# USER MANUAL

# Serinus 44

## NO/NO2/NOx/NH3 Analyser

**Version 1.0**

acoem

# acoem

Ecotech Pty Ltd is now part of the Acoem Group and as such, the branding of our instruments & software has also changed to 'Acoem'.

Over time we will be updating the content of all documents to reflect the Acoem branding convention.

In the interim, please note that while the cover of this document features Acoem branding, information contained within its pages still utilises the original 'Ecotech' name.

# Manufacturers statement

Thank you for selecting the Acoem Serinus 44  NO/NO$_2$/NO$_X$/NH$_3$Analyzer.

The Serinus series is the next generation of Acoem designed and manufactured gas analyzer, the Serinus 44 will perform  NO, NO$_2$, NO$_X$, NH$_3$ measurements over a range of 0-20ppm with a LDL of 0.4 ppb.

This User Manual provides a complete product description including operating instructions, calibration, and maintenance requirements for the Serinus 44.

Reference should also be made to the relevant local standards, which should be used in conjunction with this manual. Some relevant standards are listed in the References section of this manual.

If, after reading this manual you have any questions or you are still unsure or unclear on any part of the Serinus 44 then please do not hesitate to contact Acoem or your local Acoem distributor.

Acoem also welcomes any improvements that you feel would make this a more useable and helpful product then please send your suggestions to us here at Acoem.

Please help the environment and recycle the pages of this manual when finished using it.

# Notice

The information contained in this manual is subject to change without notice. Acoem reserves the right to make changes to equipment construction, design, specifications and /or procedures without notice.

# WARNING

Hazardous voltages exist within the analyzer. The analyzer lid should be closed and quarter turn lid fasteners locked when the analyzer is left unattended or turned on. Ensure the power cord, plugs and sockets are maintained in a safe working condition.

## Safety requirements

- To reduce the risk of personal injury caused by electrical shock, follow all safety notices and warnings in this documentation.

- If the equipment is used for purposes not specified by Acoem, the protection provided by this equipment may be impaired.

- Replacement of any part should only be carried out by qualified personnel, using only parts specified by Acoem as these parts meet stringent Acoem quality assurance standards. Always disconnect power source before removing or replacing any components.

# Factory service/warranty

This product has been manufactured within an ISO9001/ISO 14001 accredited facility with care and attention.

The product is subject to a 12-month warranty on parts and labour from date of shipment (the warranty period). The warranty period commences when the product is shipped from the factory. Lamps, fuses, batteries and consumable items are not covered by this warranty.

Each analyzer is subjected to a vigorous testing procedure prior to despatch and will be accompanied with a parameter list and a multipoint calibration check thereby enabling the analyzer to be installed and ready for use without any further testing.

To ensure that we process your factory repairs and returned goods efficiently and expeditiously, we need your help. Before you ship any equipment to our factory, please call your local Acoem service response centre (or distributor) to obtain a return authorisation number.

When you contact Acoem please provide the following information:
1. your name, telephone number and facsimile number
2. Your company name
3. The model number or a description of each item
4. The serial number of each item, if applicable
5. A description of the problem or the reason you are returning the equipment (e.g. sales return, warranty return, calibration, etc)

If you are required to return the equipment, the following documents should also be sent:
1. Your name, number and facsimile number
2. Your company name with return shipment
3. The model number or a description of each item
4. The serial number of each item, if applicable
A description of the problem/reason you are returning the equipment

# Claims for Damaged Shipments and Shipping Discrepancies

**Damaged shipments**
1. Inspect all instruments thoroughly on receipt. Check materials in the container(s) against the enclosed packing list. If the contents are damaged and/or the instrument fails to operate properly, notify the carrier and Acoem immediately.

2. The following documents are necessary to support claims:

   a. Original freight bill and bill lading
   b. Original invoice or photocopy of original invoice
   c. Copy of packing list
   d. Photographs of damaged equipment and container
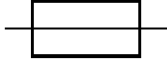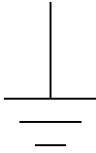   e. Contact your freight forwarder for insurance claims

   You may want to keep a copy of these documents for your records also.

   Refer to the instrument name, model number, serial number, sales order number, and your purchase order number on all claims. Upon receipt of a claim, we will advice you of the disposition of your equipment for repair or replacement.

**Shipping Discrepancies**

Check all containers against the packing list immediately on receipt. If a shortage or other discrepancy is found, notify the carrier and Acoem immediately. We will not be responsible for shortages against the packing list unless they are reported promptly (within 7 days).

# Internationally recognised symbols used on Acoem Equipment

| | | |
|---|---|---|
| | Electrical fuse | IEC 60417, No. 5016 |
| | Earth (ground) terminal | IEC 417, No. 5017 |
| | Equipotentiality | IEC 417, No. 5021 |
| | Alternating current | IEC 417, No. 5032 |
| | Caution, hot surface | IEC 417, No. 5041 |
| | Caution, refer to accompanying documents | ISO 3864, No. B.3.1 |
| | Caution, risk of electric shock | ISO 3864, No. B.3.6 |

# Manual Revision History

**Acoem Manual ID:**         **MAN 0075**
**Manual PN:**               **M010034**
**Current Revision:**        **1.0**
**Date released:**           **August2010**
**Description:**             **User Manual for the Serinus 44  NO/NO$_2$/NO$_X$/NH$_3$ analyzer**

This manual is the full user manual for the Serinus 44  NO/NO$_2$/NO$_X$/NH$_3$Analyzer. This manual contains all relevant information on theory, specifications, installation, operation, maintenance and calibration. Any information that cannot be found within this manual can be found by contacting Acoem at:

| | | |
|---|---|---|
| Email: | Help | help@ecotech.com.au |
| | Service | service@ecotech.com.au |
| | Parts | parts@ecotech.com.au |
| | Phone: | +61 1300 364 946 |
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| | | Knoxfield Victoria |
| | | Australia 3180 |
| | Website | www.acoem.com |

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# 1   Introduction

## 1.1  Description

The Serinus 44  $NO/NO_2/NO_X/NH_3$ analyzer uses gas phase chemilluminescence detection to perform continuous analysis of nitric oxide (NO), total oxides of nitrogen ($NO_X$), nitrogen dioxide ($NO_2$) and ammonia ($NH_3$). The Serinus 44 analyzer measures to a sensitivity of 0.4ppb in the range of 0-20ppm. The measurement of these three gases is performed with the following main sub-components:

- $NO_2$ to NO converter
- Delay coil ($NO_X$ channel)
- External Ammonia converter
- Ozone source with reaction chamber ($NO + O_3$)
- Photomultiplier Tube (PMT)
- Calculation of $NO_2$ and $NH_3$ from $NO/NO_X/N_X$

The concentrations are automatically corrected for gas temperature and pressure changes and referenced to 0°C, 20°C or 25°C at 1 atmosphere. This allows the Serinus 44 to sample in the most useful measurement range for NO, $NO_2$ $NO_X$ and $NH_3$. This Manual will detail the operation, preventive maintenance, cautions and health warnings.

## 1.2  Specifications

### 1.2.1  Measurement

**Range:**
- 0-50ppb, 0-20ppm auto ranging

**Lower detectable limit:**
- 0.4 ppb

### 1.2.2  Precision/Accuracy

**Precision:**
- 0.4 ppb or 0.5% of reading, whichever is greater.

**Linearity:**
- <1% of full scale

**Response time:**
- 15 seconds to 95%

**Sample flow rate:**
- 0.3 SLPM (1.0 SLPM total flow for all channels).

### 1.2.3  Calibration

**Zero drift**
- Temperature dependant:      0.1ppb per °C
- 24 hours:                            < 0.5 ppb
- 7 days:                               < 0.5 ppb

**Span drift**
- Temperature dependant:      0.1% per °C
- 7 days:                     <1% of reading

## 1.2.4  Power

**Operating voltage:**
- 99 to 132 VAC (57-63Hz) or via switch 198 to 264 VAC (47 to 53 Hz)

## 1.2.5  Operating conditions

**Ambient Temperature Range:**
- 5ºC to 40 ºC (41 ºF to 104 ºF)

**Sample pressure dependance:**
- 5% change in pressure produces less than a 1% change in reading

## 1.2.6  Communications

**Analog Output**
- Menu selectable current output of 0-20 mA, 2-20mA or 4-20 mA
  or
- Voltage output of 0 to 5 V, with menu selectable zero offset of 0%, 5%, or 10%.
- Range: 0 to full scale from 0-0.05 ppm to 0-20 ppm with 0%, 5%, and 10% offset.

