconds for the flow to stabilize and read the flow Fin.

3. Disconnect flowmeter from the input.
4. Connect the flow meter to the output of the instrument by a long tube (10 m) to reduce the oscillations, which can influence the flow measurements.
5. Take a Fout reading.

IMPORTANT!

If you use a volumetric flow meter take into account the difference in air pressure and temperature between the flow in and flow out (use the ideal gas law equation).

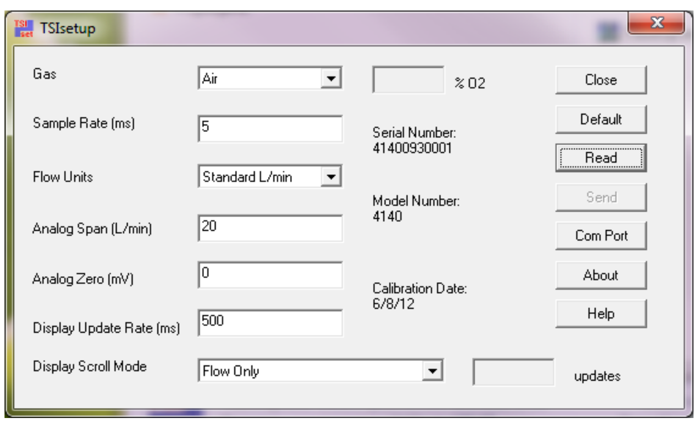
Report

| **Aethalometer SN** | **Flowmeter** | **Date** | **Fin (LPM)** | **Fout (LPM)** | **ζ (%)** |
|---|---|---|---|---|---|
| AE33-S00-0054 | TSI4100 | 15.1.2013 | 4.67 | 5.01 | 6.8 |

### 5.3 Automatic flow meter calibration

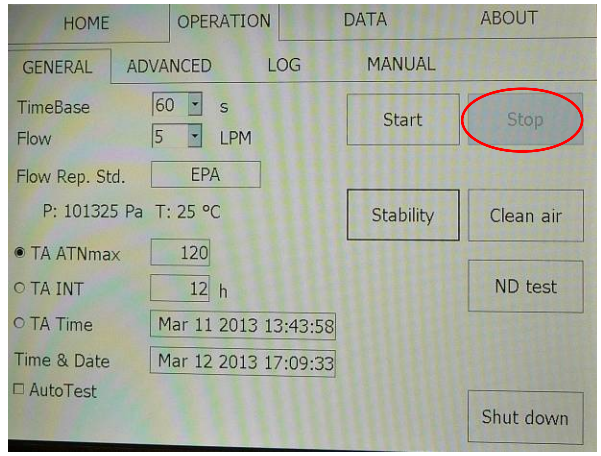
First, ensure that a leak test is completed (Section 5.1) prior to running this calibration procedure. For the automatic calibration a TSI4100 flow meter, data cable and the flow calibration pad are needed.

Before calibration check TSI4100 flow meter settings:

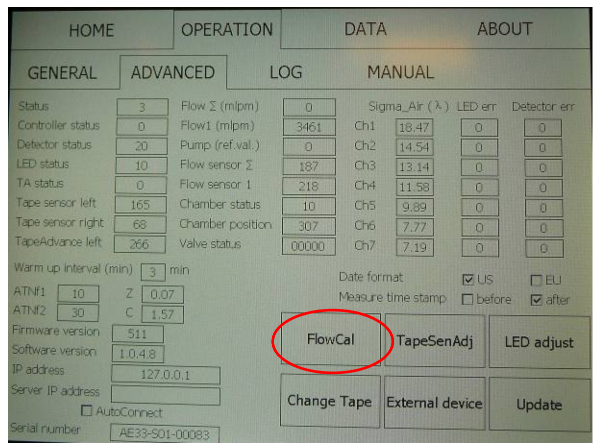


**Automatic flow calibration procedure:**

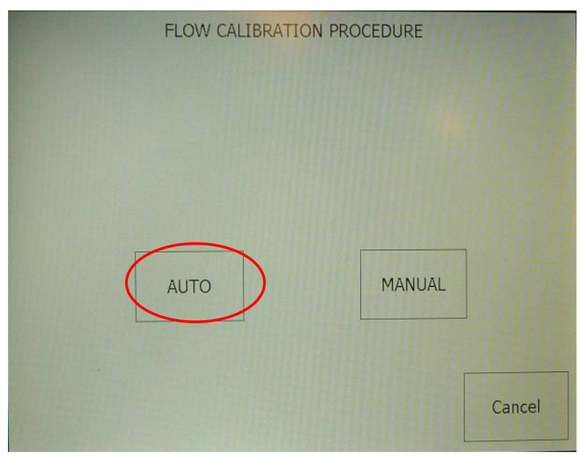
1. Stop measurements in the OPERATION >GENERAL menu (press Stop button).




