Automatic Urban and Rural Network (AURN) LSO Manual - Part B

Version 1.2 - November 2022

We are the Environment Agency. We protect and improve the environment.

We help people and wildlife adapt to climate change and reduce its impacts, including flooding, drought, sea level rise and coastal erosion.

We improve the quality of our water, land and air by tackling pollution. We work with businesses to help them comply with environmental regulations. A healthy and diverse environment enhances people's lives and contributes to economic growth.

We can’t do this alone. We work as part of the Defra group (Department for Environment, Food & Rural Affairs), with the rest of government, local councils, businesses, civil society groups and local communities to create a better place for people and wildlife.

Published by:

Environment Agency
Horizon House, Deanery Road,
Bristol BS1 5AH

www.gov.uk/environment-agency

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Updating and Version Control

This manual is a working document, intended to be updated when equipment or procedures change. This manual is provided in electronic format, and the latest version is available on the Health and Safety Database. If you are a Local Site Operator, it is your responsibility to ensure that you download and use the most up to date version.

Changes are summarised in the table below.

Revision Date	Summary of Changes	Version Number
October 2021	Addition of QAQC e-mail for London sites. Updated reference to Appendix D for gas cylinder information.	1.1
October 2021	Addition to include reference to the ALN	1.1
November 2022	Addition of sub-sections on API with Numaview software. Updated information on LSO Calibration Record Sheet. Added reminder, when changing inlet filters, to be sure to insert a filter not a backing paper. Created a separate 'Part C' annex document for all gravimetric samplers. Removed TEOM/ FDMS information as these have been retired from the network.	1.2

1. Introduction

Within the AURN there is a subset of sites in and around London, called the Automatic London Network (ALN). In this document, 'AURN' means the whole network, including ALN sites, unless specifically stated otherwise.

This part of the AURN LSO Manual contains work instructions for all monitoring equipment within the network which clearly outlines what tasks are needed to be carried out and how to do them.

The regular site visits carried out by the LSOs are a major factor in ensuring high quality data from the AURN. The following jobs are done during these site visits:

- Pre calibration checks, safety and security inspections
- Changing the particulate monitor filter (if applicable);
- Calibration of analysers;
- Post calibration checks,

As well as these routine jobs, there will sometimes be a need for non-routine site visits – for example in the event of apparent instrument or system malfunction.

LSOs will be trained in all aspects of normal equipment operation and in the relevant calibration procedures by the Quality Assurance and Quality Control (QA/QC) Unit. LSOs will need to make sure they understand the normal operating principles and characteristics of the instrumentation.

More detailed instrument tests are undertaken by QA/QC Unit personnel, in combination with the 6-monthly instrument intercalibration and servicing exercises.

Each analyser needs to be calibrated exactly as it is found, this way, any instrumental drifts which may have occurred since the previous calibration will be exactly quantified, with no possibility that changes in response have been caused by operator action.

It is essential that the procedures within this LSO Manual are followed as written, for both routine and non-routine site visits, to ensure that reliable and accurate air quality measurements are made.

The exact specification of the calibration systems at each monitoring site may differ slightly. The control of gas delivery into the analysers may use an excess flow meter, an in-line critical orifice restricting the pressure or a selectable flow regulator. Training in the use of these systems is provided by the QA/QC Unit as required.

Acting only on advice from the CMCU, instrument adjustments may be performed to optimise analyser sensitivity. If such adjustments are found to be necessary, the instrument will be recalibrated after a suitable initial stabilisation period, typically 15 minutes, so allowing the production of provisional revised calibration factors. However, full stabilisation of the instrument may take several hours and hence, ideally the instrument should be recalibrated after a further 24 hours. The CMCU will advise on this. It is not anticipated that instrument adjustments of this sort will occur frequently.

2. API Equipment - Site Operational Procedures

It is preferable that each analyser be calibrated exactly as found. In this way, any instrumental drifts which may have occurred since the previous calibration will be exactly quantified, with no possibility that changes in response have been caused by operator action. The exact procedure for undertaking zero calibrations will depend on the instrument and calibration facilities available on site, and may need to be changed depending on performance issues. Descriptions are provided for each methodology. If you are unsure which applies to your monitoring station, please contact the CMCU or QA/QC Unit.

2.1. Preparation

1. Check the pollutant levels on the front panel of each analyser to see if an episode is occurring i.e. pollution levels during the last hour are above, or close to, the trigger values as discussed in section 5.6 in Part A of the LSO Manual (O_3 >~70 ppb, NO_2 >~75 ppb, SO_2 >~90 ppb, CO >~5 ppm). If an episode is occurring, telephone the CMCU before proceeding any further. (Note - these trigger values are different from the thresholds used by the Daily Air Quality Index to defining 'high' pollution.)
2. On a new spreadsheet (or a new set of check and calibration sheets) enter Site, Date and Operator and Start Time.
3. Ensure the Operational Manual is to hand, and follow the instructions carefully.
4. Ensure that the toolkit (if supplied) with the site is complete.

Calibration results should be recorded on a dedicated electronic spreadsheet and sent to the CMCU and QA/QC unit. The electronic sheet should be used on site, to minimise the risk of errors, but if suitable facilities are not available, the results can be recorded on paper for subsequent transfer to the spreadsheet.

The most up to date version of the calibration spreadsheet should always be used: this is available on the 'Operations' page of the AURN Hub here. The CMCU will let all LSOs know when a new version of the calibration spreadsheet has been released.

2.2. Pre-Calibration Checks

A number of initial visual checks on the equipment are required. Complete all the checks for all the analysers and ancillary equipment. When all checks are complete, inform the CMCU if any are not correct before proceeding with the calibration.

2.2.1. All Analysers

The API 300 CO analyser (Figure 1), API 200 NOx analyser (Figure 2), API 100E SO_2 (Figure 3) analyser and the API 400 O_3 analyser (Figure 4) has a 2-line alphanumeric display and 3 status LED display lights on the front panel. The display is divided into 4 fields, Mode Field, Key Definition, Message and Concentration.

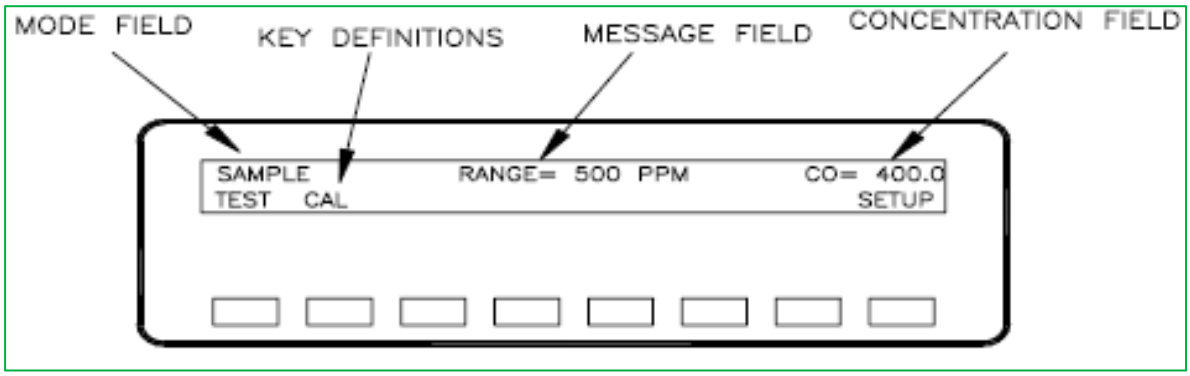


Figure 1 - Example diagram of API 300E CO analyser front panel. ©Teledyne API

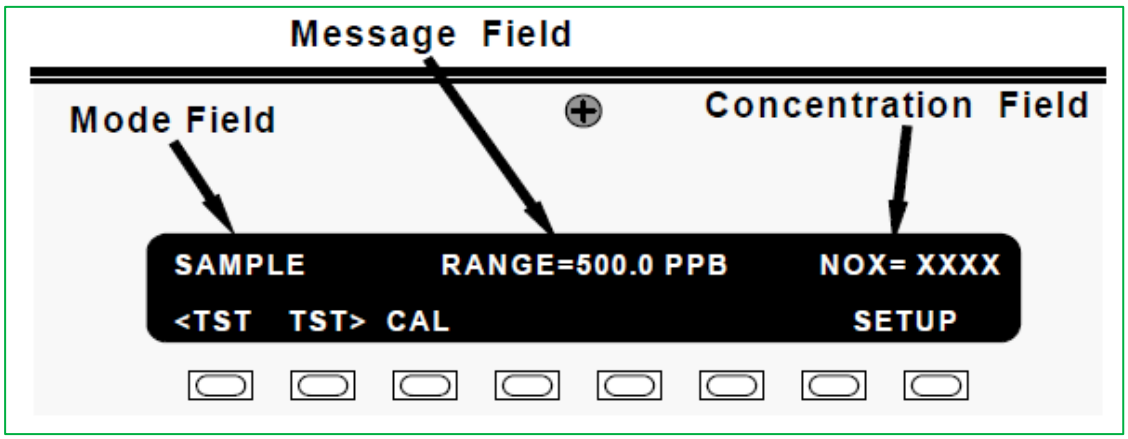


Figure 2 - Example diagram of API 200E NOx analyser front panel. ©Teledyne API

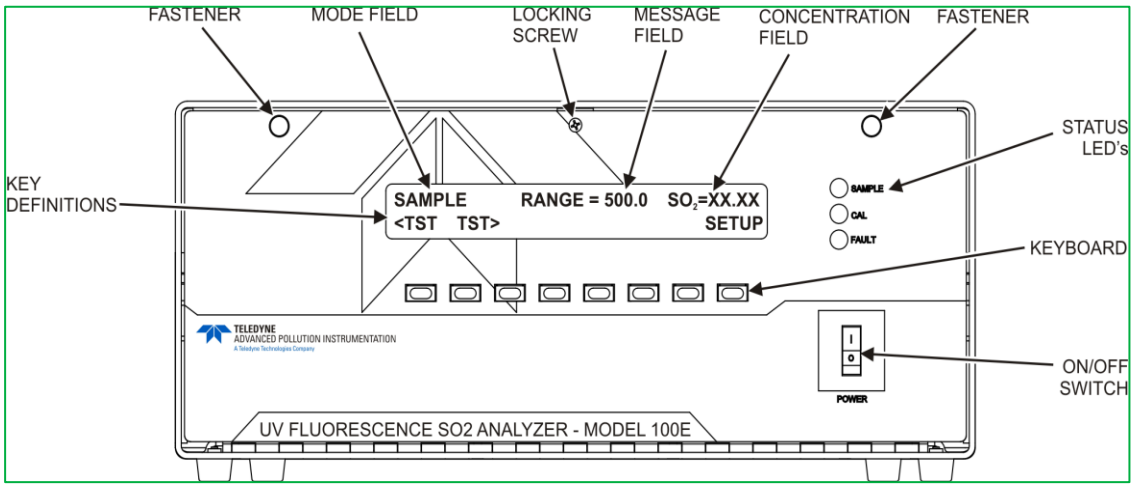


Figure 3 - Example diagram of API 100E SO_2 analyser front panel. ©Teledyne API

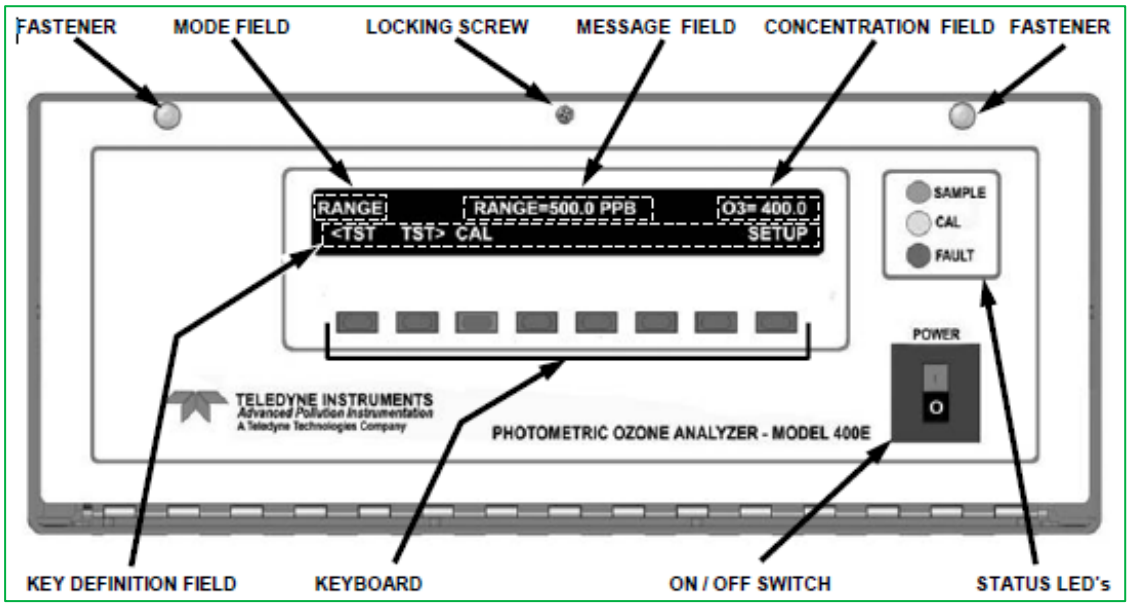


Figure 4 - Example diagram of API 400E O_3 analyser front panel. ©Teledyne API

The API T300 CO analyser, API T200 NOx analyser, API T100 SO_2 analyser and API T400 O_3 analyser have a similar layout but the display, status lights and “buttons” are presented on an LCD touchscreen. The procedures for operation and calibration are the same as for the older API 400 models.

Figure 5 shows the display of the API T300 CO analyser in sample mode

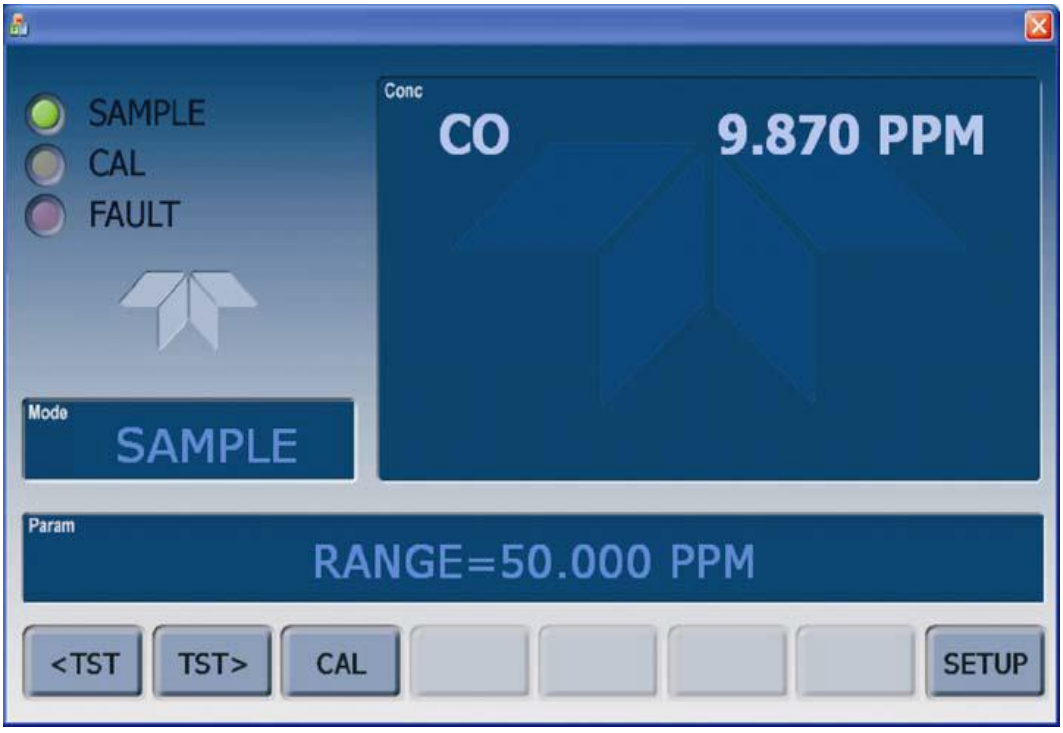


Figure 5 - Display of API T300 CO analyser. ©Teledyne API

Figure 6 - Display of API T100 SO_2 analyser. ©Teledyne API

1. In normal operation, the Mode field will show "SAMPLE", with the SAMPLE LED illuminated and the CAL and FAULT LEDs off. Check these and record on pre-calibration checklist.
2. If the red FAULT light is on (shown in Figure 6), a warning message has been generated and is still active; due to some instrument operating parameter falling outside pre-set ranges. If the FAULT light is on, two additional buttons will be identified in the Key Definition area of the display, namely MSG (message) and CLR (clear). Press the message button and record the warning message given in the message area of the screen on the calibration sheet and press clear.
3. If the red "FAULT" light is off and a message display is visible, a fault has occurred, but has been automatically rectified. Record the message and press clear.
4. A number of instrument internal operational parameters can be accessed by pressing the test (left hand) button to obtain each parameter in turn. Press this and record the result displayed in the message area of the display against the appropriate parameter on pre-calibration checklist. When all parameters on the pre-calibration checklist spreadsheet have been noted, press the test button once more. This will display the current time on the instrument display.

2.2.2. NumaView Versions

The API T300 CO analyser, API T200 NOx analyser, API T100 SO_2 analyser and API T400 O_3 analysers fitted with NumaView software have a different layout to the standard T series and earlier models, and the procedure for activating the analysers' various modes is also different. The procedures for calibration however are the same as for the older API models.

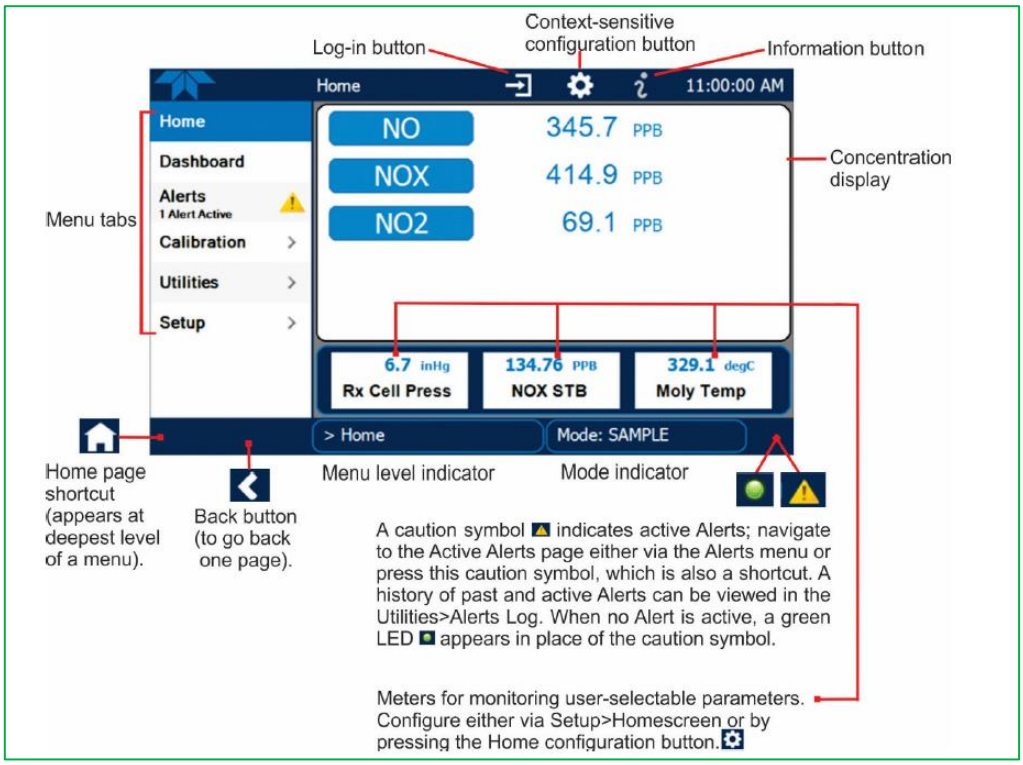


Figure 7 - Example diagram of API T200 NOx with NumaView. ©Teledyne API

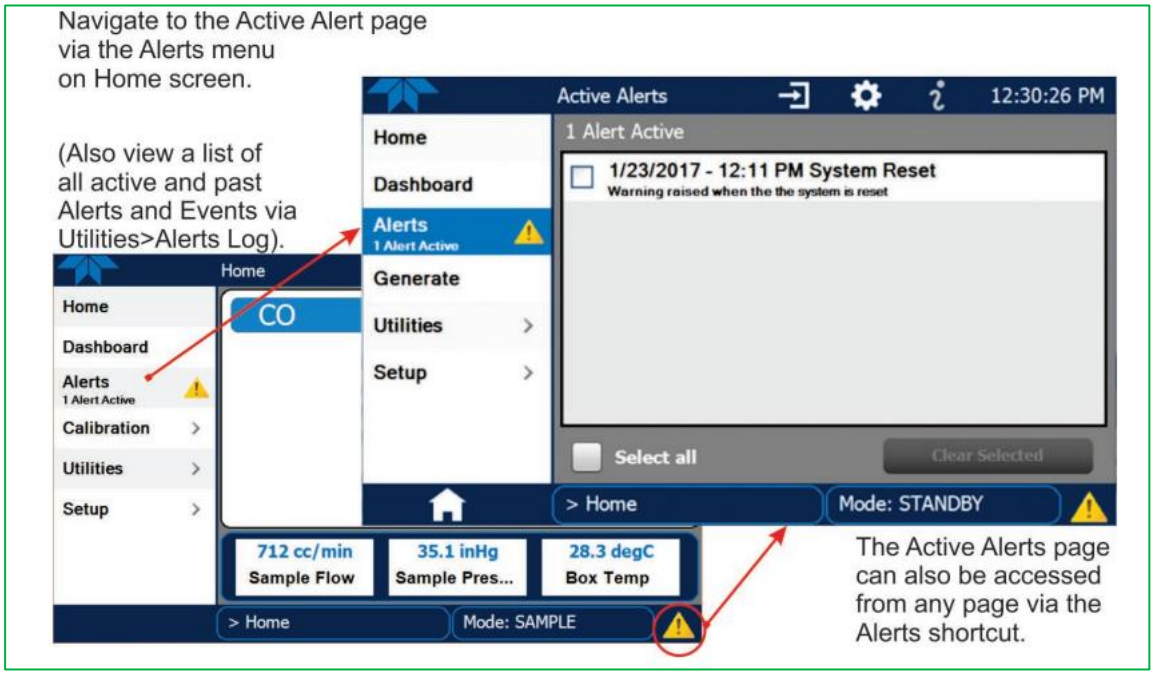


Figure 8 - Alert menu display of API T300 CO with NumaView. ©Teledyne API

1. In normal operation, the Mode field will show "SAMPLE", with the green SAMPLE LED illuminated in the bottom-right hand corner of the screen. Check this and record on pre-calibration checklist.
2. If the yellow warning triangle light is on (shown in figure 8), an error has been generated due to some instrument operating parameter falling outside pre-set

ranges. If the warning triangle is present, the cause of the warning can be identified by pressing "Alerts" which will reveal the warning(s) with a date and time stamp. Record the warnings, tick the "select all" box in the "Alerts" menu and then press "clear selected". This will clear all historic faults. If a fault is persistent, it will reappear in the "alerts" list with the current date and time stamped. If this occurs, report the persistent fault to the CMCU.

3. A number of instrument internal operational parameters can be accessed by pressing "dashboard" button from the home screen to obtain each parameter in turn. Press this and record the results displayed against the appropriate parameters on pre-calibration checklist. The dashboard is comprised of multiple pages, which can be navigated using the arrows at the bottom of the dashboard. When all parameters on the pre-calibration checklist spreadsheet have been noted, press the home button to return to the main screen.

2.2.3. Air Sampling Manifold (where fitted)

Most AURN sites no longer use manifolds. If you are LSO for a site which does, please follow the procedure below.

Record the following checks on the pre-calibration checklist.

1. Check that the sample manifold is intact and shows no sign of possible leakage.
2. Check that the blower motor is operating by listening and feeling for vibration on the motor housing.
3. Check that the instrument sample inlet tubes are connected to the manifold and the sample inlet port at the back of the rack and that these connections (including any sample inlet filter housings) are secure and leak tight.

In the case of a passive manifold sampling system (i.e. tubing from an inverted funnel) check that the tubing from the funnel is connected to the sample inlet port at the back of the instruments and that these connections are secure and leak tight. Check that the end of the sample tubing is just inside the lip of the funnel. Check the sample lines for visible obstructions and kinks and that the funnel is orientated to prevent rainwater entering the tubing.

2.2.4. Modem (where fitted) or Router

There are several types of modem used across the network. Styles and makes usually vary depending on whether the site has a landline or SIM card. For a landline modem, check that the AA, TR and MR red lights are displayed on the modem and record on the pre-calibration checklist. For a SIM card modem, check that the green light is flashing at regular intervals.

2.2.5. Zero Air Generator (where fitted)

Check the condition of the scrubbers, two of which are self-indicating; silica gel turns from orange to clear and Purafil from purple to brown as it becomes exhausted. Please note that “passive” zero air scrubbers will either be attached at the back of the API analyser or will be disconnected beside the analyser.

The LSO should routinely:

1. Check that at least 25% of the silica gel is still orange. If less than 25% of the silica gel is orange, please contact the CMCU: **do not change the silica gel yourself as it can give off a harmful dust.**
2. Check that at least 25% of the Purafil is still purple. If less than 25% of the Purafil is purple, note on the calibration record sheet, but continue with calibration. **Do not change the Purafil yourself as it can give off a harmful dust.**
3. Check that all connections are secure and tight.

2.2.6. Changing the Silica Gel

It is no longer necessary for the LSO to change the silica gel. This is carried out by the ESU.

2.2.7. Data Logger (where fitted)

Perform the following logger checks and record the results on the pre-calibration check list.

The logger clock is usually displayed on the screen. This clock is automatically updated to agree with the network central computer clock, each time data is collected from the site by telemetry. Check that the date and time displayed are correct to within 5 minutes of the current time GMT. Telephone the CMCU if the time displayed differs by more than 5 minutes from GMT.

Note: The network operates on GMT throughout the year and the clocks are not adjusted for BST.

2.2.8. Completion of Pre-Calibration Checks

If any of the above checks are not correct, inform the CMCU before proceeding with calibration. If all correct, proceed to the next section.

2.3. Analyser Calibration Procedure

Results of the calibration are to be taken from both the data logger display (if present) and the instrument's display and recorded on the calibration spreadsheet.

When closing the gas cylinder valves, care should be taken not to overtighten the valves on the gas regulator. Overtightening can damage the needle valve mechanism resulting in the regulator outlet valve failing to open. The main valve on the top of each cylinder should be tightly closed to avoid venting the cylinder.

In order to have a full and complete set of instructions for each analyser, instructions for opening gas cylinder valves are contained within the calibration procedure for each analyser. When all analysers are being calibrated, it might be beneficial for all cylinders to be opened at the same time, after ensuring that all outlet valves are closed. All cylinders can then be closed at the same time at the end of the calibration session.