**Digital Output**
- RS232 port #1:      Normal digital communication or termination panel connections
- RS232 port #2:      Multidrop port used for multiple analyzer connections on a single RS232
- USB port connection on rear panel
- 25 pin connector with discrete status and user control
- USB stick memory (front panel) for data logging, event logging and parameter storage

## 1.2.7  Physical dimensions

**Case dimensions:**
- Length:      620mm without handle (24.4" inches)
- Width:       440mm (17.3" inches)
- Height:      178mm/4RU (7" inches)

**Weight:**      22.6 kg (Analyzer)
                 10kg  (Converter)

## 1.3  Nomenclature

**Span:** A gas sample of known composition and concentration used to calibrate/check the upper range of the instrument (GPT using NO gas).

**Zero:** Zero calibration uses zero air ($NO_X$/$NH_3$ scrubbed ambient air) to calibrate/check the lower range of the instrument.

**Background:** External signals that can be confused with that of the signal being measured.

**Zero drift:** the change in instrument response to zero pollutant concentration over 12hr and 24hr periods of continuous unadjusted operation.

**Zero air:** Purified air in which the combined effect of the concentration of impurities is less than 1% of the relevant midrange of the analyzer instrument. Sufficient purified air can be obtained by passing dry ambient air through an activated charcoal filter and a particulate filter.

**External span source:** Span gas that is delivered via an external accredited cylinder (e.g. NATA/NIST).

**Sample Air:** Sample air is defined as the sample before it has entered the reaction cell, as distinguished from the exhaust air.

**Exhaust air:** Exhaust air is the sample air after it has passed through the reaction/measurement/detection cell and is moving towards being expelled from the analyzer.

**ID and OD:** Measurements of tubing, ID is the internal diameter of tubing, OD is the outer diameter.

## 1.4  Background/ Theory

Oxides of Nitrogen ($NO_x$) is the product of endothermic reactions within combustion engines and causes significant environmental pollution.

The main source of $NO_x$ is from the engine of automobiles and these pollutants are harmful to humans in their respective forms or in the creation of ozone ($O_3$) or acid rain. $NO_x$ is most prevalent in our societies as a contributor to asthmatic conditions as well as the smog found throughout many industrialized cities.

Ammonia ($NH_3$) is mainly generated from agricultural sources, with hot-spots found particularly near intensive pig and poultry farms. Ammonia pollution causes both acidification of soils and a decrease in the richness of plant species.

### 1.4.1  Measurement Theory

The measurement of the $NO/NO_2/NO_X/NH_3$ is performed via the gas phase chemiluminescence method. The Serinus 44 follows these principles and measurement techniques:

- Sample air is drawn into the reaction cell via three separate (alternating) channels the NO, $NO_X$ and $N_X$. The $NO_X$ channel travels through a delay coil enabling the same sample of air to be sampled for NO, $NO_2$ and $NO_X$.
- The $NO_X$ channel passes through an $NO_2$ to NO converter, $NO_2$ is converted to NO
- The analyzer also draws in air through an external converter ($N_X$ channel) which converts $NH_3$ into NO (and some NO into NO2).  This is then passed through the molyconverter to convert any NO2 into NO.
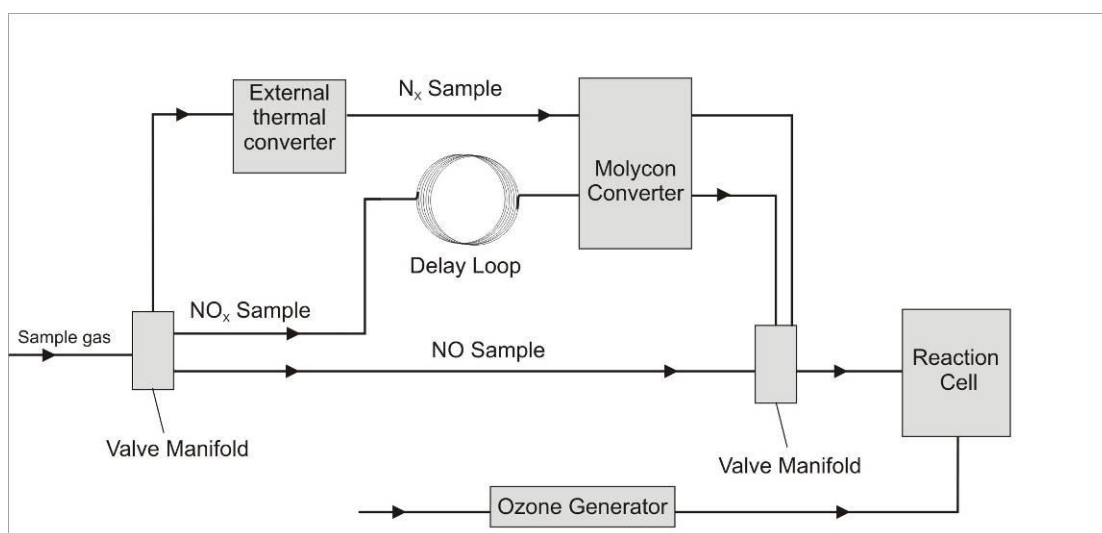


**Figure 1 Simple pneumatic diagram**

- Sample air (NO, $NO_X$ and $N_X$ channels) enter the measurement cell where NO reacts with Ozone in the following reaction

$$NO + O_3 \rightarrow NO_2\text{*} + O_2$$
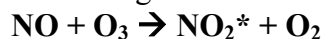
**Equation 1 Chemilluminescence reaction**

- This reaction releases energy in the form of chemiluminescence radiation (1100nm), which is filtered by the optical bandpass filter and detected by the photomultiplier tube (PMT)

- The level of chemiluminescence detected is directly proportionally to the NO in sample
- $NO_2$ is calculated by subtracting the NO measurement from $NO_X$ measurement

$$NO_X = NO + NO_2 \text{ or } NO_2 = NO_X - NO$$

**Equation 2 NO$_2$ calculation**

### 1.4.2  Kalman filter theory

The Serinus analyzer series use the advanced digital Kalman filter. This filter provides the best possible compromise between response time and noise reduction for the type of signal and noise present in ambient air analyzers.

The Kalman filter enhances measurements by modifying the filter time base variable, depending on the change rate of the measured value. If the signal rate is changing rapidly, the instrument is allowed to respond quickly. When the signal is steady, a long integration time is used to reduce noise. The system continuously analyzes the signal and uses the appropriate filtering time.

## 1.5  Instrument description

The $NO/NO_2/NO_X/NH_3$ analyzer consists of six main assemblies:
- The pneumatics to transfer sample and exhaust gas
- The sensors for the measurement of $NO/NO_2/NO_X/NH_3$ (optical cell) and other relevant parameters
- The control system which encompasses all circuit boards controlling sensors and pneumatics
- The power supply which supplies power for all the instrument processes
- The Communication module to access data
- External thermal converter
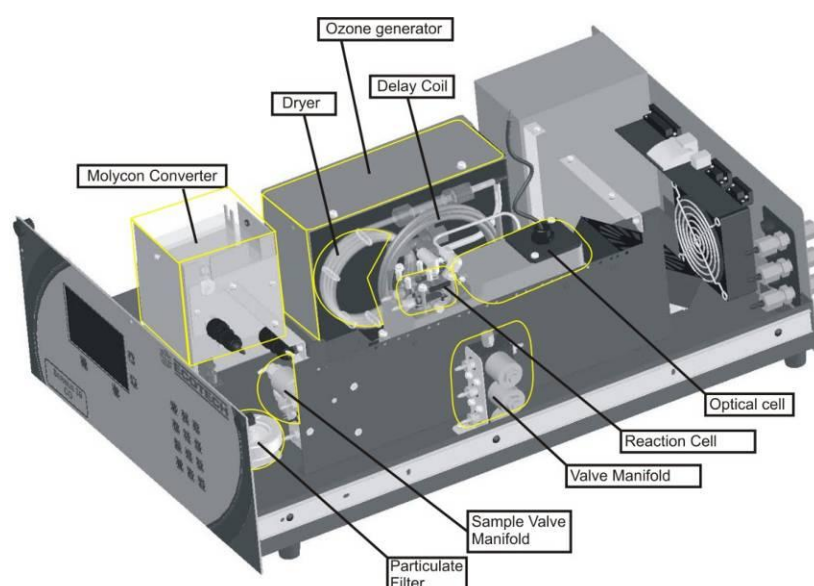


**Figure 2 Internal components diagram**

### 1.5.1        Particulate filter

The Particulate filter is a Teflon 5 micron (µm) filter with a diameter of 47mm. This filter eliminates all particles larger than 5µm that could interfere with sample measurement. There are two particulate filters fitted within the analyser one on the NO/$NO_x$ line and the other on the $N_x$ line.

### 1.5.2        Delay Loop

The delay loop is a coil of sample tubing which increases the length of time sample air takes to travel to the $NO_2$-NO converter and the measurement chamber. This delay allows the sample from the NO channel to be measured before the sample from the NOx channel arrives there.

### 1.5.3        Molycon Converter

The molycon converter uses high temperatures (325ºC) and Molybdenum chips to convert any $NO_2$ in the sample to NO. This conversion is used for $NO_X$ measurements as well as the calculation of $NO_2$.