2. In the OPERATION>ADVANCED menu press FLOWCAL.

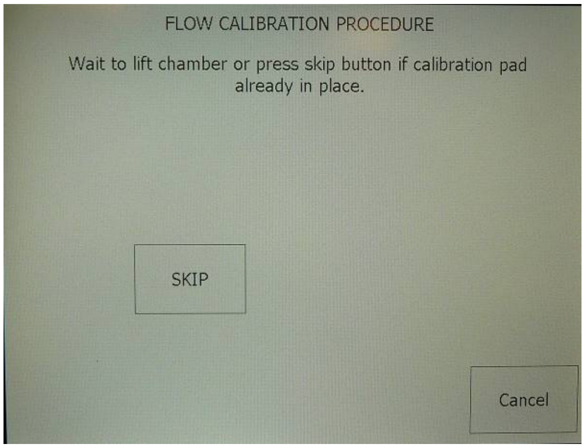



3. Press AUTO to start auto Flow meter calibration.



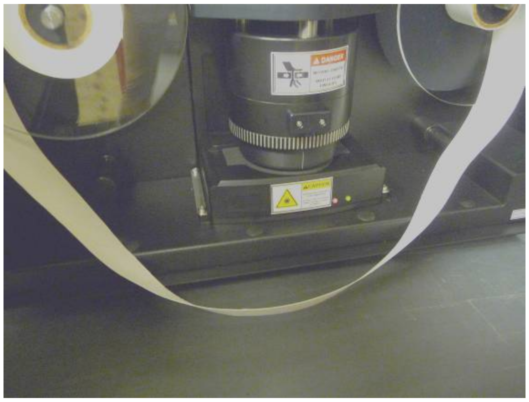
**Automatic flow calibration procedure:**

4. Wait for the measurement chamber to move to the up position.



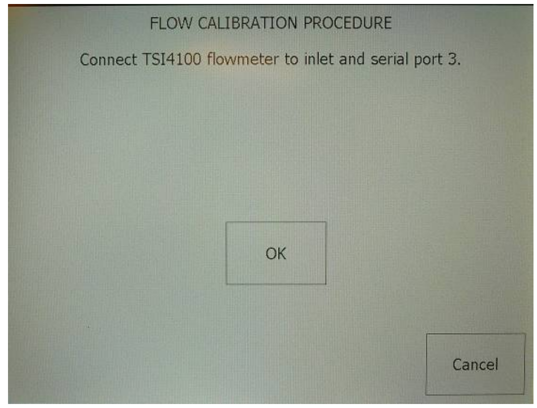

5. Once chamber is lifted, remove tape and insert the flow calibration pad.

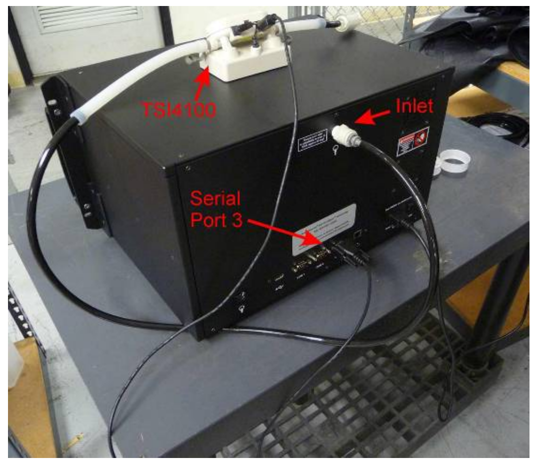
6. Press OK when finished.
   You will be prompted to wait for chamber to move back to home position, and then to make flowmeter and cable connections



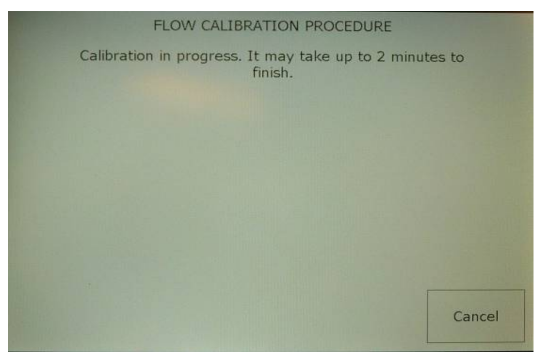
**Automatic flow calibration procedure:**

7. Connect the flow meter to the inlet of the Aethalometer, note the orientation! Connect the data cable to the serial connector on the back of the Aethalometer, then press OK.



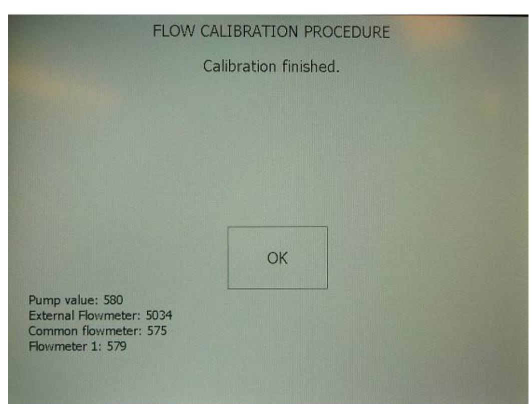




8. Once you've pressed OK to start the flow calibration, wait for it to finish, and press OK when prompted.




The display continues with prompts for completing the procedure, i.e., wait for chamber to lift, remove flow pad, return tape, wait for chamber to return to home position, etc., until the entire procedure is complete.

After completion of automatic (or manual) flow calibration and the instrument is returned to operation mode, note that the intake flow reported from a flow meter does not match the reported flow on the front panel of the 633. This is normal due to leakage around the filter tape as discussed in Section 5.2. The difference in flow may be from 4 – 7% and the 633 compensates for this difference during the BC calculation.

