

**Local Site Operator Procedure Manual for the  
Magee Aethalometer  
UK Black Smoke Network**

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Issue no: 1.3  
Issued date: Aug 2011  
Issued by: D Butterfield

**Local Site Operator Procedure Manual for the  
Magee Aethalometer**

**UK Black Smoke Network**

**Procedure: DEFRA Aethalometer 002  
Issue 1.3 August 2011**

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## **Preface**

This manual sets out the procedure to be followed by the Local Site Operator in carrying out the tasks necessary to support the operation of the Magee aethalometer at network sites. In particular, it details the routine maintenance procedures, which ensure that measured data are of acceptable quality, but also covers some basic non-routine procedures and actions that may be useful in the event of equipment problems.

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## 1.0 Introduction

In 2008, the Department for the Environment, Food and Rural Affairs (Defra) decided to replace the manual (daily) 8-port black smoke samplers in the UK Black Smoke Network with real-time Magee Aethalometers.

### 1.1 Network Design

At the start of 2008 the UK Black Smoke Network used the conventional 8-port sampler to take daily measurements of Black Smoke at 21 locations in the UK. It was planned to make a straight swap in instrumentation when installing the aethalometers, but due to siting restraints and local development pressures, two of the original Black Smoke Network sites had to be relocated.

The building housing the Halesowen 8-port sampler was due for demolition and development into new shops, so the replacement aethalometer was installed in the Dudley Central air monitoring site. The Dudley site is 4 miles from the original site and is the same site classification.

The building housing the Norwich 7 sampler was in a bad state of repair, which the Council had no control over, and there were also problems installing a phone line to the site to allow remote data download. Therefore, it was decided to install the replacement aethalometer into the Norwich AURN site. The AURN site is 2.5 miles from the original site and is the same site classification.

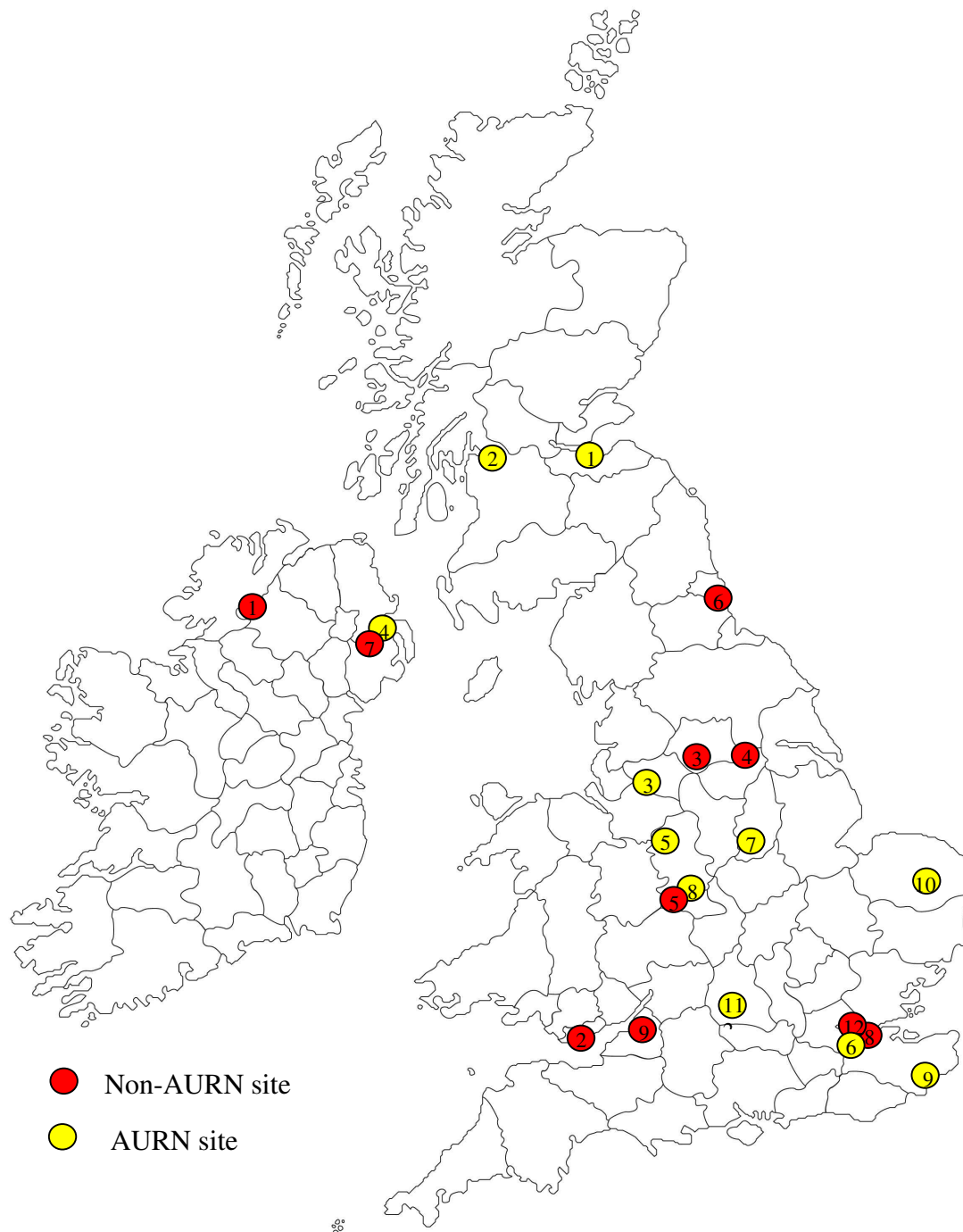
In addition to replacing all of the existing 8-port samplers with aethalometers, an aethalometer has been installed in the Harwell AURN site as part of the Particle numbers and Speciation Network.