The molybdenum converter assembly also houses a catalytic ozone destroyer that removes ozone from the instrument exhaust.

### 1.5.4        Valve Manifold

The valve manifold switches between sample gas, calibration and background gas.

### 1.5.5        Sample Valve Manifold

The sample valve manifold switches sample gas between NO, $NO_X$ and $N_X$ channels along with background and bypass flow.

### 1.5.6        Pressure Transducers

Two pressure transducers are used for the calculation of sample flow rate, one is located upstream to the critical orifices (ambient) and the other is located in the reaction cell downstream of the critical orifice (gas pressure).

### 1.5.7   HTO 1000N external thermal converter (optional)

The HTO 1000N thermal oxidizer employs both catalytic and thermal principles in the conversion of $NH_3$ to NO. Converter efficiency is between 88-94% at a temperature of 680°C.

The HTO 1000N is connected to the Serinus 44 analyzer through the Auxiliary port (on the rear of the analyzer, see section 2.3.1 for more details).

| 1.5.8 | Optical Cell |
|-------|--------------|

**Reaction Cell**

The reaction cell is designed to inject ozone into the sample, causing a chemiluminescence reaction which emits radiation of which some is filtered to a specific wavelength (1100nm) and measured by the PMT. The cell is designed to optimize the signal detected by the PMT and reduce noise.

**Optical Bandpass Filter**

The optical bandpass filter is a coloured glass that only allows light of 600nm through

**Photomultiplier (PMT)**

The PMT detects the amount of light reaching its sensors. The filtering of light reaching the PMT allows direct measurement of NO in the cell.

**PMT Cooler**

To reduce the noise of the PMT, the PMT is operated within a constant temperature of 12°C by the PMT cooler

**PMT High Voltage Supply and Preamplifier module**

This is a single component within the PMT housing. Its function is to supply high voltage to the PMT and to amplify the photocurrent signal from the PMT.

| 1.5.9 | Main Controller PCB |
|-------|---------------------|

The Main Controller PCB controls all the processes within the instrument, it contains a battery backed clock/calendar and an onboard microprocessor. The Main Controller PCB is located at the top of the instrument, above the rest of the components when the lid is removed. The PCB is hinged and can be lifted up to stand up vertically allowing easy access to instrument components underneath.

| 1.5.10 | Power supply |
|--------|--------------|

The power supply is a self-contained unit housed in a steel case designed to meet CE requirements.

It has an input voltage of 115/230VAC 50/60 Hz and an output voltage of 12 VDC power for distribution within the analyzer.

> **Note:** Input voltage can be manually changed by flicking the red switch left (230) for 220-240V or right (110) for the 100-120V. Ensure the switch is set to the correct voltage (from supply) before switching on.

**On/off switch**

Located on the back panel (bottom right facing from behind the instrument)

| 1.5.11 | **Communications** |
|---|---|

Communication between the analyzer and either a data logger, laptop or network can be performed with the following communication connections located on the back panel (see Figure 4).

**RS232 #1**

This port is designed to be used for simple RS232 communication or with a Termination Panel allowing the Serinus instrument to work as a datalogger. This function is an optional extra that can be purchased from Acoem.

**RS232 #2**

This port is designed to be used for simple RS232 communication, or in a daisy chain (multidrop) configuration (multiple analyzers connected via the same RS232 cable).

**USB**

This port can be used for instrument communication and is also good for quickly downloading data, onsite diagnostics, maintenance and firmware upgrades.

**TCP/IP (optional)**

This port is best used for remote access and real-time access to instruments when a network is available to connect with.

**External I/O port**

The Analog/Digital port sends and receives analog/digital signals to other devices. These signals are commonly used to activate gas calibrators or for warning alarms.

**Analog Outputs**

The analyzer is equipped with three analog outputs. Menu selectable as either voltage ouput 0-5VDC, or current output 0-20, 2-20, 4-20 mA

**Analog Inputs**

The Analyzer is also equipped with three analog voltage inputs (0-5VDC) with resolution of 15 bits plus polarity.

> **Warning:** Exceeding these voltages can permanently damage the instruments and void warranty

**Digital Status Inputs**

The analyzer is equipped with 8 logic level inputs for the external control of Zero/Span calibration sequences.

**Digital Status Outputs**

The analyzer is equipped with 8 open collector outputs which will convey instrument status conditions and warning alarms such as no flow, sample mode, etc.

# 2    Installation

## 2.1  Initial check

**Packaging**

The packaging which the Serinus 44 is transported in is specifically designed to minimise the effects of shock and vibration during transportation. Acoem recommends that the packaging be kept if there is a likelihood that the instrument is going to be relocated. For this purpose, it is also good to keep the red plastic caps installed in the pneumatic connections.

In the event that the packaging is to be disposed of, all the materials used are recyclable and should be disposed of accordingly.

Check the instrument with the following steps:

- Open instrument lid by using a screwdriver to undo the front quarter turn fasteners, also undo any further screws that may be installed in either the front or rear panel, then slide the lid backwards (bench top)
- Check that all pneumatic and electrical connectors are connected, if not reconnect
- Check for any visible and obvious damage
  (if damage exists contact you supplier and follow the instructions in Claims for Damaged Shipments and Shipping Discrepancies page iv)
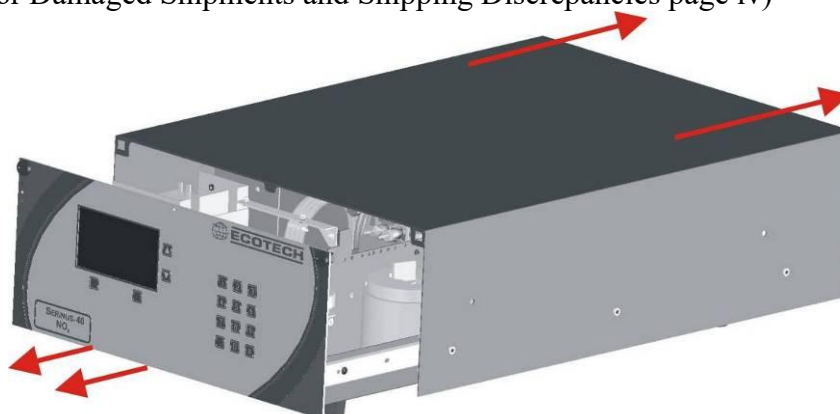


**Figure 3 Opening the lid**

**Items Received**

With the delivery of the Serinus 44, you should have received the following:

- Acoem Serinus 44 instrument            PN: E020044
- Software CD                            PN: S040001
- End Caps                               PN: B010002-02
- Manual                                 PN: M010034
- Power Cord (120V)*                     PN: 060-070110
- Power Cord (240V)*      Australia      PN: 060-070140
                          Europe         PN: 060-070120
                          UK             PN: 060-070160

*Power cord received depends on the power supply of the country (120V or 240V.).

> **Please check that all these items have been delivered undamaged. If there is any item damaged or if you are unsure, please contact your supplier BEFORE turning on the instrument.**

## 2.2  Mounting/Siting

When installing the instrument the following points must be taken into account:

- Analyzer should be placed in an environment with minimal dust, moisture and variation in temperature
- For best results analyzers should be located in a controlled environment with temperature and humidity controlled (air conditioned shelter) set to 25-27°C
- Whether in rack or placed on bench instruments should not have objects placed on top of or immediately next to (touching) casing
- Instruments should be placed with easy access to front panel (instrument screen/USB flash) and to the back panel (Communications suite/pneumatic connections)
- It is recommended that sample line be as short as possible and/or a heated manifold be used for sampling (minimizing moisture condensation in sample)
- Do not pressurize sample line under any circumstances.  Sample should be drawn through instrument from the atmosphere.  This should be done either by and internal pump if installed or by an external pump connected to the exhaust port of the analyser
- Converter should be placed in the same environment (controlled temperature, humidity) with no objects placed on or next to it (can result in fires)

