

Magee Scientific

AETHALOMETER™ TECHNICAL PROCEDURES

The Aethalometer™ is a sophisticated scientific instrument that measures the ‘Black Carbon’ component of pollution particles in the atmosphere. These particles are produced by human activities: in high concentrations they may harm public health and lead to climate change. Routine monitoring using the time resolution capability of the Aethalometer can provide the high-quality data that contributes to making effective policy decisions. However, the data quality can only be assured if the instrument is installed correctly and maintained correctly. This document describes the technical procedures that are recommended for each Aethalometer installation.

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1. INITIAL INSTALLATION

- A. Unpack the instrument carefully. Check that there was no damage during shipping. The box should contain:
- Aethalometer** instrument
 - Electrical power cable** with 3-pin plug for grounding
 - Black tubing** for sample inlet
 - Compact Flash card**
- B. Place the **Aethalometer** on a table or install it in an equipment rack. Connect the **Electrical Power Cable** to a power outlet. **IMPORTANT !!** – the power outlet **MUST** be grounded !!
- C. Connect the black tubing to the Sample Inlet fitting on the rear panel of the Aethalometer. **IMPORTANT !!** – be sure that the black tubing is pressed firmly into the o-ring fitting.
- D. **IMPORTANT !!** - Before first use we recommend that you format the Memory Card.
FORMAT PROCEDURE:
- plug the card reader to the PC
 - insert CF card into the card reader
 - find your CF card (Toshiba, etc) in the “My computer” list
 - right mouse click on your CF card
 - select Format
 - select FAT
 - click Start
- E. Open the front door of the Aethalometer. Make sure the Memory Card is installed. Turn the **Main Power Switch ON**. **DO NOT** press any keys on the **control keypad!** **DO NOT** change any settings! Wait 30 minutes.
- F. After 30 minutes, check the **Display Screen**. The **green lamp** should be **on** and **steady**. The display screen should show as follows:

<u>TIME</u>	<u>DATE</u>
<i>tape</i>	<i>saver</i>
<i>disk</i>	<u>FLOW RATE</u>
<u>BC</u>	<i>chart</i>

Check the display for Time, Date, Flow Rate, and BC as follows:

Date must be correct. **Time** should be correct within **5 minutes**. **Flow Rate** is specified according to location (usually **4.0** or **2.0** LPM) and should be correct within +/- **0.2 LPM**. The **BC** value shows the concentration of particles. In a very clean air location it may be as low as 500; in a very polluted location it may be as high as 20000.

1.1. TO CHANGE SETTINGS:

- A. If the instrument is operating, and the display screen shows data as in #16, press the **STOP** key. The screen will show “STOP again to exit”. Press the STOP key a second time. The screen will change, and show “Enter Security Code”, together with a count-down from 10. Within 10 seconds, use the key pad to enter the 3-digit security code, then press <Enter>. The screen will show “Operate”. Press the <DOWN-ARROW> key **once**, and the screen will show “Change Settings”. Press <Enter>.
- B. You may also reach the “Change Settings” menu if the power was turned **off**. Turn the main power switch **on**. Wait about 20 seconds until the computer is ready: the **green light** will **flash** and the screen will show “Magee Scientific” and a count-down from 60. Press the <DOWN-ARROW> key **once**, and the screen will show “Operate”. Press the <DOWN-ARROW> key a **second time**, and the screen will show “Change Settings”. Press <Enter>.
- C. The “Change Settings” menu allows you to change the **usual operating parameters** of **Date, Time, Flow Rate, and Tape Saver**. **DO NOT** change ANY OTHER parameters unless you know why! Press the <DOWN-ARROW> key to select the parameter that you will change. Press <Enter> to move to the next item.

Date and Time: use the <RIGHT-ARROW> key to select which number you will change. Use the <UP and DOWN-ARROW> keys to change the value.

Flow Rate: use the number keys to change the value.

Tape Saver: the settings are ‘OFF’ ; ‘X3’ ; and ‘X10’. Use the <UP and DOWN-ARROW> keys to select the choice according to your instructions.

After you have changed the settings, press <ESC>.

The screen will show “Write settings?”. Press <Enter> to save the new settings.

- D. The screen will return to the main menu item “Operate”. Press <Enter> to re-start measurement operation. Press <Enter> a second time when the screen asks “Go to Auto mode”.

2. DAILY PROCEDURES DURING ROUTINE OPERATION

A. The **Green Light** shows that the instrument is working correctly. If it is **steady**, the measurements are being made. If it is **flashing**, this means that the instrument is moving the filter tape forwards and re-initializing the optical analysis. Depending on the parameter settings, this may take up to 15 minutes; and may occur every few hours. It is therefore **not unusual** to see a flashing green light. This is normal.

B. Check the Display Screen. If the instrument is gathering data (green light is **steady**) it should show:

<u>TIME</u>	<u>DATE</u>
tape	saver
disk	<u>FLOW RATE</u>
<u>BC</u>	<i>chart</i>

Check that the Date is correct, and the Time is within 5 minutes of the correct time.
Check that the Saver parameter is correct according to the specifications for your site.
Check that the Flow Rate is within +/- 0.2 LPM of the value specified for your site.

C. Check the BC reading. This is the analysis of the concentration of BC particles in the outside air. On a clean air day it may be as low as 500 ; on a very polluted day it may be as high as 20000. Compare this with your personal observation of the outdoor air quality. If the BC number does not seem reasonable, in comparison with your personal observation, make a note.

D. **Open the door.** Check the two **Filter Tape Spools**. The **Left-Hand Spool** is the supply of new tape. If there is less than 1 cm. thickness of new tape on the roll, make a note. The **Right-Hand Spool** rolls up the used tape.