2.4. Analyser Stability Criteria

Analysers with A and E suffix (i.e. M100A, M200E, etc.) or T prefix (i.e. T100 etc.) have a built-in stability function. This can be accessed by pressing the “TEST or TST” button on the front panel until “STABIL” or “NOx STABIL”, as appropriate, is displayed. During calibration, if this value is close to zero (< 1 ppb for NO, NOx and SO_2, and < 0.5 ppm for CO) then the analyser can be considered to have stabilised and zero/span readings can be taken.

2.4.1. CO, NOx & SO_2 Analysers

The two-point calibration of all these analysers is carried out as follows:

1. Record the instrument serial number and instrument running range on the calibration record sheet.
2. Switch CO/NOx/SO_2 to "out of service" by pressing the “CAL” button on the front panel once only. This allows calibration data to be flagged. Do not press “CAL Z” or “CAL S”. The Cal light should now turn on, the sample light will switch off and the MODE will change from “SAMPLE” to “M-P Cal”.
3. Record the instrument pre-calibration checks, as mentioned in section 2.2.
4. Where a zero air cylinder is used, ensure there is sufficient pressure and flow as appropriate to the system you are calibrating. Different sites have varying system setups. Please follow the bulleted instructions below applicable to the system you are calibrating. The pressures and flows listed below may vary based on the equipment’s age and efficiency, use settings most recently recommended by the QA/QC unit or ESU. If unsure, contact the CMCU.

- **Note: the site calibration configuration may supply zero gas to other analysers at the same time. If this is the case, perform the other zero tests at the same time. It will usually not be possible to calibrate other analysers with other gases while the zero cylinder is being used.**
- **Inline excess flowmeter**: Adjust the regulator secondary pressure to 15 psi (1bar), as read from left hand dial, by turning regulator primary (closest to cylinder) valve. Slowly open the regulator outlet (furthest from cylinder) valve to produce an excess flow of ~0.5 litres per minute.
- **Rack mounted or total flowmeter**: Adjust the regulator secondary pressure to 15 psi (1bar), as read from left hand dial, by turning regulator primary (closest to cylinder) valve. By gradually turning the CO/NOx/SO_2 calibration gas control valve inside the hut, adjust the flow through the flow meter to produce 2.0 (±0.1) litres per minute.
- **Inline stainless steel critical orifice**: Adjust the regulator secondary pressure to the recommended setting advised by QA/QC (nominally 30 psi (2bar)), as read from left hand dial, by turning regulator primary (closest to cylinder) valve.
- **Inline Teflon critical orifice**: Adjust the regulator secondary pressure to the recommended setting advised by QA/QC (nominally 15 psi (1bar)), as read from left hand dial, by turning regulator primary (closest to cylinder) valve.
- **Selectable flow regulator**: Adjust the dial to 2 litre per minute.

5. Where a zero air scrubber is used, there will be a small zero air scrubber located at the back of the API CO/NOx/SO_2 analyser. Press “EXIT” on the analyser front

display, this will put the analyser back into “SAMPLE” mode, and press “CALZ”, this will change the mode to “ZERO-CAL M”.

6. Allow the analyser to stabilise on zero air for a period of **at least** 10 minutes, it is suggested that the LSO check the stability values prior to putting back in 'service' mode. For **NOx and SO_2** verify that stabilisation has occurred by checking the “Stab” value is less than 1ppb
7. Record three consecutive CO/ NOx, NO and NO_2 / SO_2 readings from the data logger and/ or instrument display, i.e. after 3 ten-second updates on the data logger display. If the zero calibration was performed using CALZ as described in 5. above, press “EXIT”, then “CAL” to return the analyser to the “MP-CAL” mode
8. If applicable, switch off the zero air generator/cylinder (see step 10 for cylinder) and disconnect it from the zero air port (if necessary). Replace the cap on the zero air inlet and tighten until finger-tight. Then with a spanner, tighten further by one quarter turn.
9. Open either the CO in air cylinder main valve/ NO in nitrogen cylinder main valve or the SO_2 in air cylinder main valve by turning it fully anticlockwise. (**Note: cylinder valves should not be left fully open due to the risk of jamming open. They should be opened fully but then turned back 1/4 of a turn to prevent this**.) Read cylinder pressure from the dial closest to the cylinder and cylinder number from barcode on the BOC cylinder neck (see step 12) and enter these on the calibration record. Do not attempt to use the cylinder if the pressure indicated is less than 300 psi (20bar). In this event contact CMCU.
10. Adjust the gas flow using appropriate instructions from step 4.
11. Allow the analyser to stabilise on this sample for a period of at least 10 minutes. Ensure that the flow measured by the flow meter (if applicable) remains stable during this time. Adjust the flow, if necessary, to 1.5 litre per minute. For NOx and SO_2 verify that stabilisation has taken place by checking the “STABIL” value is less than 1ppb.
12. Follow the instructions below for the relevant pollutant. Please note: the individual readings should be taken 1 minute apart:

- **CO** - Record three consecutive CO readings from the data logger and/ or instrument display. If fitted, turn the CO inlet selection valve from “CO WEEKLY ZERO / SPAN” to “CO AMBIENT”.
- **NOx** - Record three sets of NOx, NO and NO_2 readings from the data logger and instrument display. The readings should be taken as close as possible to each other but need not be in consecutive 10 second periods if this is not possible. The NO signal should be similar to the NOx signal and show a large deflection from the zero point previously obtained. The NO_2 signal should be close to zero. (Ideally < 10ppb but this may not always be achievable - it will depend on the instrument's channel scaling and baseline response, and on the calibration gas.)
- **SO_2** - Record three consecutive SO_2 readings from the data logger and/ or instrument display. The signal should show a large deflection from the zero point previously obtained.

13. In the following order, fully close the CO/NO/SO_2 calibration gas control valve (inside the hut), the regulator outlet valve (do not overtighten), the main cylinder valve (tightly) and the primary regulator valve. This traps gas in the regulator, thus ensuring a positive pressure and hence, no ingress of ambient air. Note that the pressure regulator dials should remain at their previous setting, if a marked

decrease is observed there is a leak in the system, and the CMCU should be informed

14. By comparing with previous calibration results obtained from the calibration just performed, satisfy yourself that the calibration has proceeded successfully. The zero value should not differ by more than ~0.25 ppm for CO or ~4 ppb for NO & SO_2 from the previous calibration. The span calibration value should not differ by more than 5% from that obtained during the previous calibration. If in doubt, repeat the relevant procedure. If the results of this are also unsatisfactory, contact the CMCU.
15. Change the CO/NOx/SO_2 sample inlet filter, following the instructions given in section 2.5
16. Record the instrument post-calibration checks, as mentioned in section 2.2
17. Switch the CO/NOx/SO_2 back into service by pressing the “Exit” button. The mode will return to "sample" and the sample light will begin to flash until the end of the current 15-minute mean.

2.4.2. CO, NOx & SO_2 Analysers with NumaView Software

The two-point calibration of all these analysers with NumaView software is very similar to the procedure outlined in section 2.4.1. However there have been significant changes to the layout and operation of the API instrument with NumaView software. Therefore, the full calibration procedure for instruments fitted with NumaView has been outlined as follows:

1. Record the instrument serial number and instrument running range on the calibration record sheet.
2. Switch CO/NOx/ SO_2 to "out of service" by pressing the “Maint Mode” button on the front panel from "off" to "on". This allows calibration data to be flagged. If the "Maint Mode" button cannot be seen on the main screen, navigate to "Setup", followed by "VARS", and then you can select "Main Mode" and change from "false" to "true". The icon in the bottom-right of the screen should now change from a green circle to a yellow warning triangle. The analyser mode will still show "SAMPLE" at this time.
3. Record the instrument pre-calibration checks, as mentioned in section 2.2.
4. Where a zero air cylinder is used, the analyser needs to be put into "M-P" calibration mode before running the cylinder. To do this, navigate to "calibration", then press "M-P" and press "Start" as shown in Figure 9. The analyser is now ready for the zero cylinder calibration. Ensure there is sufficient pressure and flow as appropriate to the system you are calibrating. Different sites have varying system setups. Please follow the bulleted instructions below applicable to the system you are calibrating. The pressures and flows listed below may vary based on the equipment’s age and efficiency, use settings most recently recommended by the QA/QC Unit or ESU. If unsure, contact the CMCU.

- **Note: the site calibration configuration may supply zero gas to other analysers at the same time. If this is the case, perform the other zero tests at the same time. It will usually not be possible to calibrate other analysers with other gases while the zero cylinder is being used.**

- **Inline excess flowmeter**: Adjust the regulator secondary pressure to 15 psi (1bar), as read from left hand dial, by turning regulator primary (closest to cylinder) valve. Slowly open the regulator outlet (furthest from cylinder) valve to produce an excess flow of ~0.5 litres per minute.
- **Rack mounted or total flowmeter**: Adjust the regulator secondary pressure to 15 psi (1bar), as read from left hand dial, by turning regulator primary (closest to cylinder) valve. By gradually turning the CO/NOx/SO_2 calibration gas control valve inside the hut, adjust the flow through the flow meter to produce 2.0 (±0.1) litres per minute.
- **Inline stainless steel critical orifice**: Adjust the regulator secondary pressure to the recommended setting advised by QA/QC (nominally 30 psi (2bar)), as read from left hand dial, by turning regulator primary (closest to cylinder) valve.
- **Inline Teflon critical orifice**: Adjust the regulator secondary pressure to the recommended setting advised by QA/QC (nominally 15 psi (1bar)), as read from left hand dial, by turning regulator primary (closest to cylinder) valve.
- **Selectable flow regulator**: Adjust the dial to 2 litre per minute.

5. Where a zero air scrubber is used, there will be a small zero air scrubber located at the back of the API CO/NOx/ SO_2 analyser. With "Maint Mode" still activated, navigate to "calibration", then press "Zero" followed by "Start" as shown in Figure 10. This will change the sample mode from "SAMPLE" to “ZERO-CAL M”.
6. Allow the analyser to stabilise on zero air for a period of **at least** 10 minutes, it is suggested that the LSO check the stability values prior to putting back in 'service' mode. For **NOx and SO_2** verify that stabilisation has occurred by checking the “Stab” value is less than 1ppb.
7. Record three consecutive CO/ NOx, NO and NO_2 / SO_2 readings from the data logger and/ or instrument display, i.e. after three ten-second updates on the data logger display. If the zero calibration was performed using a scrubber as described in 5. above, press “Stop” in "zero" mode to finish the zero calibration.
8. If applicable, switch off the zero air generator/cylinder (see step 10 for cylinder) and disconnect it from the zero air port (if necessary). Replace the cap on the zero air inlet and tighten until finger-tight. Then with a spanner, tighten further by one quarter turn. If the zero calibration was performed using a cylinder as described in 4. above, press “Stop” in "MP" mode to finish the zero calibration.
9. Before beginning the span calibration, confirm the analyser is still in maintenance mode. Then, put the analyser into MP-cal mode by pressing "MP" in the calibration menu, followed by "Start". The analyser is now ready for the injection of span gas into the system. Open either the CO in air cylinder main valve/ NO in nitrogen cylinder main valve or the SO2 in air cylinder main valve by turning it fully anticlockwise. (**Note: cylinder valves should not be left fully open due to the risk of jamming open. They should be opened fully but then turned back 1/4 of a turn to prevent this**.) Read cylinder pressure from the dial closest to the cylinder and cylinder number from barcode on the BOC cylinder neck (see step 12) and enter these on the calibration record. Do not attempt to use the cylinder if the pressure indicated is less than 300 psi (20bar). In this event contact CMCU.
10. Adjust the gas flow using appropriate instructions from step 4.
11. Allow the analyser to stabilise on this sample for a period of at least 10 minutes. Ensure that the flow measured by the flow meter (if applicable) remains stable during this time. Adjust the flow, if necessary, to 1.5 litre per minute. For NOx and

SO_2 verify that stabilisation has taken place by checking the “STABIL” value is less than 1ppb.

12. Follow the instructions below for the relevant pollutant. Please note: the individual readings should be taken 1 minute apart:

- **CO** - Record three consecutive CO readings from the data logger and/ or instrument display. If fitted, turn the CO inlet selection valve from “CO WEEKLY ZERO / SPAN” to “CO AMBIENT”.
- **NOx** - Record three sets of NOx, NO and NO_2 readings from the data logger and instrument display. The readings should be taken as close as possible to each other but need not be in consecutive 10 sec periods if this is not possible. The NO signal should be similar to the NOx signal and show a large deflection from the zero point previously obtained. The NO_2 signal should be close to zero. (Ideally < 10ppb but this may not always be achievable - it will depend on the instrument's channel scaling and baseline response, and on the calibration gas.)
- **SO_2** - Record three consecutive SO_2 readings from the data logger and/ or instrument display. The signal should show a large deflection from the zero point previously obtained.

13. In the following order, fully close the CO/NO/ SO_2 calibration gas control valve (inside the hut), the regulator outlet valve (do not overtighten), the main cylinder valve (tightly) and the primary regulator valve. This traps gas in the regulator, thus ensuring a positive pressure and hence, no ingress of ambient air. Note that the pressure regulator dials should remain at their previous setting, if a marked decrease is observed there is a leak in the system, and the CMCU should be informed.
14. By comparing with previous calibration results obtained from the calibration just performed, satisfy yourself that the calibration has proceeded successfully. The zero value should not differ by more than ~0.25 ppm for CO or ~4 ppb for NO & SO_2 from the previous calibration. The span calibration value should not differ by more than 5% from that obtained during the previous calibration. If in doubt, repeat the relevant procedure. If the results of this are also unsatisfactory, contact the CMCU.
15. Change the CO/NOx/ SO_2 sample inlet filter, following the instructions given in section 2.5.
16. Record the instrument post-calibration checks, as mentioned in section 2.2
17. Switch the CO/NOx/ SO_2 back into service by pressing the “stop” button in "MP" of the calibration menu. Then press "home" and switch the "Maint Mode" to off. If the "Maint Mode" button cannot be seen on the main screen, navigate to "Setup", followed by "VARS", and then you can select "Main Mode" and change from "true" to "false". The icon in the bottom-right of the screen should now change from a yellow warning triangle to a green circle. The analyser mode will now show "SAMPLE".

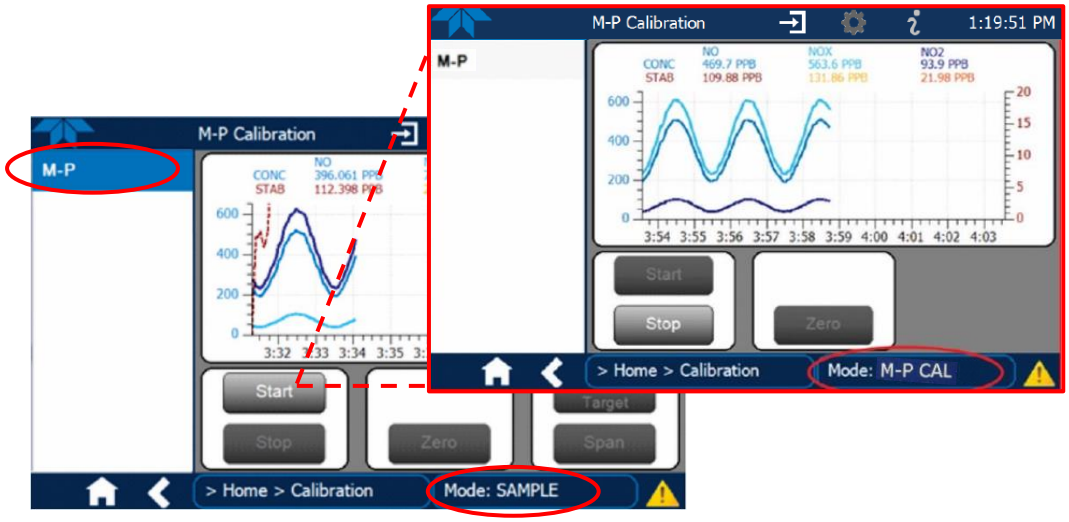


Figure 9 - Starting zero or span calibration with cylinder on API T200 with NumaView. ©Teledyne API

Figure 10 - Starting zero calibration with a scrubber on API T200 with NumaView. ©Teledyne API

2.4.3. Ozone Analyser

There is no requirement for the LSO to perform calibration of the ozone analyser during each routine site visit. The analyser performs an internal zero/span daily, and this is adequate for data ratification purposes. Calibrations for scaling ratified data are carried out every three months by the QA/QC Unit using a photometer.

1. Record the instrument number on the calibration record sheet.
2. Switch the O_3 analyser out of service by pressing CAL only once.
3. Record the instrument pre-calibration checks, as mentioned in section 2.2.
4. If directed by the CMCU, change the O_3 analyser sample inlet filter, following the instructions given in section 2.5.
5. Switch the O_3 analyser back into service by pressing EXIT.

2.4.4. Ozone Analyser with NumaView Software

As stated in section 2.4.3, LSOs are not required to calibrate ozone analysers, and are only required to change the filters. The process for changing the filter on an API ozone analyser with NumaView is as follows:

1. Record the instrument number on the calibration record sheet.
2. Switch the O_3 analyser out of service by switching "Maint Mode" from "off" to "on" from the home screen. If the "Maint Mode" button cannot be seen on the main screen, navigate to "Setup", followed by "VARS", and then you can select "Main Mode" and change from "false" to "true".
3. Record the instrument pre-calibration checks, as mentioned in section 2.2
4. If directed by the CMCU, change the O_3 analyser sample inlet filter, following the instructions given in section 2.5
5. Switch the O_3 analyser back into service by switching "Maint Mode" from "on" to "off" from the home screen. If the "Maint Mode" button cannot be seen on the main screen, navigate to "Setup", followed by "VARS", and then you can select "Main Mode" and change from "true" to "false".

2.5. Changing Analyser Sample Inlet Filters

The API analyser sample inlet filters will be changed after every calibration visit – unless otherwise discussed with the CMCU. In the event of a filter appearing badly soiled or showing signs of water ingress, the site operator should inform the CMCU. Most API analysers have the filter mounted inside the front panel, which hinges down to allow access. The components of the analyser filter housing can be seen in Figure 11. Some API-equipped sites have the sample filter holder mounted on the front panel of the instrument rack.

Detailed instructions for sample inlet filter changing (panel-mounted holder):

1. Unscrew the two brass nuts on filter holder.
2. Lift top cover of filter holder off bottom section.
3. Remove "O" ring and used filter.
4. Inspect filter for signs of excessive soiling or water ingress and inspect O-ring.
5. Take clean filter from box using the tweezers supplied and insert into base of filter holder. (If tweezers are missing, contact CMCU for a replacement).
6. Please note, filters are supplied with protective backing papers between them. Be sure to take the filter, not the backing paper (which should be discarded).
7. Replace "O" ring in filter holder.
8. Replace top of filter holder and secure with brass nuts. The brass nuts should be hand tightened.

Detailed instructions for sample inlet filter changing (internal-mounted holder):

9. Pull down hinged analyser front panel.

10. Unscrew the black metal ring anti-clockwise and put aside.
11. Lift the glass filter cover off and put aside. The black rubber O-ring may come away with the glass; if so, separate the two then inspect the O-ring for damage and replace it in the slot in the holder.
12. Remove the white plastic O-ring and put aside.
13. Inspect filter for signs of excessive soiling or water ingress and remove.
14. Take clean filter from box using the tweezers supplied and insert into base of filter holder.
15. Replace white plastic O-ring on top of the filter ensuring the notches are on the top side.
16. Once the new filter, white plastic O-ring and black rubber O-ring are in place; fit the glass filter cover back on, ensuring that any severe chips are on the top side.
17. Screw on the black metal ring clockwise hand tight and close the front panel.

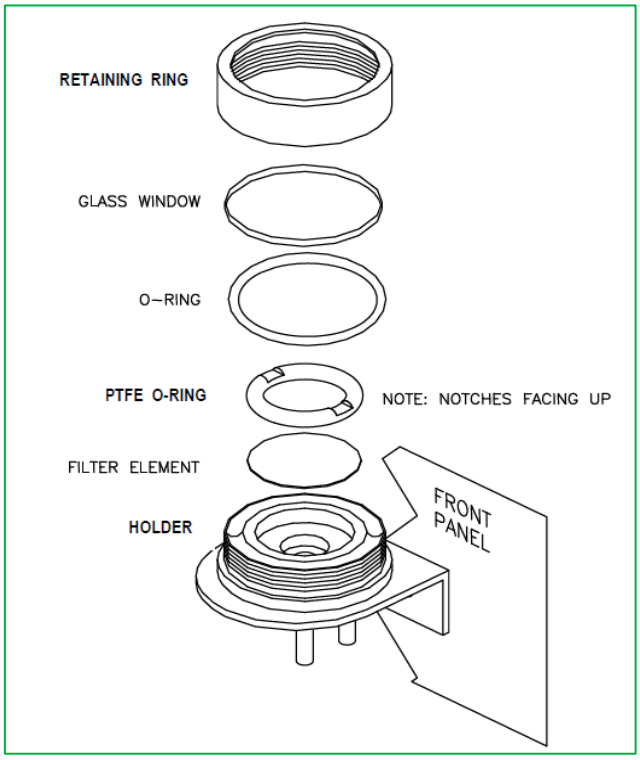


Figure 11 - Diagram of API filter housing components. ©Teledyne API

2.6. Post Calibration Checks

The operator must critically review the discrete measurements taken during calibration and comment on any unusual or suspect results or occurrences such as excessive noise or cyclic response changes. This is to alert network managers to any instrumentation faults which may be masked in averaged data. In addition, the post-calibration check sheet must be completed as follows:

1. All checks detailed in section 2.2 must now be repeated and recorded on the post-calibration check sheet as follows:

- CO Analyser
- NOx Analyser
- SO_2 Analyser
- Ozone Analyser
- PM Analyser (not required if not attended to at the visit)
- Air Sampling Manifold (not required if pre-calibration was OK)
- Modem

2. Complete the final check section of the post-calibration check sheet.
3. Complete the calibration end time.
4. Ensure all analysers are back in service.
5. Please refer to the Leaving Site Guidance for addition checks to carry out

3. Beta Attenuation Monitor Model 1020 - Site Operational Procedures

3.1. Introduction

The sequence of procedures that an LSO will have to undertake for a BAM 1020 at every visit are as follows:

1. Initial diagnostic pre-checks on arrival.
2. Leak test. If the BAM passes this leak test, no further action is required.
3. If the BAM fails the leak test, the nozzle should be cleaned.
4. Repeat the leak test: if the BAM passes this time, no further action is required.
5. If the BAM fails the second leak test after cleaning, repeat the nozzle cleaning.
6. Repeat the leak test. If it fails again after cleaning the nozzle twice, inform the CMCU to initiate an ESU call-out.

Other tasks that the LSO will have to do on a regular basis are

- Cleaning of Inlet Head
- Cleaning the collector assembly
- Cleaning the acceleration chamber
- Cleaning the nozzle and vane
- Cleaning the Sharp Cut Cyclone (SCC)
- Filter Tape installation
- A second leak test after cleaning components and/or after tape replacement
- LSO call out faults

3.2. Health and Safety Considerations for the Met One BAM

The BAM contains a small, sealed radioactive source of beta radiation (carbon 14, or ^{14}C). This is the source of the beta particles used in the measurement process. Carbon 14 is a radioactive material and is therefore dangerous if it gets inside the body (if swallowed, inhaled or absorbed through the skin). That is not a risk here, because the source is sealed and safely contained inside the BAM. For this reason, you must not attempt to access, modify or remove the BAM's sealed beta source for any reason.

It has been found that, when the door of the BAM's case is open, a detectable amount of beta radiation may emerge from the BAM, through the slit between the tape and the source, probably having been scattered by the tape and the material on it.

Beta radiation consists of fast-moving electrons. The beta radiation from ^{14}C is of relatively low energy; it cannot penetrate through the case of the BAM, can only travel around 22 cm through air, and – most importantly - cannot penetrate even the outer layer of your skin.

However, it is known that direct exposure of the lens of the eye to beta radiation can increase the risk of developing the eye condition of cataracts (where the lens becomes opaque). This is a known risk for people whose eyes are directly and frequently exposed to beta radiation (such as health professionals regularly carrying out certain medical imaging procedures), and there exists an occupational exposure limit specifically for the lens of the eye.

When carrying out BAM maintenance tasks such as nozzle cleaning or tape changing, the operator will have the door open and may have their eyes close to the tape slit. While it is currently our understanding that any risk is very small, (because of the low energy of the beta radiation, and because such tasks are infrequent and do not take long), as a precaution we are recommending that safety glasses are worn when carrying out such tasks. Beta particles will not be able to pass through the plastic material they are made of.

We are therefore making the following recommendations to Local Site Operators and others who carry out work on a BAM 1020 that involves opening its door:

1. We remind you not to attempt to access, modify or remove the BAM's sealed beta source for any reason.
2. It is recommended to wear safety glasses when working on the BAM 1020 with its door open. As well as offering more than adequate protection for the extremely small risk of any long-term eye damage from exposure to radiation the beta source, this will also minimise any other risk of eye injury from other maintenance activities such as cleaning nozzles.

Safety glasses are already provided at all AURN monitoring stations that have BAMs (because they are necessary for other work at the sites). We would like to reassure all LSOs that BAMs are a safe method of measuring particulate matter and the above is an additional safety recommendation from Radiation Protection Advisors in the UK. The QAQC Unit (in their role as Health and Safety Co-ordinator) would be happy to answer any questions or concerns you may have.

3.3. BAM Main Menu and Key Board Functions

The "Main Menu" and keyboard are shown in Figure 12below, followed by a description of the keyboard functions.

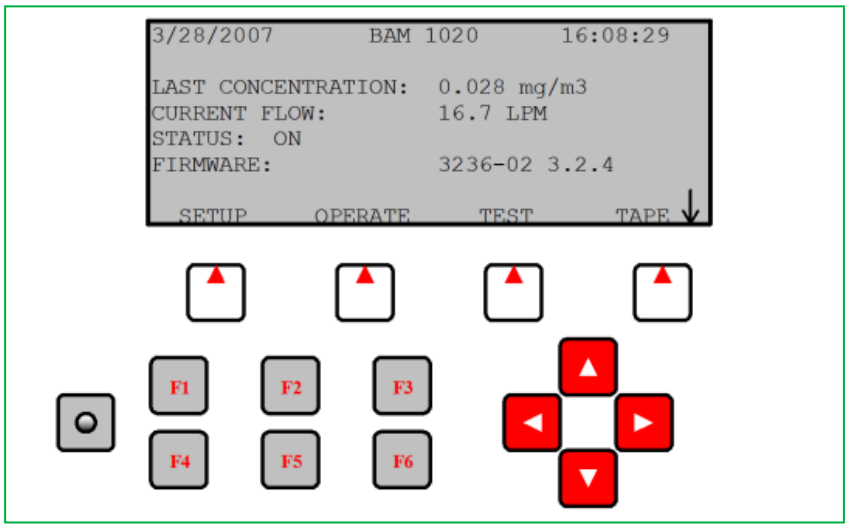


Figure 12 - Main Menu and Keyboard lay out

Soft Keys:

Directly beneath the display are four white buttons called “soft-keys” or “hot-keys”. These are dynamic keys whose function changes in response to a menu option displayed directly above each key on the bottom row of the display. Whatever menu option is displayed above one of these keys is the function which that key will perform in that particular menu. These are used throughout the entire menu system for a wide variety of functions. For example, changes/updates made within a menu are usually not saved unless a SAVE soft-key is pressed. EXIT is also another common soft-key function.