## 2.3  Instrument setup

When the Serinus has been mounted in a suitable site, the following sections must be followed to ready the analyzer for monitoring.
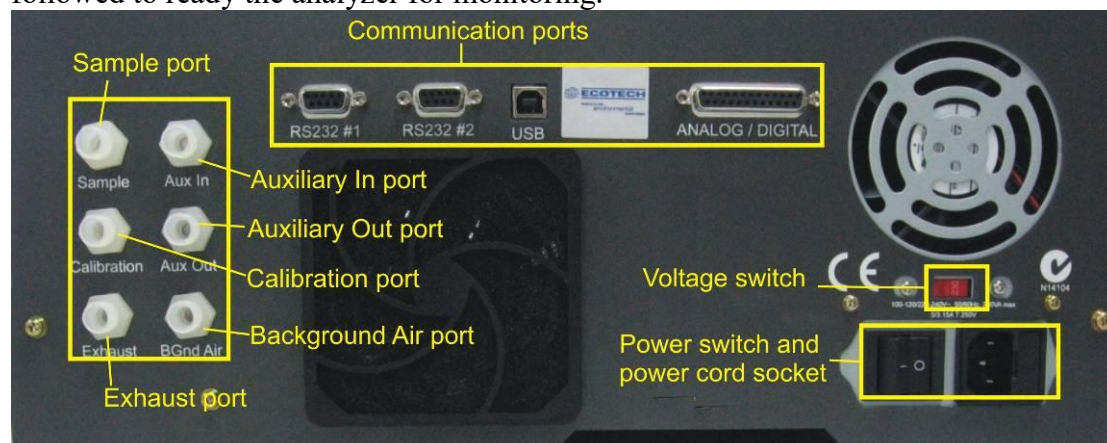


**Figure 4 Instrument Back panel**

### 2.3.1  Pneumatic connections

The Serinus 44 contains 6 pneumatic ports on the back panel of the analyzer; sample port, calibration port, exhaust port, background air port, auxiliary in port and auxiliary out port.. All tubing and fittings used should follow the instructions below:

- Must be made of Teflon$^®$ FEP material, Kynar$^®$, stainless steel, glass or any other suitably inert material
- Sample line should be no more than 2 meters in length with ⅛ inch ID, ¼ inch OD
- Sample inlet pressure should not exceed 5 kPa above ambient pressure
- Tubing must be cut squarely and any burrs removed
- Remove nut, insert tubing through back of nut with tube extending 1 inch through front
- Place tubing into port until it hits the tube stop inside fitting
- Move nut onto fitting and tighten nut (clockwise) finger tight
- Nuts should be re-tightened when instrument reaches operating temperature

**Sample port**

The sample port must be connected to an ambient source of sample air. When using a sample manifold the Serinus requires at least 1.5 slpm delivered to the sample manifold (1 slpm for measurement plus approx. 50% overflow)

**Calibration port**

The calibration port should be connected to the span/zero source. It is recommended that a gas calibrator be used with a Nitrogen Oxide GPT source to deliver precise concentrations of NO and $NO_2$.

**Exhaust port**

The sample air is expelled from the analyzer through the exhaust port.

The exhaust tubing should be fitted to a vacuum pump (minimum: 1.2 SLPM at 50 kPa).

Alternatively if using the internal pump then exhaust tubing can be vented to external air.

> **Note:** It is recommended that exhaust air is not expelled into a shelter/room inhabited by people; it should be expelled into the external air, away from the sample inlet.

**Background**

The background port is used to supply air to the ozone generator within the instrument.

**Auxiliary In port**

The Auxiliary In port (AUX In) brings air in from the converter and is connected to the "Outlet" of the HTO 1000N.

**Auxiliary Out port**

The Auxiliary Out port (AUX Out) takes air from the analyzer and delivers it to the converter. Tubing is connected to the "Inlet" of the HTO 1000N.

## 2.3.2  Power connections

When connecting the power source the following must be adhered to:

| **Warning** |
| :---: |
| **The following points MUST be followed; incorrect setup and activation of instrument may cause damage and will void warranty** |

- Verify that the red switch (above power switch) is switched to the correct setting (240V or 110V)
- The three pin power plug (with ground) **MUST** be used with an earthed power socket (3 pin)
- Connect the power plug into the mains power point and turn the power switch on

## 2.3.3  Communications connections

There are a number of different ways to communicate with the analyzer, select one of the following options

**RS232 #1**

- Connect this port to a data logger (such as WinAQMS) with an RS232 cable.
- This port is also designed to be used with a Termination Panel allowing the Serinus instrument to work as a datalogger. This function is an optional extra and should be purchased from Acoem.

**RS232 #2**

- Connect RS232 cable from instrument to computer, datalogger or in a daisy chain formation.

> **Note:** when using daisy chain formations ensure each analyzer is given a unique instrument ID

- Configure computer/datalogger software for data export/remote control

**USB**

- Connect USB cable to computer and run either the Serinus data downloader program or WinAQMS logger

**TCP/IP (optional)**

- Plug in network cord (this cord should be attached to network)
- Use Serinus downloader program to access instrument and download data (supplied on utilities CD)

**Analog/Digital Status Function**

- This port is used to send/receive analog and digital signals. This port is normally used to connect with a gas calibrator, or to activate alarm signals.
- Contains 8 digital inputs, 8 digital outputs and 3 analog inputs and 3 analog outputs

## 2.3.4  Analyzer set up

- Ensure USB memory key is installed
- Check battery is turned on at main controller PCB (Figure 5)
- Ensure all pneumatics are connected as described above
- Ensure Converter is plugged in and turned on
- Turn on analyzer and allow warm-up procedure to complete (section 3.1)
- Check/Set time and date (section 3.5.2.5)
- Set filter to desired monitoring option
- Set internal data logging options
- Set analog/digital inputs and outputs settings
- Leave instrument to warm up for 2-3 hours (until Molycon is warm) and converter for 4 hours, wait for a stable concentration measurement for at least 1 hour
- Perform pressure sensor check  (section 6.4.9)
- Perform leak check (section 6.4.5)
- Perform a multipoint calibration (see section 4.3)
- Instrument is now ready

## 2.4  Transporting/Storage

Transporting the Serinus should be done with great care. It is recommended that the packaging the Serinus was delivered in should be used for any transport as it ensures minimal damage to the instrument. When transporting or storing the instrument the following points should be followed:

- Turn off instrument and allow to cool down
- Remove all pneumatic, power and communication connections*
- Remove instrument from rack
- Replace red plugs into pneumatic connections
- Place instrument back in plastic bag with desiccant packs and seal bag (Ideally the bag it was delivered in)
- Place back in foam and box instrument was delivered in if possible, if not find some equivalent packaging which provides protection from damage
- Instrument is now ready for long term storage or transportation

> **Note:** After transport or storage, instrument must be set up and calibrated see section 2.3.4

*if storing over long period (6 months) turn the battery off by switching the following switch on the main processor board (Figure 5) to the left
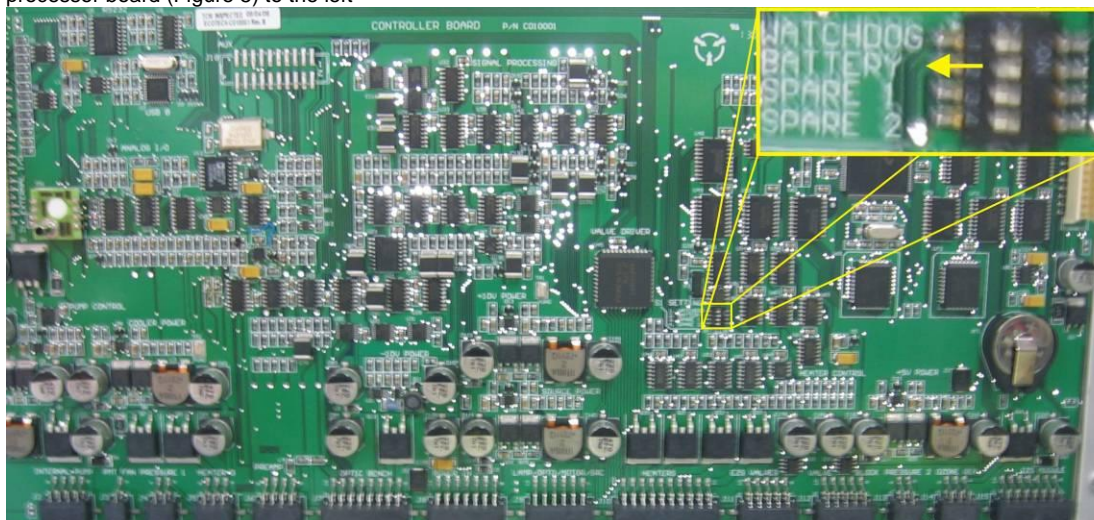


**Figure 5 Switching battery off**

# 3 Operation

## 3.1 Warmup

As the instrument is turned on it will adjust itself ready for monitoring. No measurements are taken during the warm-up.

When the main screen appears the action line of the instrument will display the following warm up activities:

**High voltage check:**
Instrument setting upper voltage limit for measurement

**Molycon is cold→ warm→ hot**
Instrument progressively increases the temperature of the Molycon until it reaches the desired temperature 319ºC. When heating from cold the Molycon will take approximately 60 minutes to reach desired temperature.