IMPORTANT : look at the **gray spots** that are collected on the tape on the right-hand side. Check to be sure that the spots have sharp and clear edges. If the spots have the appearance of **soft edges**, the analysis chamber may need cleaning.

E. If your instrument has a **Floppy Disk Drive**, check the screen display "**Disk**". This shows the time remaining for data recording capacity, expressed in **Weeks** (w), **Days** (d) or **Hours** (h). If the remaining capacity is less than one day, insert a new disk.

IMPORTANT : If your instrument has the **Memory Card Drive**, **NEVER REMOVE THE MEMORY CARD UNLESS THE POWER IS SWITCHED OFF.**
The instrument **must** be switched **off** before removing or inserting a memory card.

3. INSTALLATION OF CONSUMABLE SUPPLIES DURING ROUTINE OPERATION

- A. The Aethalometer makes its measurement by analyzing the particles collected on the filter tape spot. When the spot reaches a maximum density, the tape advances to make a new spot. This may occur every few hours, or only once per day, depending on whether the air is clean or highly polluted. Each roll of tape provides about 1500 spots. After some months of operation, the tape is all used and must be changed.
- B. The instrument also uses a “**Bypass Cartridge Filter**”. This is located inside the cabinet at the rear. According to the parameter settings, some of the sampled air flows through this filter, and it gradually becomes black. The condition of this filter does not affect the quality of the data analysis, but the Cartridge Filter should be changed if it is very black. The policy for these stations is to **change the Cartridge Filter** on **every 2nd Tape Roll**.
- C. To install a new roll of **Filter Tape**, do the following steps. Refer to photos 3C.1 – 3C.5:
- a. Stop the measurements using the STOP key and the Security Code. Open the door, switch OFF the electrical power and remove the power cord.
 - b. Remove the two clear plastic spool covers with thumb-screws.
 - c. Remove the black metal light shield with thumb-screws.
 - d. With scissors, cut the tape on the left side. Remove the small remaining amount of new tape on its cardboard center, from the left-hand spool. Leave 5 cm of unused filter tape on the left-hand side of the optical analysis cylinder.
 - e. Take the new roll of filter tape out of its packing and put it on the spool hub. The new tape should un-roll from the left side.
 - f. Using about 5 cm of adhesive tape, join the start of the new roll to the end of the old tape on the left side of the optical analysis cylinder. Make sure that the tape passes underneath the gray guide rod on the left side. This guide rod can be pulled out on a pin and socket if necessary, but must always be replaced.
 - g. With the fingers of your left hand, lift the frame that holds the optical analysis cylinder, by squeezing up against the springs that press it down. It will lift up only about 2 mm.
 - h. With your right hand, pull the used tape towards the right-hand side. As you pull the old tape, the adhesive will pull the new tape forwards. Pull the new tape under the guide rod; under the optical analysis cylinder; and through the rollers. Pull about 15 cm of new tape through to the right-hand side.
 - i. Dis-connect the adhesive tape. Remove the roll of used filter tape from the right-hand spool. If you do not have a new cardboard center, unroll the used tape and re-use the cardboard center.
 - j. Using about 5 cm of adhesive tape, attach the end of the new tape to the cardboard center.
 - k. **MAKE SURE** that the new tape passes **UNDER** the moving tension arm. Put the cardboard center onto the right-hand spool hub.

- l. Replace both clear plastic spool covers. **FINGER TIGHT ONLY!**
- m. Switch the electrical power ON. Watch the display screen and wait for the 60-second count-down.
- n. **IMPORTANT**: the software tape capacity estimator must be re-set to '100%'. Press the <DOWN-ARROW> key until you see the menu heading "Replace Tape". Press <Enter>. The screen will ask "List Instructions?" Press <Enter> for NO. The screen will ask "Tape correctly installed?" Press <Enter> for YES.
- o. Press the **Tape Tension** switch to activate the motor for the right-hand spool. Check that the spool cover turns (slowly !) and tightens the tape on the right-hand side. **IMPORTANT** : check that when the tape becomes tight, the tension arm must move to the left and its switch will stop the motor.
- p. Press the **Tape Advance** switch and hold it for **30 seconds**. The **optical analysis cylinder** should lift up, and the **rollers** should turn (slowly !). The rollers will pull the new tape forwards about 1 cm. Release the switch, and the system will continue until the rollers have made one complete turn (60 seconds). At the end of this time, the motor will stop and the analysis cylinder will release and be pressed down by its springs.
- q. Replace the black metal light shield. **FINGER TIGHT ONLY!**