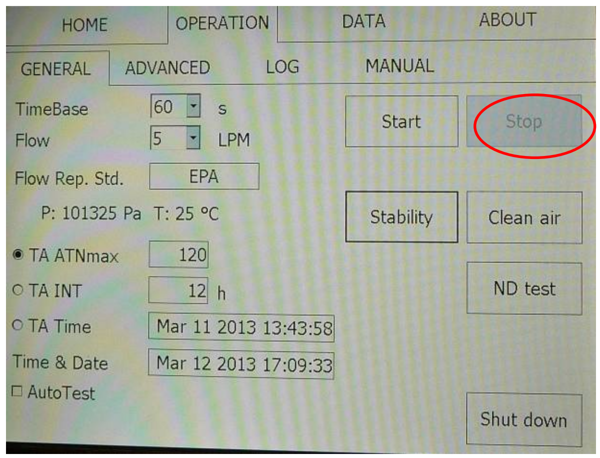


## 5.4 Manual flow meter calibration

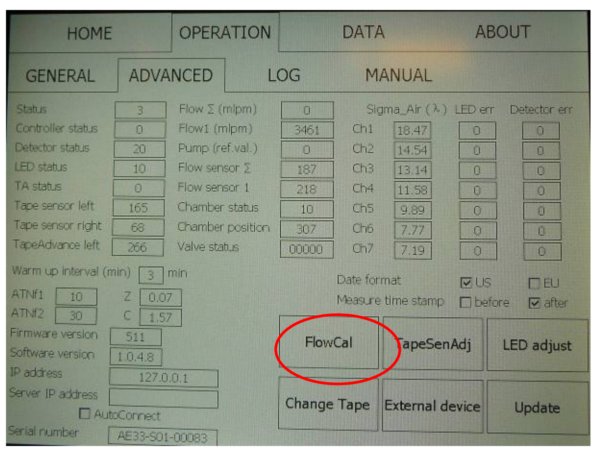
First, ensure that a leak test is completed (Section 5.1) prior to running this calibration procedure. For the manual calibration a flow meter, data cable and the flow calibration pad are needed. Please note flow measurements are in Milliliters, and maximum flow rate should be no greater than 5 LPM (5,000 milliliters).

**Manual flow calibration procedure:**

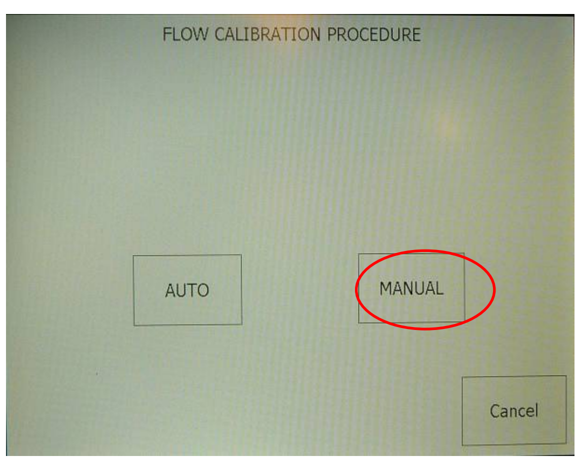
1. STOP measurements in the OPERATION>GENERAL menu.




2. In the OPERATION>ADVANCED menu press FLOWCAL.

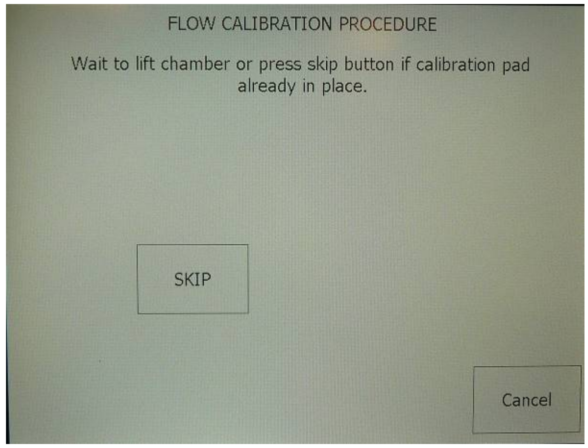



3. Select MANUAL to start the manual flow calibration.

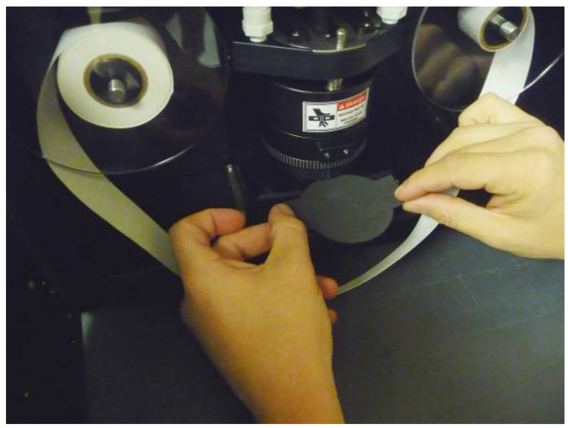


**Manual flow calibration procedure:**

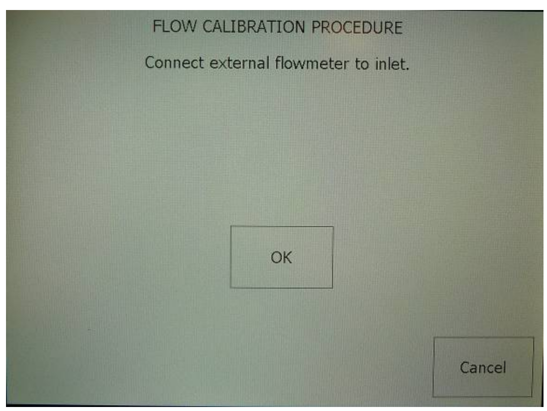
4. Wait for the measurement chamber to move to the up position.