In October 2009 the Bradford Town Hall site was closed when Defra reviewed it's monitoring requirements.

Figure 1 shows the locations of the aethalometers.

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**Figure 1 Location of Aethalometers making up the UK Black Smoke Network**

Tables 1A and 1B below give the site names and classifications for the UK Black Smoke Network:

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Key	Site Name	Site Type	Start year	Reason
1	Strabane 2	A3	1999	NI region, urban background, high Black Smoke
2	Cardiff 12	A1	1961	Wales region, urban background
3	Halifax 17	B3	2003	NW region, urban background
4	South Kirkby 1	B3	1970	NE region, urban background High Black Smoke
5	Dudley Central	N/A	N/A	W Mid region, urban background
6	Sunderland 8	A2	1961	NE region, urban background
7	Dunmurry 3	X	1993	NI region, urban background, high Black Smoke. Colocated with PAH Network
8	Woolwich 9	B3/E	1955	London region, urban background
9	Bath 6	B3	1981	SW region, urban background

**Table 1A Non-AURN**

- A1 Residential area with high-density housing (probably terraced), or with medium-density housing in multiple occupation, in either case surrounded by other built-up areas.
- A2 Predominantly A1, but interspersed with some industrial undertakings.
- A3 Residential area with high-density housing or medium-density housing in multiple occupation surrounded by, or interspersed with, other areas with low potential air pollution output (parks, fields, coast).
- B3 Residential area with medium-density housing surrounded by or interspersed with areas with low potential air pollution output (parks, fields, coast), or any residential area with low-density housing.
- D2 Town centre with limited commercial area, possibly mixed with old residential housing and/or minor industry.
- E Smoke control area or smokeless zone (the letter to be added to the primary classification). X
- X Unclassified or mixed area.

Key	Site Name	Site Type	Other Analysers
1	Edinburgh St Leonard's	Urban Background	TEOM FDMS PM <sub>10</sub>
2	Glasgow Centre	Urban Centre	TEOM FDMS PM <sub>10</sub>
3	Manchester Piccadilly	Urban Centre	TEOM FDMS PM <sub>10</sub>
4	Belfast Centre	Urban Centre	TEOM FDMS PM <sub>10</sub>
5	Stoke Centre	Urban Centre	TEOM FDMS PM <sub>10</sub>
6	North Kensington	Urban Background	TEOM FDMS PM <sub>10</sub> + number counting & sizing + ECOC + anions & cations + manual PM <sub>2.5</sub>
7	Nottingham Centre	Urban Centre	TEOM FDMS PM <sub>10</sub>
8	Birmingham Tyburn	Urban Background	TEOM FDMS PM <sub>10</sub>
9	Folkestone, Kent Network	Rural	TEOM PM <sub>10</sub>
10	Norwich	Urban Background	TEOM FDMS PM <sub>10</sub>
11	Harwell	Rural	TEOM FDMS PM <sub>10</sub> + PM <sub>2.5</sub>
12	Marylebone Road	Roadside	TEOM FDMS PM <sub>10</sub> + number counting & sizing + ECOC + anions & cations + manual PM <sub>2.5</sub>

**Table 1B AURN sites**

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## **1.2 Instrumentation**

An overview of the workings of the aethalometer is given below and is taken from the “The Aethalometer”<sup>1</sup> by ADA Hanson.