Photo 3C.1



Photo 3C.2



Photo 3C.3



Photo 3C.4

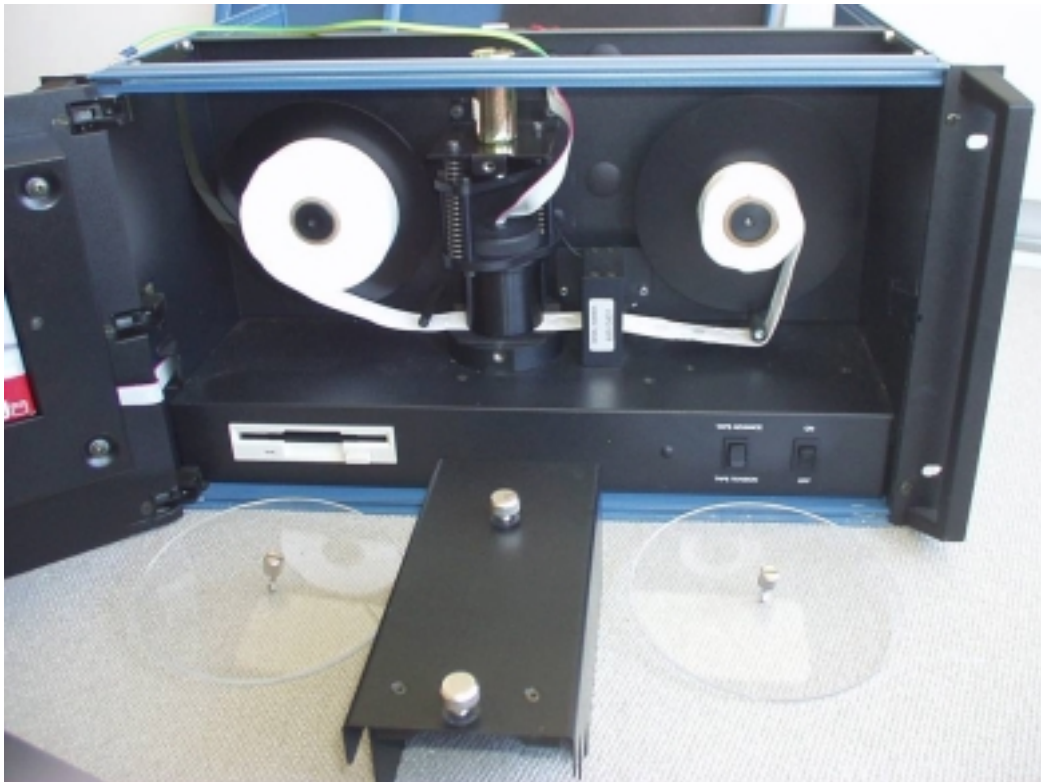


Photo 3C.5

- D. To replace the **Bypass Cartridge Filter** in **OLDER UNITS**, do the following steps. Refer to photos 3D.1 – 3D.4 .
- a. Stop the measurements using the STOP key and the Security Code. Open the door, switch OFF the electrical power and remove the power cord.
 - b. Remove the **electrical power supply cable** from the rear panel.
 - c. Remove the **sample inlet tube** from the “**Inlet**” connector on the rear panel.
NOTE ! : it is probable that this is a “grip” connector that is sealed with an internal o-ring. If so, the gray ring that circles the tubing where it enters, must be **pushed inwards** at the same time that the tubing is **pulled outwards**.
 - d. With a small flat (-) screwdriver, remove the 6 screws that hold the rear panel.
 - e. The **bypass cartridge filter** is at the rear of the compartment. It has smooth tube ends that are held in “grip” connectors.
 - f. Press on the gray ring of the inner grip connector using a screwdriver or the two sides of a pair of pointed-nose pliers. Pull the cartridge filter out of the connector.
 - g. In the same way, pull the other side of the cartridge filter out of the outer grip connector.
 - h. Install the new cartridge filter. The arrow should point inwards towards the center of the instrument. **Make sure** that the smooth tube ends of the cartridge filter are pushed **firmly** into the o-ring seals of the grip connectors.
 - i. Replace the rear panel with 6 screws.
 - j. Replace the sample inlet tube: if it is a “grip” connector, make sure that the tube is pushed **firmly** into the fitting.



Photo 3D.1



Photo 3D.2



Photo 3D.3

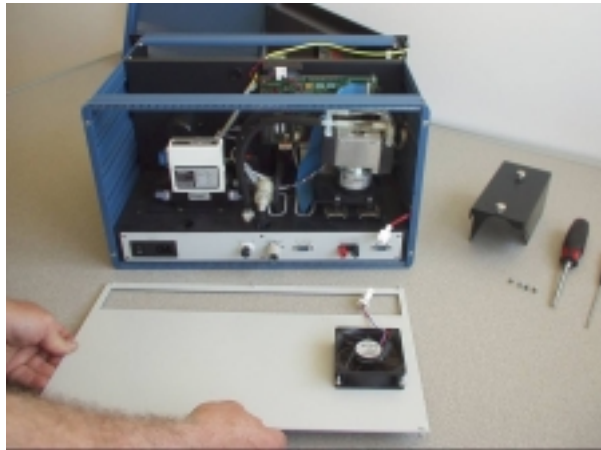


Photo 3D.4

- E. To replace the **Bypass Cartridge Filter** in **NEWER UNITS**, do the following steps. Refer to photos 3E.1 – 3E.5 .
- Stop the measurements using the STOP key and the Security Code. Open the door, switch OFF the electrical power and remove the power cord.
 - The **bypass cartridge filter** is between the chamber and the right filter role. It has smooth tube ends that are held in “grip” connectors.
 - Press on the gray ring of the inner grip connector using a screwdriver or the two sides of a pair of pointed-nose pliers. Pull the cartridge filter out of the connector.
 - In the same way, pull the other side of the cartridge filter out of the outer grip connector.
 - Remove the connectors from both ends of used cartridge filter (C) and install them on the new one.
 - Install the new cartridge filter. The arrow should point downwards. **Make sure** that the smooth tube ends of the cartridge filter are pushed **firmly** into the o-ring seals of the grip connectors.