5. Remove tape and insert the flow calibration pad (note the orientation of the flow pad is critical), and press OK and wait for the chamber to return to home position.

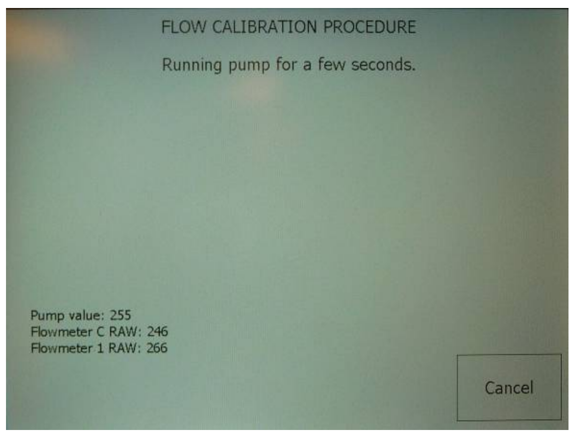


6. Connect the flow meter to the inlet of the Aethalometer (note the orientation of the flow meter), then press OK.



**Manual flow calibration procedure:**

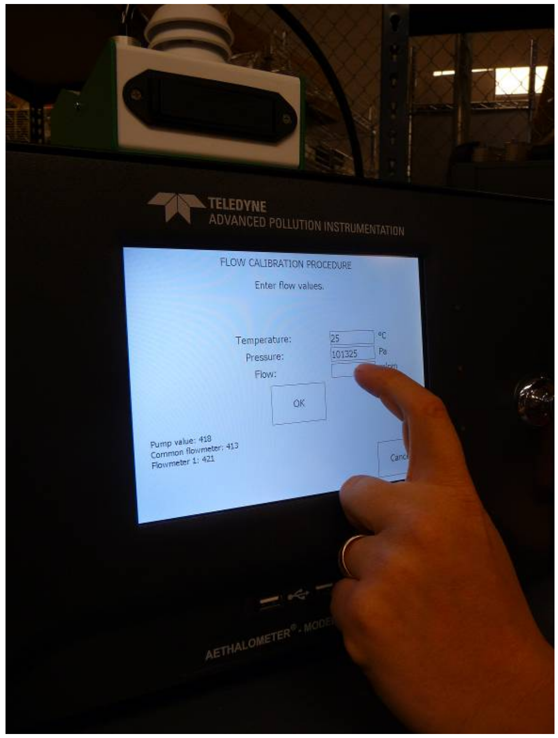

7. Wait for the pump to run for several seconds to achieve a stable flow.

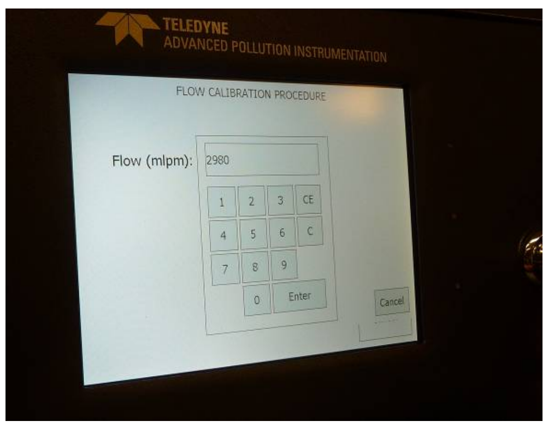


**Manual flow calibration procedure:**

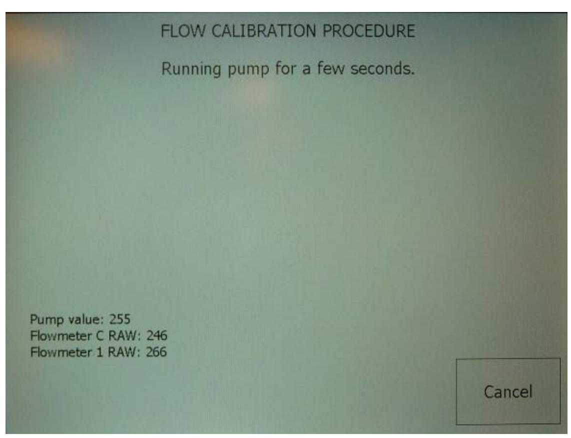
8. In the display's blank FLOW field enter the flow value from your flow meter measured in or converted to milliliters (this will be approximately 900) tap screen in Flow field, used screen keyboard to enter numbers and click Enter.

   Also enter the EPA standard temp and pressure of 25 C and 1 atmosphere or 101325 Pa and select OK.