After this warm-up has completed the instrument will immediately begin taking measurements as seen in section 3.4

## 3.2 General operational information

The Serinus is operated with the use of 3 sets of buttons. There are the selection buttons, scrolling buttons and keypad.
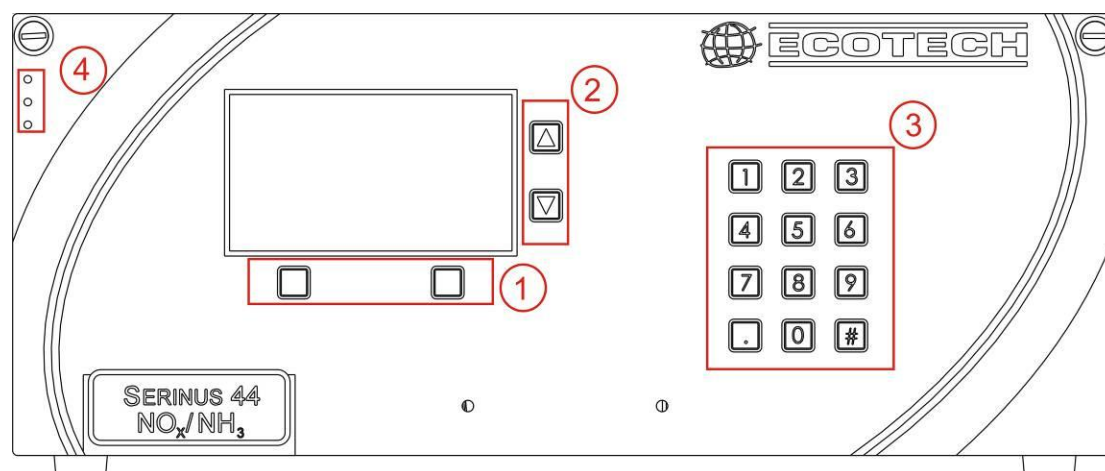


**Figure 6 Serinus front panel**

**(1) Selection buttons**
> The selection buttons will perform the function specified directly above it on the screen i.e. quick menu, main menu, open, back, select, start etc

**(2) Scrolling buttons**
> The scrolling buttons allow users to scroll up and down through menus. The scrolling buttons are also used to scroll side to side through editable fields (Date, time, concentration etc). On the main screen these buttons are used for adjusting contrast.

**(3) Keypad**

The keypad contains numbers 0-9, decimal point (.) and hash (#). The keypad is used to input numbers and concentrations when numbers on the screen are highlighted. In some circumstances the decimal point and hash are used for different functions (as explained on that specific screen).

**(4) Instrument status lights**

Located in the top left corner these lights indicate the status of the instrument as a whole.

a. A red light indicated that the instrument has a major failure and is not functioning

b. A orange light indicates there is a minor problem with the instrument, but instrument may still take measurements reliably

c. A green light indicates that the instrument is working fine and there are no problems

In the case of a yellow or red light enter the Main menu → Analyzer State → Status menu to find which components are failing (see section 3.5.2.1).

If both red and orange light are shining then this indicates the instrument is in the bootloader.

## 3.3  Main screen

The main screen is composed of 7 parts, the Readings, the Status/Error line, the time, the Instrument Activity line, menu buttons, the concentration units and USB detection. The contrast is adjustable only from the main screen, pressing the up scroll arrow will darken the screen; pressing the down scroll arrow will lighten it.
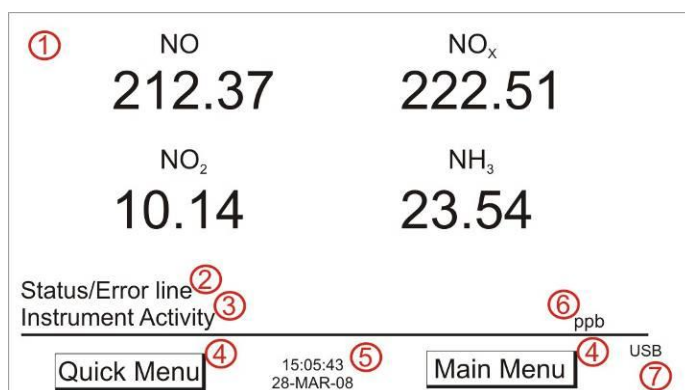


**Reading (1)**

The Reading section takes up most of the screen, it displays the concentration being measured in real time including during calibrations. When the instrument is changed in the Front screen field (General settings section 3.5.2.5) from "inst only" to "inst & avg" the reading will display both the average concentration (above) and the instantaneous concentration.

### Status/Error line (2)

The Status/Error line provides users with information on any problems the instrument may have. It includes all the status/errors contained in the Status Menu section 3.5.2.1.

### Instrument Activity (3)

The Instrument activity line shows what function the instrument is currently performing. This will generally be showing three groups of actions; Warm-up (section 3.1), Measurement (section 3.4) or Calibration (section 4).

### Menu buttons (4)

The Menu buttons are used on the main screen to enter one of two menus. The Quick Menu (section 3.5.1) contains all information and features necessary in scheduled maintenance; the Main Menu (section 3.5) contains all information and fields available to users and is generally only used during initial setup.

### Time and Date / Nx (5)

The Time and Date are displayed in between the menu buttons at the bottom of the screen. Time and Date are displayed as selected in section 3.5.2.5.  When on the main screen, the $N_x$ reading replaces the date for 15 seconds every 20 seconds.

### Concentration Units (6)

The current instrument units are displayed at the bottom right hand corner of the main screen.

### USB detection (7)

A USB symbol will be displayed in the bottom right corner when the USB key is plugged in (behind front panel). If the USB symbol is not shown the USB key should be reattached. Underneath the USB symbols arrows may be displayed which indicates data transfer. The USB key must not be removed whilst this is happening.

## 3.4  Sampling

The Serinus 44 $NO_X$ analyzer is a triple channel monitoring instrument meaning it measures sample air through three different paths. These three paths are used to measure NO (Sample), $NO_X$ (Sample Aux) and $N_X$ (Sample Aux2). From these measurement cycles two calculations are performed to get measurements of $NO_2$ (difference between NO and $NO_X$) and $NH_3$ (difference between $N_X$ and $NO_X$).

The instrument measures NO $NO_X$ and $N_X$ in groups of 15 (5 of each), it switches between each of the 3 channels 5 times per cycle. For each cycle performed a Background is performed first, this is used to determine fluorescence without NO present removing any background noise from the signal. The Sampling procedure follows:

X1

| | |
|---|---|
| Background fill | Cell fills with background air |
| Background measure | Background air measured |
| Background purge | Background air removed from cell |

X5

| | |
|---|---|
| Sample fill | NO sample fills cell |
| Sampler measure | NO sample measured |
| Sample fill aux | $NO_X$ sample fills cell |
| Sample measure aux | $NO_X$ sample measured |
| Sample fill aux2 | $N_X$ sample fills cell |
| Sample measure aux2 | $N_X$ sample measured |

## 3.5  Menus and screens

The Menu system is divided into 2 sections, the Quick Menu and the Main Menu. The quick menu contains all information and operations necessary during scheduled maintenance visits. The main menu contains all fields that are accessible to users; they provide information on component failures, measurement parameters as well as editable fields and test procedures.

### 3.5.1  Quick Menu

The quick menu is designed to contain all the tools for maintenance performed by operators in one easy to use screen. The quick menu allows operators to perform calibrations/checks, check important parameters and review service history in one menu.

**Span Calibrate**
This field is used to perform a span calibration. This option should be used only when a known concentration of span gas is running through the measurement cell. When this is happening activate the span calibrate field, a window will open with editable numbers, change the numbers to match the concentration that the instrument is reading and select accept. The instrument span calibration has now been performed.

**Zero calibrate**
This field is used to correct the zero calibration setting. This option should be used only when zero gas is measured by the instrument. When this is happening activate the zero calibrate field, a window will open with editable numbers, leave the numbers at 0000.000 and select accept. The instrument zero calibration has now been set.

**Event Log**
This field enters a screen with a log of all the events that the instrument performs. These events include calibrations, errors, backgrounds, warnings. This log is stored on the removable USB flash memory.

**Instrument**
This field allows the instrument to be set to either "Online" (data being validated) or "Offline" (data not validated). This field is used to change the instrument into "Offline" when service work is being performed.

**Safely remove USB stick**
This feature must be activated to safely remove the USB stick (also occurs in the quick menu 3.5.5).

**Gain**
A multiplication factor used to adjust the concentration measurement to the appropriate level (set at calibration).

**Service due**
A non-editable field that notifies the user when the next instrument service is due. This value is editable in the "Next service due" field of the Service menu (section 3.5.5). This field is only displayed in the 2 weeks prior to the date displayed in this field, or after the date has occurred.

## 3.5.2  Analyzer State

Displays the status of various parameters that effect instrument measurement and various functions. There are 4 sub menus within this menu and 3 non-editable fields described below.

***Event Log***
This field enters a screen with a log of all the events that the instrument performs. These events include calibrations, errors, backgrounds, warnings. This log is stored on the removable USB flash memory.

***Firmware Ver.***
This field displays the firmware version currently in use on this analyzer. This can be important when performing diagnostics and reporting back to the manufacturer.