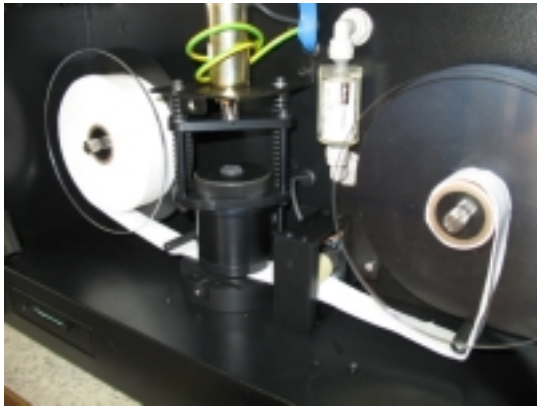


Photo 3E.1



Photo 3E.2



Photo 3E.3



Photo 3E.4



Photo 3E.5

4. CLEANING AND PREVENTIVE MAINTENANCE

4.1. CLEANING OF NEW DESIGN OPTICS (rack mount since 2006)

- A. The Aethalometer optical analysis consists of the following main components:
- The **L.E.D. Light Source**. Many instruments have 10 LED's of different wavelengths.
 - The **Analysis Cylinder**. This has a **glass window** to allow the light to shine through; an **air flow connector** for the sample to enter; and the **outline ring** in the lower glass window to define the collecting spot on the filter tape.
 - The **filter tape**. This collects the particles.
 - The **base**. This contains a **suction port** whose outline matches the ring; a hose connector for the air suction flow; one **light detector** (“**Sensing**”) under a window beneath the suction port; and one light detector (“**Reference**”) under a window on the left-hand side, beneath clean filter tape.
- B. The **sample air stream** flows through the inlet tubing; into the **analysis cylinder**; through the **outline ring** and onto the **filter tape**. If the air stream also contains dust particles, they may gradually deposit on the insides of the optical chamber. This does not affect the data, but will gradually reduce the performance of the instrument.
- C. It is therefore necessary to **disassemble** and **clean** the optics at least every six months. Do the following steps, and refer to photos 4.2C.1 – 4.2C.17.

While you are doing this work, fill out a copy of the Summary Report Sheet

- Stop the measurements using the STOP key and the Security Code. Open the door, switch OFF the electrical power and remove the power cord.
- Remove the two **clear plastic spool covers** with thumb-screws.
- Remove the **black metal light shield** with thumb-screws.
- With a cross (+) screwdriver, remove the 4 screws that hold the **top cover plate** of the instrument. Dis-connect the **electrical grounding wire** from the cover plate, and remove the plate.
- With your thumb and main finger, unscrew the **Top Cap** of the **cylinder**. This has an **electrical cable** passing through it.
- Carefully pull the **top cap** up and away from the **cylinder**. The **Optical Source** is a small round electronic board with the **LED's** attached on the underneath side. If you look into the top of the cylinder, you will see that this board is aligned by **two vertical pins** located in **two small** holes. Pull the board up and out on its cable.
- With one hand, lift up the **horizontal frame**, against the two springs. With your other hand, remove the **Spacing Ring** that is underneath the frame.

- g) With one hand, reach into the rear compartment of the instrument and find the **Sample Inlet Tube** that attaches to the **Inlet Fitting** of the **cylinder**. Hold this tightly.
- h) With your other hand, pull forwards on the **cylinder** so that the **inlet tube** disconnects from the **fitting**. Remove the **cylinder** from the instrument so that you can examine it.
- i) Unscrew bottom glass ring from the cylinder and clean them both with cotton sticks and a few drops of alcohol.
- j) The **glass surfaces** of the cylinder should be clean and clear. A few small spots are OK. However, it is very important that there must be **NO LOOSE MATERIAL** inside the cylinder. This includes insects; fragments of leaves; pieces of fluff; small threads; or anything that could move.
- k) Screw the bottom glass ring back to the cylinder. Watch out for the o-ring and the pins proper position before you put them together.
- l) Pull the **Filter Tape** forwards, so that you can examine the **Base**. With a soft cloth or brush, remove any accumulation of white quartz fibers that may be on the **Suction Inlet** or the **Reference Detector Window**.
- m) Put the **filter tape** back in its correct place. Make sure that it passes underneath the **gray guide pin** on the left-hand side.
- n) With one hand inside the compartment, find the **sample inlet tube**. With the other hand, put the **cylinder** back in place under the **lifting frame**, and **BE SURE** to re-connect the **inlet tube** by pushing it onto the **fitting**.
- o) Put the **spacing ring** between the cylinder and the lifting frame.
- p) Wipe the **LED lamps** of the **optical source** very carefully with a soft cloth or a small soft brush, just in case there is any dust on them.

THE NEXT STEPS (R – U) ARE DIFFICULT. BE CAREFUL AND PATIENT

- q) Insert the **Optical Source Board** into the hole at top. Rotate it with a finger-tip until the **two pins** fit into the **two holes**.
- r) **Carefully** push the threaded **Top Cap** into the hole. In order for the threads to get started, it may be necessary to hold the **top cap** with one hand, while moving the **cylinder** and **spacing ring** very slightly from side to side. You will feel when the **top cap** moves down and into the threaded socket in the cylinder.
- s) While you are doing this, the **optical source board** may jump out of its pins. If so, repeat the process, be patient!
- t) Screw the **top cap** into the **cylinder**. Use **THUMB AND FINGER ONLY !!** When it is tight, there should be no gap above the **spacing ring**.
- u) With the fingers of your left hand, lift the frame that holds the optical analysis cylinder, by squeezing up against the springs that press it down. It should lift up and leave a gap of about 2 mm. where the tape passes under. With your right hand, pull the tape about 5 cm. towards the right-hand side, so that the operation will start with a fresh area.
- v) Replace the **clear plastic spool covers** and the **black metal light shield**.

4.2. **CLEANING OF OLD DESIGN OPTICS**

- A. The Aethalometer optical analysis consists of the following main components:
- The **L.E.D. Light Source**. Many instruments have 10 LED's of different wavelengths.
 - The **Analysis Cylinder**. This has a **glass window** to allow the light to shine through; an **air flow connector** for the sample to enter; and the **outline ring** in the lower glass window to define the collecting spot on the filter tape.
 - The **filter tape**. This collects the particles.
 - The **base**. This contains a **suction port** whose outline matches the ring; a hose connector for the air suction flow; one **light detector** (“**Sensing**”) under a window beneath the suction port; and one light detector (“**Reference**”) under a window on the left-hand side, beneath clean filter tape.
- B. The **sample air stream** flows through the inlet tubing; into the **analysis cylinder**; through the **outline ring** and onto the **filter tape**. If the air stream also contains dust particles, they may gradually deposit on the insides of the optical chamber. This does not affect the data, but will gradually reduce the performance of the instrument.
- C. It is therefore necessary to **dis-assemble** and **clean** the optics. This must be done at least **every 6 months**. Do the following steps, and refer to photos 4.2C.1 – 4.2C.14.