Arrow (Cursor) Keys:

The four red arrow keys are used to scroll up, down, left, and right to navigate in the menu system, and to select items or change fields on the screen. The arrow keys are also often used to change parameters or increment/decrement values in the menu system.

Contrast Key:

The key with a circular symbol on it is for adjusting the light/dark contrast on the LCD display. Press and hold the key until the desired contrast is achieved. It is possible to over-adjust the contrast and make the entire display completely blank or completely dark, so be careful to set it to a visible level or it may appear that the unit is not operating.

Function Keys F1 to F6:

The function keys serve as shortcuts to commonly used menu screens and can be safely pressed at almost any time without interrupting the sample cycle. The F keys are only functional from the main menu screen or for entering passwords. The factory default password is F1, F2, F3, F4.

F1 Current:

This key is a shortcut to the OPERATE > INST screen, used to display the instantaneous data values that are being measured by the BAM 1020. The F1 key can be used without interrupting a sample cycle.

F2 Average:

This key is a shortcut to the OPERATE > AVERAGE screen, used to display the latest average of the data recorded by the BAM-1020. The F2 key can be used without interrupting a sample cycle.

F3 Error Recall:

This key allows the user to view the errors logged by the BAM 1020. The errors are sorted by date. The last 12 days which contain error records are available, and up to the last 100 errors can be viewed. The F3 key can be used without interrupting a sample cycle.

F4 Data Recall:

This key allows the user to view the data stored in the BAM 1020, including concentrations, flow, and all six external channels. The data are sorted by date, and the user can scroll through the data hour-by-hour using the soft-keys. Only the last

12 days which contain data records are available in this menu. The F4 key can be used without interrupting a sample cycle.

F5 Transfer Module:

This key is used to copy the memory contents to an optional transfer storage module to retrieve the digital data without a computer. This function is rarely used. Met One recommends downloading the data with a laptop, computer or modem connection.

F6 (Blank):

This key is not assigned a data function.

3.4. Preparation

1. Upon arrival at the site, check the pollutant levels on the front panel of each analyser to see if an episode is occurring i.e. PM_{10} levels during the last hour are about 100 µg m^{-3}. (*Note: the hourly mean 'trigger values' we use in this situation to determine whether an episode may be occurring are different from the 'high' threshold of the Daily Air Quality Index*).
2. Using the most up to date electronic calibration sheets provided enter Site, Date and Operator and Start Time.
3. Ensure the manufacturer's Operational Manual is to hand and follow the instructions carefully.
4. Ensure that the site toolkit (if provided) is complete.

If "out of service" switches are not fitted at the site, the CMCU should be telephoned upon arrival. This will allow them to ensure that calibration data is not disseminated as ambient data.

3.5. Pre- and Post- Calibration Checks

In this section, a number of initial visible checks are made on the equipment. Complete all the checks for all the analysers and ancillary equipment. When all checks are complete, inform the CMCU if any are not correct.

To obtain the required information use the various keypad functions on the monitor front panel (i.e. soft keys and Arrow keys).

If any of the above checks are not correct, inform the CMCU before proceeding.

3.6. Modem (where fitted)

Check that the light on the modem is flashing and all connections are secure. Record on the pre-calibration checklist provided.

3.7. Leak Test Procedure

The LSO should carry out a leak check on the BAM **during every routine visit** whether or not the tape needs to be replaced. The CMCU will provide each LSO with a leak test valve, which should be kept at the site along with the HEPA filter used for zero tests.

Leak tests are needed in the following situations:

1. An 'as found' leak test, carried out at each routine visit before carrying out any cleaning or maintenance.

2. A second leak test after cleaning the nozzle and vane, and/or changing the tape if necessary.
3. Before and after a zero test is carried out using a HEPA filter. The QA/QC Unit will usually put the HEPA filter on (at routine QA/QC audits): the LSO will often be responsible for removing it – and then carrying out the leak test.

Leaks in a BAM may occur due to misalignment of the inlet, or burrs on the tape gripping mechanism. Both require intervention by the ESU: however, in order for the ESU to be able to correctly diagnose these problems, the LSO needs to adhere to the above.

The following leak check procedure is adapted from the manufacturer's manual *(BAM 1020 Particulate Monitor Operation Manual BAM 1020-9800 Rev K*) with permission of the instrument's UK supplier:

1. Enter the TEST > TAPE menu on the BAM. This will stop the operation cycle of the unit. Press the FWD soft key to advance the tape 1 "window" to a clean, unused spot.
2. Remove the PM_{10} head from the inlet tube and install the leak test valve onto the inlet tube. If a $PM_{2.5}$ cyclone is used, install the leak check valve on top of the cyclone, since the cyclone is a possible source of leaks and should be tested. Turn the valve to the OFF position to prevent any air from entering the inlet tube.
3. Enter the TEST > PUMP menu and turn the pump on. The standard flow rate shown on the BAM display should stabilize at less than **1.0 l/min** in about 20 seconds. Record the as-found results. The 'as found' leak rate should be noted on the LSO calibration sheet. If the leak rate is below 0.8 l/min, then proceed to step 5.
4. If the leak rate is 0.8 l/min or greater, first attempt the leak check again with the $PM_{2.5}$ cyclone removed (if used). Then clean the nozzle and vane as described in section 3.11 and perform the check again. If the leak rate is 0.8 l/min or greater, then please note this on the LSO calibration sheet and inform the CMCU who will advise on the best course of action.
5. Turn the pump off and remove the leak test valve.

Having carried out the cleaning procedures below and cleaned the nozzle and changed the tape if necessary, please carry out a second leak test. This is particularly important if the tape was changed. **This is an important final step - if it does not pass this second leak test, please contact CMCU**.

Also, if a zero test is carried out, please do another leak test after removing the HEPA filter.

3.8. Cleaning the PM_{10} Head

The PM_{10} head is located on the sample inlet tube above the roof of the monitoring station. Use the ladder, with due regard to personal safety, to gain access to the monitoring station roof. Extra care should be taken if raining as the roof of the station may be slippery when wet.

The PM_{10} inlet needs to be cleaned each time the filter tape is changed to ensure optimal performance. The cleaning materials required are all provided by the ESU, and will be replenished at each six-monthly service:

- A small brush
- Lint free tissues (ordinary household tissues are not suitable as they may leave particles of debris in the system)
- Cotton buds (again, ordinary household cotton buds are not suitable: please use only the ones supplied by the ESU).
- Silicon grease

You will also need a supply of fresh clean water. This need not be distilled water: tap water is adequate.

The inlet components are to be cleaned by brushing off accumulated dust using the small brush, then wiping with damp lint-free tissues or cotton buds as appropriate and wiping dry with a lint-free tissue.

3.9. Cleaning the Collector Assembly (Monthly)

1. Clean the walls, the three tubes protruding from the collector plate, and the base of the assembly with a damp lint-free tissue. Rinse with clean, fresh tap water, and dry using a clean lint-free tissue.
2. Use damp cotton buds to clean the three tubes, base of the assembly and weep hole in the collector plate where the moisture runs out to the rain jar. Rinse with clean, fresh tap water.
3. Disconnect rain jar assembly from lower collector plate assembly. Clean inside brass tube with damp cotton buds. Rinse with clean, fresh tap water and dry with a clean cotton bud.
4. Remove the rain jar and clean. For units with a cork sealing ring inside the cap of the jar, put a *thin coating* of silicon grease on the gasket and install the jar. If the sealing gasket is neoprene, no silicon grease is required.
5. Reconnect rain jar assembly to lower collector assembly. Ensure rain jar is sitting vertically.
6. Inspect the two inlet tube O-rings for wear and inform the Management Unit if they need to be replaced. Wipe off any grease present and apply a *thin coating* of fresh silicon grease to the O-rings.
7. Clean the internal threads of the assembly with a damp lint-free tissue.

3.10. Cleaning the Acceleration Assembly (Quarterly)

1. Mark the upper and lower plates of the assembly with a pencil so that the unit can be correctly aligned on reassembly.
2. Unscrew the four Philips screws from the top plate and remove the top plate and four spacers.
3. Clean the top plate, deflector cone, insect screen, internal walls and the underside plate. Do this by first brushing accumulated dirt off them using the small brush. The components can then be wiped with a lint-free tissue dampened with clean water. Dry with a clean lint-free tissue.
4. Inspect the large diameter O-ring for wear and inform the Management Unit if they need to be replaced. Wipe any grease off with a tissue and apply a thin coating of fresh silicon grease to the O-ring and the aluminium threads.
5. Careful reassemble, using the pencil marks to align the top and bottom plates.

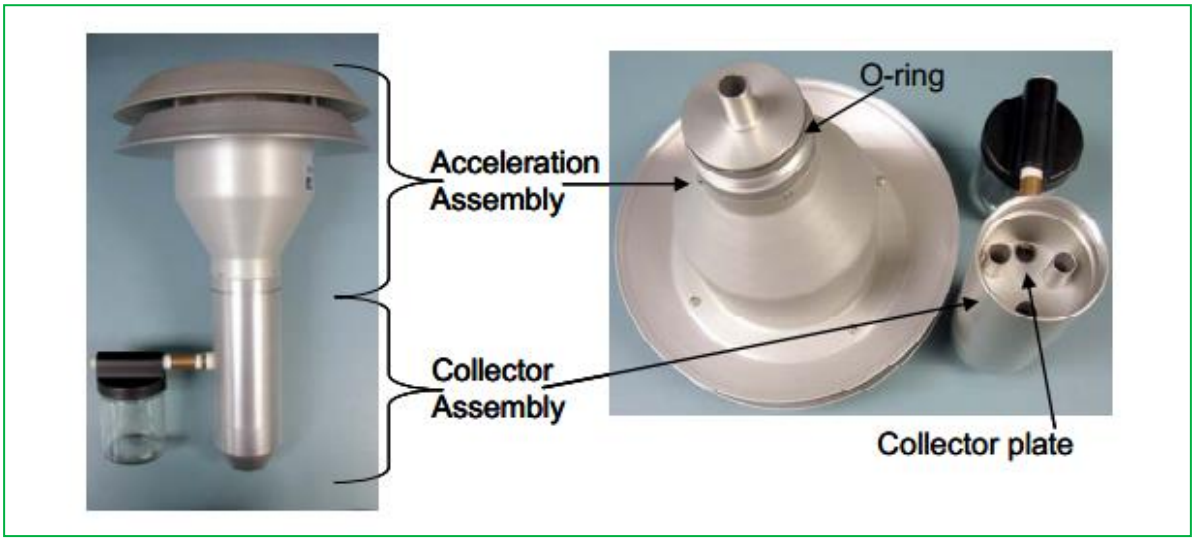


Figure 13 - The PM_{10} inlet head

3.11. Clean the Nozzle and Vane

Regularly cleaning the BAM 1020 nozzle helps prevent leaks and optimizes data accuracy. Monthly cleaning (and at every filter tape change) has generally proven adequate for this procedure, but more frequent cleaning may be necessary in some environments.

High leak values normally indicate a build-up of filter material at or near the nozzle/filter paper interface, compromising the interface “seal”, allowing air to be drawn in around the nozzle perimeter. Left uncorrected, the accuracy of the measurements can be affected and, in some situations, negative concentration values and/or low correlation with reference equipment may result.

When the nozzle is lowered, the downward pressure on these pieces of filter material can punch a hole in the tape (Figure 14, right panel). A puncture in the tape allows the beta particles to pass through without attenuation. This defect may reduce the post-sample count, and, in situations of low ambient PM concentrations, may cause this count to be larger than the pre-sample count, resulting in a negative concentration.

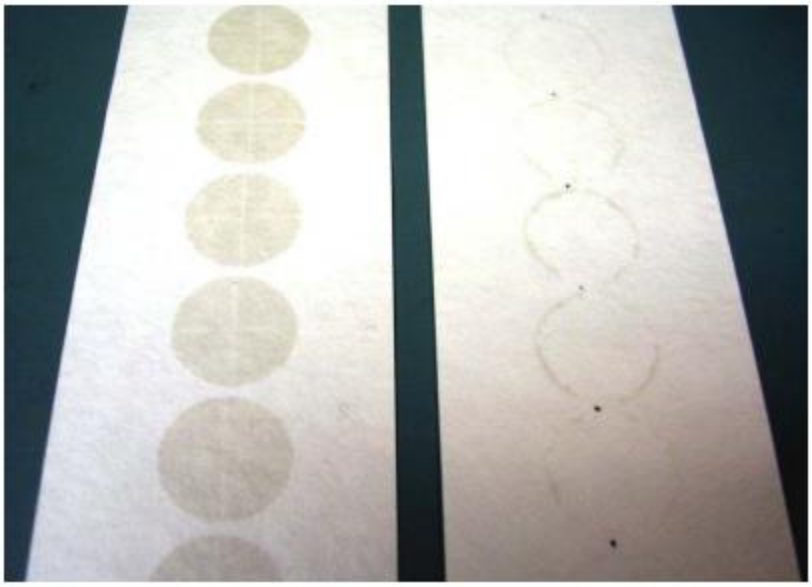


Figure 14 - Filter tape from a BAM-1020 with a clean nozzle and vane (left) and from a poorly maintained unit (right), where debris accumulation under the nozzle has punched a hole in the tape and caused the nozzle to leak, creating the halo effect. (Photo courtesy of Met One)

The following steps are needed to clean the nozzle and vane. Refer to the photos above

1. Raise the nozzle in the TEST > PUMP menu. Remove the filter tape (if installed) from the nozzle area. It is not necessary to completely remove the tape from the spools.
2. With the nozzle up, use a small flashlight to inspect the crosshair vane.
3. Clean the vane with a cotton-tipped applicator and clean, fresh tap water. Hardened deposits may have to be carefully scraped off with the wooden end of the applicator or a dental pick or similar tool.
4. Lower the nozzle in the TEST > PUMP menu. Lift the nozzle with your finger and insert another cotton swab moistened with clean fresh water between the nozzle and the vane. Let the nozzle press down onto the swab with its spring pressure (Figure 15, left panel).
5. Use your fingers to rotate the nozzle while keeping the swab in place. A few rotations should clean the nozzle lip.
6. Repeat the nozzle cleaning until the swabs come out clean. Dry the nozzle if necessary, with a clean lint-free tissue.
7. Inspect the nozzle lip and vane for any burrs which may cause leaks or tape damage.
8. *Finally, carry out a leak test.*

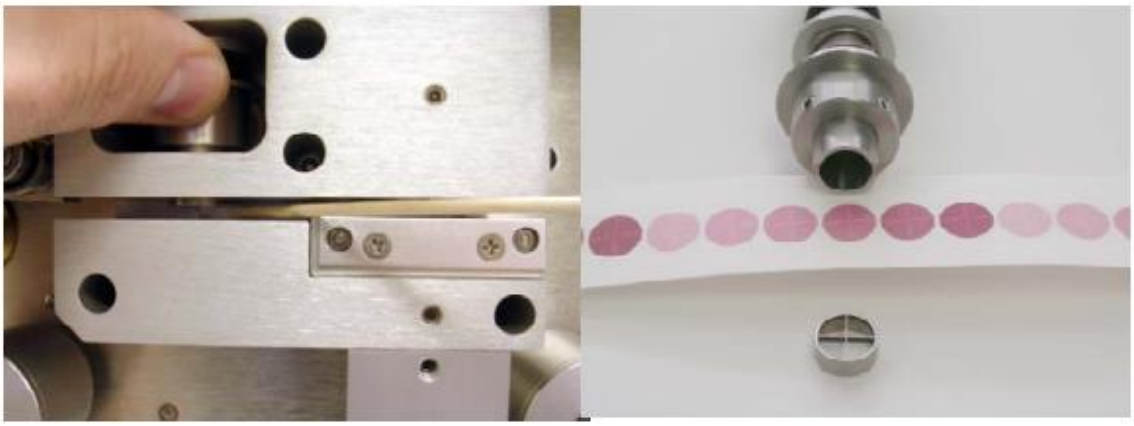


Figure 15 - A cotton-tipped applicator and clean, fresh tap water are used to clean the BAM-1020 nozzle and vane (left panel). A view of the nozzle, sampled filter tape, and filter tape support vane are shown in the right panel.

3.12. Clean Sharp Cut Cyclone (SCC) ($PM_{2.5}$ only)

The Sharp Cut Cyclone (SCC) (Figure 16) is an essential component of the inlet system. It needs to be diligently maintained or it will corrode. Disassemble and clean the SCC following these steps:

1. Remove the SCC from its installed position in the instrument.
2. Pull off the side transfer tube. If it is too tight to remove by hand, pry it off with a rigid plastic lever. Care should be taken to not damage the two O-ring seals.
3. Unscrew the top cap and the grit pot.
4. Use suitable (non-VOC-containing) wipes, or if unavailable, a dampened cloth, to remove all visible deposits.
5. These deposits are most likely to be found at the bottom of the cone (located beneath the grit pot) and inside the grit pot.
6. Inspect all O-rings for shape and integrity. If they are at all damaged or deteriorated, contact the Management Unit who will arrange for them to be replaced. Lubricate all O-rings with light grease. It is important to lubricate the transfer tube to avoid difficulty in disassembly.
7. Clean hands with a suitable wipe or similar media.
8. Assemble in reverse order and reinstall.

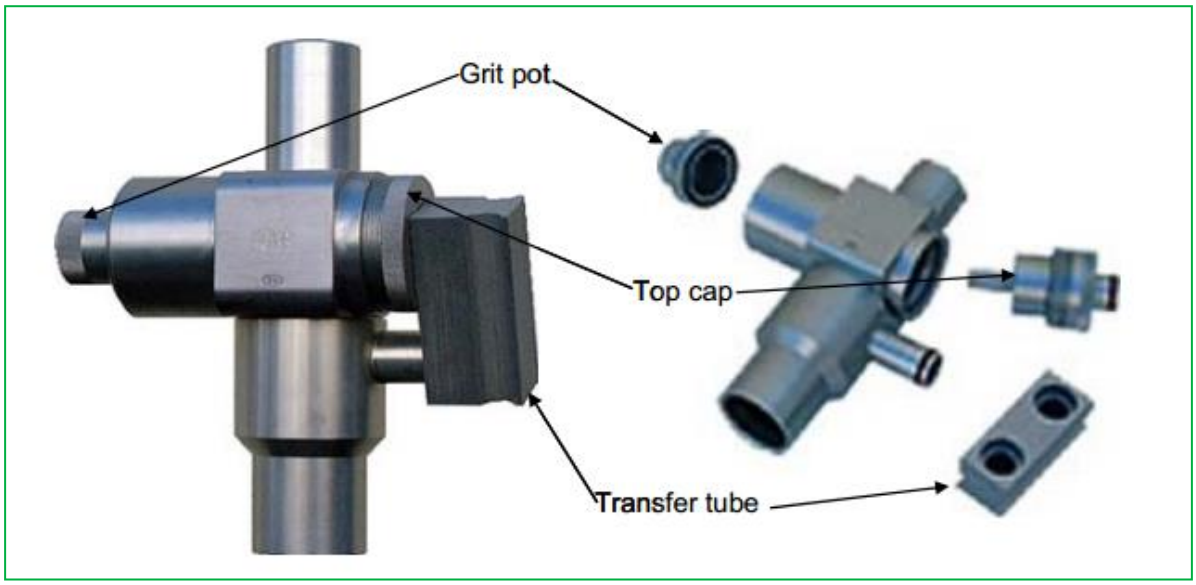


Figure 16 - $PM_{2.5}$ Sharp Cut Cyclone

3.13. Filter Tape Installation

A roll of filter tape must be loaded into the BAM-1020 for sampling. One roll of tape should last approximately two months under normal operation. It is the responsibility of the LSO to have at least one spare roll (ideally several) available to avoid interruptions in operation. If there are no spare filter tapes please inform the CMCU.

The tape should be checked at each visit and changed when it is getting near the end of the roll. **Filter tape should never be "flipped over" or re-used! This will result in measurement problems**.

To load a new roll of filter tape, follow the steps and diagram below. Gloves must be worn whilst installing new tape.

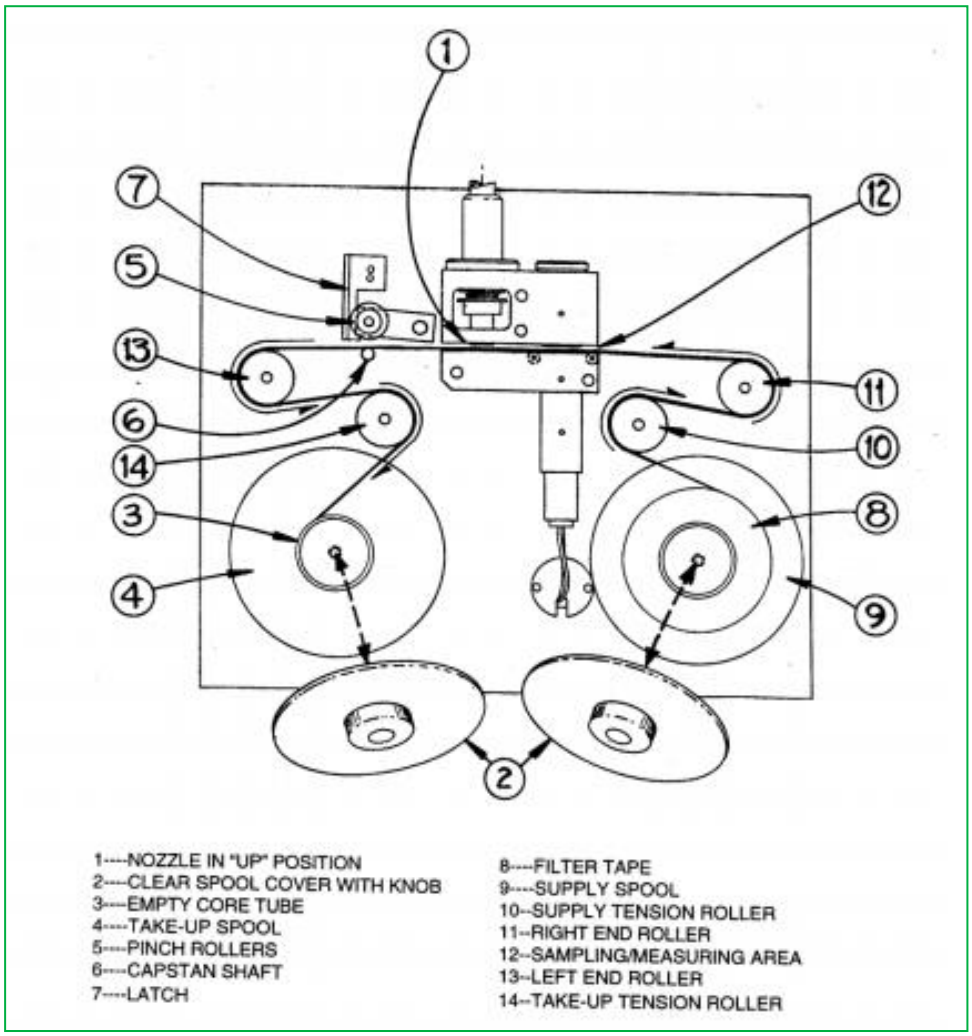


Figure 17 - Filter tape changing procedures

1. From the MAIN MENU screen, press the <TAPE> soft key to enter the TAPE menu (Note: This is not the same as the TEST > TAPE menu). If the nozzle is not in the UP position, press the <TENSION> soft-key to raise the nozzle.
2. Lift the rubber pinch roller assembly and latch it in the UP position (see Numbers 5 and 7 in Figure 17). Unscrew and remove the two clear plastic spool covers.
3. An empty core tube MUST be installed on the left (take-up) reel hub. This provides a surface for the used tape to spool-up on. Met One supplies a plastic core tube to use with the first roll of tape. After that, you can use the empty core tube left over from your last roll (right reel hub) to spool-up the new roll. Never fasten the filter tape to the aluminium hub.
4. Load the new roll of filter tape onto the right (supply) reel, and route the tape through the transport assembly as shown in Figure 17. Attach the loose end of the filter tape to the empty core tube with cellophane tape or equivalent.
5. If the tape change is a result of a tape break do not replace with entirely new spool unless it is close to being empty. Remove used filter tape from the left-hand spool and attach loose end to the empty core tube.

6. Rotate the tape roll by hand to remove excess slack, and then install the clear plastic spool covers. The covers will clamp the rolls to the hubs to prevent slipping.
7. Align the filter tape so that it is centred on all of the rollers. Newer units have score marks on the rollers to aid in visually centring the tape.
8. Unlatch and lower the pinch roller assembly onto the tape. The BAM will not function if the pinch rollers are latched up, and it has no way of automatically lowering the roller assembly!
9. Press the <TENSION> soft-key in the TAPE menu. The BAM-1020 will set the tape to the correct tension and alert you if there was an error with the process.
10. While still in the TAPE menu, press the <SELF TEST> soft key. The BAM-1020 has a built-in self-test function which automatically tests most of the tape control and flow systems of the unit. (The self-test can also be used if the operator suspects a problem with the unit.) The tests will take a couple of minutes, and the BAM-1020 will display the results of each tested item with an OK or a FAIL tag (see Figure 17). If all of the test items are OK, the status will show SELF TEST PASSED as shown in the drawing below. If any item fails, the status will show ERROR OCCURRED. If an error or Failed status occurs, address the item identified, and perform the SELF TEST again. If the problem cannot be resolved, call the CMCU.
11. Press the <EXIT> soft key to return to the main menu. The BAM will automatically begin normal sampling operations at the top of the next hour.
12. After replacing the tape, a leak test should be carried out.
13. When you leave the site, be sure to take away the old, used BAM tape that you have removed. As well as keeping the site tidy, this will prevent the possibility of it being re-installed in the BAM by mistake in the future.

3.14. BAM Error Codes

Table 3.1 below gives a list of possible BAM error codes that LSO may see when on site. Also given are actions that the LSO may carry out while on site to test the monitor. These however should only be undertaken after contacting the CMCU.

Table 3.1 - BAM 1020 Error Codes and Actions

E	Telemetry reset, indicates that the system time was reset. This may occur after a power outage. Check to see that date and time (GMT) are correct through SETUP option.
U	Telemetry fault, indicates a fault with the remote telemetry system. Check to see if telemetry connections are secure and the light on the modem is flashing.
I	Internal error. NCAR. Contact CMCU
L	Power failure; Make sure unit is on. Check power lead is not loose or damaged at back of BAM. If power has been interrupted to BAM check date and time is corrected. If not reset clock through SETUP.