***Power Failure***
This field displays the time and date of the last power failure occurred (or power was disconnected from analyzer)

### 3.5.2.1  Status

The Component status menu contains a list of the main components within the instrument and their status.

***Cell Temp***
The cell temperature must be within ± 10% of the heater set point (section 3.5.2.5)

***Valve Manifold***
If temperature of valve manifold is outside 10% of the heater set point

***Converter Temp***
The converter temperature must be between 250 ºC and 350 ºC to pass.

***Cooler Status***
Status of the PMT cooler

***Sample Flow***
Indicates whether the instrument has sample flowing through

***A/D Input***
A reference voltage is sent to analog to digital input chip, this field will display a pass or fail indicating if the board is working or not

***Chassis Temp***
Displays whether the Chassis temperature is within the acceptable limits

***USB Key***
Detects whether a USB key is plugged into the USB port and instrument is logging

### 3.5.2.2 Temperatures

*Temperature Units*
Editable field to allow the user to change the current temperature units of the analyzer.

*Set point (CELL)*
Editable field that sets the temperature that heated components are regulated at (default value is 50°C).

*Cell*
Temperature of the optical reaction cell.

*Converter*
Temperature of the molybdenum converter (molycon).

*Chassis*
Displys the temperature of air inside the chassis, measured on the microprocessor board.

*PMT Cooler*
Temperature of the cooled PMT block (should be 13°C).

*Manifold*
Temperature of the orifice heater in the valve manifold.

### 3.5.2.3 Pressures

*Pressure units*
Select the units that pressure will be displayed in (torr, psi, bar, atm, kPa)

*Ambient*
Current ambient pressure (outside the analyzer)

*Cell*
Current pressure within the measurement cell

*Manifold*
Current pressure in the valve manifold.

*Sample Flow*
Indicates the gas flow through the sample port of the instrument, should be around 1.00

> **Note:** Will indicate 0.00 if the flow transducer senses flow has gone to zero.

## 3.5.2.4 Voltages

*Conc Voltage (RAW)*
Voltage from the preprocessor proportional to the detected gas signal
from the reaction cell. This voltage represents the actual measurement of
gas

*High Voltage*
PMT power supply high voltage reading

*Analog Supply*
+12 volt (primary) power supply

*Digital Supply*
+5 volt microprocessor power supply

*-10V supply*
-10 volt reading from the main controller board

## 3.5.2.5     General Settings

*Decimal Places*
Select "Edit" to change the amount of decimal places (0-5) used for
concentration on the front screen

*Conc. units*
Select the units that concentration will be displayed in (ppm, ppb, ppt,
$mg/m^3$,$\mu g/m^3$, $ng/m^3$)

*Temp. units*
Select the units that temperature will be displayed in (ºC, ºF, K)

*Pressure units*
Select the units that pressure will be displayed in (Torr, Psi, Bar, atm,
KPa)

*System Date*
The date can be entered in this screen by selecting "change" and using
the keypad and scroll buttons to change date

*System Time*
The time can be entered in this screen by selecting "change" and using
the keypad and scroll buttons to change time (24 hour clock)

*Backlight*
Select how long (minutes) the instrument backlight will stay on for
(30 secs, 1 min, 2 mins, 5 mins, 10 mins)

### Front screen
Change the display of concentration on the front screen between either just display the instantaneous concentration (inst. only) or both instantaneous and average concentration (Inst & avg).

## 3.5.3  Measurement settings

### Average period
Set the time period over which the average will be calculated: Minutes (1, 3, 5, 10, 15, or 30) or Hours (1, 4, 8, 12, or 24)

### Filter type
Sets the type of digital filter used. Choices are:
No filter, Kalman, 10 sec, 30 sec, 60 sec, 90 sec, 300 sec

> **Note:** The Kalman filter is the factory default setting and also gives the best overall performance for this instrument.

### $NO_2$ Filter
When enabled this function will apply a low pass digital filter to $NO_2$ measurement removing any artificial signal resulting from pneumatic differences between NO and $NO_X$ gas lines

### Noise
The standard deviation of the concentration. The manner in which this is calculated is as follows:
1.  Take a concentration value once every two minutes
2.  Store 25 of these samples in a first in, last out buffer
3.  Every two minutes, calculate the standard deviation of the current 25 samples. This is a microprocessor-generated field and cannot be set by the operator

> **Note:** This reading is only valid if zero air or a steady concentration of span gas has been fed to the analyzer for at least one hour.

## 3.5.4  Calibration menu

### *Span Calibrate*
This field is used to perform the span calibration setting. This option should be used only when a known concentration of span gas is running through the measurement cell. When this is happening activate the span calibrate field, a window will open with editable numbers, change the numbers to the concentration that the instrument is receiving and select accept. The instrument span calibration has now been performed.

### *Zero calibrate*
This field is used to correct the zero calibration setting. This option should be used only when zero gas is running through the measurement cell. When this is happening activate the zero calibrate field, a window will open with editable numbers, leave the numbers at 0000.000 and select accept. The instrument zero calibration has now been set.

### *Pressure calibration*
This field allows the user to calibrate the pressure sensors as explained in section 4.7

### *Cal. type*
Select the "Calibration type" field and select either Timed or Manual. Timed calibration is an automatic calibration controlled by the
- Interval between cycles,
- Length of each calibration cycle,
- When the calibrations will begin from,
- Whether the calibration will perform automatic compensation.

Manual calibration will perform a manual calibration depending on the calibration mode selected below.

### *Span Compensation*
When "enabled" the instrument will adjust the gain from the span concentration, when set to "disabled" instrument gain will not be updated.

### *Cal. Port* Select whether the instrument will sample from the external span/zero source (Calibration port) or from the internal span/zero source (IZS)

### *Cal. Pressure*
This field displays the measured pressure during the last calibration (for NO reference)

### *Cal. Pressure 2*
This field displays the measured pressure during the last calibration (for $NO_X$ reference)

### *Cal. Pressure 3*
This field displays the measured pressure during the last calibration (for $N_X$ reference)

### *Cal Temperature*
Temperature at which the instrument performed its last span calibration

### *Converter efficiency*
Editable field where the efficiency of the $NO_2$ converter (calculated in section 4.4) is entered.

### *$NH_3$ Converter efficiency*
Editable field where the efficiency of the $NH_3$ converter (calculated in section 4.5) is entered.

============================================
## MANUAL MODE
============================================

### *Cal. mode*
When in Manual mode the instruments operational mode can be chosen from the following:
- Measure: is the normal measurement through the sample port
- Cycle: performs a zero, then a span then returns to measure mode. The length of time spent measuring calibration gases is set in cycle time (below)
- Span: this mode will take air through the calibration port so that a span calibration can be performed
- Zero: this mode will take air through the calibration port so that a zero calibration can be performed

============================================
## TIMED MODE
============================================

**-- Date**           Enter the date for the first calibration (will display next calibration time after the first calibration is complete)

**-- Time**           Enter the time (during the day above) that calibrations will be performed

**-- Repeat**         Sets the amount of time between each calibration (from the above time and date)

> **Note:** The units of the repeat interval can be changed by pressing the # key (minutes, hours, days)

### *Span Cal Level*
Enter the concentration of span gas used during the timed span calibrations.

### *Cycle time*
Set the time period that the zero and span calibrations will last for during Timed Calibration (1 to 59 minutes) or when Cal. Mode (above) is set to cycle.

## 3.5.5 Service

The Service Menu displays information used to diagnose problems or suspected problems. The settings return to the previously set conditions when the operator leaves this menu.

### *Diagnostics*
See section 3.5.5.1

### *Calculation factors*
See section 3.5.5.2

### *Ozonator*
This field allows the user to turn the Ozonator on and off

**Note:** The ozonator will not be active if there is a flow fault due to safety reasons

### *Save configuration*
Saves instrument EEPROM settings to USB key including (calibration and communication settings, units, instrument gain etc). If you have problems with your instrument use this function to save setting to the removable USB stick and send them to your supplier with your service enquiry.

### *Save parameter list*
Activating this function will save the parameters value to a text file. This allows it to be sent to the operators relevant service center or Acoem for troubleshooting and fault finding.

### *Load configuration*
Loads instrument EEPROM setting from USB key (including calibration and communication settings, units, instrument gain etc).

### *Service*
Select either "in maintenance" or "online". When the instrument is being serviced select "in service" and the instrument will be flagged as undergoing service. The "out of service" is used for normal operation.

### *Auto-Backup Interv*
The Param list and config file are automatically saved onto the USB at the interval set in this field.

### *Load Auto-Backup Config*
Loads up the last auto backup configuration (best used when the configuration has recently been changed in error).