While you are doing this work, fill out a copy of the Summary Report Sheet

- Stop the measurements using the STOP key and the Security Code. Open the door, switch OFF the electrical power and remove the power cord.
 - Remove the two **clear plastic spool covers** with thumb-screws.
 - Remove the **black metal light shield** with thumb-screws.
 - With a cross (+) screwdriver, remove the 4 screws that hold the **top cover plate** of the instrument. Dis-connect the **electrical grounding wire** from the cover plate, and remove the plate.
 - With your thumb and main finger, unscrew the **Top Cap** of the **cylinder**. This has an **electrical cable** passing through it.
 - Carefully pull the **top cap** up and away from the **cylinder**. The **Optical Source** is a small round electronic board with the **LED's** attached on the underneath side. If you look into the top of the cylinder, you will see that this board is aligned by **two vertical pins** located in **two small** holes. Pull the board up and out on its cable.
 - With one hand, lift up the **horizontal frame**, against the two springs. With your other hand, remove the **Spacing Ring** that is underneath the frame.
 - With one hand, reach into the rear compartment of the instrument and find the **Sample Inlet Tube** that attaches to the **Inlet Fitting** of the **cylinder**. Hold this tightly.
 - With your other hand, pull forwards on the **cylinder** so that the **inlet tube** disconnects from the **fitting**. Remove the **cylinder** from the instrument so that you can examine it.

- i. Put a few drops of **Liquid Soap** into the inside of the **cylinder**, and immerse the entire cylinder in a basin of hot water. Shake the cylinder back and forth vigorously so that the soap and water clean the interior of the cylinder. Rinse the cylinder in a second basin of clean hot water.
- j. Pour a small amount of alcohol into the cylinder, and rinse. This will remove any drops of water. Put the cylinder in a warm place and allow it to dry.
- k. The **glass surfaces** of the cylinder should be clean and clear. A few small spots are OK. However, it is very important that there must be **NO LOOSE MATERIAL** inside the cylinder. This includes insects; fragments of leaves; pieces of fluff; small threads; or anything that could move.
- l. Pull the **Filter Tape** forwards, so that you can examine the **Base**. With a soft cloth or brush, remove any accumulation of white quartz fibers that may be on the **Suction Inlet** or the **Reference Detector Window**.
- m. Put the **filter tape** back in its correct place. Make sure that it passes underneath the **gray guide pin** on the left-hand side.
- n. With one hand inside the compartment, find the **sample inlet tube**. With the other hand, put the **cylinder** back in place under the **lifting frame**, and **BE SURE** to re-connect the **inlet tube** by pushing it onto the **fitting**.
- o. Put the **spacing ring** between the cylinder and the lifting frame.
- p. Wipe the **LED lamps** of the **optical source** very carefully with a soft cloth or a small soft brush, just in case there is any dust on them.

THE NEXT STEPS (R – U) ARE DIFFICULT. BE CAREFUL AND PATIENT

- q. Insert the **Optical Source Board** into the hole at top. Rotate it with a finger-tip until the **two pins** fit into the **two holes**.
- r. Carefully push the threaded **Top Cap** into the hole. In order for the threads to get started, it may be necessary to hold the **top cap** with one hand, while moving the **cylinder** and **spacing ring** very slightly from side to side. You will feel when the **top cap** moves down and into the threaded socket in the cylinder.
- s. While you are doing this, the **optical source board** may jump out of its pins. If so, repeat the process, be patient!
- t. Screw the **top cap** into the **cylinder**. Use **THUMB AND FINGER ONLY !!** When it is tight, there should be no gap above the **spacing ring**.
- u. With the fingers of your left hand, lift the frame that holds the optical analysis cylinder, by squeezing up against the springs that press it down. It should lift up and leave a gap of about 2 mm. where the tape passes under. With your right hand, pull the tape about 5 cm. towards the right-hand side, so that the operation will start with a fresh area.
- v. Replace the **clear plastic spool covers** and the **black metal light shield**.