R	Reference membrane stuck, membrane motor timed out without completing extension/withdrawal of membrane. Contact CMCU and or ESU
N	Nozzle stuck, nozzle motor timed out; Manually test using TEST/PUMP/Nozzle UP and DOWN. Look for deposits on nozzle lip. Clean if required
F	Flow error, flow <10 or >20 lpm; Perform manual flow audit using Test/PUMP/Pump ON. If flow is <10 lpm, check line to pump for obstructions or crimps in line. If zero flow is greater than 1 lpm, check for deposits on nozzle lip.
p	Pressure error, pressure drops more than 300 mm Hg during the cycle or the reference mass flow deviates more than ±5%; Check line to pump for breaks in line and leaks in inlet and pump connections to instrument.
D	Deviant membrane density indicates that the reference membrane was out of limits by more than ±3%; NCAR. Contact CMCU
C	Count error, any count is <10000. NCAR. Contact CMCU
T	Tape error, any tape breakage or tape motor movement error; Check that there is tape and install new roll if needed, check for tears in tape and re-tape if needed, advance tape several positions and watch movement using Test/PUMP/Tape Advance.

4. Ecotech Serinus - Site Operational Procedures

4.1. Preparation

1. Upon arrival at the site, check the pollutant levels on the front panel of each analyser to see if an episode is occurring i.e. pollution levels during the last hour are above, or close toe, the trigger values as discussed in Table 5.1 in Part A of the LSO Manual (O_3 >~70 ppb, NO_2 >~75 ppb, SO_2 >~90 ppb and CO >~5 ppm). If an episode is occurring telephone the CMCU before proceeding any further.
2. Take a new set of check and calibration sheets and enter Site, Date and Operator and Start Time.
3. Ensure the Operational Manual is to hand and follow the instructions carefully.
4. Ensure that the site toolkit (if provided) is complete.
5. Switch the analyser out of service. This can be done by either:

- Pressing the QUICK MENU button and scroll down to INSTRUMENT, press SELECT once. Scroll down from ONLINE to IN MAINTENANCE. Press the ACCEPT button to confirm your choice. The analyser should now display INSTRUMENT IN MAINTENANCE. Press BACK until you return to the main screen.
- Pressing the MAIN MENU button and scroll down to SERVICE MENU. To enter the Service Menu, press OPEN. Scroll down to INSTRUMENT and press SELECT once. Scroll down from ONLINE to IN MAINTENANCE. Press the ACCEPT button to confirm your choice. The analyser should now display INSTRUMENT IN MAINTENANCE. Press BACK until you return to the main screen. At the end of the calibration analysers can be put back into service by reversing the above steps.

If “out of service switches” or a similar mechanism for flagging calibration data are not present on the analyser or at the site, the CMCU should be telephoned upon arrival. This will allow them to ensure that calibration data is not disseminated as ambient data.

Calibration results should be recorded on a dedicated electronic spreadsheet and sent to the CMCU and QA/QC unit. The electronic sheet should preferentially be used on site, to minimise the risk of errors, but if suitable facilities are not available, the results can be recorded on paper for subsequent transfer to the spreadsheet in the office.

4.2. Pre-Calibration Checks

In this section, a number of initial visible checks are made on the equipment. Some checks require a tick and some require a value to be recorded on the pre-calibration sheet. Complete all the checks for all the analysers and ancillary equipment. When all checks are complete, inform the CMCU if any are not correct, before proceeding with the calibration.

4.2.1. NOx & SO_2 Analyser

The Ecotech Serinus 40 NOx analyser and the Ecotech Serinus 50 SO_2 analyser have displays which in normal operation shows either the current NOx, NO_2 and NO concentrations, the average NOx, NO_2 and NO concentrations or the current SO_2 concentration, the average SO_2 concentration (model dependant), the operation mode of the analyser, time of day, date, quick menu and main menu options. This display is termed the 'primary screen'. If a failure condition is detected, fault lights will be displayed to the left of the 'primary screen'. The entire list of failures is displayed on the STATUS MENU screen, highlighted error.

1. Check the display and record the current readings and the current time on the pre-calibration checklist. Telephone the CMCU if the time displayed differs by more than 5 minutes from Greenwich Mean Time.
2. If a failure condition is detected, fault lights will be displayed to the left of the 'primary screen'. If there are any faults present, the ANALYSER STATE MENU should be checked. To access this menu, press the MAIN MENU button and scroll down to ANALYSER STATE MENU. To enter the ANALYSER STATE MENU, press OPEN. For a list of all faults, scroll to STATUS MENU and press OPEN. A full list off all main components will be displayed. Each component will either be highlighted as pass or error. Note down any components which have highlighted errors. To return to the primary screen press the BACK button.
3. Access to the analyser's internal parameters from the primary screen is press the MAIN MENU button option. Using the arrow keys move the cursor to the ANALYSER STATE MENU option and then press OPEN. Note the values of the parameters on the pre-calibration checklist from the Temperature, Pressure & Flow and Voltage menus. To return to the primary screen press BACK.

4.2.2. Air Sampling Manifold (where fitted)

Record the following checks on the pre calibration checklist.

Check that the sample manifold is intact and shows no sign of possible leakage.

Check that the blower motor is operating by listening and feeling for vibration on the motor housing.

Check that the instrument sample inlet tubes are connected to the manifold and the sample inlet port at the back of the instruments and that these connections are secure and leak tight.

In the case of a passive manifold sampling system (i.e. tubing from an inverted funnel) check that the tubing from the funnel is connected to the sample inlet port at the back of the instruments and that these connections are secure and leak tight. Check that the end of the sample tubing is just inside the lip of the funnel. Check the sample lines for visible obstructions and kinks and that the funnel is orientated as to prevent rainwater entering the tubing.

4.2.3. Modem (where fitted)

Check that the lights on the modem are lit, the 25-way connector is secure, and the telephone line is plugged into the BT socket or the aerial is connected if a SIM card modem. Record on the pre-calibration checklist.

4.2.4. Data Logger (where fitted)

Air quality monitoring stations differ in that some record data from analysers using a discrete data logger (often recording analyser analogue output voltages), whereas other stations record data on the analysers internal logging system. Exact procedures are dependent on the type of logger present, contact the CMCU for specific instructions.

The logger clock is usually displayed on the screen. This clock is automatically updated to agree with the network central computer clock, each time data is collected from the site by telemetry. Check that the date and time displayed are correct to within five minutes of the current time GMT. Telephone the CMCU if the time displayed differs by more than five minutes from GMT. Note that the network operates on GMT throughout the year and the clocks are not adjusted for BST.

4.2.5. Zero Air Generation

If the zero air is produced using a scrubber, check the condition of the scrubber materials in the canisters, two of which are self-indicating; silica gel turns from orange to clear and Purafil from purple to brown as it becomes exhausted.

1. Check that at least 25% of the silica gel is still orange. If less than 25% of the silica gel is orange note on the calibration record sheet and contact the CMCU, but continue with calibration. **Do not change the silica gel yourself as it can give off a harmful dust.**
2. Check that at least 25% of the Purafil is still purple. If less than 25% of the Purafil is purple, note on the calibration record sheet, but continue with calibration**. Do not change the Purafil yourself as it can give off a harmful dust.**
3. Check the tubing from the canisters is secure and the lid is tight.

If a zero air cylinder gas is used, note the gas pressure in the calibration sheet.

4.2.6. Completion of Pre-Calibration Checks

If any of the above checks are not correct, inform the CMCU before proceeding with calibration. If all correct, proceed to the next section.

4.3. Analyser Calibration Procedure

Results of the calibration will be taken from either the data logger display (if fitted) or the instrument's display for recording on the calibration record sheets.

When closing the gas cylinder valves, care should be taken not to overtighten the valves on the gas regulator. Overtightening can damage the needle valve mechanism resulting in the regulator outlet valve failing to open. The main valve on the top of each cylinder should be tightly closed to avoid venting the cylinder.

In order to have a full and complete set of instructions for each analyser, instructions for opening gas cylinder valves are contained within the calibration procedure for each analyser. When all analysers are being calibrated, it might be beneficial for all cylinders to be opened at the same time, after ensuring that all outlet valves are closed. All cylinders can then be closed at the same time at the end of the calibration session.

4.3.1. Analyser Stability Criteria

The Ecotech Serinus series analysers show both instantaneous and average concentrations on the LDC display. By examining both of these, the analyser stability can be assessed. During calibration, if the values are (± 2 ppb for NO, NOx, SO_2 and O_3 and ±0.1 ppm for CO) then the analyser can be considered to have stabilised.

4.3.2. NOx & SO_2 Analysers

A two-point calibration of the analysers is undertaken during each site visit or in the rare event of an analyser adjustment. The calibration is carried out as follows:

1. Record the instrument serial number on the calibration record sheet.
2. Switch the NOx/ SO_2 “INSTRUMENT" service control to "IN MAINTENANCE". See section 4.1
3. If the zero calibration system is not permanently connected to the analyser, locate the inlet line to the NOx/ SO_2 analyser, and disconnect it from the manifold.
4. Connect the zero air to the inlet line (if not already connected) so that the analyser is now sampling air from the zero air cylinder.
5. Different sites have varying system setups. Please follow the following instructions applicable to the system you are calibrating. The pressures and flows listed below may vary based on the equipment’s age and efficiency, use settings most recently recommended by the QA/QC Unit or ESU. If unsure, contact the CMCU. **Note: the site calibration configuration may supply zero gas to other analysers at the same time. If this is the case, perform the other zero tests at the same time. It will usually not be possible to calibrate other analysers with other gases while the zero cylinder is being used**.

- **Inline excess or total flowmeter**: Adjust the regulator secondary pressure to 15 psi (1bar), as read from left hand dial, by turning regulator primary (closest to cylinder) valve. Slowly open the regulator outlet (furthest from cylinder) valve to produce an excess flow of ~0.5 litres per minute.
- **Rack mounted or total flowmeter**: Adjust the regulator secondary pressure to 15 psi (1bar), as read from left hand dial, by turning regulator primary (closest to cylinder) valve. By gradually turning the NOx/ SO_2 calibration gas control valve inside the hut, adjust the flow through the flow meter to produce 1.5 (±0.1) litres per minute.
- **Inline stainless steel critical orifice**: Adjust the regulator secondary pressure to the recommended setting advised by QA/QC (nominally 30 psi (2bar)), as read from left hand dial, by turning regulator primary (closest to cylinder) valve.
- **Inline Teflon critical orifice**: Adjust the regulator secondary pressure to the recommended setting advised by QA/QC (nominally NOx 15 psi (1 bar) and SO2 30 psi (2bar)), as read from left hand dial, by turning regulator primary (closest to cylinder) valve.
- **Selectable flow regulator**: Adjust the dial to 2 litres per minute.

6. **NOx ONLY**: Allow the analyser to stabilise on zero air for a period of not less than 10 minutes. Use the stabilisation criteria described in section 4.3.1 to confirm stabilisation has occurred.
7. Record three consecutive NOx, NO, NO_2/ SO_2 readings from the data-logger or instrument display (depending on site configuration), allow 10 seconds between

each reading. **For SO_2** Use the stabilisation criteria described in section 4.3.1 to confirm stabilisation has occurred

8. Close the zero air cylinder (see step 12) and connect the span cylinder calibration line (depending on site set up).
9. Open the NO/ SO_2 in air cylinder main valve by turning it fully anticlockwise. (**Note**: cylinder valves should not be left fully open due to the risk of jamming open. They should be opened fully but then turned back 1/4 of a turn to prevent this.) Read cylinder pressure from right hand dial and cylinder number from tag on cylinder and enter these on the calibration spreadsheet. Do not use the cylinder if the pressure indicated is less than 300 psi. In this event contact CMCU immediately.
10. Adjust the regulator secondary dial to the required pressure following step 5.
11. **FOR SO_2 ONLY**: Allow the analyser to stabilise on this sample for a period of at least 10 minutes. Ensure that the excess flow measured by the flow meter remains stable during this time. Adjust the flow, if necessary, to maintain 1.5 litre per minute.
12. Record three consecutive sets of SO_2/ NOx, NO, NO_2 readings from the data-logger or instrument display (depending on site configuration), **FOR SO_2 ONLY** - allow 10 seconds between each set of readings. The signal should show a large deflection from the zero points previously obtained. Use the stabilisation criteria described in section 4.3.1 to confirm stabilisation has occurred.
13. In the following order, fully close the regulator outlet valve (do not overtighten), the main cylinder valve (tightly) and the primary regulator valve. This traps gas in the regulator, thus ensuring a positive pressure and hence, no ingress of ambient air. Note that the pressure regulator dials should remain at their previous setting, if a marked decrease is observed there is a leak in the system, and the CMCU should be informed.
14. Check that the results from this calibration are consistent with those of the previous calibration. All zero values should not differ by more than 10 mV (~ 4 ppb) from the previous calibration. The span calibration value should not differ by more than 5% from that obtained during the previous calibration. If in doubt, repeat the relevant procedure. If the results of this are also unsatisfactory, contact the CMCU.
15. Change the NOx/ SO_2 analyser sample inlet filter, following the instructions given in part 4.4 of this section.
16. Ensure the ambient sample line is connected to the analyser and manifold.
17. Switch the NOx/ SO_2 "INSTRUMENT" service control to "ONLINE". See section 4.1, step 5.

4.4. Changing Analyser Sample Inlet Filters

The analyser sample inlet filters are situated either external to the analyser, in separate filter housing along the inlet line or inside the analyser, just behind the main buttons to the right of the front panel, and must be changed at the frequency that the LSO's attend site for routine maintenance at all sites. If a filter appears unusually dirty, inform the CMCU. In the instance that both external and internal filters are present then only change the external filter.

Detailed instructions for external sample inlet filter changing:

1. Check if external filter house is Thermo (orange cap) or Monitor Labs (black cap).
2. For Thermo use filter house tools provided to unscrew, for Monitor Labs use hands.
3. Lift the top cover of the filter holder off the bottom section.
4. Inspect filter for signs of excessive soiling. Inspect the perimeter of the filter holder for signs of wear and cross threading.
5. Removed soiled filter from the base of the filter housing and then take clean filter from box using the tweezers supplied and insert into base of filter holder. (If tweezers are missing, contact CMCU for a replacement).
6. Please note, filters are supplied with protective backing papers between them. Be sure to take the filter, not the backing paper (which should be discarded).
7. Replace top of filter holder and secure.
8. Check that Teflon lines to filter holder are well secured.

Detailed instructions for internal sample inlet filter changing:

1. Pull/ push back the top of the analyser cover, the filter holder should be situated to the right of the analyser.
2. Unscrew the front of the filter holder.
3. Lift the top cover of the filter holder off the bottom section.
4. Inspect filter for signs of excessive soiling. Inspect the perimeter of the filter holder for signs of wear and the effectiveness of the filter holder clip.
5. Removed soiled filter from the base of the filter holder and then take clean filter from box using the tweezers supplied and insert into base of filter holder.
6. Replace top of filter holder and secure.
7. Check that Teflon lines to filter holder are well secured.

4.5. Post-Calibration Checks

The operator must critically review the calibration he/she has undertaken and comment on any unusual or suspect results or occurrences. In addition, the post-calibration check sheet must be completed as follows:

All checks detailed in section 4.2 must now be repeated and recorded on the post-calibration check sheet as follows:

- CO Analyser
- NOx Analyser
- SO_2 Analyser
- Ozone Analyser
- BAM or Fidas Air Sampling Manifold (if applicable - not required if pre-calibration was OK)
- Modem
- Data Logger

1. Compare the results of the post calibration checks to the pre-calibration values. If any there are any large unexpected changes notify the CMCU
2. Complete the final check section of the post-calibration check sheet. If no 'out of service' switches are present telephone the CMCU to notify them that the calibration is complete so that they may restore data dissemination.
3. Complete the calibration end time.
4. Please refer to the Leaving Site Guidance for additional checks to carry out.

5. Horiba Equipment 370 Series - Site Operational Procedures

5.1. Preparation

1. On arrival at the site, check the pollutant levels on the front panel of each analyser to see if an episode is occurring i.e. pollution levels during the last hour are above, or close to, the trigger values as discussed in section 5.6 of Part A of the LSO Manual (O_3 >~70 ppb, NO_2 >~75 ppb, SO_2 >~90 ppb and CO >~5 ppm). If an episode is occurring, telephone the CMCU before proceeding further. Usually, the CMCU will advise delaying the calibration until the episode is over.
2. Take a new set of check and calibration spreadsheets and enter Site, Date and Operator and Start Time. This can be done directly into the spreadsheet (on a laptop), or written onto a paper printout of the spreadsheet, and entered electronically back at your office.
3. Ensure the Operational Manual is to hand and follow the instructions carefully.
4. Ensure that the site toolkit (if provided) is complete.

Calibration results should be recorded on a dedicated electronic spreadsheet and sent to the CMCU and QA/QC Unit. The electronic sheet should preferentially be used on site, to minimise the risk of errors, but if suitable facilities are not available, the results can be recorded on paper for subsequent transfer to the spreadsheet in the office.

5.2. Pre-Calibration Checks

A number of initial visual checks are made on the equipment. Complete all the checks for all the analysers and ancillary equipment. When all checks are complete, inform the CMCU if any are not correct, before proceeding with the calibration.

5.2.1. All Analysers

The APMA-370 CO analyser, APNA-370 NOx analyser, APSA-370 SO_2 analyser and the APOA-370 O_3 analyser all have a full graphic LCD touch screen (Figure 18) that, via a system of menus, can display a variety of analyser information such as pollutant concentration and system error messages. In addition, control of the calibration of the site analyser is undertaken via the system calibration menu. A screen saver function on the analyser automatically turns the screen off when no key has been pressed for 30 minutes: touching the LCD touch screen will turn the screen back on.

Figure 18 - Front panel of Horiba APMA-370 CO analyser. ©Horiba

1. In normal operation, the analyser should be displaying the current ambient CO/ NO, NO_2 and NOx/ SO_2/ O_3 concentration, the Mode field showing "MEAS", the correct time and date should be displayed on the top line of the display, and the padlock symbol showing it as locked. Check the status of the analyser display and record the various parameters on the pre-calibration checklist.
2. The alarm indicator is a small LED light situated to the bottom left of the LCD display. This should be showing green if everything is OK with the analyser. If the LED is showing red, then it is possible that a system malfunction has occurred. To view this fault, select the “alarm” button on the touch screen display and note down the fault onto the calibration sheet. To exit Alarm page, select “Close” on the display.
3. The analyser monitors several important pieces of information about its current operation. Of these, sample flow and various reaction cell parameters are of particular interest. To find these parameters you must first unlock the front screen by selecting the “Padlock” symbol situated top right of the LCD touch screen display.
4. Next select “key Unlock”, then insert the password of “1234” and select “Set”. The padlock symbol will now appear open and a spanner icon will flash showing that the analyser is out of service. The Alarm indicator will also turn red.
5. To access Pre-Calibration Parameters first select the “Menu” button, then scroll using the cursor icon to the “Maintenance” page and select “Analog Input”.
6. From here take down all appropriate parameters (stated in the pre calibration sheet) found within “Analog Output 1/2” and “Analog Output 2/2”. Select “Close” until you return to the front screen.

5.2.2. Air Sampling Manifold (where fitted)

Record the following checks on the pre-calibration checklist.

1. Check that the sample manifold is intact and shows no sign of possible leakage.
2. Check that the blower motor is operating by listening and feeling for vibration on the motor housing. If the manifold is HORIBA supplied the LED on the blower casing should be lit.
3. Check that the instrument sample inlet tubes are connected to the manifold and the sample inlet port at the back of the rack and that these connections are secure.

5.2.3. Modem (where visible/fitted)

Check that the modem is powered and record on the pre-calibration checklist.

5.2.4. Data Logger (where fitted)

Air quality monitoring stations differ. Exact procedures are dependent on the type of logger present, contact your CMCU for specific instructions.

The logger clock is usually displayed on the screen. This clock is automatically updated to agree with the network central computer clock, each time data is collected from the site by telemetry. Check that the date and time displayed are correct to within five minutes of the current time GMT. Telephone the CMCU if the time displayed differs by more than five minutes from GMT. Note that the network operates on GMT throughout the year and the clocks are not adjusted for BST.

5.3. Analyser Calibration Procedure

Results of the calibration will be taken from both the data logger display (if present) and the instrument's display and recorded on the calibration spreadsheets.

When closing the gas cylinder valves, care should be taken not to overtighten the valves on the gas regulator. Overtightening can damage the needle valve mechanism resulting in the regulator outlet valve failing to open. The main valve on the top of each cylinder should be tightly closed to avoid venting the cylinder.

In order to have a full and complete set of instructions for each analyser, instructions for opening gas cylinder valves are contained within the calibration procedure for each analyser. When all analysers are being calibrated, it might be beneficial for all cylinders to be opened at the same time, after ensuring that all outlet valves are closed. All cylinders can then be closed at the same time at the end of the calibration session.

5.3.1. CO/NOx/SO_2 Analyser

The two-point calibration of the analysers are carried out as follows:

1. Record the instrument serial number on the calibration spreadsheet.
2. The analyser is automatically flagged as "out of service" when the analyser is unlocked. This prevents calibration data being disseminated as ambient concentrations.
3. On the LCD touch screen display select “CAL”, then “MEAS”, then “ZERO”. Select “SET” to initiate the zeroing of the analyser. Ensure cylinder is open.
4. Note the concentrations down after six minutes or after the readings have stabilised (the value should not vary by more than ± 0.2 ppm for CO or ± 2 ppb for NOx & SO_2). **For NOx only** note down the instrument gain values for zero and span. These are situated under “ZERO” and “SPAN” on the Cal front page beside “SPAN CONC.”
5. Record three consecutive CO/NOx, NO, and NO_2/ SO_2 readings from the data logger (where present) and instrument display, i.e. after thirty second intervals record the value from the analyser display.

6. Before initiating the Span cycle, record the cylinder pressure from the dial closest to the cylinder head and cylinder number from tag on cylinder, and enter these on the calibration record. Do not use the cylinder if the pressure indicated is less than 300 psi. In this event contact the CMCU.
7. Initiate the Span sequence by selecting “ZERO” on the Cal front screen, then “SPAN” on the LCD touch screen display. Select “SET” to initiate SPAN sequence. Ensure the cylinder valve is open.
8. Allow the analyser to stabilise on span gas for a period of at least six minutes or after the analyser has stabilised (the value should not vary by more than ± 0.4ppm for CO or ± 2ppb for NOx & SO_2).
9. Record three consecutive CO/ NOx, NO, and NO_2/ SO_2 readings from the data logger (where present) and instrument display, i.e. after thirty-second intervals record the value from the analyser display.
10. **For NOx only** - Repeat steps 1 to 9 using the on-site NO_2 calibration cylinder (if still fitted). The NO signal should be close to that obtained while performing the zero calibration. The NOx and NO_2 signals should show the same approximate large deflection.
11. To exit calibration menu, select “SPAN”, then “MEAS”, then “SET”, then “CLOSE” to go back to front screen.
12. Check that the analyser returns to normal ambient concentrations (you can use the value you recorded during the analysers pre-calibration checks as a rough indication of ambient values, bearing in mind that at strongly traffic related sites these concentrations may vary over fairly short timescales).
13. By considering previous calibration results, satisfy yourself that the calibration has proceeded successfully. The zero value should not differ by more than ~0.25 ppm for CO or ~4ppb for NOx & SO_2, from the previous calibration. The span calibration value should not differ by more than 5% from that obtained during the previous calibration. If in doubt, repeat the relevant procedure. If the results of this are also unsatisfactory, contact the CMCU.
14. Change the CO/NOx/SO_2 sample inlet filter, following the instructions given in section 5.4.

5.3.2. Ozone Analyser

1. Record the instrument serial number on the calibration spreadsheet.
2. The analyser is automatically flagged as "out of service” when the analyser is unlocked. This prevents calibration data being disseminated as ambient concentrations.
3. Change the O_3 sample inlet filter, following the instructions given in section 5.4.

5.4. Changing Analyser Sample Inlet Filters

The analyser sample inlet filters situated on the front of the instrument rack must be changed at the frequency that LSOs attend sites for routine maintenance. If a filter appears unusually dirty, please inform the CMCU.

Detailed instructions for sample inlet filter changing:

1. Open the analyser front panel by pressing down right side of the panel (front right), the analyser panel swings open with a door action hinged on the left.
2. The sample filter is situated on the centre or right of the analyser unit, mounted in a vertical orientation for ease of access.
3. Turn the filter cover anticlockwise and then remove.
4. Remove the sample filter.
5. Inspect filter for signs of excessive soiling and inspect the gasket and O-ring to ensure they are not damaged.
6. Take clean filter from box using the tweezers provided. If the tweezers are missing, contact CMCU for a replacement.
7. Please note, filters are supplied with protective backing papers between them. Be sure to take the filter, not the backing paper (which should be discarded).
8. Insert the clean filter into the filter holder (careful not to dislodge/lose the gasket and O-ring under the sample filter). On the APMA and APNA (CO and NOx) the notched face of the gasket should be pointing outwards. Otherwise leaks will occur.
9. Replace the filter cover.

5.5. Post Calibration Checks

The operator must critically review the calibration he/she has undertaken and comment on any unusual or suspect results or occurrences. In addition, the post-calibration check spreadsheet must be completed as follows:

1. All checks detailed in section 5.2 must now be repeated and recorded on the post-calibration check spreadsheet as follows:

- CO Analyser
- NOx Analyser
- SO_2 Analyser
- Air Sampling Manifold (if applicable - not required if pre-calibration was OK)
- Modem
- Data Logger (where applicable)

2. Complete the final check section of the post-calibration check sheet. Ensure that the Analyser is back in “Mode: MEAS” on the front screen.
3. Put the analyser back into service (if not done so already) by selecting the “Padlock” icon in the top right of the touch screen, select “Key Lock”, then “Close”. This will bring you back to the front screen.
4. Complete the calibration end time.
5. Please refer to the Leaving Site Guidance for addition checks to carry out.

6. Monitor Labs 98 Series Equipment - Site Operational Procedures

6.1. Preparation

1. On arrival at the site, check the pollutant levels on the front panel of each analyser to see if an episode is occurring i.e. pollution levels during the last hour are above, or close to, the trigger values as discussed in section 5.6 in Part A of the LSO Manual (O_3 >~70 ppb, NO_2 >~75 ppb, SO_2 >~90 ppb and CO >~5 ppm). If an episode is occurring telephone the CMCU before proceeding. You may be advised to delay the calibration until the episode is over.
2. Take a new set of check and calibration sheets and enter Site, Date and Operator and Start Time. This can be done directly into the spreadsheet (on a laptop) or written onto a paper printout of the spreadsheet and entered electronically back at your office.
3. Ensure the Operational Manual is to hand and follow the instructions carefully.
4. Ensure that the site toolkit (if provided) is complete.
5. Switch the analyser out of service. This can be done by either:

- Press the MENU/ENET button and scroll down to OUT OF SERVICE MENU, press ENTER twice, the word IN should be flashing. Press the UP button and the flashing word should change to OUT. Press ENTER then EXIT until you return to the main screen.
- If the OUT OF SERVICE MENU is not present and there are no rack-mounted or data logger service switches/buttons, there is a "SERVICE" toggle switch mounted on the secondary panel behind the instrument front panel. To access this panel, grasp the front top corners of the front panel and pull forward. The panel will pop loose and pivot forward. Flick the switch to OUT and replace front panel.

At the end of the calibration, analysers can be put back into service by reversing the above steps.

If “out of service switches” or a similar mechanism for flagging calibration data are not present on the analyser or at the site, the CMCU should be telephoned upon arrival. This will allow them to ensure that calibration data is not disseminated as ambient data.