### **1.2.1 What Does The Aethalometer Measure?**

The Aethalometer™ is an instrument that provides a real-time readout of the concentration of ‘Black’ or ‘Elemental’ carbon aerosol particles (‘BC’ or ‘EC’) in an air stream. These particles (“soot”) are emitted from all types of combustion, most notably from diesel exhaust.

‘BC’ is defined by ‘blackness’, an optical measurement. The Aethalometer uses a continuous filtration and optical measurement method to give a continuous readout of real-time data. The ‘EC’ definition is based on a thermal-chemical measurement, an analysis of material collected on a filter sample for several hours and then heated in a gas stream. There is no accepted definition of elemental carbon. Different thermal parameters as used by different EC analysis protocols will actually yield different EC numerical results, even on portions of the same filter samples. The optical analysis for BC is consistent and reproducible. A wide body of published research shows that the Aethalometer BC measurement is closely proportional to filter-based EC measurements.

The Aethalometer performs the optical analysis and data readout ‘*on the spot*’. The results are available immediately to the user, without waiting for analysis of a sample at a laboratory.

The Aethalometer is a self-contained, automatic instrument. It requires no consumable materials, no gas cylinders, and no operator attention. It runs automatically: plug it in and walk away. It requires no calibration other than periodic checks of the air flow meter response.

### **1.2.2 Measurement Principle**

The Aethalometer draws the air sample through the inlet port, typically at a flow rate of a few liters per minute, using a small internal pump. The flow rate is monitored by an internal mass flow meter and is stabilized electronically to the set point value entered in software.

The Aethalometer collects the sample on a quartz fiber filter tape, and performs a continuous optical analysis, while the sample is collecting. During this process, the

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tape does **not** move. The tape **only** moves forward when the spot has reached a certain density. In a city, the tape may advance 3 or 4 times per day. In a rural location, each spot may last a day or longer. The roll of tape contains 1000 spots.

The analysis gives one new reading every time base period. The user sets the time base for the desired data rate. The data is written to diskette; transmitted by the COM port; and produced as an analog voltage.

*Faster time base = more rapid response, but more instrument noise.*

*Slower time base = less noise, but you 'lose' the time details.*

For the Black Smoke Network the time base has been set to 15 minutes.

## 2.0 Routine Operation Of The Sampler

The aethalometer requires no routine intervention by the Local Site Operator (LSO) apart from changing the tape approximately once per year.

If there is a power cut the aethalometer will start automatically on the restoration of the power supply.

The memory card should never be removed from the sampler with the power turned on. If you are instructed to remove the card by NPL, please ensure that the instrument is switched off at the switch behind the front door of the instrument.

### 2.1 Security Code

Some procedures, including installing a new tape, require a security code to be entered into the aethalometer.

**The default security code is "111" followed by the "Enter" key.**

There is a slight delay between pressing a key on the keyboard before a character appears on the screen, so be patient in pressing a key and waiting for the corresponding character to appear.



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## 2.2 Stopping The Current Measurement

This is a ‘protected’ function and requires the Security Code as a password.

The *Operate* procedure can be interrupted by pressing the STOP key: the screen will display the message “-- STOP key PRESSED --” .. “STOP again to exit”. The user must then **PRESS THE STOP KEY AGAIN**. However, the measurements will only actually terminate if the user can enter the correct *security code* within a 10-second time window. If the correct *security code* is entered, the program returns to the *main system menu*: if the code is not correct, measurement operations simply continue. These precautions are implemented to prevent accidental or unauthorized stopping of the measurements.

Note: the security code is initially set at the factory to the value **111**.