--------------------------------------------------------------------------------

### *Instrument*

This field allows the instrument to be set to either "Online" (data being validated) or "Offline" (data not validated). This field is used to change the instrument into "Offline" when service work is being perform

### *Next service due*

An editable field where the user can set the date when the next instrument service is required. Section 6.3 has a recommended maintenance schedule that may be used as a basis for the interval entered above. This value is also displayed as a non editable field in the quick menu section 3.5.1.

### *Rebuild EventLog Index*

This feature will rebuild the logs on the USB key. This is necessary when any changes to the files or folders on the USB key have been made (including within a file). Rebuilding the log index will re-index all the contents and thus allow the instrument to view error logs.

### *Safely remove USB stick*

This feature must be activated to safely remove the USB stick (also occurs in the quick menu 3.5.1).

### *System Restart*

Activating this will reboot the microprocessor. This action is useful when uploading new firmware or if the instrument has frozen.

-----------------------------------------------------------------------------------

### *Avg conc. (NO)*

Displays the NO average concentration (based on the averaging period set in the Measurement Settings menu).

### *Avg conc. ($NO_X$)*

Displays the $NO_X$ average concentration (based on the averaging period set in the Measurement Settings menu).

### *Avg conc. ($NO_2$)*

Displays the $NO_2$ average concentration (based on the averaging period set in the Measurement Settings menu).

### *Avg conc. ($NH_3$)*

Displays the $NH_3$ average concentration (based on the averaging period set in the Measurement Settings menu).

## 3.5.5.1 Diagnostics

The Diagnostics menu provides a large variety of features that allow the user to investigate problems with the analyzer or gain a greater insight into what the instrument is doing. This Menu contains 3 sub menus and 3 editable fields, the 3 editable fields are presented directly below for your convenience and the sub menus after them.

### 3.5.5.1.1 Pres/temp/flow Comp

Set to either On or Off.
On is used to compensate analyzer measurements for environmental fluctuations that might affect readings (pressure, temperature and flow). Off is used only when running diagnostics to see fluctuations in readings.

### 3.5.5.1.2 Diagnostics mode

The instrument can be placed in 4 diagnostic modes:
- Operate which leaves the instrument in normal operation mode
- Optic which configures the instrument for tests on the optical measurement source
- Electrical which configures the instrument for testing of the electrical circuits
- Preamp which configures the instrument for testing of the pre-amplification circuitry

### 3.5.5.1.3 Control loop

When "enabled" the instrument will control all processes within the instrument.
- Selecting Disabled will pause the instruments control over certain processes and parameters (digital pots, internal pump etc). The user can now manually alter and adjust digital pots.
- When instrument is put back in "Enabled" mode or taken back to main screen the new pots will be set and instrument will resume control over pots.

### 3.5.5.1.4 Digital pots menu

Preprocessor pots are electronically controlled digital potentiometers used for adjustments to operations of the analyzer. Each pot is set with digits 0 to 255 in a non-wraparound scrolling field (recommended range is show within brackets).

| | |
|---|---|
| **High Volt Adj** | *(130-150)* |
| **High Voltage** | *(640-670)* |
| **PGA gain** | *(1-128)* |
| **Input pot** | *(104)* |
| **Conc Voltage (RAW)** | *(0-3)* |
| **Conc Voltage** | *(0-3)* |
| **PMT Test LED** | |
| **Test pot** | *(0)* |

Valve menu
The valve menu allows the user to observe the opening and closing of valves as well as the ability to open and close them manually

### *Valve sequencing*

When set to "on" the instruments valves will switch as normal, when set to "off" the instrument will hold the valves in their current formation and valves can be opened and closed via the above fields.

> **Note:** valve sequencing will remain off unless the instrument has returned to main screen for over 2 minutes.

### *NO Select*

Shows the current operation of the NO select valve. This valve switches the sample either straight through to the cell, or bypasses the sample out the exhaust port of the instrument (open = NO sample to the measurement cell, closed = bypass the measurement cell).

### *NOx Select*

Shows the current operation of the NOx select valve. This valve switches the molycon converted sample to flow either through to the cell, or to bypass the sample out the exhaust port of the instrument (open = NOx sample to the measurement cell, closed = bypass the measurement cell).

### *Nx Select*

Shows the current operation of the Nx select valve. This valve switches sample from the external thermal converter to flow through to the cell (open = Nx sample to the measurement cell, closed = bypass the measurement cell).

### *Background select*

Shows the current operation of the background select valve. This valve determines whether the sample is pre-reacted with ozone before arriving at the cell. Doing so creates no reaction in the cell and enables a cell „background" measurement to be taken. Selecting switch will change the valve to the alternative state (open = react sample before cell, closed = sample as per normal).

### *Span/Zero select*

Shows the action of the valve that determines whether Sample gas or Calibration gas/internal zero air is being sampled (Open = Span/Zero, Closed = Sample gas).

### *Cal Port Select*

Shows the action of the valve that determines whether the instrument calibration gas is taken from the Calibration port or, if installed, the Internal Zero (Open = Internal zero, Closed = Calibration port).

*Pressurised Span (OPT)*
Shows the action of the valve that determines whether the instrument
calibration gas is taken from the optional pressurised span port

*Pressurised Zero (OPT)*
Shows the action of the valve that determines whether the instrument
zero air calibration gas is taken from the optional pressurised zero air
port

### 3.5.5.1.5 Tests

*Screen test*
Will perform a screen test by activating lines on the screen so that the
operator can determine if there are any faults in the screen

*Digital Inputs*
This menu item allows the user to set which pin the power source is
located on and also displays the pins that digital inputs are located on.

> **Note:** Changes performed with this
> item will disrupt the normal logging

*Digital Outputs*
This menu item allows the user to view the the pins that digital outputs
are located on

> **Note:** Changes performed with this
> item will disrupt the normal logging

*Analog Inputs & Outputs*
Displays the pins that analog inputs are located on and allows the user to
set the analog outputs

> **Note:** Changes performed with this
> item will disrupt the normal logging

## 3.5.5.2 Calculation factors

The Calculation factors screen summarises the values used to calculate
different aspects of measurement and calibration. The following fields
are found for the different gases measured.

*Instrument gain*
A multiplication factor used to adjust the NO/NOx/Nx concentration
measurement to the appropriate level (set at calibration).

*Zero Offset NO*
This field displays the offset created from a zero calibration, this is the
concentration measured from zero air and is subtracted from NO.

*Background (NO)*
The correction factor calculated from the background cycle (used to
eliminate background interferences).

### *P/T/F Correction*
Displays the correction factor applied to the concentration of directly measured gases (NO, NOx, Nx). This correction is for changes in pressure, temperature and flow.

### *Zero Offset  NO$_2$*
This field displays the offset created from a zero calibration, this is the concentration measured from zero air and is subtracted from NO.

### *Conv. EfficiencyNO$_2$*
The efficiency that the converter converts NO$_2$ into NO (%)

### *Conv. EfficiencyNH$_3$*
The efficiency that the external converter converts NH$_3$ into NO (%)

### 3.5.6  Communications

#### 3.5.6.1 Analog Output Menu

The analogue output menu is split into three sections, one for each measurement parameter (NO, $NO_2$, $NO_X$). The following fields are found in one or all of these sections.

*Output type*
Setting the output to be either current or voltage, only some of the fields below will be displayed depending on which analog output type is selected

*Range*
Set upper range limit (in concentration units) to desired $NO_X$ concentration. This value cannot exceed the "Over Range" value

*Over-ranging*
Set to "Enabled" or "Disabled" to turn the over-ranging feature on or off

*Over range*
This field is only visible when Over-ranging is set to enabled. Set to desired over range value. This value cannot be set below the RANGE value. This is the alternate scale the recorder or DAS indicates when over-ranging is active and enabled. (When 90% of the set range is reached, this auto range is effective. When 80% of the original range is reached, it returns to the original range.)

*Offset (Voltage only)*
Choices are 0V, 0.25V, and 0.5V. Recorder or DAS output will reflect this.

*5V Calibration (Voltage only)*
Enables the user to calibrate the analog output at a full scale point.

*0.5V Calibration (Voltage only)*
Enables the user to calibrate the analog output at a low point.

*Current range (Current only)*
Choose the range that the current will be offset by (0-20, 2-20, 4-20)

*20mA calibration (Current only)*
Enables the user to calibrate the current output at a full scale point

*4mA Calibration (Current only)*
Enables the user to calibrate the current output at a low point

### 3.5.6.2 Data Logging Menu

***Data Log Setup –Quick***
Allows up to 15 parameters to be logged. After each parameter (labelled "Logging Param. 1" – "Logging Param. 15") place the number of the parameter that is to be logged found in:
- Appendix A Advanced Protocol Parameter List for parameter number list
- Data Log setup –GUI below

***Data Log setup –GUI***
This field works in tandem with the "Data Log setup –Quick" field and is used when the parameter number is not known. The user can enter each logging parameter field (P1-P15) and scroll through all the parameters that can be logged. Once the parameters to be logged has been filled out, the parameter numbers can be copied from within the "Data Log Setup –Quick" field for future use.