Calibration results should be recorded on a dedicated electronic spreadsheet and sent to the CMCU and QA/QC Unit. The electronic sheet should be used on site, to minimise the risk of errors, but if suitable facilities are not available, the results can be recorded on paper for subsequent transfer to the spreadsheet in the office.

6.2. Pre-Calibration Checks

A number of initial visible checks are made on the equipment. Complete all the checks for all the analysers and ancillary equipment. When all checks are complete, inform the CMCU if any are not correct, before proceeding with the calibration.

6.2.1. All Analysers

The Monitor Labs models ML9830 CO analyser, ML9841A NOx analyser, ML9850 SO_2 analyser and ML9810 O_3 analyser have a liquid crystal display which in normal

operation shows the current CO/NO/SO_2/O_3 concentration, the operation mode of the analyser, time of day, date and a main menu option. This display is termed the 'primary screen'. If a failure condition is detected, a fault will be displayed on the status line above the operating mode line. If there are multiple failures, the failure at the top of the list will be displayed on the status line. When this failure clears, the next failure on the list will be displayed. The entire list of failures is displayed on the SYSTEM FAULTS menu screen.

This picture (Figure 19 shows the front panel of the ML9830 CO analyser however, the front panel of each analyser looks the same apart from what is displayed on the LCD.

Figure 19 - Front panel of ML9830 CO analyser. ©Ecotech

1. Check the display and record the current readings and the current time on the pre-calibration checklist. Telephone the CMCU if the time displayed differs by more than 5 minutes from Greenwich Mean Time (GMT)
2. If any fault messages are displayed, record these. Access to the faults list is by pressing SELECT when the cursor is flashing in the MAIN MENU option. Use the down arrow to move the cursor to the SYSTEM FAULTS option and then press SELECT. To return to the primary screen press EXIT twice.
3. Access the analyser's internal parameters from the primary screen by pressing SELECT when the cursor is flashing in the MAIN MENU option. Using the down arrow move the cursor to the INSTRUMENT STATUS option and then press SELECT. Note the values of the parameters on the pre-calibration checklist. To return to the primary screen press EXIT twice.

6.2.2. Air Sampling Manifold (where fitted)

Record the following checks on the pre-calibration checklist.

1. Check that the sample manifold is intact and shows no sign of possible leakage.
2. Check that the blower motor is operating by listening and feeling for vibration on the motor housing.
3. Check that the instrument sample inlet tubes are connected to the manifold and the sample inlet port at the back of the rack and that these connections (including any sample inlet filter housings) are secure and leak tight.

In the case of a passive manifold sampling system (i.e. tubing from an inverted funnel) check that the tubing from the funnel is connected to the sample inlet port at the back of the instruments and that these connections are secure and leak tight. Check that the end of the sample tubing is just inside the lip of the funnel. Check the

sample lines for visible obstructions and kinks and that the funnel is orientated so as to prevent rainwater entering the tubing.

6.2.3. Modem (where fitted)

Check that the lights on the modem are lit, the connector is secure, and the telephone line is plugged into the BT socket or the aerial is connected if a SIM card modem. Record on the pre-calibration checklist.

6.2.4. Zero Air Generation

Zero air may be provided by chemical scrubber towers (with or without a pump) or using a zero air cylinder. For scrubber-equipped sites at which all pollutants are measured, two zero towers will be present, check the condition of the scrubber materials in the canisters, two of which are self-indicating; silica gel turns from orange to clear and Purafil from purple to brown as it becomes exhausted.

1. Check that at least 25% of the silica gel is still orange. If less than 25% of the silica gel is orange please contact the CMCU. **Do not change the silica gel yourself as it can give off a harmful dust.**
2. Check that at least 25% of the Purafil is still purple. If less than 25% of the Purafil is purple, note on the calibration record sheet, but continue with calibration. **Do not change the Purafil yourself as it can give off a harmful dust.**
3. Check the tubing from the canisters is secure and the lid is tight.

6.2.5. Changing the Silica Gel

It is no longer necessary for the LSO to change the silica gel. This is carried out by the ESU.

6.2.6. Data Logger (where fitted)

Perform the following logger checks and record the results on the pre-calibration check list.

The logger clock is usually displayed on the screen. This clock is automatically updated to agree with the network central computer clock, each time data is collected from the site by telemetry. Check that the date and time displayed are correct to within five minutes of the current time GMT. Telephone the CMCU if the time displayed differs by more than five minutes from GMT. Note that the network operates on GMT throughout the year and the clocks are not adjusted for BST.

6.2.7. Completion of Pre-Calibration Checks

If any of the above checks are not correct, inform the CMCU before proceeding with calibration. If all correct, proceed with the calibration.

6.3. Analyser Calibration Procedure

Results of the calibration will be taken from either the data logger display (if fitted) or the instrument's display for recording on the calibration record sheets. The display is to be used to determine that the instrument has fully stabilized in its response to the gas sample being introduced at its inlet.

When closing the gas cylinder valves, care should be taken not to overtighten the valves on the gas regulator. Overtightening can damage the needle valve mechanism resulting in the regulator outlet valve failing to open. The main valve on the top of each cylinder should be tightly closed to avoid venting the cylinder.

In order to have a full and complete set of instructions for each analyser, instructions for opening gas cylinder valves are contained within the calibration procedure for each analyser. When all analysers are being calibrated, it might be beneficial for all cylinders to be opened at the same time, after ensuring that all outlet valves are closed. All cylinders can then be closed at the same time at the end of the calibration session.

6.3.1. Analyser Stability Criteria

The ML98XX series analysers show both an instantaneous and an average concentration on the front panel display. By examining both of these values, the analyser stability can be assessed. During calibration, if both values are the same (± 2 ppb for NO, NOx, SO_2 and O_3 and ±0.1 ppm for CO) then the analyser can be considered to have stabilised.

6.3.2. CO, NOx & SO_2 Analysers

A two-point calibration of the analysers is undertaken during each site visit or in the rare event of an analyser adjustment. The calibration is carried out as follows:

1. Record the instrument serial number on the calibration record sheet.
2. Switch the CO/NOx/SO_2 "SERVICE" control to "OUT". See section 6.1.
3. If the zero calibration system is not permanently connected to the analyser, locate the inlet line to the CO/NOx/SO_2 analyser, and disconnect it from the manifold
4. Connect the zero air line (if not already connected) so that the analyser is now sampling air from the zero air cylinder.
5. Different sites have varying system setups. Please follow the following instructions applicable to the system you are calibrating. The pressures and flows listed below may vary based on the equipment's age and efficiency, use settings most recently recommended by the QA/QC Unit or ESU. If unsure, contact the CMCU.

Note: the site calibration configuration may supply zero gas to other analysers at the same time. If this is the case, perform the other zero tests at the same time. It will usually not be possible to calibrate other analysers with other gases while the zero cylinder is being used.

- **Inline excess flowmeter**: Adjust the regulator secondary pressure to 15 psi (1bar), as read from left hand dial, by turning regulator primary (closest to cylinder) valve. Slowly open the regulator outlet (furthest from cylinder) valve to produce an excess flow of ~0.5 litres per minute.

- **Rack mounted or total flowmeter**: Adjust the regulator secondary pressure to 15 psi (1bar), as read from left hand dial, by turning regulator primary (closest to cylinder) valve. By gradually turning the CO calibration gas control valve inside the hut, adjust the flow through the flow meter to produce 1.5 (±0.1) litres per minute.
- **Inline stainless steel critical orifice**: Adjust the regulator secondary pressure to the recommended setting advised by QA/QC (nominally 30 psi (2bar)), as read from left hand dial, by turning regulator primary (closest to cylinder) valve.
- **Inline Teflon critical orifice**: Adjust the regulator secondary pressure to the recommended setting advised by QA/QC (nominally 15 psi (1bar)), as read from left hand dial, by turning regulator primary (closest to cylinder) valve.
- **Selectable flow regulator**: Adjust the dial to 2 litre per minute

6. For CO, NOx & SO_2 allow the analyser to stabilise on zero air for a period of at least 10 minutes. Use the stabilisation criteria described in section 6.3.1 to confirm stabilisation has occurred.
7. Record three consecutive CO/NOx, NO, NO_2/ SO_2 readings from the data-logger or instrument display (depending on site configuration), allow 10 seconds between each reading.
8. Close the zero air cylinder (see step 12) and connect the span cylinder calibration line (depending on site set up).
9. Open the CO/NO/SO_2 calibration gas cylinder main valve by turning it fully anticlockwise. (Note: cylinder valves should not be left fully open due to the risk of jamming open. They should be opened fully but then turned back 1/4 of a turn to prevent this.) Read cylinder pressure from right hand dial and cylinder number from the tag on the cylinder, and enter these on the calibration spreadsheet. Do not use the cylinder if the pressure indicated is less than 300 psi. In this event contact the CMCU immediately
10. Adjust the regulator secondary dial to the required pressure following step 5.
11. **For CO & SO_2** allow the analyser to stabilise on this sample for a period of at least 10 minutes. Ensure that the excess flow measured by the flow meter remains stable during this time. Adjust the flow, if necessary, to maintain 1.5 litre per minute. For CO use the stabilisation criteria described in section 6.3.1 to confirm stabilisation has occurred.
12. Record three consecutive sets of CO/NOx, NO and NO_2/SO_2 readings from the data-logger or instrument display (depending on site configuration), for NOx, NO and NO_2 allow 10 seconds between each set of readings. The signal should show a large deflection from the zero points previously obtained. For NOx, NO, NO_2 & SO_2 use the stabilisation criteria described in section 6.3.1 to confirm stabilisation has occurred.
13. In the following order, fully close the regulator outlet valve (do not overtighten), the main cylinder valve (tightly) and the primary regulator valve. This traps gas in the regulator, ensuring a positive pressure and therefore, no ingress of ambient air. Note that the pressure regulator dials should remain at their previous setting, if a marked decrease is observed there is a leak in the system, and the CMCU should be informed.
14. Check that the results from this calibration are consistent with those of the previous calibration. The zero value should not differ by more than 10 mV (~0.5 ppm) for CO or 10 mV (~4 ppb) for NO, NOx & NO_2 and SO_2 from the previous

calibration. The span calibration value should not differ by more than 5% from that obtained during the previous calibration. If in doubt, repeat the relevant procedure. If the results of this are also unsatisfactory, contact the CMCU.

15. Change the CO/NOx/SO_2 analyser sample inlet filter, following the instructions given in section 6.4.
16. **CO only** - Reconnect the ambient sample line to the analyser. Switch the CO "SERVICE" control to "IN" when the analyser has fallen to the ambient levels seen prior to the calibration. See section 6.1.
17. **NOx & SO2 only** - Ensure the ambient sample line is connected to the analyser and manifold. Switch the NOx/SO_2 "SERVICE" control to "IN". See section 6.1.

6.3.3. Ozone Analyser

There is no longer a requirement to perform the two-point calibration of the ozone analyser during each site visit. The analyser performs an internal zero/span daily, and this is adequate for data ratification purposes. Calibrations for scaling ratified data are carried out every three months by the QA/QC Unit using a photometer.

1. Record the instrument number on the calibration record sheet.
2. Switch the O_3 "SERVICE" control to "OUT". See section 6.1.
3. Change the O_3 analyser sample inlet filter, following the instructions given in part 13.5 of this section.
4. Switch the O_3 "SERVICE" control to "IN". See section 6.1.

6.4. Changing Analyser Sample Inlet Filters

The analyser sample inlet filters situated on the rear of the instruments must be changed at the frequency that the LSOs attend site for regular maintenance. If a filter appears unusually dirty, inform the CMCU. Detailed instructions for sample inlet filter changing:

1. Unscrew the fasteners on filter holder.
2. Lift top cover of filter holder off bottom section.
3. Remove "O" ring (if fitted) and used filter.
4. Inspect filter for signs of excessive soiling and inspect "O" ring (if fitted). Inspect the perimeter of the filter holder for signs of wear and the effectiveness of the filter holder clip. Adjust the tension of the sprung retaining wire if necessary.
5. Take clean filter from box using the tweezers supplied and insert into base of filter holder. (If tweezers are missing, contact CMCU for a replacement).
6. Please note, filters are supplied with protective backing papers between them. Be sure to take the filter, not the backing paper (which should be discarded).
7. Replace "O" ring in filter holder (if fitted).
8. Replace top of filter holder and secure.
9. Check that Teflon lines to filter holder are well secured.

6.5. Changing the Daily CO Cylinder (Where fitted)

The CO analyser uses a second cylinder to perform daily checks on the performance of the instrument. Because of this, it will be necessary for LSOs to replace this cylinder periodically.

1. If not already fitted, connect the regulator to the cylinder using the spanner provided. Ensure that the regulator is tightly fitted to the cylinder (The CO regulator has a left-hand thread).
2. The regulator must be purged. To do this briefly open the main cylinder valve and close it again. Open the regulator output valve. The sound of escaping gas should be heard, and the 'cylinder' pressure gauge should fall rapidly. If it does not fall check that the main cylinder valve is fully turned off. When the gas present in the regulator has fully vented the regulator should be closed once more. This should be repeated twice leaving the regulator closed.
3. Connect the Teflon tubing from the analyser to the output of the regulator.
4. Open the cylinder main valve by turning it fully anticlockwise. (**Note: cylinder valves should not be left fully open due to the risk of jamming open. They should be opened fully but then turned back 1/4 of a turn to prevent this**.) Check that there are no leaks from around the regulator seals, using the “SNOOP” leak detecting solution provided. Tighten the regulator, if necessary. Record the cylinder pressure from the right-hand dial.
5. Adjust the regulator secondary pressure to 15 psi, as read from the left-hand dial, by turning the regulator pressure control (right-hand) valve. Slowly open the regulator outlet valve (left-hand) fully.
6. Turn the CO "SERVICE" control to "OUT", allowing data to be flagged. See section 6.1.
7. Press the span button on the front of the analyser. A click should be heard as the solenoid valve opens.
8. Fully open the cylinder main valve. Slowly open the regulator output valve to allow gas to flow to the analyser. Adjust the regulator secondary pressure to 15 psi, as read from the left-hand dial, by turning the regulator pressure control (right-hand) valve.
9. Regulate the flow using the regulator output such that the excess flow is around 1.5 litres/min.
10. Note the span value on the analyser front panel. This should be within 10% of the value of the cylinder. If not contact the CMCU.
11. Press measure to return to sampling ambient air. When the measured values have returned to ambient levels switch the "SERVICE" switch to "IN". See section 6.1.

6.6. Post- Calibration Checks

The operator must critically review the calibration he/she has undertaken and comment on any unusual or suspect results or occurrences. In addition, the post-calibration spreadsheet must be completed as follows:

1. All pre-calibration checks detailed in section 6.2 must now be repeated and recorded on the post-calibration spreadsheet as follows:

- CO Analyser
- NOx Analyser
- SO_2 Analyser
- Ozone Analyser
- BAM or FidasAir Sampling Manifold (if applicable - not required if pre-calibration was OK)
- Modem (if applicable)
- Data Logger

2. Compare the results of the post calibration checks to the pre-calibration values. If there are any large unexpected changes notify the CMCU.
3. Complete the final check section of the post-calibration spreadsheet and ensure all analysers are back in service. If no out of service switches are present, telephone the CMCU to notify them that the calibration is complete so that they may restore data dissemination.
4. Complete the calibration end time.
5. Please refer to the Leaving Site Guidance for addition checks to carry out.

7. Monitor Labs 98 Series Equipment with Envidas Data Logger and Solenoid Calibration System

7.1. Preparation

1. On arrival at the site, check the pollutant levels on the front panel of each analyser to see if an episode is occurring i.e. pollution levels during the last hour are above, or close to, the trigger values as discussed in section 5.6 in Part A of the LSO Manual (O_3 >~70 ppb, NO_2 >~75 ppb, SO_2 >~90 ppb and CO >~5 ppm). If an episode is occurring, telephone CMCU before proceeding further. Usually, the CMCU will advise delaying the calibration until the episode is over.
2. Take a new set of check and calibration spreadsheets and enter Site, Date and Operator and Start Time. This can be done directly into the spreadsheet (on a laptop), or written onto a paper printout of the spreadsheet, and entered electronically back at your office.
3. Ensure the Operational Manual is to hand and follow the instructions carefully.
4. Ensure that the site toolkit (if provided) is complete.

Calibration results should be recorded on a dedicated electronic spreadsheet and sent to the CMCU and QA/QC Unit. The electronic sheet should be used on site, to minimise the risk of errors, but if suitable facilities are not available, the results can be recorded on paper for subsequent transfer to the spreadsheet in the office.

7.2. Pre-Calibration Checks

In this section, a number of initial visual checks are made on the equipment. Complete all the checks for all the analysers and ancillary equipment. When all checks are complete, inform the CMCU if any are not correct, before proceeding with the calibration.

7.2.1. All Analysers

The Monitor Labs models ML9830 CO analyser, ML9841A NOx analyser, ML9850 SO_2 analyser and ML9850 O_3 analyser have a liquid crystal display which in normal operation shows the current CO concentration, the operation mode of the analyser, time of day, date and a main menu option. This display is termed the ‘primary screen’. If a failure condition is detected, a fault will be displayed on the status line above the operating mode line. If there are multiple failures, the failure at the top of the list will be displayed on the status line. When this failure clears, the next failure on the list will be displayed. The entire list of failures is displayed on the SYSTEM FAULTS menu screen.

This picture (Figure 20) shows the front panel of the ML9830 CO analyser however, the front panel of each analyser looks the same apart from what is displayed on the LCD.

Figure 20 - Front panel of ML9830 CO analyser© Ecotech

1. Check the display and record the current readings and the current time on the pre calibration checklist. Telephone the CMCU if the time displayed differs by more than 5 minutes from Greenwich Mean Time (GMT).
2. If any fault messages are displayed, record these. Access to the faults list is by pressing SELECT when the cursor is flashing in the MAIN MENU option. Use the down arrow to move the cursor to the SYSTEM FAULTS option and then press SELECT. To return to the primary screen press EXIT twice.
3. Access the analyser's internal parameters from the primary screen by pressing SELECT when the cursor is flashing in the MAIN MENU option. Using the down arrow move the cursor to the INSTRUMENT STATUS option and then press SELECT. Note the values of the parameters on the pre calibration checklist. To return to the primary screen press EXIT twice.

7.2.2. Air Sampling Manifold (where fitted)

Record the following checks on the pre calibration checklist.

1. Check that the sample manifold is intact and shows no sign of possible leakage.
2. Check that the blower motor is operating by listening and feeling for vibration on the motor housing.
3. Check that the instrument sample inlet tubes are connected to the manifold and the sample inlet port at the back of the instruments and that these connections are secure and leak tight.

In the case of a passive manifold sampling system (i.e. tubing from an inverted funnel) check that the tubing from the funnel is connected to the sample inlet port at the back of the instruments and that these connections are secure and leak tight. Check that the end of the sample tubing is just inside the lip of the funnel. Check the sample lines for visible obstructions and kinks and that the funnel is orientated so as to prevent rainwater entering the tubing. This style of manifold is unlikely to be found in combination with an Envidas logger and solenoid switches.

7.2.3. Modem (where fitted)

Check that the lights on the modem are lit, the 25-way connector is secure, and the telephone line is plugged into the BT/relevant socket or the aerial is connected if a SIM card modem. Record the pre calibration checklist.

7.2.4. Data Logger

The Envidas logger is a fully integrated data-logger and system controller. There are few controls or indicators for the operator to interface with, therefore the operator is only required to observe and record the status of each pollutant channel.

1. Open the door on the front of the Envidas logger module.
2. Observe (and record on the pre-calibration checks form) the status of the indicator lights for each pollutant channel.
3. Close the door on the logger module.

If any of the pollutant channels are switched to any state other than ‘SAMPLE’ (i.e. ‘ZERO’, ‘SPAN’, ‘FILTER’ or ‘SERVICE’) the management unit should be informed.

7.2.5. Solenoid Switches

Solenoid switches allow easy switching from ambient to zero or span gases.

7.2.6. Zero Air Generation

Zero air may be provided by chemical scrubber towers (with or without a pump) or using a zero air cylinder. For scrubber-equipped sites at which all pollutants are measured, two zero towers will be present, check the condition of the scrubber materials in the canisters, two of which are self-indicating; silica gel turns from orange to clear and Purafil from purple to brown as it becomes exhausted.

1. Check that at least 25% of the silica gel is still orange. If less than 25% of the silica gel is orange please contact the CMCU. **Do not change the silica gel yourself as it can give off a harmful dust.**
2. Check that at least 25% of the Purafil is still purple. If less than 25% of the Purafil is purple, note on the calibration record sheet, but continue with calibration. **Do not change the Purafil yourself as it can give off a harmful dust.**
3. Check the tubing from the canisters is secure and the lid is tight.

7.2.7. Completion of Pre-Calibration Checks

If any of the above checks are not correct, inform the CMCU before proceeding with calibration. If all correct, proceed to the next section.

7.3. Analyser Calibration Procedure

Results of the calibration will be taken from the instrument's display for recording on the calibration record spreadsheets.

When closing the gas cylinder valves, care should be taken not to overtighten the valves on the gas regulator. Overtightening can damage the needle valve mechanism resulting in the regulator outlet valve failing to open. The main valve on the top of each cylinder should be tightly closed to avoid venting the cylinder.

In order to have a full and complete set of instructions for each analyser, instructions for opening gas cylinder valves are contained within the calibration procedure for each analyser. When all analysers are being calibrated, it might be beneficial for all cylinders to be opened at the same time, after ensuring that all outlet valves are

closed. All cylinders can then be closed at the same time at the end of the calibration session.

7.3.1. Analyser Stability Criteria

The ML98XX series analysers show both an instantaneous and an average concentration on the front panel display. By examining both of these values, the analyser stability can be assessed. During calibration, if both values are the same (± 2 ppb for NO, NOx, SO_2 and O_3 and ±0.1 ppm for CO) then the analyser can be considered to have stabilised.

7.3.2. CO/NOx/SO_2 Analyser

The following two-point calibration of the analysers is to be undertaken during each site visit (or in the rare event of an analyser adjustment). The calibration is carried out as follows:

1. Record the instrument serial number on the calibration record sheet.
2. Open the door on the front of the Envidas logger module and press the relevant button to set the CO/NOx/SO_2 analyser to 'ZERO'. This sets the solenoid valves to introduce zero gas to the analyser whilst also flagging the data as calibration data and not to be used. If a zero cylinder is used, ensure it is open.
3. Allow the analyser to stabilise on zero air for at least 10 minutes. For NOx & SO_2 Verify that stabilisation has occurred, i.e. the NOx and NO/SO_2 concentrations displayed on the instrument front panel vary by no more than 2 ppb.
4. Record three consecutive CO/ NOx, NO, NO_2/ SO_2 readings from the instrument display, allowing 10 seconds between each reading
5. On the front of the Envidas logger module press the relevant button to set the CO/NOx/SO_2 analyser to 'SPAN'. This sets the solenoid valves to introduce span gas to the analyser whilst also flagging the data as calibration data and not to be used. Ensure cylinder is open.
6. Read the cylinder pressure of the CO/NO/SO_2 in air calibration cylinder from the right-hand dial and cylinder number from the label on the cylinder and enter these on the calibration sheet. Do not use the cylinder if the pressure indicated is less than 300 psi (approx. 20 bar). In this event contact the CMCU immediately.
7. Allow the analyser to stabilise on this sample for a period of at least 10 minutes. When stabilised, the concentration displayed on the analyser front panel should not vary by more than 0.2ppm for CO and 2ppb for NOx and NO or SO_2.
8. Record three consecutive CO/ NOx, NO, NO_2/ SO_2 readings from the instrument display. **For SO_2**: (depending on site configuration) from the zero point previously obtained, the signal should show a large deflection.
9. Check that the results from this calibration are consistent with those of the previous calibration. The zero value should not differ by more than ~0.5 ppm for CO and 4 ppb for NOx & SO_2 from the previous calibration. The span calibration value should not differ by more than 5% from that obtained during the previous calibration. If in doubt, repeat the relevant procedure. If the results of this are also unsatisfactory, contact the CMCU.

10. Change the CO/NOx/SO_2 analyser sample inlet filter, following the instructions given in section 7.4.
11. On the front of the Envidas logger module press the relevant button to set the CO/NOx/SO_2 analyser to ‘SAMPLE’ when the analyser has fallen to the ambient levels seen prior to the calibration.

7.3.3. Ozone Analyser

There is no longer a requirement to perform the two-point calibration of the ozone analyser during each site visit. The analyser performs an internal zero/span daily, and this is adequate for data ratification purposes. Calibrations for scaling ratified data are carried out every three months by the QA/QC Unit using a photometer.

1. Record the instrument serial number on the calibration record sheet.
2. Put the analyser out of service by pressing SERVICE or, if present FILTER on the front of the Envidas and a red LED should come on.
3. Change the O_3 analyser sample inlet filter, following the instructions given in section 7.4 of this section.
4. Put the analyser back into service by pressing the relevant button again.

7.4. Changing Analyser Sample Inlet Filters

The analyser sample inlet filters situated on the front of the instrument rack must be changed at a frequency that LSOs attend site for regular maintenance. If a filter appears unusually dirty, inform the CMCU.

Detailed instructions for sample inlet filter changing:

1. Unscrew the front of the filter holder.
2. Lift the top cover of the filter holder off the bottom section.
3. Inspect filter for signs of excessive soiling. Inspect the perimeter of the filter holder for signs of wear and the effectiveness of the filter holder clip.
4. Take clean filter from box using the tweezers supplied. (If the tweezers are missing, contact CMCU for replacement).
5. Please note, filters are supplied with protective backing papers between them. Be sure to take the filter, not the backing paper (which should be discarded).
6. Insert clean filter into base of filter holder
7. Replace top of filter holder and secure.
8. Check that Teflon lines to filter holder are well secured.

7.5. Changing the Daily CO Cylinder (Where Fitted)

Some network sites use separate cylinders for weekly calibration and daily auto-calibration. This is not the case for Envidas equipped monitoring stations, so there will be no need to change a daily CO cylinder.

7.6. Post- Calibration Checks

The operator must critically review the calibration he/she has undertaken and comment on any unusual or suspect results or occurrences. In addition, the post calibration check spreadsheet must be completed as follows:

1. All checks detailed in section 7.2 must now be repeated and recorded on the post calibration check spreadsheet as follows:

- CO Analyser
- NOx Analyser
- SO_2 Analyser
- Ozone Analyser
- BAM or FidasAir Sampling Manifold (if applicable - not required if pre calibration was OK)
- Modem
- Data Logger

2. Compare the results of the post calibration checks to the pre calibration values. If any there are any large unexpected changes notify the CMCU
3. Complete the final check section of the post calibration check spreadsheet. If there are no out of service switches present, telephone the CMCU to notify them that the calibration is complete so that they may restore data dissemination.
4. Complete the gas cylinder pressure table at the end of the calibration spreadsheets.
5. Complete the calibration end time.
6. Please refer to the Leaving Site Guidance for addition checks to carry out.