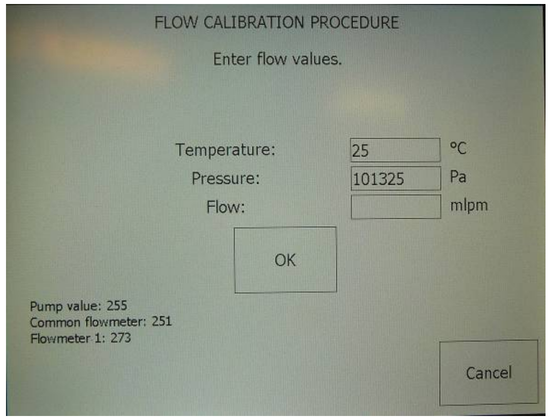




9. Wait for the pump to run for several seconds to achieve a stable flow.

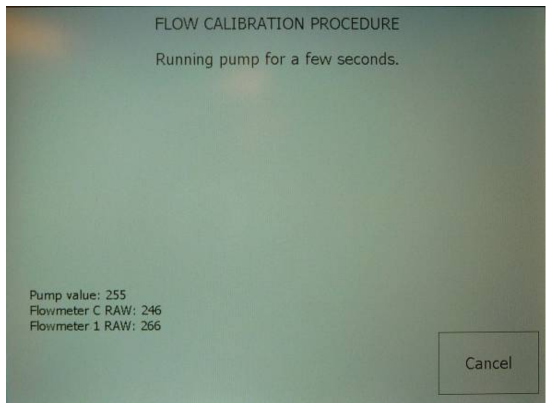


**Manual flow calibration procedure:**

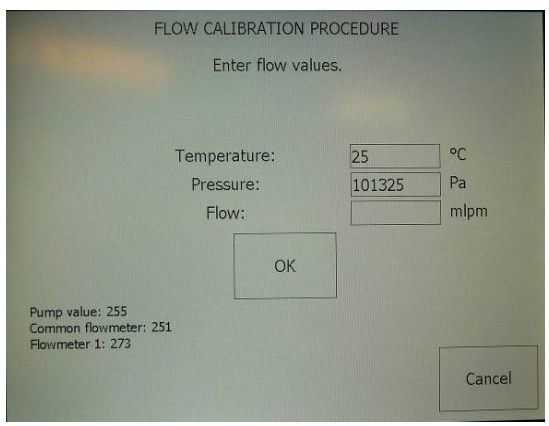
10. In the display's blank FLOW field enter the flow value from your flow-meter measured in or converted to milliliters (this will be approximately 3000; do NOT change the pressure or temperature settings), and select OK.




11. Wait for the pump to run for several seconds to achieve a stable flow.

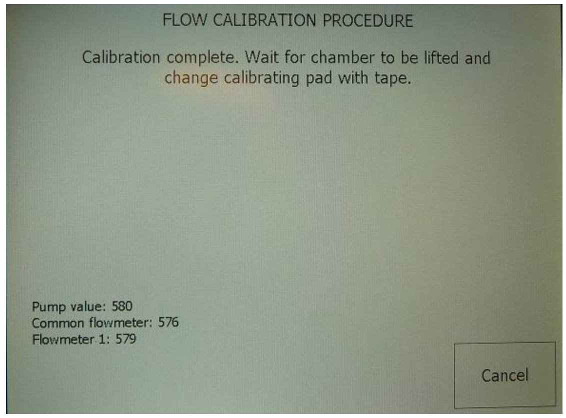



12. In the display's blank FLOW field enter the flow value from your flow-meter measured in or converted to milliliters (this will be approximately 5000; do NOT change the pressure or temperature settings), and select OK.

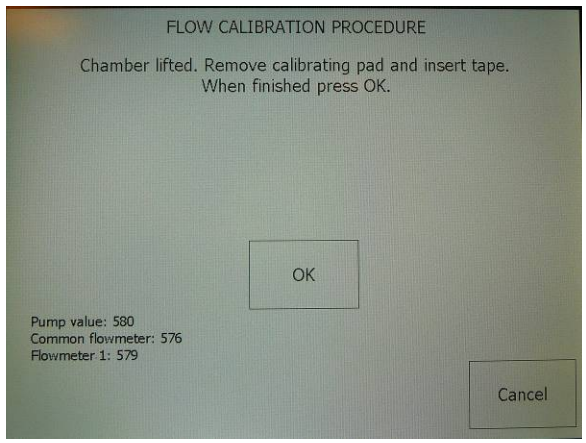


**Manual flow calibration procedure:**

13. The screen displays a message, "Wait for calibration to finish", and then displays notice when the calibration is finished and prompts user to wait for next steps.




14. Remove the flow calibration pad, reinsert and tighten tape, and press OK, and wait for the chamber to return to home position.




After completion of manual (or automatic) flow calibration and the instrument is returned to operation mode, note that the intake flow reported from a flow meter does not match the reported flow on the front panel of the 633. This is normal due to leakage around the filter tape as discussed in Section 5.2. The difference in flow may be from 4 – 7% and the 633 compensates for this difference during the BC calculation.

There will be some faults present on the unit after the flow calibration is complete. To remove the faults, power down the instrument with both the front and back power switches, and then re-start and allow it to cycle through the self-test.

The manual flow calibration is now complete.

To resume taking measurements, go to the OPERATION>GENERAL tab and press Start.

## 5.5 Manual stability test

Stability test is conducted without flow to determine the performance of the light source – detector pair. In the Operation/General tab select the desired timebase and click “Stability” button to start the test. Stability test is marked by status 1024. During the test BC values will be calculated assuming there is 5 LPM air flow. Manually stop the test when the desired test duration is complete.