## 2.3 Filter Tape Changing

Each tape provides ~1000 sampling spot locations. Each spot lasts from a few hours in cities to as long as several months at remote locations, and so changing the tape roll is only required occasionally. The display screen shows an **estimate** of the percentage of the tape roll that remains: when this falls below 10%, the ‘Check’ lamp on the display panel will be lit.

Note that the ‘Tape Remaining’ percentage is a **software-based estimate**, not an actual measurement of the tape spool. Under some conditions, the estimate can become inaccurate and reach zero even though there is filter tape remaining on the supply spool. Even if the yellow ‘Check’ lamp is lit, and a warning message is displayed on the screen, the instrument **will continue to provide valid data** until the filter tape actually runs out.

The “Tape Remaining” value is collected during the routine remote data collection from the instrument. The Environmental Research Group (ERG) at King’s College London will alert the LSO to change the tape, when there is 10% of the tape life remaining. Please attend the site within a week of this notification and change the tape. Please contact ERG when the tape has been changed. A spare tape is kept on site.

When the tape is eventually all used, it is necessary to install a fresh roll, according to the procedures set out below. The menu option ‘*Install New Tape*’ offers an abbreviated set of sequential instructions with prompts to guide the user through the

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necessary steps. This software procedure also resets the tape supply percentage counter to 100%.

For this reason, the ‘*Install New Tape*’ software procedure *must* be used when installing a fresh roll of tape. If you are familiar with the procedure, you may bypass the screen instructions, but you must use the procedure in order to reset the counter. The ‘Install New Tape’ procedure is ‘protected’ and requires the Security Code as a password.

## 2.3.1 Procedure To Change Filter Tape

*You will need scissors and adhesive tape.*

1. Stop measurements, turn off the pump (if external). Do not switch off the instrument power.
2. Select “*Install New Tape*” from the Main Menu. Choose instructions if required.
3. Remove the two thumbscrews securing the analyzer chamber center cover plate.
4. Remove the two thumbscrews securing the clear plastic front spool flanges.
5. Pull out the gray plastic guide rod (with banana jack) on the left side of the analyzer chamber.
6. Use scissors, cut the tape on the left hand (supply) side. Leave a few centimeters.
7. Remove the unused portion of the previous roll of tape from the supply side spindle. Open the box of new tape and take out the new roll.
8. Put the new roll of tape on the supply side spindle.
9. Using adhesive tape, stick the start of the new filter tape to the end of the old filter tape on the left side of the analyzer chamber.
10. Press and hold the “Tape Advance” button with your left hand. The inlet assembly will lift about 2 mm - just enough to release the clamping force on the tape.
11. With your right hand, pull the old tape out to the right, with the new tape stuck to it. Pull about 20 cm. of new tape through. Cut off the old tape.
12. Remove the filled spool of used tape from the right-hand (take-up) side. Unroll it in order to retrieve the brass spring clip and the cardboard center. Discard the used filter tape, retain the clip and the cardboard center.
13. Be sure not to dislodge the o-ring, which is behind the cardboard center.
14. Put the empty cardboard center onto the take-up hub.
15. Take about 10 cm. of the new tape, and thread it under the swinging roller arm that controls the tension. Clamp it under the spring clip onto the cardboard center. Turn the cardboard center counter-clockwise to roll up the slack tape onto itself.

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16. Replace the clear flange on the supply spool side. Tighten the thumbscrew firmly but not excessively. Check by pulling on the unrolling portion on the left, that the supply roll can turn against a little friction. Plug the guide rod back in to its banana jack.
17. Replace the clear flange on the take-up spool side. Tightening the thumbscrew clamps the cardboard hub against the o-ring behind it, which provides the grip to pull the tape.
18. Press the “Tape Tension” switch, roll up any slack tape on the right-hand side.
19. Replace the analyzer chamber cover plate and its two thumbscrews.
20. Reset tape counter.
21. Start measurements.

### 2.3.1.1 Install New Tape – Software Procedure Prompts

The first screen asks ‘*List Instructions ?*’. If **NO** is selected, the instrument assumes that the operator is familiar with the tape installation procedure, and will not require guidance. The software skips the detailed instructions, re-sets the tape counter to 100%, and returns to the *Main Menu*.