8. The Fidas

8.1. Initial Checks

A number of initial visual checks are made on the equipment. Complete all the checks for all the analysers and ancillary equipment. Calibration results should be recorded on a dedicated electronic spreadsheet and sent to the CMCU and QA/QC Unit. The electronic sheet should preferably be used on site, to minimise the risk of errors, but if suitable facilities are not available, the results can be recorded on paper for subsequent transfer to the spreadsheet in the office. When all checks are complete, inform the CMCU if any are not correct, before proceeding with the calibration.

If the site uses an Envirologger (see Figure 21 below, not all sites use one), then this must be placed into Service Mode before carrying out calibrations or other checks. Press the ‘service’ button located on the Envirologger; a red light should illuminate. The Envirologger is now in ‘service’ mode.

Figure 21 - The Envirologger

The Fidas has a touch screen front panel, the main start screen display is shown in diagram below:

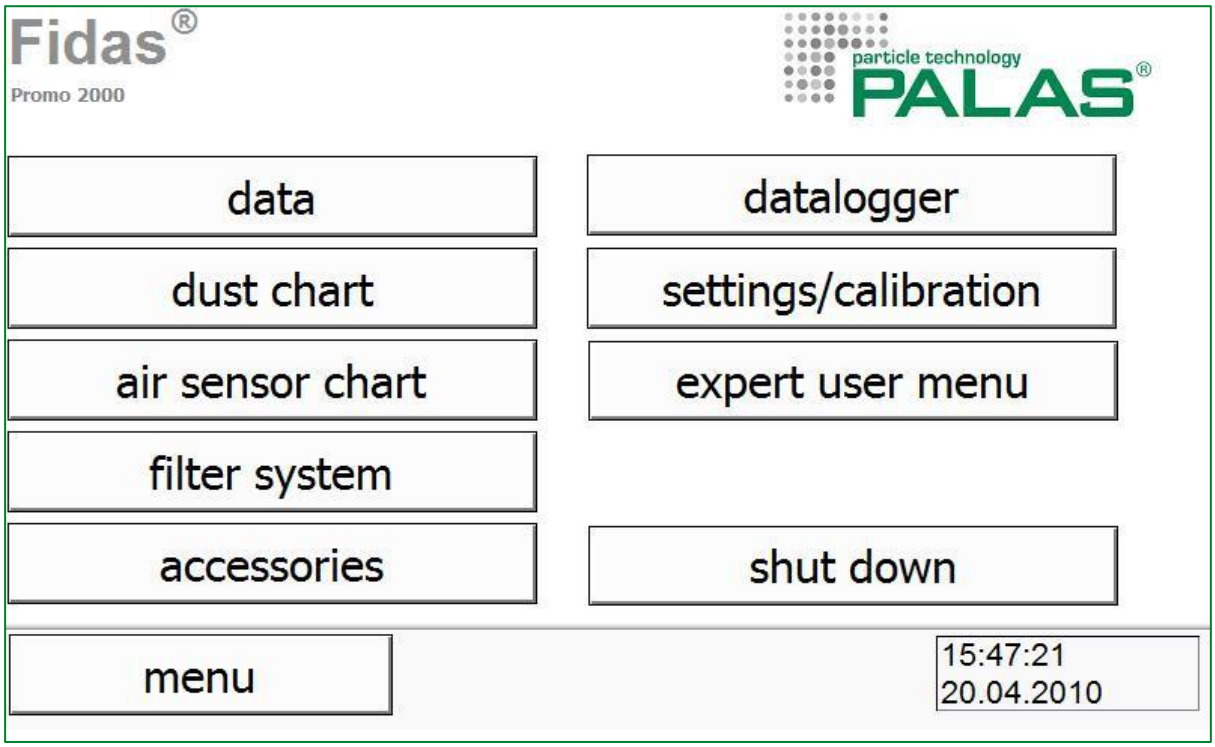


Figure 22 - The Fidas Touch Screen

The user can change from one display option to another by using the touch display.

NOTE – The screen is fully active even when the screen is dark. As a result, there is an accidental risk that "shut down" could be pressed to activate the screen, which will initiate the shut-down procedure. For this reason, users are encouraged to press the top left of the screen on first arrival, and to ensure the analyser in the measurements page when leaving site.

Press the 'data' icon on top left of the screen. This will allow the user to see the current data overview. Record the current readings from the front panel and the current time on the pre-calibration checklist. Telephone the CMCU if the time displayed differs by more than five minutes from Greenwich Mean Time.

Dust:

- PM_1
- $PM_{2.5}$
- PM_4
- PM_{10}
- PM total (total mass concentration)
- Cn: Particle number concentration in particles per cm3 (P cm-3)

Air sensors:

- Relative humidity
- Temperature
- Barometric pressure NOTE: Pressure is displayed as hPa which is the same as mBar.

To return to the home page press ‘menu’.

8.1.1. PM Diagnostics

Press ‘device status’ to access the PM diagnostics page. Check the display and record the current readings in the pre calibration checklist (Figure 23).

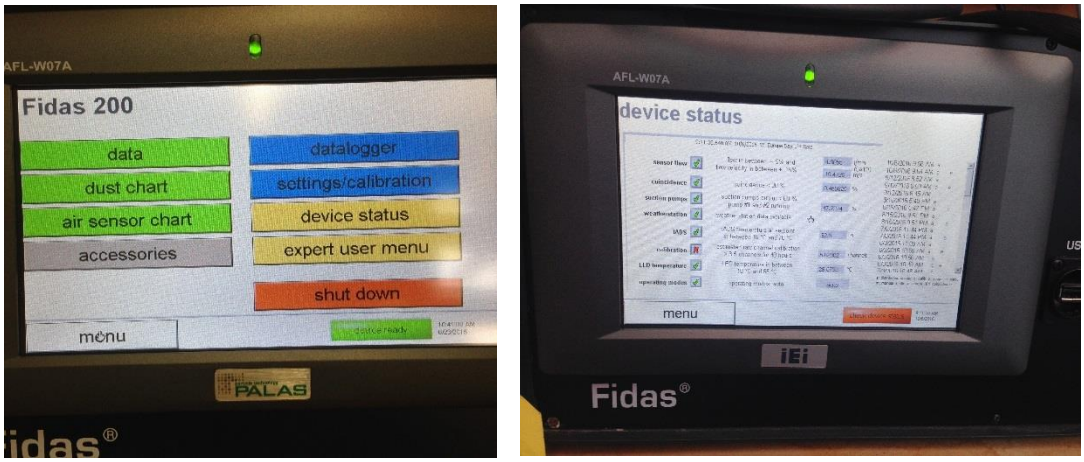


Figure 23 - Fidas 'Diagnostics' Screen

8.1.2. Completion of Pre-Calibration Checks

If any of the above checks are not correct, inform CMCU before proceeding with calibration. If all correct, proceed to the next section.

8.2. Analyser Calibration Procedure

Do not attempt the calibration procedure when there is any type of precipitation (e.g. rain, snow, drizzle).

The instructions below describe how to carry out a two-point calibration of the Fidas instrument. Results of the calibration will be taken from the instrument's display for recording on the calibration record sheets:

8.2.1. Checking the Zero of the Fidas

The following steps are needed to carry out a zero test on the Fidas.

1. Remove head located in head cage using the allen key provided if required.
2. Connect the HEPA filter to inlet as in Figure 24, making sure it is a tight fit around inlet.
3. With the HEPA filter connected, Press ‘Data’ on front screen of the instrument.
4. Wait approximately 20 seconds

5. All readings should go down to zero. The particle count (Cn) readings (P cm-3) should go to zero within a minute, while PM_{10}, $PM_{2.5}$ etc (µg cm-3), which report on a rolling average, take about 20 minutes. After 20 minutes, note down all the values on the calibration spreadsheet.
6. Remove the HEPA filter and place in box provided.
7. Keep head detached from inlet for next calibration process.
8. Press ‘menu’ on analyser front screen to return to the homepage.

Figure 24 - Fidas head (left): Fidas head with HEPA Filter attached (right)

8.2.2. To Check the Peak Response of the Fidas

Note: at the time of writing it is not envisaged that the LSO will be required to routinely carry out this procedure. Instructions are included here for information.

Should you be required to do so, the following steps are needed to carry out a span test on the Fidas:

1. Press "settings/calibration" on the front screen of the instrument (see Figure 25).
2. Press "sensor calibration" and wait for the IADS to reach the correct set point. Progress can be seen by the colour indicators.
3. Press "continue with calibration".
4. With the head still detached, go to sample inlet located on the roof and connect long silicone tubing to the sample inlet.
5. Shake the calibration dust bottle to get cloud inside the bottle. Make a note of the type of calibration dust used. It will either be “MonoDust 1500” or “CalDust 1100”. Remove the lid and put the end of tubing into the cloud, allow to sample for 5 seconds and remove the tube from the bottle. **Do not** put tubing in too far. Dust taken into the inlet should not be visible!
6. On the top right of the instrument screen, the display will list the following on the top two lines:
   “Calibration Cal Dust 1500 peak at 141
   measured Peak at xxx.xx”

   Note down this value. If MonoDust 1500 is being used, the result must be within

the range 139.5 to 142.5. If CalDust 1100 is used, the peak should be between 128.5 to 113.5.

7. Press ‘OK’ and allow the IADS temperature to stabilise; progress can be seen by the bar display.
8. Wait for PM levels to go back down before taking the instrument out of ‘service’ mode.
9. Press activate auto modus and press menu to return to the home page.
10. Place the head back on the Inlet do not tighten the screw.

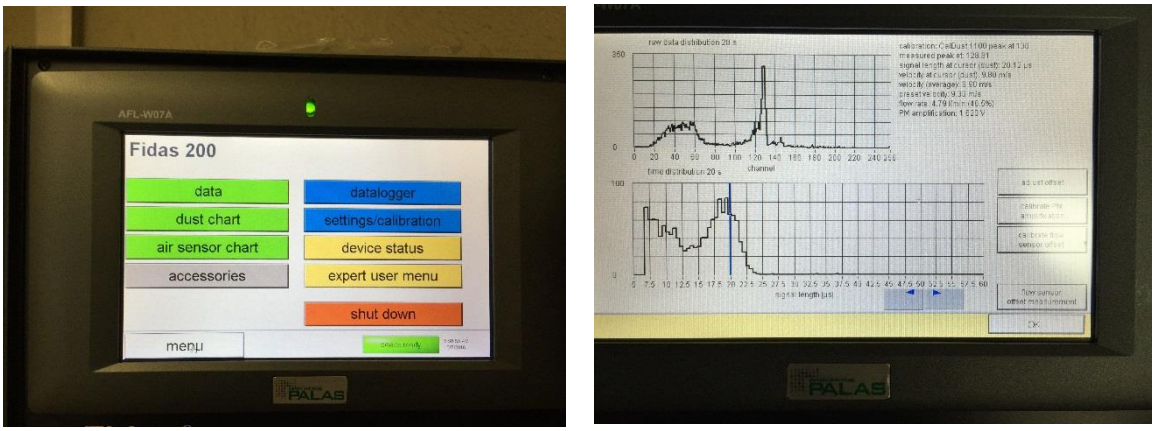


Figure 25 - Fidas Settings/Calibration Screen

8.3. Post-Calibration Checks

Repeat the PM diagnostics section and note down all values in the Post calibration section on the calibration sheet. Leave the instrument on the data screen.

8.3.1. Post Calibration Checks

The operator must critically review the calibration he/she has undertaken and comment on any unusual or suspect results or occurrences. In addition, the post-calibration check sheet must be completed as follows:

1. Compare the results of the post calibration checks to the pre-calibration values. If there are any large unexpected changes notify the CMCU.
2. The Envirologger (if fitted) must be placed back out of Service Mode. Press the ‘service’ button located on the Envirologger – Red light should disappear. The Envirologger is now collecting data.
3. Complete the final check section of the post-calibration check sheet. Check all analysers are back in service/operation mode.
4. Complete the calibration end time.
5. Please refer to the Leaving Site Guidance for addition checks to carry out.

9. Thermo Fisher I Series Equipment – Site Operational Procedures

9.1. Preparation

1. Upon arrival at the site, check the pollutant levels on the front panel of each analyser to see if an episode is occurring i.e. pollution levels during the last hour are above, or close to, the trigger values as discussed in section 5.6 of Part A (O_3 >~70 ppb, NO_2 >~75 ppb, SO_2 >~90 ppb and CO >~5 ppm). If an episode is occurring, telephone CMCU before proceeding any further.
2. On a new spreadsheet (or a new set of check and calibration sheets) enter Site, Date and Operator and Start Time.
3. Ensure the Operational Manual is to hand and follow the instructions carefully.
4. Ensure that the site toolkit (if provided) is complete.
5. The analysers can be switched out of service by either:

- Pressing “Menu”, scrolling down to “Instrument controls” and selecting “Service mode”. Switch the service mode on by pressing “Return”. Press “►” to return to the main screen. A spanner should appear on the bar on the screen. If the spanner does not appear, the CMCU should be telephoned immediately before proceeding any further with the calibration. This will allow them to ensure that calibration data is not disseminated as ambient data or:
- If displayed, press the "SERV" key on the main screen to enter service mode. Switch the service mode on by pressing “Return”. Press “►” to return to the main screen. A spanner should appear on the bar on the screen. If the spanner does not appear, the CMCU should be telephoned immediately before proceeding any further with the calibration. This will allow them to ensure that calibration data is not disseminated as ambient data

Calibration results should be recorded on a dedicated electronic spreadsheet and sent to the CMCU and QA/QC Unit. The electronic sheet should be used on site, to minimise the risk of errors, but if suitable facilities are not available, the results can be recorded on paper for subsequent transfer to the spreadsheet in the office.

9.2. Pre-Calibration Checks

In this section, a number of initial visual checks are made on the equipment. Complete all the checks for all the analysers and ancillary equipment. When all checks are complete, inform the CMCU if any are not correct, before proceeding with the calibration.

In case of difficulty operating the logger, contact your CMCU who will be able to offer assistance.

9.2.1. All Analysers

The Thermo Electron model 48i CO, Thermo Electron model 42i Nitrogen Oxides, Thermo Electron model 431 SO_2 and Thermo Electron model 49i O_3 analysers have an LCD display which, in all operating modes, shows the current CO/ NO, NO_2 and NOx/ SO_2 / O_3 concentrations.

1. Check the display and record the current CO/NO, NO_2 and NOx/SO_2/O_3 concentration in the pre-calibration checklist, and check the analyser is in service mode-see section 9.1.
2. Record any fault warnings/unusual display status.
3. Access the analysers alarm status from the primary screen by using the “Alarm” and arrow keys. Note any alarms displayed. To return to the primary screen press “►”.
4. Access the instrument operating parameters by pressing the "DIAGS" key. Scroll down, using the arrow and enter keys, to access and record all of the required temperature, pressure and flow parameters in the pre-calibration checklist. To return to the primary screen press “►”.

9.2.2. Air Sampling Manifold (where fitted)

Record the following checks on the pre-calibration checklist.

1. Check that the sample manifold is intact and shows no sign of possible leakage.
2. Check that the blower motor is operating by listening and feeling for vibration on the motor housing.
3. Check that the instrument sample inlet tubes are connected to the manifold and the sample inlet port at the back of the rack and that these connections (including any sample inlet filter housings) are secure and leak tight.

In the case of a passive manifold sampling system (i.e. tubing from an inverted funnel) check that the tubing from the funnel is connected to the sample inlet port at the back of the instruments and that these connections are secure and leak tight. Check that the end of the sample tubing is just inside the lip of the funnel. Check the sample lines for visible obstructions and kinks and that the funnel is orientated as to prevent rainwater entering the tubing.

9.2.3. Modem (where fitted)

There are several types of modem used across the network. Styles and makes usually vary depending on whether the site has a landline or SIM card. For a landline modem, check that the AA, TR and MR red lights are displayed on the modem and record on the pre-calibration checklist. For a SIM card modem, check that the green light is flashing at regular intervals.

9.2.4. Zero Air Generation

Zero air may be provided by chemical scrubber towers (with or without a pump) or using a zero air cylinder. For scrubber-equipped sites at which all pollutants are measured, two zero towers will be present, check the condition of the scrubber materials in the canisters, two of which are self-indicating; silica gel turns from orange to clear and Purafil from purple to brown as it becomes exhausted.

1. Check that at least 25% of the silica gel is still orange. If less than 25% of the silica gel is orange please contact the CMCU **Do not change the silica gel yourself as it can give off a harmful dust.**

2. Check that at least 25% of the Purafil is still purple. If less than 25% of the Purafil is purple, note on the calibration record sheet, but continue with calibration. **Do not change the Purafil yourself as it can give off a harmful dust.**
3. Check the tubing from the canisters is secure and the lid is tight.

9.2.5. Changing the Silica Gel

It is no longer necessary for the LSO to change the silica gel. This is carried out by the ESU.

9.2.6. Data Logger (where fitted)

Air quality monitoring stations exact procedures are dependent on the type of logger present, contact your CMCU for specific instructions.

The logger clock is usually displayed on the screen. This clock is automatically updated to agree with the network central computer clock, each time data is collected from the site by telemetry. Check that the date and time displayed are correct to within 5 minutes of the current time GMT. Telephone the CMCU if the time displayed differs by more than 5 minutes from GMT. Note that the network operates on GMT throughout the year and the clocks are not adjusted for BST.

9.2.7. Completion of Pre-Calibration Checks

If any of the above checks are not correct, inform CMCU before proceeding with calibration.

If all correct, proceed to the next section.

9.3. Analyser Calibration Procedure

Results of the calibration will be taken from the data logger display (if fitted) and the instrument's display for recording on the calibration record sheets.

When closing the gas cylinder valves, care should be taken not to overtighten the valves on the gas regulator. Overtightening can damage the needle valve mechanism resulting in the regulator outlet valve failing to open. The main valve on the top of each cylinder should be tightly closed to avoid venting the cylinder.

In order to have a full and complete set of instructions for each analyser, instructions for opening gas cylinder valves are contained within the calibration procedure for each analyser. When all analysers are being calibrated, it might be beneficial for all cylinders to be opened at the same time, after ensuring that all outlet valves are closed. All cylinders can then be closed at the same time at the end of the calibration session.

9.3.1. Analyser Stability Criteria

During a zero calibration the analyser would be considered stable when the variation of readings over a five-minute period are <0.2 ppm for CO and <1 ppb for NO, NOx and SO_2. During a span calibration the variation of readings over a five-minute period should not exceed 0.3 ppm for CO or 3 ppb for NO, NOx and SO_2.

9.3.2. CO, NOx & SO_2 Analysers

The two-point calibration of all these analysers is undertaken during each site visit or in the rare event of an analyser adjustment. The calibration is carried out as follows:

1. Record the instrument number on the calibration record sheet.
2. Press the out-of-service switch (detailed in section 9.1). This allows calibration data to be flagged. Methodologies for flagging calibration data may vary between systems, in case of difficulty consult the CMCU.
3. If necessary, locate the inlet line to the CO/NOx/SO_2 analyser, and disconnect it from the manifold.
4. This step is different depending on whether the zero air at the site is provided by a scrubber or from a zero air cylinder.
5. At scrubber equipped sites: connect the zero air canister to the inlet line so that the analyser is now sampling air through the zero air canister.

- **For CO** the zero air scrubber to be used is the one containing the orange silica gel and the black hopcalite. The silica gel end should be open to the environment, the hopcalite end connected to the instrument.
- **For NOx and SO_2** the zero air scrubber to be used is the one containing the pink Purafil and the black charcoal. The Purafil end should be open to the environment, the charcoal end connected to the instrument.
- At cylinder equipped sites: set the calibration valve (if present) to “Zero” and open the zero air gas cylinder. Different sites have varying system setups. Please follow the following instructions applicable to the system you are calibrating. The pressures and flows listed below may vary based on the equipment’s age and efficiency, use settings most recently recommended by the QA/QC Unit or ESU. If unsure, contact the CMCU. **Note: the site calibration configuration may supply zero gas to other analysers at the same time. If this is the case, perform the other zero tests at the same time. It will usually not be possible to calibrate other analysers with other gases while the zero cylinder is being used**.
- **Inline excess flowmeter**: Adjust the regulator secondary pressure to 15 psi (1bar), as read from left hand dial, by turning regulator primary (closest to cylinder) valve. Slowly open the regulator outlet (furthest from cylinder) valve to produce an excess flow of ~0.5 litres per minute.
- **Rack mounted or total flowmeter**: Adjust the regulator secondary pressure to 15 psi (1bar), as read from left hand dial, by turning regulator primary (closest to cylinder) valve. By gradually turning the CO/NO/SO_2 calibration gas control valve inside the hut, adjust the flow through the flow meter to produce 1.5 (±0.1) litres per minute.
- **Inline stainless steel critical orifice**: Adjust the regulator secondary pressure to the recommended setting advised by QA/QC (nominally 30 psi (2bar)), as read from left hand dial, by turning regulator primary (closest to cylinder) valve.
- **Inline Teflon critical orifice**: Adjust the regulator secondary pressure to the recommended setting advised by QA/QC (nominally 15 psi (1bar)), as read from left hand dial, by turning regulator primary (closest to cylinder) valve.
- **Selectable flow regulator**: Adjust the dial to 2 litre per minute.

6. Allow the analyser to stabilise on zero air for a period of at least 10 minutes.

7. Record three consecutive CO/NOx, NO, NO_2/SO_2 readings from the data-logger and/or instrument display (depending on site configuration), allow 10 seconds between each reading.
8. Turn off the zero air cylinder following the instructions in step 13. Remove the inlet line if required.
9. If necessary, connect one end of the excess flow meter to the inlet line, the other end to the regulator attached to the:

- Carbon monoxide (CO) in air calibration gas cylinder. (Cylinder-equipped sites) Set the calibration valve to “Span”.
- Nitric oxide (NO) in nitrogen calibration gas cylinder. Turn the calibration valve (if fitted) to “NO Span”
- SO_2 in air calibration gas cylinder. (Cylinder-equipped sites) Set the calibration valve to “Span”

10. Open the CO/NO/ SO_2 in air cylinder main valve by turning it fully anticlockwise. (Note: cylinder valves should not be left fully open due to the risk of jamming open. They should be opened fully but then turned back 1/4 of a turn to prevent this.) Read cylinder pressure from right hand dial and cylinder number from tag on cylinder and enter these on the calibration sheet. Do not use the cylinder if the pressure indicated is less than 300 psi (20bar). In this event contact CMCU immediately.
11. Adjust the regulator secondary pressure to the required setting as per step 4.
12. Allow the analyser to stabilise on this sample for a period of at least 10 minutes. Ensure that the excess flow measured by the flow meter (if fitted) remains stable during this time. Adjust the flow, if necessary, to maintain 1.5 litre per minute.
13. Record three consecutive CO/ NOx, NO, NO_2/ SO_2 readings from the data logger and/or instrument display (depending on site configuration). **For NOx, NO, NO_2** only allow 10 seconds between each set of readings. For all the signal should show a large deflection from the zero point previously obtained.
14. In the following order, fully close the regulator outlet valve (do not overtighten), the main cylinder valve (tightly) and the primary regulator valve. This traps gas in the regulator, ensuring a positive pressure and therefore, no ingress of ambient air. Note that the pressure regulator dials should remain at their previous setting, if a marked decrease is observed there is a leak in the system, the CMCU should be informed.
15. By considering previous calibration results (if present) obtained from the calibration just performed, satisfy yourself that the calibration has proceeded successfully. The zero value should not differ by more than ~0.5 ppm for CO & SO_2 or 10 mV (~4 ppb) for NOx/NO/NO_2 from the previous calibration. The span calibration value should not differ by more than 5% from that obtained during the previous calibration. If in doubt, repeat the relevant procedure. If the results of this are also unsatisfactory, contact the CMCU.
16. Change the CO/NOx/SO_2 analyser sample inlet filter, following the instructions given in section 9.4.
17. If necessary, reconnect the ambient sample line to the analyser. Turn the calibration valve to “Ambient”.

18. Switch the CO/NOx/SO_2 analyser back into service by exiting the service mode when the analyser has fallen to ambient levels. Access the “Service Mode” as described in section 9.1 and switch service mode off. The spanner should disappear from the bar on the screen.

9.3.3. Ozone Analyser

There is no longer a requirement to perform the two-point calibration of the ozone analyser during each site visit. The analyser performs an internal zero/span daily, and this is adequate for data ratification purposes. Calibrations for scaling ratified data are carried out every three months by the QA/QC Unit using a photometer.

1. Record the instrument number on the calibration record sheet.
2. Switch the analyser out of service using the steps in section 9.1.5.
3. Change the O_3 analyser sample inlet filter, following the instructions given in part 10.4 of this section.
4. Switch the analyser back into service reversing the steps in section 9.1.5.

9.4. Changing Analyser Sample Inlet Filters

The analyser sample inlet filters will be either situated on the front panel of the instrument rack or free hanging along the sample line and need to be changed after every calibration visit – including the ozone analyser filter for all sites. If a filter appears unusually dirty, please inform the CMCU.

Detailed instructions for sample inlet filter changing:

1. Using the plastic spanner tool provided, unscrew the orange/green locking ring on filter holder.
2. Lift top cover of filter holder off bottom section.
3. Remove the filter and inspect for signs of excessive soiling and inspect "O" ring (if fitted). Inspect the perimeter of the filter holder for signs of wear and diminished effectiveness of the filter holder clip.
4. Take clean filter from box using the tweezers supplied. (If the tweezers are missing, contact CMCU for a replacement).
5. Please note, filters are supplied with protective backing papers between them. Be sure to take the filter, not the backing paper (which should be discarded).
6. Insert clean filter into base of filter holder.
7. Replace top of filter holder and secure with orange/green locking ring. Use the plastic spanner tool provided to ensure the housing is completely leak tight.
8. Check that Teflon lines to filter holder are well secured.