**Interpretation of the results:**

- Average BC values should be close to zero if the Aethalometer is warmed up (was measuring for a few hours just before conducting the test).
- Point to point variation of BC (PPBC) is calculated as an average absolute difference between the consecutive BC measurements. It depends on the timebase, tested channel and spot. For example at 1 s timebase PPBC61 = approx. 400 ng/m$^3$.

## 5.5 Manual clean air test

Clean air test is conducted using the built-in filter to determine the performance of Aethalometer under the standard flow condition. In the Operation/General tab select the desired timebase and flow, then click “Clean air” button to start the test. Clean air test is marked by status 2048. Manually stop the test when the desired test duration is complete.

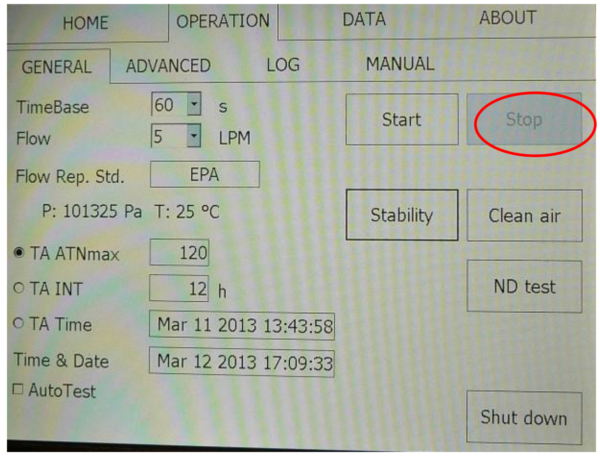
**Interpretation of the results:**

- Average BC values should be close to zero if the Aethalometer is warmed up (was measuring for a few hours just before conducting the test). It is possible to observe a short transient due to filter compression.
- Point to point variation of BC (PPBC) is calculated as an average absolute difference between the consecutive BC measurements. It depends on the selected timebase, flow and tested channel. For example PPBC61 = approx. 500 ng/m$^3$ at 5 LPM and 1 s timebase.

## 5.6 Cleaning the optical head

### Optical head cleaning procedure:

1. STOP measurements in the OPERATION>GENERAL menu.

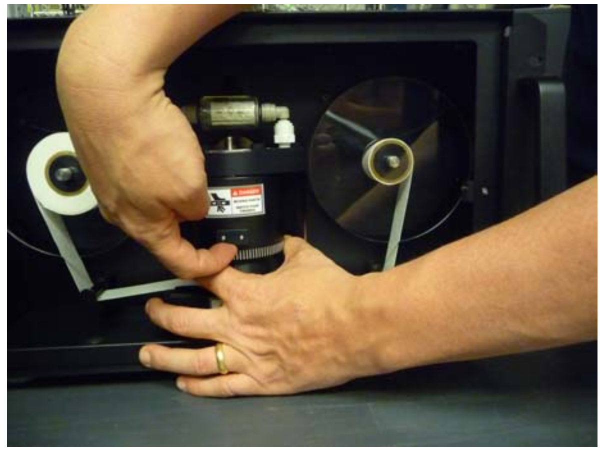



2. Manually lift the chamber (pressing down the retention pin at top, front, center).

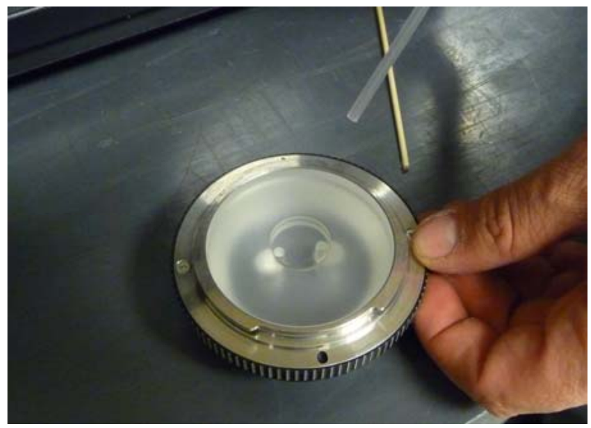
3. Locate the release button.

**Optical head cleaning procedure:**

4. While pressing the release button upward, grasp optical head and turn to loosen and remove.



5. Use compressed air (AVOID spraying liquid) or to remove dust/debris from the optical head surfaces and platform.

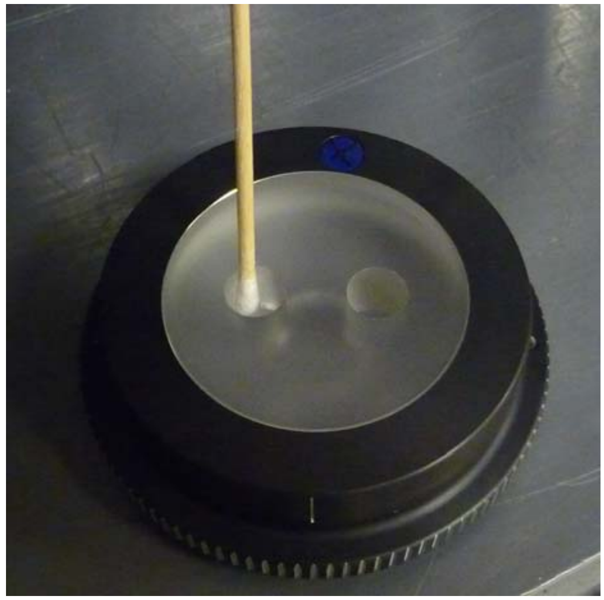


Optical head top.