Photo 4.2C.1

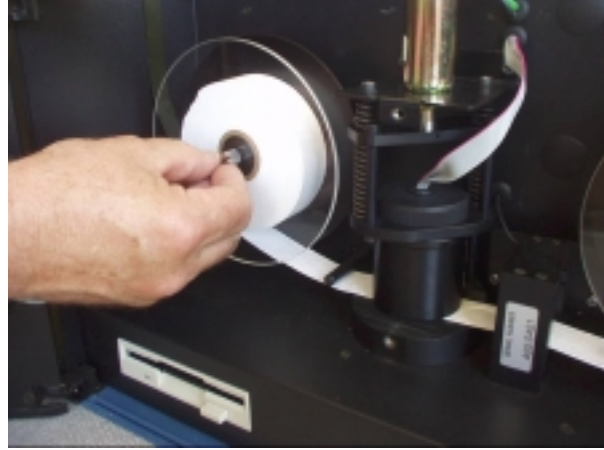


Photo 4.2C.2



Photo 4.2C.3



Photo 4.2C.4



Photo 4.2C.5



Photo 4.2C.6

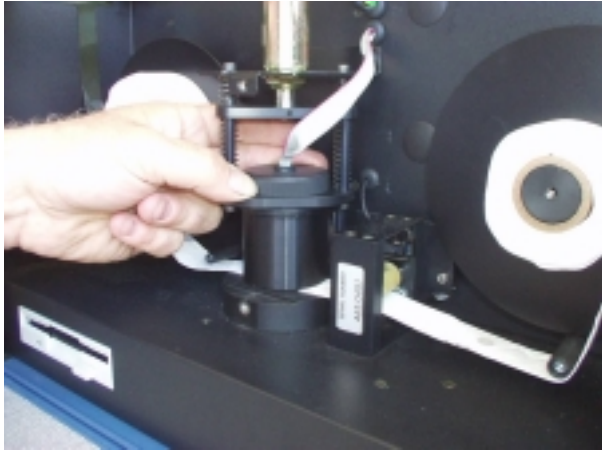


Photo 4.2C.7

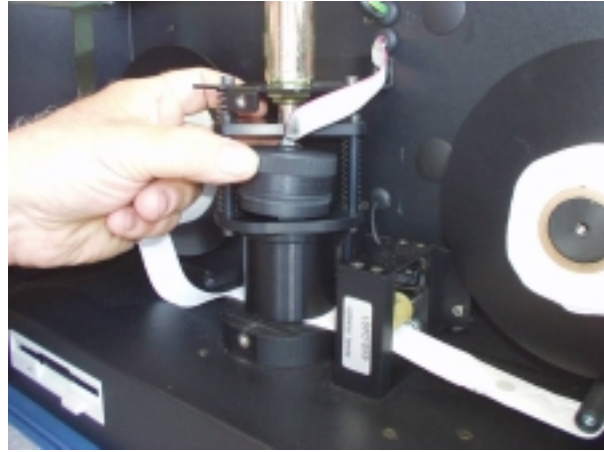


Photo 4.2C.8

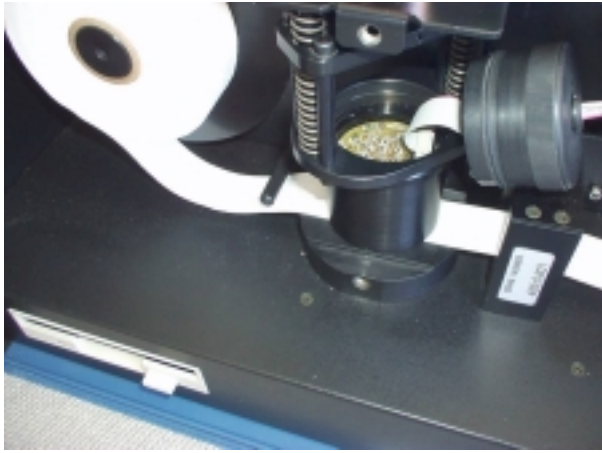


Photo 4.2C.9



Photo 4.2C.10

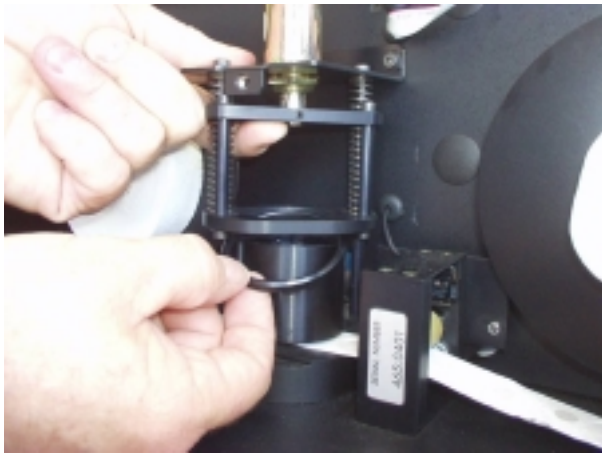


Photo 4.2C.11

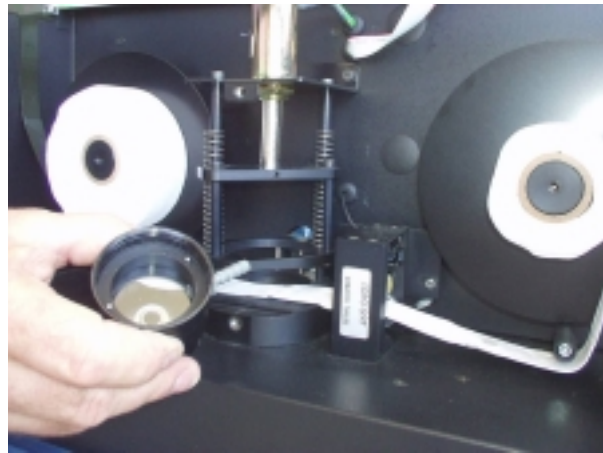


Photo 4.2C.12



Photo 4.2C.13



Photo 4.2C.14



Photo 4.2C.15



Photo 4.2C.15



Photo 4.2C.16



Photo 4.2C.17

4.3. CHECK BYPASS CARTRIDGE FILTER

Before you replace the **top cover plate**, be sure to examine the **Bypass Cartridge Filter**. If it is very black, replace it. Instructions are given in Section 3D above.

4.4. CHECK COOLING FAN

Before you replace the **top cover plate**, re-connect the **electrical power cable** and switch the instrument ON. Look at the **Cooling Fan** on the rear panel and check that it works. Switch the electrical power OFF. Replace the **top cover plate** – remember to re-attach the **grounding wire**.

4.5. **PERFORM INSTRUMENT “SELF-TEST” PROCEDURE**

The Aethalometer software menu contains a “**Self Test**” procedure. This will test the operation of all main instrument components and will inform you of any problems that the software can detect.