9.5. Post-Calibration Checks

The operator must critically review the calibration he/she has undertaken and comment on any unusual or suspect results or occurrences. In addition, the post-calibration check sheet must be completed as follows:

1. All pre-calibration checks detailed in section 9.2 must now be repeated and recorded on the post-calibration check sheet as follows:

- CO Analyser
- NOx Analyser
- SO_2 Analyser
- Ozone Analyser
- BAM or Fidas
- Air Sampling Manifold (if appropriate - not required if pre-calibration was OK)
- Modem

2. Compare the results of the post calibration checks to the pre-calibration values. If there are any large unexpected changes notify the CMCU.
3. Complete the final check section of the post-calibration check sheet. Check all analysers are back in service. If no out of service switches are present, telephone the CMCU to notify them that the calibration is complete so that they may restore data dissemination.
4. Complete the calibration end time.
5. Please refer to the Leaving Site Guidance for addition checks to carry out

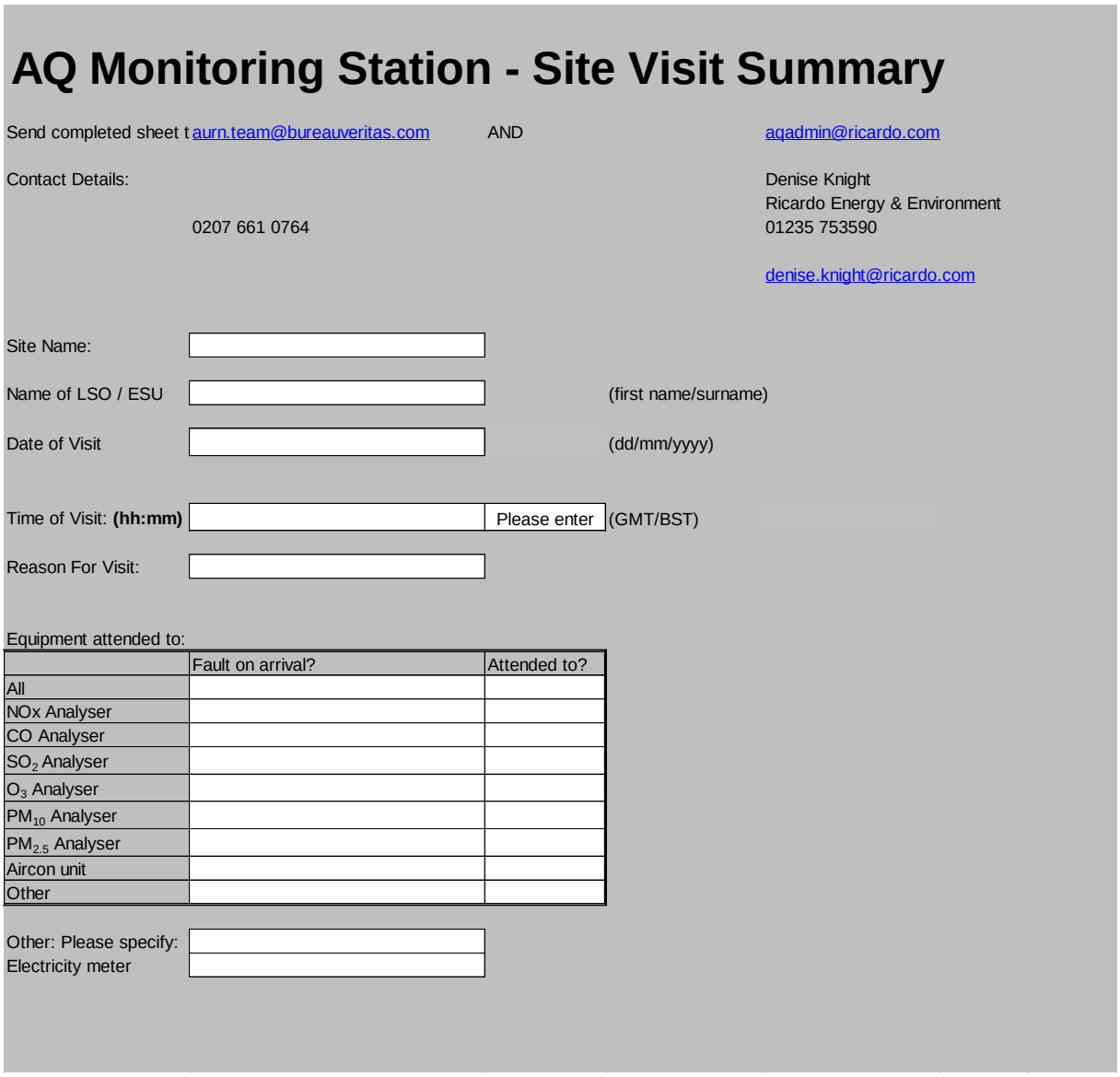
10. Leaving Site Checks

1. Inspect the cabinet inside and outside for security and safety purposes, paying particular attention to electrical and telephone connections. Check for any signs of vandalism, especially if this may affect safety or lead to deterioration in data quality. Immediate action must be taken to rectify any situation which may lead to members of the public or monitoring personnel being at risk.
2. Check that the roof area and any fittings are secure. If you have had to access the roof (to clean the inlet of a particulate analyser – see relevant instructions), check that that there are no loose items left on the roof and then stow the ladder safely inside the hut.
3. Where applicable check that all cylinders are firmly closed and the cylinder store locked (Note: if the cylinders are used for auto-calibration purposes, via solenoid control, the cylinders must be left on).
4. Ensure the cabinet is clean and tidy.
5. Upon completion of the calibration and on returning to your office, e-mail the Local Site Operator (LSO) Calibration Sheet to the QA/QC Unit at aqadmin@ricardo.com for non-ALN sites, AURN_ALN_Calibration@npl.co.uk for ALN sites and the CMCU at aurn.team@bureauveritas.com
6. (These e-mail addresses are provided on the calibration sheet, which will be updated if they change). Keep a copy, so that there is a backup calibration history of all the instruments.

11. Calibration Sheets

LSOs must use the AURN calibration spreadsheet (Figure 26) to record calibration and diagnostics information. The software allows all information collected during the calibration to be readily used to improve the quality of the validated and ratified data. The spreadsheet is specifically designed to be read automatically by software at the QA/QC Unit to minimise the risk of transcription errors. The spreadsheet should work with all versions of Microsoft Excel for PC and Macintosh from 2003 onwards and (with slightly reduced functionality) the latest version of Excel for iPad/iPhone. It may not work correctly in OpenOffice. The required calibration information is automatically transferred into the write protected "NETCEN" tab ready for automatic upload at the QA/QC Unit.

It is very important to use the most up to date version of the calibration sheet! Download the latest version from the Operations page of the AURN Hub.



AQ Monitoring Station - Site Visit Summary

Send completed sheet t aurn.team@bureauveritas.com AND aqadmin@ricardo.com

Contact Details:

Denise Knight
Ricardo Energy & Environment
0207 661 0764 01235 753590

denise.knight@ricardo.com

Site Name:

Name of LSO / ESU (first name/surname)

Date of Visit (dd/mm/yyyy)

Time of Visit: **(hh:mm)** Please enter (GMT/BST)

Reason For Visit:

Equipment attended to:

	Fault on arrival?	Attended to?
All		
NOx Analyser		
CO Analyser		
SO_2 Analyser		
O_3 Analyser		
PM_{10} Analyser		
$PM_{2.5}$ Analyser		
Aircon unit		
Other		

Other: Please specify:
Electricity meter

Figure 26 - Opening screen for the Calibration Spreadsheet v1.22 (Latest version at time of writing, Sep 2022).

Information is entered in a series of tabs (Figure 27) that follow a similar format to the traditional paper forms. The site is selected from a list, eliminating the risk of misidentification of the site. Revised versions of the sheet will be issued as appropriate upon the commissioning of new sites. There is a facility to record free text as necessary.

It is recommended that you take a laptop with you to the site if possible and complete the spreadsheet as you carry out the calibration. If you do not have access to a laptop, or if it is not feasible to take it on site visits the spreadsheets may be copied, for example, into Word, printed out and the paper copy completed on site. However, when you return to your office it is important to transfer the data from the paper copy into the original electronic version of the spreadsheet, and then e-mail this to the QA/QC Unit.

Always e-mail the actual spreadsheet to the QA/QC Unit; please do not email a pdf version, or a scan of the paper copy to them. This is because the QA/QC Unit's data handling software reads the data directly from the spreadsheet. It cannot read from a faxed or scanned copy.

To use the spreadsheet:

1. Open the file and select the Intro page (if not already selected)
2. Enter all the basic info: Select your site from the drop-down menu, enter your name, date and time and select the reason for visit from the drop-down menu.
3. Select the Pre Cal page. Confirm that there is no pollution episode occurring before proceeding. For the analysers you have on site, select the analyser types from the drop-down menus. A series of specific diagnostic parameters will then appear – having consulted the relevant sections of the LSO Manual, enter the required values as appropriate. Scroll down for the PM diagnostics tables. It is possible some software versions on analysers may display slightly different parameters - if you can't find a specific value, just leave the box blank.
4. A typical example of a checklist awaiting completion is shown in Figure 27.

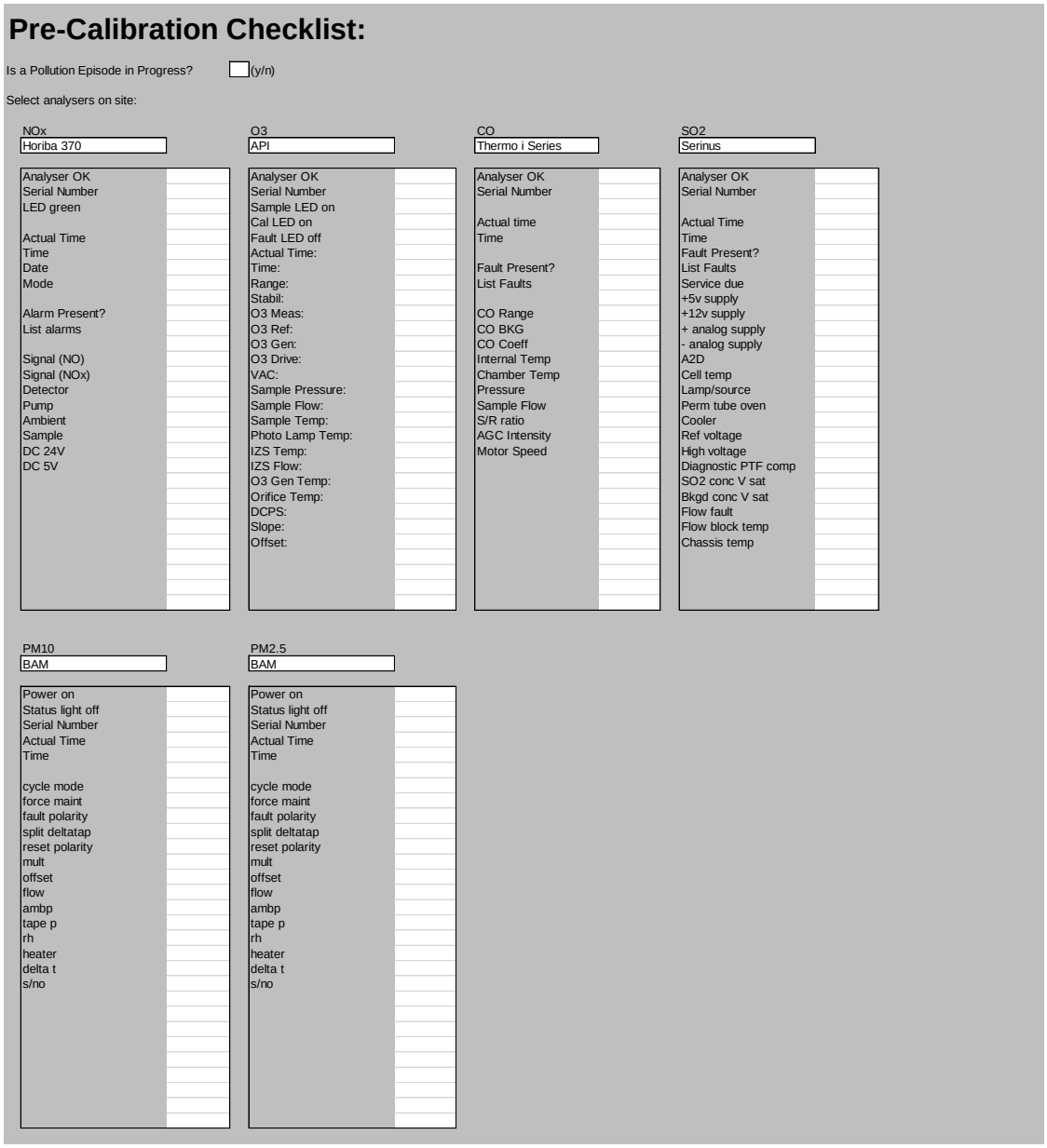


Figure 27 - Pre-calibration Checklist (v1.22)

5. Select the Cal page. Turn on any Status Flags or out of service switches (consult this LSO Manual for details) and click on the box next to the “Turn all status flags on:” message. The calibration tables will now appear. If the monitoring station records data through an external data logger, click the “External Data logger present?” box, for another set of tables to appear. If printing out a copy to take to site, click on the “Turn all status flags on” first so that the tables appear on your printout.
6. Perform zero and cylinder calibrations as described in this LSO Manual. NOx, SO_2 and ozone values should be entered in ppb (value typically between 0 and 1000 ppb) and CO in ppm. Once each calibration point is stable, take three replicate measurements for each pollutant species at about 1 minute apart – this will help to prove that the analyser has stabilised. See Figure 28.

Calibration

Turn all status flags on: Yes

External Datalogger present? Enter

Zero (Analyser Front Panel)

	1	2	3	Input check (identical cells or outlier)
NOx:				(ppb/ppm)
NO:				(ppb/ppm)
NO2:				(ppb/ppm)
CO:				(ppb/ppm)
SO2:				(ppb/ppm)
O3:				(ppb/ppm)

Cal Cylinder (Analyser Front Panel)

	1	2	3	
NOx:				(ppb/ppm)
NO:				(ppb/ppm)
NO2:				(ppb/ppm)
CO:				(ppb/ppm)
SO2:				(ppb/ppm)
O3:				(ppb/ppm)

Cylinders	Cyl no	Pressure	Concentration (if known) (NOx)	(NO)	Units
NO:					psi
Calibration CO:					
Daily CO:					
SO2:					
Zero:					

Scroll dow

Air Liquide cylinders-use stamped n
BOC-use 14 digit barcode number

Fidas PM calibration

	P/cm^3	Conc
Zero:		

Measured peak

Monodust: Monodust type:

BAM PM Maintenance

	PM10		PM2.5	
First leak check		l/min	First leak check	l/min
Nozzle Cleaned?			Nozzle Cleaned?	
Second leak check		l/min	Second leak check	l/min
Tape type on arrival			Tape type on arrival	

Change All Gas Analyser Filters: (y/n)

PM10 Tape Changed?: (y/n) New tape type
PM10 Heads Cleaned?: (y/n)

PM2.5 Tape Changed?: (y/n) New tape type
PM2.5 Heads Cleaned?: (y/n)

Comments

NOx

CO

SO2

O3

PM10

PM2.5

Figure 28 - Calibration page (v1.22)

7. Enter all the cylinder details, including cylinder number, pressure and units, not forgetting any zero and Daily CO cylinders that may be present at site. (Note, the latest versions of the spreadsheet have a photo indicating where to find the cylinder ID number: for BOC cylinders now being supplied to AURN sites, the cylinder number is the bar-code number on the cylinder label).
8. Once the calibration is complete, return the calibration gases to their as-found condition and change the sample inlet filters.
9. Carry out the BAM maintenance as appropriate. (LSOs do not normally need to carry out Fidas calibration.)
10. Enter any comments you have in the boxes provided at the bottom of the Cal page.
11. Select the Post Cal page and fill in the appropriate diagnostics.
12. Select the Final Page. Complete all the questions, enter the end time and fill in any final comments.
13. The Save File button will automatically save the spreadsheet with a unique file name "Site Name dd-mm-yy.xls". The file will be saved in the default folder for Excel file saves.
14. Press the Save File button and close Excel. Email the actual Excel file (not a scan or pdf copy) to the contacts on the Intro page.
15. Remember to reset all status flags and turn all cylinders off as normal.

Upon completion of the calibration and on returning to your office, e-mail the Local Site Operator (LSO) Calibration Sheet to the following:

- the CMCU at aurn.team@bureauveritas.com for all sites.
- The QA/QC Unit at aqadmin@ricardo.com for non-ALN sites,
- The separate ALN QA/QC Unit AURN_ALN_Calibration@npl.co.uk for ALN sites.

(These e-mail addresses are provided on the calibration sheet, which will be updated if they change). Keep a copy of the Calibration Sheet yourself, so that there is a backup calibration history of all the instruments.

12. Supply and Replacement of On-Site Gas Cylinders

It is the responsibility of the gas standards supplier (currently BOC UK & Ireland) to ensure delivery of accredited calibration gas cylinders. They also supply the daily CO autocalibration cylinders, and zero air cylinders, to some sites. Cylinders will be delivered by the gas standards supplier.

The QA/QC Unit or the CMCU may arrange for replacement of a cylinder before it is empty, should the need arise.

An inventory of the cylinders used in the network is maintained by the QA/QC Unit and is available online via the AURN Hub.

12.1. What You Need to Do

From the details given on the calibration spreadsheet completed by the LSO at each routine calibration visit, the gas standards supplier can see which cylinders are low and need replacing. BOC UK & Ireland will take a full pressure gas cylinder from stock, and their customer services team will contact the LSO and agree a convenient day and time for the cylinder delivery and confirm the delivery details below:

12.1.1. Delivery Details Confirmation

1. If the delivery/collection is NOT taking place at the AURN monitoring station, please ensure the arrangements are clearly communicated with BOC customer services and the location for the delivery and a later collection date can be arranged.
2. When arranging a cylinder collection/delivery date with BOC, please stipulate that the collection is for an AURN cylinder and confirm the cylinder type which has been recorded as low pressure is indeed low in case an error occurred with the calibration data entry. Deliveries will be made at an agreed time and date between the hours of 0900-1600 Monday to Friday.
3. Please confirm to BOC Customer Services that you are trained, competent and have the correct spanner to remove the regulator to facilitate the collection. The CMCU and QA/QC Unit can assist if you or the colleague going to the site does not know what to do. This is an opportunity to let the AURN team know you need some help.

It is intended that the delivery will be scheduled to coincide with a routine calibration visit. About an hour before the delivery, the driver will call ahead, so that the LSO has time to get there and receive the cylinder. However, if the LSO is already on route due to the travel time to the site and is therefore unavailable to take the call the delivery will still occur as planned.

The gas standards supplier driver will deliver the replacement cylinder, assisting with getting this to the cylinder rack, and take away the empty cylinder. The LSO will need to undertake the following requirements during the cylinder exchange:

12.1.2. On Site Exchange Requirements

1. Get the empty cylinder ready for collection, by removing the gas pressure regulator (instructions below).

2. When the exchange occurs please do not take the opportunity to return non-AURN cylinders at the same time, as this can cause confusion with AURN records and invoicing. Similarly, please do not return AURN cylinders to BOC when a collection occurs of non-AURN cylinders if you use the same supplier.
3. Please allow the 'old' cylinder to be collected when the 'new' cylinder is delivered, even if it is not quite empty. It is more efficient for BOC to take back the old cylinder, refill and re-use it. Also, uncollected 'empties' will take up space in the monitoring station and may be a hazard.
4. There will be delivery paperwork you will need to complete and email a copy to the Environment Agency. It is important that each cylinder, delivered or collected, is clearly recorded on the delivery note, by cylinder barcode number.

Should there be a leak, or accidental discharge of gas, and the cylinder is empty, please telephone BOC (0845 8787027) for emergency advice.

For routine gas replacement, please contact BOC directly on 0845 8787027. If the current cylinder is completely empty and you have not been contacted regarding replacement, please contact CMCU and/or QA/QC Unit for advice.

12.1.3. Removing the Regulator

The LSO will need to remove the gas pressure regulator from the empty cylinder and replace it on the new cylinder. Although this is a simple procedure, training is necessary to ensure it is carried out safely. This training will be provided by the QA/QC unit where required. **Always wear safety glasses when changing cylinders and regulators, and protective footwear when moving cylinders**.

The procedure is as follows:

- Ensure cylinder valve is fully turned off;
- Depressurise the regulator, by operating the purge valve on the system. The regulator will not unscrew safely when still under pressure;
- Unscrew the regulator using the spanner supplied. Note that BS14 and BS15 (all CO cylinders) are left hand threads i.e. are unscrewed clockwise. Left-handed fittings are distinguished by notches cut in the fitting nut;
- Connect the regulator to the new cylinder, ensuring that the sealing washer is intact. Take care not to cross-thread the regulator on the cylinder valve. When tightening the regulator, apply moderate force only; do not over-tighten.
- Close the regulator outlet valve (small knob) or turn the flow knob to zero. Gently open the cylinder valve; the inlet pressure gauge should rise. Turn the cylinder valve off, and check the regulator fitting for leaks, using a leak detection fluid such as "SnoopTM" fluid if necessary.
- Purge the air from the regulator by allowing gas from the cylinder to flush out all air in the regulator and line through the purge valve - repeat twice. Air in the cylinder system may give false readings and cause the nitric oxide (NO) calibration gas to become unstable and the concentration change.
- If the system is on non-continuous operation, pressurise the regulator and close the cylinder valve. The regulator should be left in this pressurised state to ensure there is no ingress of ambient air. If the system is on continuous operation (i.e. for daily autocalibrations), leave the cylinder valve open, with a quarter turn back from the fully open position, with the system under pressure.

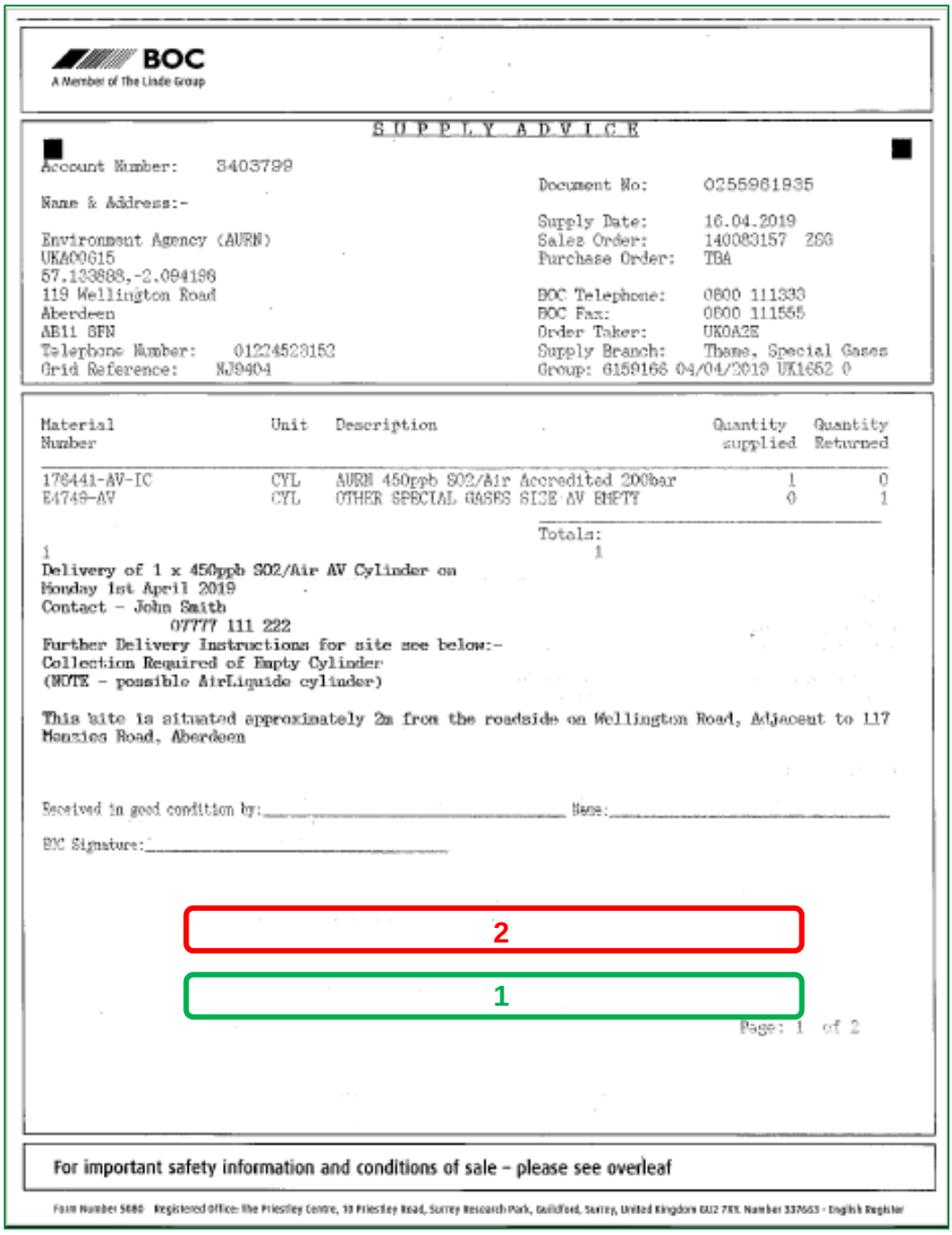
This completes the regulator changing procedure. Full details of the regulator changing procedure are also provided in Appendix D: this should be printed out and displayed on a wall inside the monitoring station cabin, enclosure or building.

If you have any questions, please contact the QAQC Unit on AQadmin@ricardo.com for AURN sites, AURN_ALN_Calibration@npl.co.uk for ALN sites.

12.1.4. Delivery and Collection Paperwork

The delivery driver will give you a collection/delivery note to sign, and examples are given below. Please check that:

1. The returned cylinder barcode number written into the area circled and labelled as ‘1’ below matches the barcode on the physical cylinder. *If the collected cylinder is from Air Liquide (the previous gas supply contractor) this will be the stamped cylinder number.*
2. The number of cylinders being returned are correctly recorded.
3. The delivered cylinder barcode number written into the area circled and labelled as '2' below and gas type matches the cylinder provided by the driver.



BOC
A Member of The Linde Group

SUPPLY ADVICE

Account Number: 3403799

Name & Address:-

Environment Agency (AURN)
UKA00615
57.133888,-2.094196
119 Wellington Road
Aberdeen
AB11 6FN
Telephone Number: 01224523152
Grid Reference: NJ9404

Document No: 0255961935

Supply Date: 16.04.2019
Sales Order: 140083157 2S0
Purchase Order: TBA

BOC Telephone: 0800 111333
BOC Fax: 0800 111555
Order Taker: UK0A2E
Supply Branch: Thame, Special Gases
Group: G159166 04/04/2019 UK1652 0

Material Number	Unit	Description	Quantity supplied	Quantity Returned
176441-AV-IC	CYL	AURN 450ppb SO2/Air Accredited 200bar	1	0
E4749-AV	CYL	OTHER SPECIAL GASES SIZE AV EMPTY	0	1

Totals:
1

1
Delivery of 1 x 450ppb SO2/Air AV Cylinder on
Monday 1st April 2019
Contact - John Smith
07777 111 222
Further Delivery Instructions for site see below:-
Collection Required of Empty Cylinder
(NOTE - possible AirLiquide cylinder)

This site is situated approximately 2m from the roadside on Wellington Road, Adjacent to 117 Menzies Road, Aberdeen

Received in good condition by:_____ Name:_____

BOC Signature:_____

2

1

Page: 1 of 2

For important safety information and conditions of sale - please see overleaf

Form Number 5080 Registered Office: The Priestley Centre, 10 Priestley Road, Surrey Research Park, Guildford, Surrey, United Kingdom GU2 7XX. Number 337663 - English Register

Figure 29 - BOC Supplier Advice

Figure 30 - Example of barcode number

You will now need to scan, or photograph, the delivery/collection note, and email it to the Environment Agency at AQmonitoringUK@environment-agency.gov.uk.

Please send this as soon as possible after the delivery/collection has occurred. Include the **official AURN site name** and any comments which may be relevant. Please ensure that the original copy of the delivery/collection note is kept for your records and if possible photograph the cylinder serial number in question.

If you have any queries or feedback on cylinder collections, please get in touch with BOC Customer Services representatives: Charmaine Rymer and Daniel Hibbert of the Customer Service Team; Tel 0845 8787027, email, Charmaine.rymer@boc.com and Daniel.hibbert@boc.com

If you need to raise a concern on a problem with a delivery / collection, or require further training or help, please get in touch with the CMCU: Bureau Veritas; Central Tel 0345 600 1828, email: aurn.team@bureauveritas.com .