Optical head platform

**Optical head cleaning procedure:**

6. Alternatively, use a cotton swab. Ensure to clean both top and bottom of optical head.



Optical head bottom.

7. Return the optical head: first align the notched marker.

8. Insert and turn to secure in place.

**Optical head cleaning procedure:**

## 5.7 Changing the bypass cartridge filter

Bypass filter changing procedure:

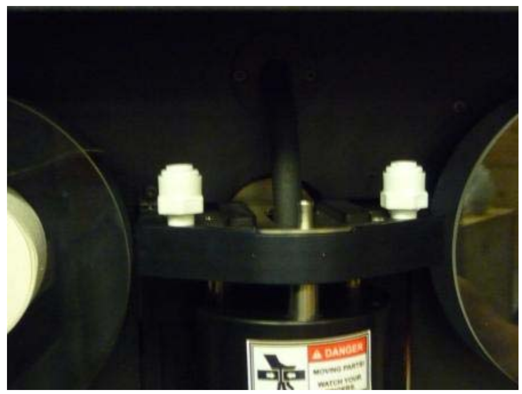
1. Open instrument door to access bypass cartridge filter.


2. Hold down bottom fitting on one side while pulling up on cartridge fitting.

Bypass filter changing procedure:

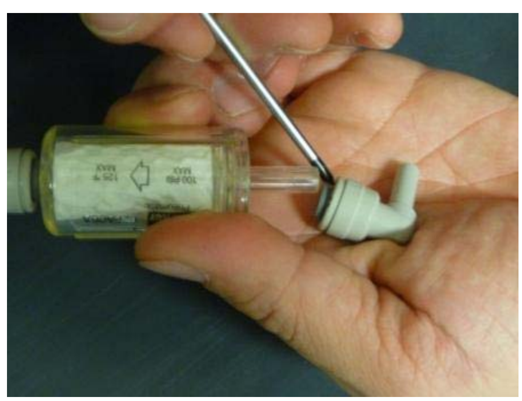
3. Repeat on other side.

4. Remove cartridge.




5. Gently wedge small, flat tool between fitting and cartridge.

6. Carefully pry fittings from both ends of cartridge, and dispose of used cartridge in accordance with local regulations.



Bypass filter changing procedure:

8. Securely slide fittings onto ends of new cartridge.

9. Place new cartridge on chamber optical head, ensuring that the arrow printed on the filter points to right.

10. Changing the bypass cartridge filter is now complete.

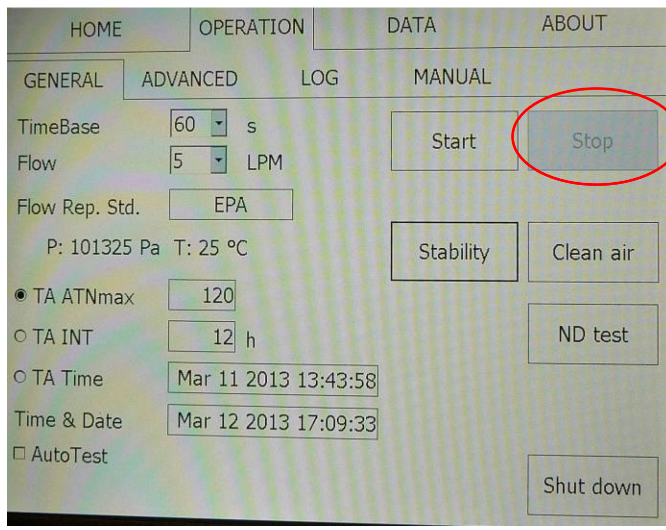
## 5.8 Calibrating the tape sensor

Tape sensor calibration is performed at the factory and should only be conducted when removing the Measurement chamber from/to the Aethalometer. This procedure requires special calibration cylinders: the small cylinder has diameter of 39 mm; the large cylinder has a diameter of 102 mm.

(NOTE: It is essential to secure the calibration cylinders with the tape retention disks during calibration).

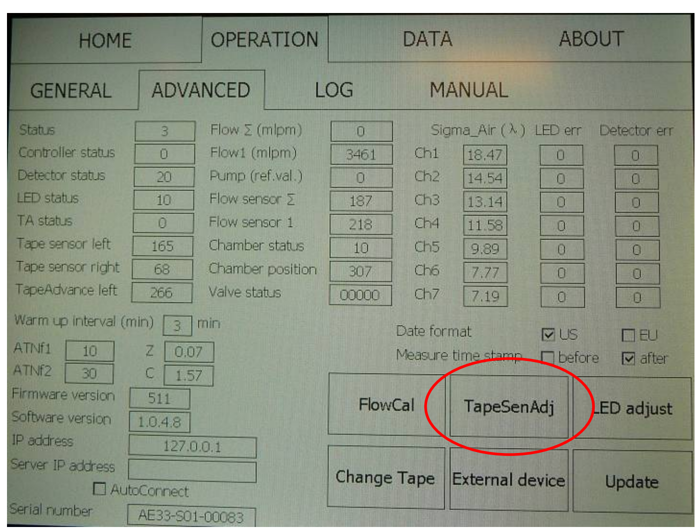
Tape sensor calibration procedure:

1. In the Operation / General menu press Stop to stop measurements, then carefully remove the sampling tape. (Refer to Section 3.4 Filter tape installation).