- A. Switch the electrical power ON. Wait about 20 seconds until the computer is ready: the **green light** will **flash** and the screen will show “**Magee Scientific**” and a count-down from 60. Press the <**DOWN-ARROW**> key **once**, and the screen will show “**Operate**”. Press the <**DOWN-ARROW**> key more times until you see the menu choice “**Selftest**”. Press <**Enter**>.
- B. The **Self Test Procedure** is automatic. Watch the screen and take notes. In case of any failures, the instrument will show a warning message. The tests are as follows:
- C. Test of all **LED Light Source Lamps**. If your instrument has **7-wavelength optics**, the procedure will test “**Lamp 1**” to “**Lamp 7**”. For each lamp test, the screen will show “**Lamp (n) .. OFF**” and then “**Lamp (n) .. ON**”. This test will show if all of the light sources and the detectors are working correctly.
- D. Test of **Pump, Flow**, and operation of **Bypass Valve**. The screen will show the air flow rate with the **bypass valve** ‘on’ and ‘off’. This test will show if there is a problem with the pump, or a blockage of the bypass valve.
- E. Test of **Analog Signal Output**. This test exercises the **analog output terminals** on the rear panel, with signal voltages of 0, 1, 2 and 5 volts DC, to allow for setting up an external analog data recorder. Press the ‘Enter’ key to proceed from one value to the next.
- F. Test of **Digital Data COM Port**. This tests the data transmission from the COM port on the rear panel, to test communications with an external network. This routine first allows the user to change COM parameters (baud rate, etc.) if needed. The screen then prompts “**ENTER to send data**”. Press **ENTER** to transmit one data line using the COM parameters. This may be repeated as often as needed. Press **ESC** to escape.
- G. Test of **Display Screen**. The screen and the **Status Indicator LED Lamps** are cycled on and off; the screen is filled with characters; and the back-light is turned on and off.
- H. Test of **Tape Advance Mechanism**. The tape feeder is activated: the user is prompted to watch the mechanism to verify correct operation. A countdown timer indicates the approximate duration of the test.
- I. Write your notes on the tests (C – H).

4.6. **SUMMARY REPORT SHEET : CLEANING AND PREVENTIVE MAINTENANCE**

After the cleaning and preventive maintenance, review your notes to check for completeness. Use this form to summarize your findings. Contact either your management or your distributor, and send this page by fax to inform them of the results of your work.

Station / Location		Serial No.	Date, time	Your name
Task No.	Description	Result / Comments / Observations		
4.2C a - d	Remove covers			
4.2C e - f	Remove optical source			
4.2C g - i	Remove cylinder			
4.2C j - k	Wash cylinder			
4.2C l - m	Clean - No loose material !			
4.2C n - p	Re-install cylinder			
4.2C q	Soft brush optical source			
4.2C r - u	Re-install optical source			
4.2C v - w	Replace covers			
4.3	Check cartridge filter			
4.4	Check cooling fan			
4.5 A	Start Self-Test procedure			
4.5 C	Self-test lamps			
4.5 D	Self-test pump			
4.5 E	Self-test analog output			
4.5 F	Self-test digital output			
4.5 G	Self-test display screen			
4.5 H	Self-test tape advance			

5. FIRST-LEVEL DIAGNOSIS IN CASE OF PROBLEMS

- A. The following procedures provide a “First-Level Diagnosis” to try to discover the cause of problems, if an instrument is reported to be “**not working**”. These tests are not a substitute for full examination in an instrument laboratory: they are a means for the local site technician to discover if the problem can be repaired locally, or if the instrument must be returned to the central laboratory. It is therefore important to take detailed notes during the following procedures, to make a report. At the end of this section we have provided a Summary Report Sheet as a guide: however, you should be sure to add your personal notes.
- B. For the following tests, the instrument should be placed on a table with access front and rear. The **air sample inlet tubing** should be dis-connected from the **threaded fitting** on the rear panel. To do this, **push in** on the gray ring around the tubing, while (at the same time) **pull** the tubing out. Next, **un-screw** the threaded fitting, so that you can see the female-threaded receptacle on the rear panel. Make sure that the electrical power cord is connected to a grounded (3-pin) outlet; the **Rear Panel Power Switch** (next to the power cable input on the rear panel) is switched ON; and the **Main Power Switch** inside the front door is switched OFF.

5.1. POWER AND DISPLAY SCREEN

- A. Using the **main power switch** inside the front door, switch the electrical power ON. Look closely at the top of this switch: it contains a **small red light**. Is the red light on? If so, we know that the electrical power supply is good. Switch the power OFF.
- B. Look closely at the **Display Screen**, and switch the power ON. The screen should illuminate; should show an internal software code; and should then fill with the letters “M .. A .. G .. E .. E”. If this works correctly, we know that the display screen is good.

5.2. COMPUTER AND PROGRAM

- A. Continue to look at the display screen. The **top left corner** should show a blinking square. This shows that the **Main Computer** is loading its program. This takes a few seconds. When it is ready, the screen should show the words “Magee Scientific”; the Software Version Number; and a count-down from 60 to zero. If this works correctly, we know that the main computer is good, and the software program has loaded. Make a note of the Software Version Number that is shown on the 2nd line of the screen.

- B. Press the <DOWN-ARROW> key: the screen will show 'Operate'. Press it again; it will show 'Change Settings'. Press again; it will show 'Signals & Flow'. Press <Enter>, press <Enter> again.