13. Site Audits and Intercalibration Visits

An important part of the QA/QC programme for the AURN network are the audits and intercalibration visits. All sites will be visited for audit and intercalibration service as detailed below. The QA/QC unit is also responsible for the training of LSOs. Site audit/intercalibration schedules are listed on the AURN Hub website, normally starting in the first week of January and July (plus April and October for ozone) and lasting approximately 10 weeks. During these periods, QA/QC staff will contact LSOs to arrange for entry to the monitoring stations and for the LSO to attend for audit purposes when necessary.

13.1. Site Audits

In order to ensure that proper procedures, as detailed in this manual, are being carried out, the QA/QC Unit will audit sites as part of the site intercalibrations.

During site audits, which may or may not coincide with a normal weekly/fortnightly calibration visit, the site operator must be present if requested and be able to produce for the QA/QC Unit all records relating to the site operation. The site operator may be asked to demonstrate any routine site operational procedure and show that this can be competently carried out.

In addition, short notice or unannounced audits may also be performed. The QA/QC Unit reserves the right to visit sites as often as is necessary to ensure that correct procedures are being followed.

13.2. Intercalibration Visits

Every six months (three months for ozone analysers) the QA/QC Unit will undertake detailed checks on analyser performance and calibration prior to the sites being serviced by the ESU. As noted above, the QA/QC Unit will also use their visit to audit site records and LSO procedures.

It is not the purpose of this manual to describe fully operations to be undertaken at these intercalibration visits, but the sections below indicate the scope and range of the functions to be performed. During the intercalibration exercise these will include:

- Full network intercomparison covering all pollutants and analyser types;
- Production of ozone data scaling factors by performing reference ozone photometer intercalibrations at all sites;
- Verification of site transfer gas standard integrity;
- Calibration of the particulate analyser electronic, flow measurement, and mass measurement systems.
- Analyser operational performance tests.

On completion of the intercalibration site visit, the QA/QC Unit will report any problems identified (e.g. failed NOx converter) immediately to the CMCU. The LSO will also be notified – this is usually done via e-mail. Full details and results of the intercalibrations are reported in conjunction with the data ratification reports.

14. Non-Routine Site Visits

Data from the AURN is inspected daily by the CMCU. Full consideration will be given to ambient pollution levels being measured, and the range of available auto-calibration and instrument status data. If "suspect" data is identified from a particular monitoring site, the CMCU will first carry out a series of checks remotely. If these checks indicate a possible instrument or infrastructural malfunction, the Local Site Operator will be asked to visit the site and investigate the problem.

By considering ambient and auto-calibration data, the CMCU will often be able to diagnose the problem remotely. The LSO will then be told what further manual tests, if any, to carry out on-site. It is not possible to anticipate all potential problems, but basic guidelines for fault diagnosis are given in the “Troubleshooting” section.

Having carried out the tests requested, the LSO should convey their results to the CMCU and await further instructions. The LSO may then be asked to perform basic remedial actions to rectify any faults (for example, ensuring electrical supplies to the instruments). Local site operators are not expected to carry out repairs requiring detailed knowledge of the instrument’s operation. These more serious problems will be referred to the ESU.

If there is a particulate matter analyser at the site, the LSO may be asked to perform tasks specific to the operation of that instrument – for example, changing a BAM tape. When the LSO has carried out any tests or basic repairs, it is their responsibility to fully document these actions, and the results. Once the problem has been rectified, the CMCU may ask the LSO to carry out a routine calibration, according to the standard procedures. As with routine calibrations, the results must be forwarded to the CMCU and QA/QC Unit as soon as possible in order to allow data to be scaled correctly.

Similarly, all action taken by the ESU will be documented and forwarded to the CMCU and QA/QC Unit. In the event of the instrument being repaired on site, it will be the responsibility of the ESU to recalibrate the instrument after a suitable stabilization period. If, however, the instrument is removed and repaired off-site, a calibration must be undertaken by the ESU before removal (where possible).

Any replacement instruments must be calibrated by the ESU upon installation. The documentation forwarded to the CMCU and the QA/QC Unit must show clearly that this is a replacement instrument, and the time allowed between instrument power up and calibration must be recorded.

Following inter-calibration audits, particulate monitoring instruments may be subject to zero checks by the QA/QC Unit, as detailed in section 5.4 in Part A of the LSO Manual. This involves fitting a filter on the inlet in place of the PM head for a period of a few days, so that the instrument is sampling particulate-free air. The LSO will be asked to return to site to remove the filters and replace the PM head and ensure the sharp cut cyclone remains correctly fitted to the $PM_{2.5}$ analyser after zero tests, as appropriate by the CMCU. The PM heads will be left on site by the QA/QC unit and the filters should be left on site by the LSO once removed so that they are available for the next test. If analyser performance is poor, zero checks may be run at any time between inter-calibrations.

14.1. On-Site Procedures in the Event of Non-Routine Site Visits

It is impossible to list here every possible problem and its solution. However, it is generally possible to systematically test the measurement chain in order to discover the cause of the problem and effect its solution.

The non-routine call-out of site operators will be at the request of the CMCU, who will supply information on which piece of equipment has malfunctioned, together with relevant fault symptoms and possible causes.

It is very important that all checks and remedial action carried out are fully documented.

The LSO will not need to carry out tests on analysers or ancillary equipment which have not been reported as faulty. As far as possible, the site should be left "free running" to maintain instrument response continuity and maximise data capture.

On-site problems, when they occur, generally fall into six categories:

1. Loss of mains or telephone/mobile connection to the site. This will be detected by CMCU being completely unable to contact the site by telemetry.
2. Analyser malfunction. This will generally affect data from only one analyser.
3. Data-logging or telemetry malfunction. This may have the same symptoms as (a) above or may result in normal line connection to the site but inability to receive any meaningful data.
4. Auto-calibration malfunction.
5. Site vandalism.
6. Air conditioning faults.
7. Replacement of BAM tapes.

15. Troubleshooting

This section provides examples of common problems and faults that may arise during the routine operation or calibration of the automatic analysers. In some cases, the faults are easy to correct, but sometimes a call-out visit from the Equipment Support Unit may be required. If a fault is identified, the CMCU should be informed immediately and they will advise whether or not the corrective measure needs to be performed by experienced service engineers. No instrument adjustments should be performed by the LSO unless acting on the advice of the CMCU.

This section first gives basic on-site test procedures, then covers the following topics in more detail:

- Sampling Faults
- Calibration Drift
- High Noise or Erratic Response
- Site cylinder gas
- Spurious Data
- Examples of internal sampling
- Example of erratic data after poor filter change
- Auto-calibration Run-ons
- Auto-Calibration Run-on for a NOx Instrument.

15.1. On-Site Test Procedures

15.1.1. Loss of Mains or Telephone Connection.

1. Verify that mains power is being supplied to all site circuits, i.e. lighting, air conditioning, and instrument circuits.
2. Re-set the modem or router.
3. In the case of mains failure having occurred, the complete site operation should be thoroughly checked subsequent to reconnection. Many electronic units are susceptible to losing their program after mains failure.

15.1.2. Analyser Malfunction

1. Is the analyser receiving mains power? Check for blown fuses in the electricity supply unit, the instrument plug and the current protect fuse on the instrument itself.
2. Verify that the analyser is properly connected to the data-logger (where fitted) and/or the modem. Check all communications leads are firmly attached at each end.
3. Is the instrument sampling ambient air? Check that:

- the manifold system is functioning and is not blocked in any way;
- the instrument is connected solely to the manifold, and is not sampling from auto-calibration units or indoor air;
- the sample lines are positioned correctly and are not sampling indoor air;
- the instrument pump is functioning;
- there are no obvious restrictions to air flow through the instrument, ensuring the instrument flow rates fall within manufacturer guidelines;
- sample inlet filter holders are closed tightly and not leaking.

4. Having verified that the instrument samples ambient air, the introduction of span gas through the ambient inlet should produce a detectable response from the system.
5. Perform the routine instrument checks, as described in the relevant section within Part B of this document, to verify optimum performance of the analyser.
6. Connect a calibration gas cylinder to the instrument and conduct a calibration check following the procedures detailed in the relevant section of Part B.
7. Having allowed the appropriate stabilisation times, observe the reading on the instrument front panel. If this shows that the analyser has responded to the calibration gas, as would normally be expected, the problem does not lie in the actual measurement process.
8. Verify that the analyser response on the data logger or front panel is normal.

15.1.3. Data-logging or Telemetry Malfunction

1. Are the data logger and modem receiving mains power? Check for blown fuses or trips in the electricity supply unit, the equipment plugs, and the current protect fuses on the equipment itself.
2. If applicable, verify that the cables connecting logger to modem and modem to BT telephone socket are in place and are not damaged in any way. However, the majority of sites now have SIM modems or routers.
3. Verify that the logger set-up programme has not become corrupted by checking carefully the display screen.
4. You may be asked to observe the modem display while telemetry communications from the CMCU to the site are being attempted.
5. You may be asked to reset the modem and/or the Code Activated Switch (CAS).

15.1.4. IZS Unit Malfunction

The CMCU will advise on the need for checking Internal Zero and Span (IZS) units, if problems are identified.

15.1.5. Site Vandalism

Record details of site vandalism and report them to the CMCU (and to the police if serious criminal damage has occurred).

If the sampling manifold is damaged, it is important to note whether the damage occurs above or below the roof level. Take a photo with your mobile phone and send to CMCU. Alternatively, if this does not show the problem clearly, a sketch to show exactly where breakages are should be provided. The CMCU will advise on temporary repairs, where possible.

15.2. Sampling Faults

Symptom	Possible Cause	Check/Action
No response signal	Power cut or mains disconnected	Ensure cables are properly connected Air conditioning unit thermal cut-out may have triggered the power to be switched off
	No sample flow	Check flow meter reading low Check vacuum gauge reading low Check pump not working or disconnected Check filter holder not sealed Check sample flow reading Check analyser is in sample mode
	Component malfunction e.g. ozoneator fault lamp fault electronics problem defective photomultiplier tube	Check analyser diagnostics or fault warning messages
	Date and time is out of sync after power outage.	Check date and time on front panel.
	Loss of Firmware	Check front panel is showing usual data. Blank screen may indicate loss of firmware

Symptom	Possible Cause	Check/Action
Internal sampling, Smoothed or dampened response, no diurnal variation (see Figure 31 and Figure 32)	Sample line disconnected	Check that the sample line is securely connected to the sample inlet port at the back of the analyser or rack
	Leak in sample inlet filter holder	Check seal on sample inlet filter Check sample inlet filter housing is finger tight Check all parts of the filter housing has been installed properly
	Leak from inside the analyser itself e.g. leaking permeation drier hydrocarbon kicker reaction cell pneumatic lines IZS solenoid valve	Check for sample flow and vacuum gauge for an indication. Check all plumbing lines are tight.
Low Sample Flow	Dirty/overloaded Filter	Check filter to see if it is overloading or dirty. Change if required. Sample flow should return to normal.
	Blockage in sample line	Disconnect sample line from inlet at back of analyser. If flow returns to normal then there is a possible blockage in the sample line. Contact CMCU.
	Faulty pump	Check to see if there are any holes or kinks in pump tubing. Listen to hear if there the pump is noisier than usual.
BAM - Repeated Leak Check Failure	Nozzle is leaking	Check tape and thoroughly clean nozzle removing paper debris
	Nozzle is not descending fully to the tape	Nozzle assembly requires engineer intrusive investigation. Contact CMCU

Symptom	Possible Cause	Check/Action
BAM - Tape Error	Tape run out or tape broken	Replace with new tape or re-fix tape onto spools
BAM - Intermittent Tape Errors	Tape slipping on tape spools	Check tape inserts are not loose and re-tighten the tape spools
	Poorly fitting tape	Replace tape and contact CMCU

15.3. Calibration Drift

Symptom	Possible cause	Check/Action
Span response unstable or differs by more than 10% from previous manual calibration	Calibration gas not left on long enough for response to stabilise	Concentrations should not be vary by more than +/- 2ppb
	Analyser not completely warmed up after repair	Allow analyser sufficient time to warm up and stabilise (usually 2-3 hours)
	Insufficient flow of calibration gas	Check excess flow and/or cal system connections are tight
	Calibration gas cylinder unstable or nearly empty	Check gas supply. Site gas cylinder pressure should be above 300psi. If not inform CMCU.
	Analyser adjustment, repair or service has taken place	Check site records and ESU documentation
	Calibration cylinder changed	Check calibration cylinder number
	Backing paper inserted or left on the Teflon sample filter	Check filter holder
	Teflon filter clogged or contaminated (possibly by charcoal from zero air scrubber)	Visual inspection of filter paper for dirt or blockage
	Leak in sampling system causing dilution of the calibration gas	Check sample flow and vacuum. A low vacuum indicates a leak or defective pump
	Incorrect analyser response range (usually seen as half or double the expected calibration value)	Check analyser range setting

Zero response unstable	Zero air scrubber exhausted	Check condition of scrubber materials: silica gel (orange okay, clear used) Purafil (purple okay, brown used)
	Zero air cylinder empty or close to empty	Check cylinder pressure. If below 300ppb inform CMCU for replacement
	Loose connection or filter housing	Check filter housing and all zero sample line connections are secure
Falling NO_2 span response during calibration	Molybdenum converter fault	Check calibration screen to see if NO_2 span response is steadily falling during the calibration. Alternatively take span readings at 2, 10, and 20-minute intervals to see if the response falls Check diagnostics to see if there is converter temperature fault
	Molybdenum converter material has been consumed	Full converter test required and replacement converter needed
	NO_2 gas cylinder nearly empty.	Check cylinder pressure
	Unstable calibration source. NO_2 cylinders are often subject to changes in concentration	Verify stability of calibration source (recalibration of cylinder required)
Unusually slow response time to span gas	Sample capillary or solenoid blocked	Check sample flow rate and vacuum. A high vacuum indicates a blockage.
Auto-calibration span low or falling day by day	NO_2/SO_2 permeation tube or autocal cylinder empty. Check for IZS fault on front panel	Check for IZS fault on front panel. Check concentration of autocal cylinder and if autocal cylinder is turner on.
Zero baseline stepping	Automatic zero adjustment causing step changes in the zero baseline at uncontrolled times	Check that the analyser's automatic zero adjustment function is deactivated.

15.4. High Noise or Erratic Response

Symptom	Possible cause	Check/Action
High noise response seen as rapid fluctuations in the mV response	Analyser range incorrectly set	Check that the analyser operating range has not been changed
	Sample pump not operating smoothly	Check sample flow and listen to pump for any indication of irregular pumping action
	Component failure	Check instrument diagnostics
Negative ambient response	Change in site temperature. CO and SO_2 analysers may be sensitive to an increase or decrease in rack or cabin temperature	Check site temperature and air-conditioning unit
Intermittent response problem	Component malfunction e.g. faulty lamp, chopper motor or gas filter correlation wheel	Check analyser diagnostics
BAM - data instability	Environmental conditions	Check the air conditioning operation and setting

15.5. Site Gas Cylinders

Symptom	Possible cause	Check/Action
Site cylinder running out of gas quickly	Cylinder left on	Check cylinder is turned off before leaving site not just the regulator valves.
	Regulator not connected properly	Ensure regulator is properly connected to the site cylinder
		Ensure connections to sample line are secure
		Check sealing washer is connected to regulator and has not perished
	Faulty regulator	Leave regulator pressurised
Oxidation of NO cylinders	Contamination, manufacturing defect or poor installation of cylinder	When installing the cylinder, check that the cal system is in calibration mode. This enables any gas mixture, caused by installing the regulator, to be vented out.
		Check cal system tubing. Cal system may require stainless steel tubing instead of PTFE

15.6. Spurious Data

Symptom	Possible cause	Check/Action
High concentration spikes seen at unusual times e.g. high ozone during the night	Interference problem	O_3 - ensure 1 micron sample filters are used in the sample filter holder SO_2 - check performance of the hydrocarbon kicker.
	Irregular auto calibration span	Check timing of autocalibrations
High concentrations during high temperature periods	High temperatures causing elevated baseline response	Check instrument is not over-heating. Check air conditioning unit and vents

Symptom	Possible cause	Check/Action
Spurious high PM_{10} or $PM_{2.5}$ concentrations – often followed by periods of low negative response	These may be genuine episodes due to bonfire night celebrations or other phenomena such as dust storms	Compare data with other nearby monitoring sites (data available on the UK-AIR Air website)
Negative NO_2 data recorded during episode periods – usually only seen at roadside sites	Instrument response may be too slow for rapidly fluctuating concentrations	Check instrument set up is appropriate for the site environment

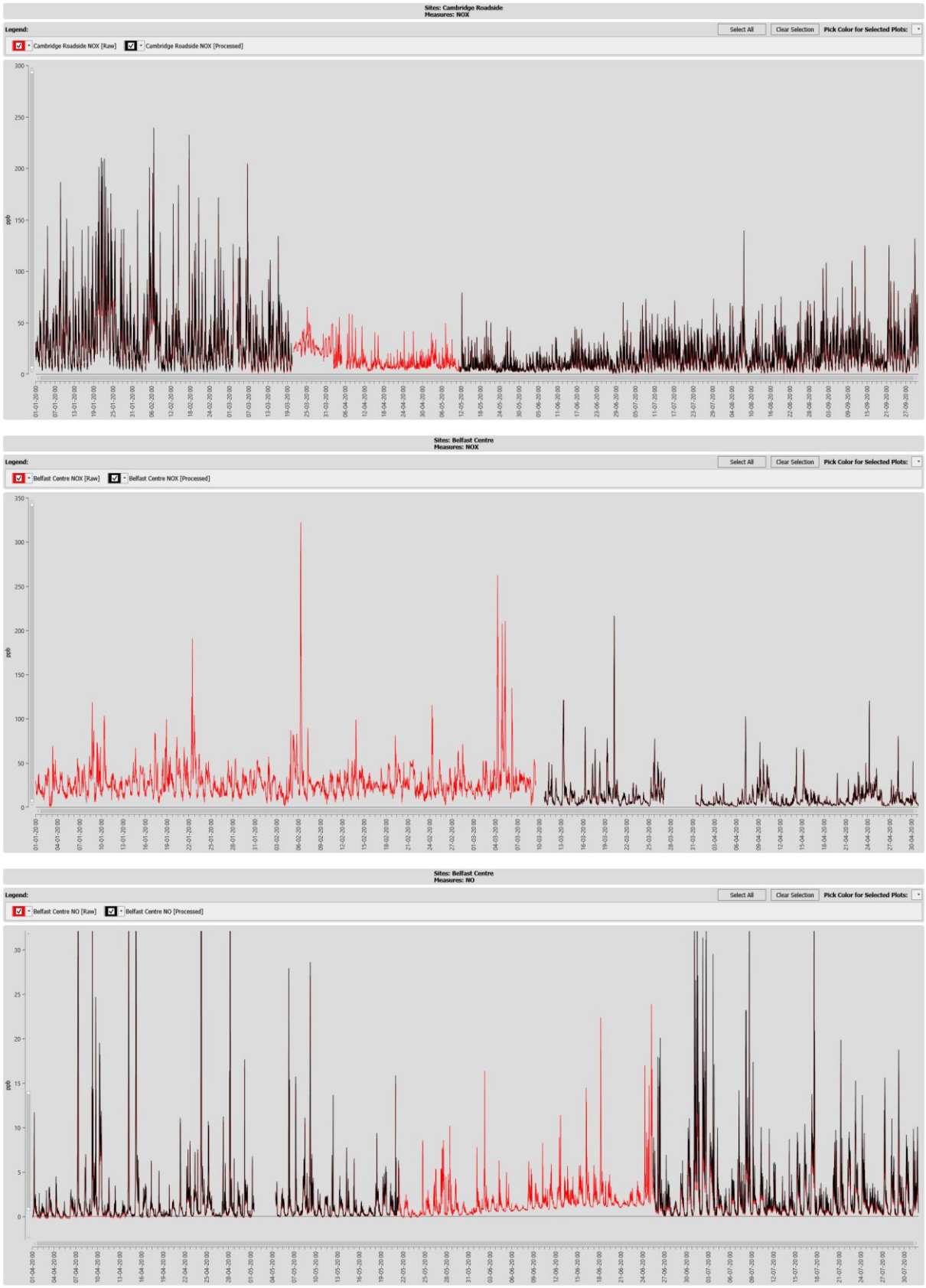


Figure 31 - Examples of internal sampling NOx and NO (affected period in red)

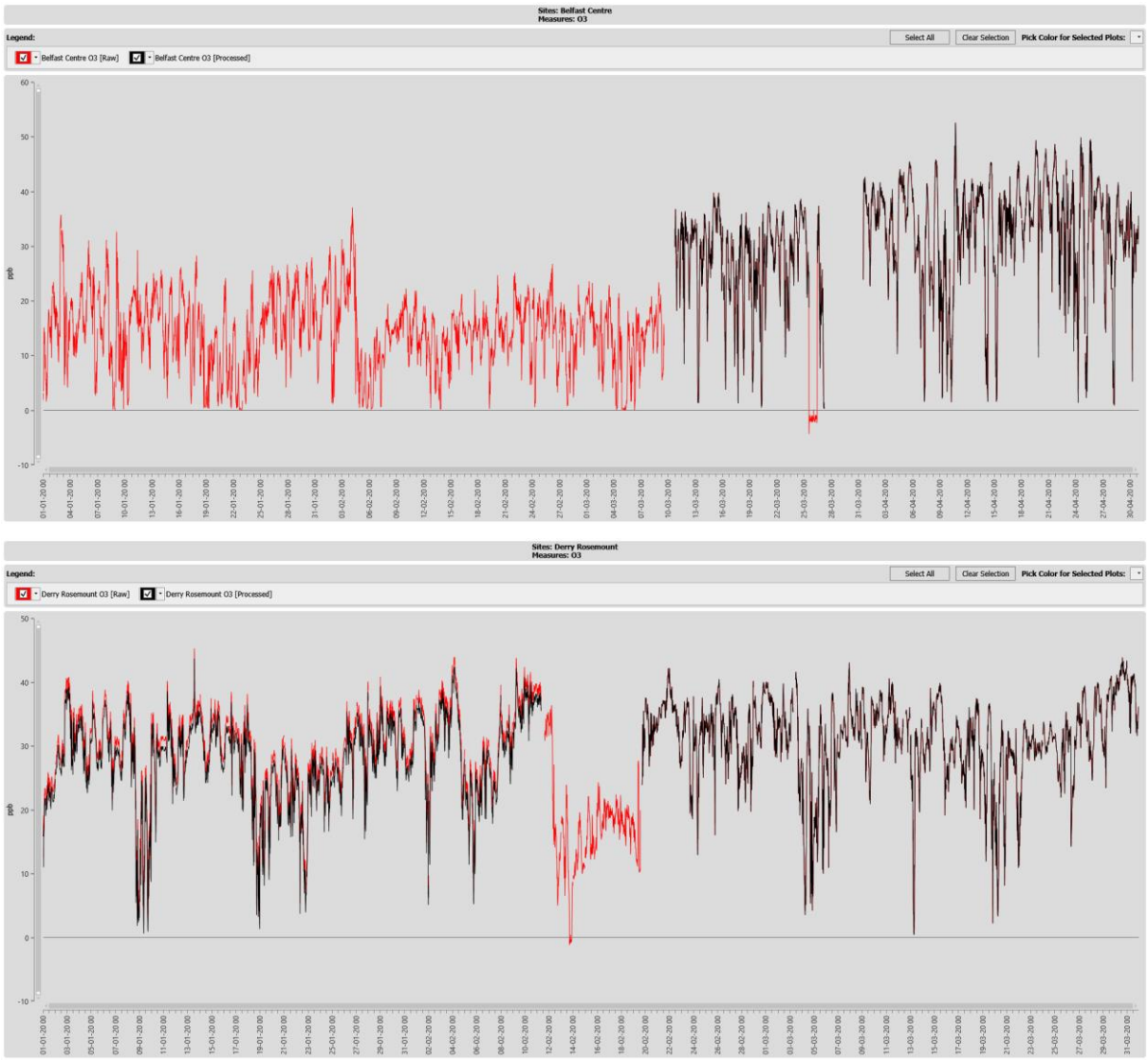


Figure 32 - Further examples of internal sampling - ozone (affected period in red)

15.7. Auto-Calibration Run-ons

Most instruments in the AURN perform an automatic calibration cycle every night. Zero gas and then span calibration gas are introduced into the instruments between the times of 0045 and 0115. The resultant readings for these gases are used to identify instrument breakdowns or excessive drifts. Data during the calibration cycle are flagged as zero and span measurements and are not used to calculate the reported ambient measurements.

A problem can occur if the solenoid valves in the pneumatic system do not close fully after the cycle. Calibration gas may then leak into the instrument during the ambient measurement period. The fault can be identified by calculating the diurnal variation of concentrations during this period (i.e. calculating the average concentration for each 15-minute period).

Figure 33 shows the average diurnal cycle of 15-minute and hourly average NO_2 concentrations at an AURN site exhibiting autocalibration run-on. This example shows that the calibration gas introduced between 0045 and 0115 remained in the instrument until about 0200. The ambient measurements between 0130 and 0200 are therefore invalid and must be removed during data ratification. Hourly averages, which are the basic reporting time period for the AURN, are calculated from at least three valid 15-minute

concentrations. So, if this correction is required throughout a year, one hour out of twenty-four will be lost which is 4% of the annual data capture. This can be a serious source of data loss when the target data capture is 90%.

ESUs should ensure solenoid valves are cleaned and free from leaks during the service to minimise this effect.

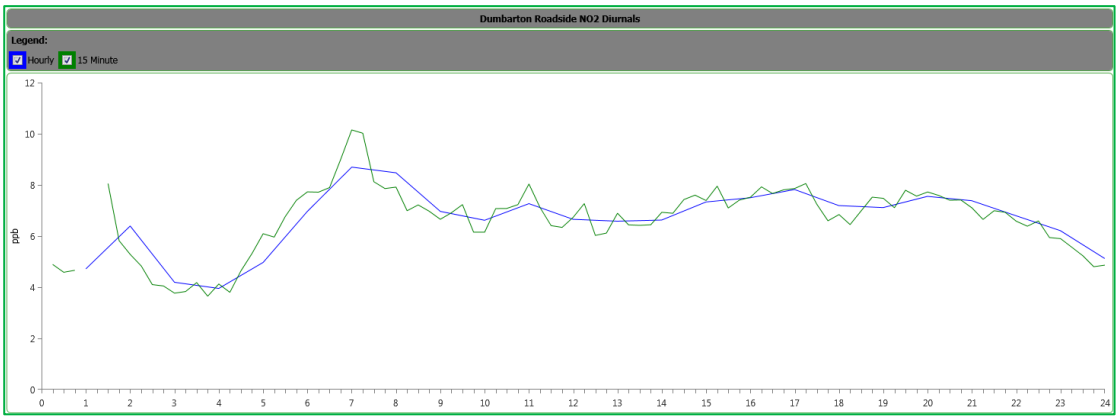


Figure 33 - Example of Auto-Calibration Run-On

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