If **YES** is selected, the display screen guides the user through all the operations required for changing the tape. After each phrase, the user must press any key to proceed to the next:

1. Remove spool screws
2. Remove cover screws
3. Pull out guide rod
4. Cut old tape
5. Remove supply roll
6. Remove take up roll
7. Install new roll
8. Lift up chamber 2 mm
9. Push tape through
10. Lift up chamber 2 mm
11. Pull 10 cm tape
12. Install take up hub
13. Clip tape to hub
14. Push in guide rod
15. Replace cover
16. Replace spools
17. Tighten spool screws

The screen then asks: ‘Is the tape properly replaced?’ Entering **YES** will re-set the tape counter to 100% and finish the process.

## **2.4 Starting Measurements**

To start the measurements the “operate” mode must be selected from the main menu.

1. Repeatedly press “Esc” to get to the main menu.
2. Press the “up” or “down” arrow until “Operate” is displayed - press enter
3. The display will show “Go to Auto Mode” – press enter
4. The display will show “UV Channel On” – press enter

The instrument immediately proceeds with fully automatic operation, and no further operator interaction is required.

## **2.5 Replacement Of Bypass Filter Cartridge**

The bypass filter cartridge is located at the rear of the upper chassis, above the sample inlet port. Its flow path is between a side connection to the sample inlet, and the bypass valve. When the bypass valve is not activated, pump suction is applied to the filter support grid in the analytical cylinder base, and the sample air stream is drawn from the inlet port through the filter tape. When the bypass valve is activated, pump suction is disconnected from the filter, and is instead connected directly to the sample inlet port, through the filter cartridge attached to a side fitting on the inlet. The purpose of the filter cartridge is to remove any particles from this air stream that might otherwise contaminate the bypass valve, the air mass flow meter and the pump.

The condition of the bypass filter cartridge does not affect the analytical operation of the Aethalometer™, provided it is not completely blocked. Even if it becomes visibly dark, it will not compromise the validity of the Aethalometer data. The flow resistance of the bypass filter cartridge is always much less than the flow resistance of the quartz fiber filter tape. Therefore, even if the cartridge becomes substantially loaded with collected particles, it will not affect the airflow. The reason for changing the bypass filter cartridge is simply to prevent it from becoming completely blocked with dust or other aerosol particles.

The bypass valve is activated only under the following conditions:

During filter tape advances. This removes suction from the underside of the filter tape, while it is being pulled across the support grid. This reduces the drag on the tape and reduces the probability of scraping quartz fibers from the tape.

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During operation of the 'Tape Saver' mode. This applies a time fractionation to the sample air stream during each time base period, to reduce the number of liters of air from which BC is collected. This reduces the rate of BC accumulation and prolongs the lifetime of each filter spot under conditions of high concentration.

If 'Tape Saver' is not used, very little airflow passes through the bypass filter cartridge: only during tape advances. In this case, the filter cartridge will last a long time before it starts to become visibly dark. If 'Tape Saver' is used, sample air will flow through the filter cartridge for a substantial fraction of the operating time, and the filter cartridge will collect a greater deposit of particles. If the bypass filter cartridge is visibly dark, replace it during the routine process of cleaning the inlet cylinder.

To replace the Bypass Filter Cartridge:

Press on the release ring of the fitting to allow the cartridge stem ends to be pulled out. When inserting the new cartridge, be sure to press the stems firmly into the fittings, to seal them in the internal o-rings.

## 3.0 Additional Information

The following sections give additional information on the operation of the Aethalometer

### 3.1 *Diagnostic checks*

The front panel has 5 lamps to indicate the instrument status:

**RUN** (green):

- Steady: Normal operation, measurement data is valid.
- Flashing: Normal operation, but there is no valid data because the instrument is performing a tape advance or (re-) initializing.

**PAUSE** (yellow): Indicates that the instrument is ready for measurements, but was stopped by the operator pressing the STOP key. Also lit in *manual mode* in the *operate procedure* until all operator interactions are completed

**CHECK** (yellow): Flashing - something must be checked - data disk almost full, tape almost all used, or air flow rate has changed more than 10%.

**ERROR** (red): Flashing - a serious error has occurred, the instrument has stopped.

**STOP** (red): Instrument is not ready to run: stopped either by a serious error or when operator is in a menu/setup mode.

The status of each light needs to be checked. If the Run light is not illuminated at all and one of the fault lights are lit then ERG / NPL needs to be contacted immediately.