5.3. **DATA ACQUISITION AND OPTICAL TEST**

- A. The display screen should start (slowly) to show lines of numbers. The first line is 'RefV', the light-detector voltage signal for the Reference channel. The second line is 'SenV', the light-detector voltage signal for the Sensing channel. The third line is 'FlowV', the voltage signal from the **Air Flow Sensor**. If you can see these three lines of numbers, this shows that the computer measurement of voltage signals (the analog-digital converter) on the **Main Electronics Board** is good. If, however, the display does **not** show these lines of data, but remains blank for a long time, we know that the analog-digital converter is bad.
- B. Open the front door of the instrument. With one hand, press the panel switch '**Tape Advance**' for a short time only – about 5 seconds. At the same time, use your other hand to pull the filter tape forwards about 2 cm. This makes sure that we have a clean piece of filter tape in the analytical area.
- C. Next, take note of the data values shown on the display screen for 'RefV' and 'SenV'. At first, on the right-hand side of the top line, you will see 'Lamp = 0'. The **optical source lamps** are turned OFF. The two data values should be close to zero, usually 0.05 V or less. Now, **press the keypad key "1"**. After a few seconds, the top right screen will show 'Lamp = 1'. This shows that **Lamp Number 1** of the **optical source** has been turned ON. The two data values should increase. Write down the values of 'RefV' and 'SenV' for Lamp No. 1. These values should ideally be in the range of 1 to 4 V. **The exact value is not important !!**
- D. Repeat the process for Lamp Nos. 2 through 7, by pressing the **keypad keys 2 to 7**. In each case, write down the data values for RefV and SenV. It is normal for these values to be all different. However, they should all lie in the range of 1 to 4 V. **SPECIAL NOTE !** If any of the data values are greater than 5 V, notify your manager. Press the keypad **0** so that the display screen shows 'Lamp = 0' and the SenV and RefV data return to small values close to zero.

5.4. **PUMP AND AIR FLOW**

- A. Now observe the third line of the **display screen**. It shows “FlowV”, which is the signal voltage from the **air mass flow sensor**. The computer converts this sensor voltage into an **air flow rate** measured in **Liters Per Minute (LPM)** using the software calibration factors. The computed flow in LPM is also shown on the third line of the screen. It is normally set to a value between 2 and 5 LPM. Write down the flowrate in LPM.
- B. Place your finger over the **air sample inlet receptacle** – the female-threaded hole on the rear panel. You should be able to feel the suction. When you remove your finger, there should be a slight “**pop**”. If you can not feel any suction, this means that there is an **air leak** inside the instrument.
- C. Look at the **air flow rate** that is shown on the **display screen**. Now put your finger over the **air sample inlet**. The flow rate should **reduce** when the inlet is blocked. NOTE ! – it will **not** reduce to zero! – however, it should reduce to a minimum value of less than 2 LPM for a short time. After a longer time, the computer will increase the speed of the motor and the suction will increase. The required test is to take note of the minimum flow rate that is displayed when the inlet is temporarily blocked.

5.5. **TAPE ADVANCE MECHANISM**

- A. Open the front door, and remove the black metal **Light Shield** by loosening the two thumb-screws. With thumb and finger, lift up the **analytical cylinder** against the springs. It will move only about 2 mm. With your other hand, pull the **filter tape** towards you, out of the slot between the analytical cylinder and the **base**. The tape will become wrinkled: this is OK. This will allow you to see the 2 mm gap. Look into this gap to make sure that it is clean, and not filled with white quartz fiber ‘fluff’. If it seems that there is a deposit of quartz fiber in the gap, use a small piece of thin cloth and pull it back and forth through the 2 mm gap, to remove the fibers.
- B. Lift up the **analytical cylinder** and pull about 5 cm. of the the quartz fiber tape through the **tape advance rollers** and towards the right-hand **spool**. **Make sure** that the filter tape passes under the guide rod on the left-hand side; and under the moving **tension control arm** on the right-hand side. Release the analytical cylinder, so that the **springs** press it down onto the tape. With your fingers, move the tension control arm from side to side, and check that it moves freely over about 2 cm.
- C. Press the **Tape Tension Switch**. The right-hand spool will turn slowly, and will gradually collect the loose tape on the right-hand side. When the tape finally becomes tight, the **tension control arm** will move slowly to the left. When it reaches its limit, the arm will activate a switch that turns the **tension motor** OFF. Check that the motor finally stops turning.
- D. With a pencil, make a small mark on the filter tape, near the analytical cylinder. Now press the **Tape Advance Switch**, and hold it for about 20 seconds. When you first press it, you should hear a “click” sound, and the electro-magnet will lift up the **analytical cylinder**. The **tape advance motor** will start to turn the **grip rollers**, slowly. After about 15 seconds, a switch will click to keep the motor turning for one complete revolution. You may now release the front panel switch: the cycle takes one minute.
- E. Watch the pencil mark on the **filter tape**, and check that it moves forwards about 1 cm. The tape movement occurs only in the middle of the 1-minute cycle time. When the **grip roller** completes its cycle, the switch will release. The electro-magnet is turned OFF, and the cylinder will fall down onto the filter tape with a “click” sound.
- F. Check that the complete tape advance process worked successfully.

5.6. ***SUMMARY REPORT SHEET : FIRST-LEVEL PROBLEM DIAGNOSIS***

After the tests, review your notes to check for completeness. Use this form to summarize your findings. Contact either your management or your distributor, and send this page by fax to inform them of the results of your tests.

Station / Location	Serial No.	Original description of problem		Date, time	Your name
Test No.	Description	Pass	Fail	Numerical Result / Comments / Observations	
5.1A	Main Power				
5.1B	Display Screen				
5.2A	Computer				
5.2A	Software Version Number				
5.3A	Electronic Data Acquisition				
5.3C	SenV, RefV (Lamp=0)				
5.3C	SenV, RefV (Lamp=1)				
5.3D	SenV, RefV (Lamp=2)				
5.3D	SenV, RefV (Lamp=3)				
5.3D	SenV, RefV (Lamp=4)				
5.3D	SenV, RefV (Lamp=5)				
5.3D	SenV, RefV (Lamp=6)				
5.3D	SenV, RefV (Lamp=7)				
5.4A	FlowV, Flow (LPM)				
5.4B	Block inlet – suction?				
5.4C	Minimum flow LPM (blocked)				
5.5A	Tape zone - clean				
5.5B	Tension control arm				
5.5C	Tension motor				
5.5D	Electromagnet lift				
5.5D	Grip rollers turning				
5.5E	Tape moved forwards				