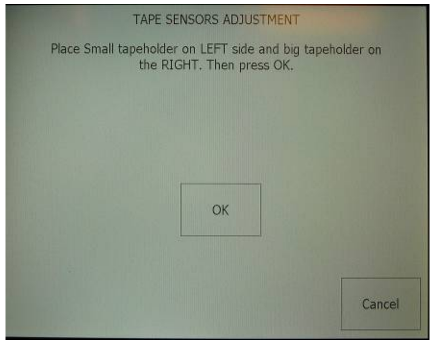

At this point, remove the tape as instructed in the Change Tape Procedure, then continue as follows:

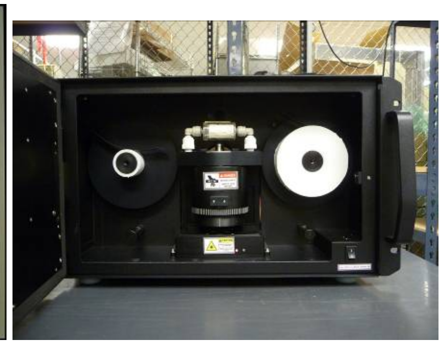
2. In the Operation / Advanced menu press “TapeSenAdj”



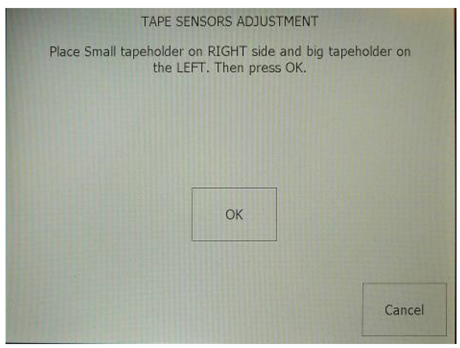
Tape sensor calibration procedure:

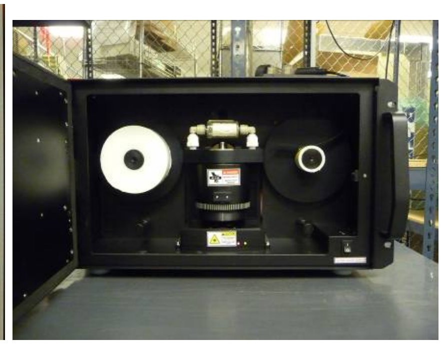
3. The Tape Sensors Adjustment screen prompts to place the small tapeholder [cylinder] on left and large on right, then press OK. Secure with tape retention disks (not shown in illustration) before pressing OK!



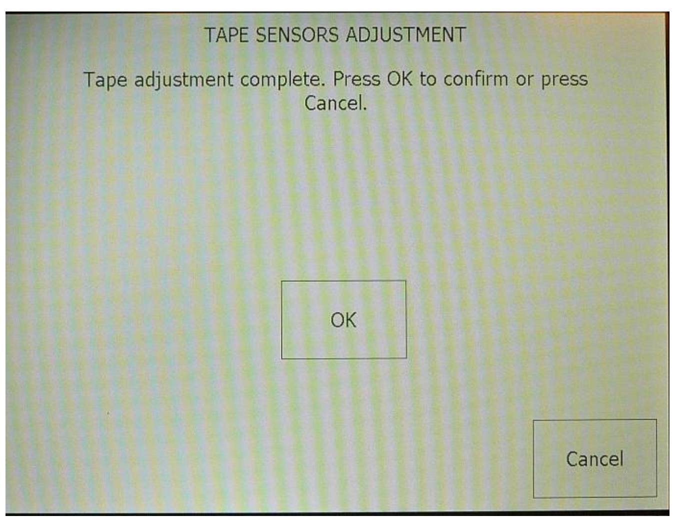
4. The next prompt is to switch the tapeholders [cylinder], then press OK. Secure with tape retention disks (not shown in illustration) before pressing OK!



5. Last screen shows that the adjustment is complete.

6. After you've pressed either OK or Cancel, return the sampling tape per the applicable steps in Section 3.4 Filter tape installation).



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# 6 TECHNICAL SUPPORT and CONTACT INFORMATION

If this manual and its troubleshooting & service section do not solve your problems, technical assistance may be obtained from:

**Teledyne API, Technical Support**
**9480 Carroll Park Drive**
**San Diego, California 92121-5201USA**

| | |
|---|---|
| **Toll-free Phone:** | 800-324-5190 |
| **Phone:** | 858-657-9800 |
| **Fax:** | 858-657-9816 |
| **Email:** | sda_techsupport@teledyne.com |
| **Website:** | http://www.teledyne-api.com/ |

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# 7 SPARE PARTS LIST

Following is a list of spare parts available for order through the Sales Department:

| | |
|---|---|
| DU0000146 | Filter Tape for 633 |
| DU0000196 | Flow calibration pad |
| TU0000034 | Static dissipative inlet tubing (8-ft) |
| DU0000148 | PM2.5 inlet at 5-lpm |
| KIT0000400 | Inlet mounting kit |
| WR0000008 | Power Cord |
| WR0000101 | RS-232 Cable (6-ft) |
| WR0000258 | RS-232 Null Modem adapter |
| FT0000338 | 3/8”-1/4” NPTF Reducer |