**If the tape usage indicator on the screen shows less than 10% tape left then the tape needs to be changed, see section 2.3.**

## **3.2 Data Download**

Data is normally remotely collected via a modem. If this should fail for a prolonged period of time then data can be manually downloaded and sent to NPL.

To download the data from the memory card in the aethalometer, the current analysis cycle has to be stopped and the instrument turned off. The memory card must never be removed from the analyser while it is powered up.

Procedure for downloading data from the aethalometer:

1. Stop the current measurement, see Section 2.2
2. Open the front door and turn off the analyser using the switch on the right hand side.
3. Remove the memory card (LHS of instrument) and insert it into a card reader connected to a laptop or PC.
4. Copy all files from the memory card that have been created since the last download date onto the laptop or PC.
5. If the memory card is >90% full then delete off a proportion of the oldest files with filenames in the form of: BCxxxxxx.CSV, where xxxxxx is in the date in the form ddmmyy.
6. Replace the memory card into the slot on the LHS and push fully in.
7. Turn the analyser back on using the switch on the RHS.
8. Restart the analysis cycle, see Section 2.4.
9. E-mail the downloaded data files to NPL to the following e-mail addresses:
  - a. [david.butterfield@npl.co.uk](mailto:david.butterfield@npl.co.uk)
  - b. [sonya.beccaceci@npl.co.uk](mailto:sonya.beccaceci@npl.co.uk)
10. Record the data download date and time for reference at the next download.

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## 4.0 Quick Reference Summary

**To Start:** Plug in and switch on. Instrument starts automatically without any operator attention. Data collection will begin after approximately 5 minutes. *Instrument takes about 30 minutes to warm up and finally stabilize.*

**To Exit Cleanly with Data Summary:** Press STOP key, watch screen. Press STOP key again. Enter "Security Code" of **111**. Summary file will be written to disk.

**Data Card:** Do not remove when instrument is switched on.

**Flow Rate** is set by software and automatically stabilized. Flow may read out in 'Standard' units (sea level) or 'Volumetric' units (corrected for altitude and temperature).

### **To Change Settings:**

Switch on, get opening screen.

Press any key to get top item in Main Menu, '*Operate*'.

Press **down-arrow** to get next menu item, '*Change Sys. Settings*'. Press **Enter**.

Scroll through settings list with down-arrow. Press **Enter** to access an item.

First one is ***Date & Time***.

Next one is ***Time base*** : Set to 15 minutes for Network operation.

Next is ***Flow rate*** : Set to 4 LPM for Network operation.

To change an item, use arrow keys, make selection, press **Enter** to confirm, press **Esc** to escape from the systems-settings menu. Confirm change.

**To Advance Tape to a Fresh Spot:** Press the 'Tape Advance' switch **upwards** and hold for about **15 seconds**. The mechanism will engage and take about 1 minute to advance the tape: data will settle down after about another 1 minute.

**Data Tradeoffs:** lifetime of tape spot. When spot saturates, tape automatically advances, data will be interrupted Shorter time base = better response to rapid changes in concentration, but noisier data.

**Note:** The instrument is set to run with a time base of 15 minutes for Network operation.



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## 5.0 Contact Details

### Day-to-Day Operation

The first point of contact for reporting any problems with the instrument is the Environmental Research Group (ERG) at King's College, London. They collect data from the instruments on a daily basis and may be already aware of a problem.

ERG Contact Details:

Duty officer 020 7848 4022

### Equipment Support Group (ESU)

The equipment support unit for the aethalometers is Air Monitors Ltd. Their contact details are below. Please route all emergency call outs through the duty officer at ERG.

Air Monitors can be phoned from site with help in routine operation or basic fault finding.

Air Monitors Details: [enquire@airmonitors.co.uk](mailto:enquire@airmonitors.co.uk)

01452 849111

### Network Management

NPL manages the Network on behalf of Defra. All general enquiries and LSO contract enquiries should be directed to the below

David Butterfield 020 8943 6391 [david.butterfield@npl.co.uk](mailto:david.butterfield@npl.co.uk)

Sonya Beccaceci 020 8943 6852 [sonya.beccaceci@npl.co.uk](mailto:sonya.beccaceci@npl.co.uk)

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