***Data Log Interval***
Set the interval (length) of time that measurement data will be logged over i.e. 1 minute data, 5 minute data etc

### 3.5.6.3 Serial Communications

***Multidrop ID***
The ID address of the analyzer when Multidrop RS232 communications is used.

***Aux Bavarian ID***
When using the Bavarian protocol two ID"s are returned - one for NO (Multidrop ID), one for NOx (Aux Bavarian ID). The Multidrop ID is used to identify the analyzer when requesting data using the Bavarian protocol.

***Baud*** *(RS232 #1)*
Set the Baud rate that the instrument will communicate over
(1200, 2400, 4800, 9600, 14400, 19200, 38400)

***Protocol*** *(RS232 #1)*
Set the protocol used for communication either EC9800, Bavarian or Advanced

***Baud*** *(RS232 #2)*
Set the Baud rate that the instrument will communicate over
(1200, 2400, 4800, 9600, 14400, 19200, 38400)

***Protocol*** *(RS232 #2)*
Set the protocol used for communication either EC9800, Bavarian or Advanced

### 3.5.6.4 Digital Inputs Menu

Assign the digital input 0-7

### 3.5.6.5 Digital Outputs Menu

Assign the digital outputs 0-7

# 4   Calibration

Calibrations with the Serinus 44 incorporates the HTO converter and should be performed as outlined below with no changes to the analyzer-converter configuration. Span gas used throughout all procedures is NO or $NH_3$ gas.

## 4.1  Zero Calibration

Zero calibrations are used to set the zero point of the analyzer.

> **Note:** This calibration is unnecessary in most situations and should only be performed if required. Acoem recommends that zero calibration not be used unless specifically required.

Performing a zero calibration can be performed through either the Calibration port or Sample port. Follow the relevant instructions below:

**Calibration port**
1. Ensure suitable zero source containing an ammonia scrubber is connected to the "Calibration port" on the back panel of analyzer (see section 2.3.1)
2. Enter the main menu → Calibration menu → Calibration mode
3. Select the Calibration mode to be zero
4. Allow the instrument to stabilize (15 minutes)
5. Enter the Quick Menu and select "Zero Calibration"
6. A box will appear with editable numbers, select 0.00
7. Instrument will perform Zero calibration, when finished the instrument will return to normal activities

**Sample port**
1. Ensure suitable zero source (using an ammonia scrubber) is connected to the "sample port" on the back panel of analyzer (see section 2.3.1)
2. Let the instrument stabilize
3. Enter the quick menu and select "Zero Calibration"
4. A box will appear with editable numbers, select 0.00
5. Instrument will perform Zero calibration, when finished the instrument will return to normal activities

## 4.2  Span Calibration

Performing a span calibration can be performed through either the Calibration port or Sample port. Span calibrations calibrate the instrument to the upper limits of normal monitoring. Acoem recommends that 80% of full scale should be sufficient for calibrations in ambient monitoring situations 400 ppb. Follow the   relevant instructions below:

**Calibration port**

1. Ensure a suitable NO span gas source is connected to the "Calibration Port" on the back panel of analyzer (see section 2.3.1)
2. Set the span source to a known concentration (80% full scale recommended)
3. Enter the Main menu → Calibration menu → Calibration mode
4. Select the Calibration mode to be span
5. Let the instrument stabilize (15 minutes)
6. Enter the quick menu and select "Span Calibration"
7. A box will appear with editable numbers, select the concentration being delivered to the instrument
8. Instrument will perform Span calibration, when finished the instrument will return to normal activities

**Sample port**

1. Ensure a suitable NO span gas source is connected to the "Sample Port" on the back panel of analyzer (see section 2.3.1)
2. Set the span source to a known concentration
3. Let the instrument stabilize (15 minutes)
4. Enter the quick menu and select "Span Calibration"
5. A box will appear with editable numbers, select the concentration being delivered to the instrument.
6. Instrument will perform Span calibration, when finished the instrument will return to normal activities

## 4.3  Multipoint Calibration

The multipoint involves supplying the instrument with span gas at multiple known concentrations and recording the output of the instrument. Multipoint calibrations are used to determine the linearity of concentration curve against concentration voltage; the instrument gain should not be adjusted to each individual point.

1. Ensure a suitable NO span source is connected to the instrument from a gas calibrator (Acoem recommends the GasCal-1100) through the sample port
2. Record analyzer instrument gains before performing calibration (section 3.5.1)
3. Perform a precision check using zero air as described in section
4. Perform a span calibration as described in section 4.2
5. Set up a program for measuring the span concentration through 5 steps down from 80%  of full scale

> Example for full scale of 500ppb
> a.  Set the 1$^{st}$ concentration on the gas calibrator to 400ppb, allow instrument to sample for 15 minutes, record measurement.
> b.  Set the 2$^{nd}$ concentration on the gas calibrator to 300ppb, allow instrument to sample for 15 minutes, record measurement.
> c.  Set the 3$^{rd}$ concentration on the gas calibrator to 200ppb, allow instrument to sample for 15 minutes, record measurement.
> d.  Set the 4$^{th}$ concentration on the gas calibrator to 100ppb, allow instrument to sample for 15 minutes, record measurement.
> e.  Set the 5$^{th}$ point at a concentration of 0ppm (zero air); allow the instrument to sample for 15 minutes and record measurement.

6. The linearity and correlation can be calculated for each point manually or all points calculated within excel
7. **Manual Calculations**
   Record the concentration measurement at each point and determine the percent difference between instrument response and the supplied concentration using the following equation

$$\frac{\text{Instrument Response - Supplied Concentration}}{\text{Supplied Concentration}} \times 100 = \text{Percent Difference}$$

**Equation 3 Instrument accuracy**

8. If the difference between values is less than 1% then the instrument is within specifications. Otherwise a Leak Check and or service are required
9. **Microsoft Excel**
   Alternatively all the data can be placed in an excel spreadsheet in columns next to the supplied concentration.
10. Create an X Y scatter plot of expected calibration against instrument response, right click on either point and select "Add Trendline". Tick the "Display equation on chart" and "Display R-squared value on chart"  in the options tab
11. The linear regression equation y = mx + b will be displayed

| 0 | 1 |
|-----|-----|
| 100 | 101 |
| 200 | 201 |
| 300 | 300 |
| 400 | 400 |
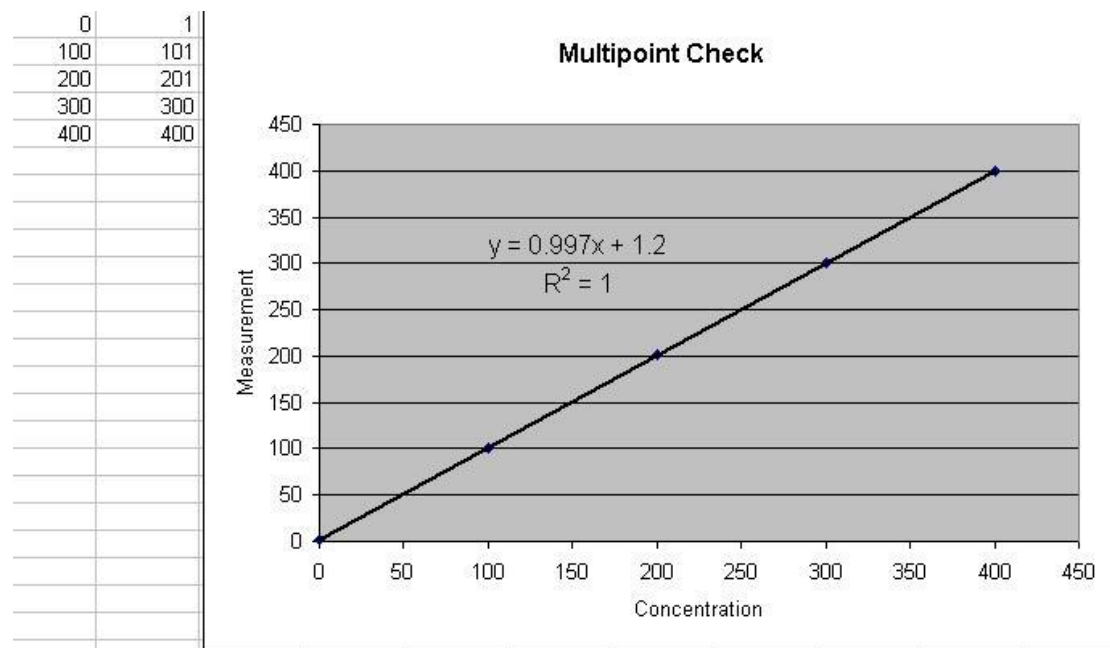


**Figure 7 Excel graph of Multipoint Calibration**

12. Accept the calibration if the following are found:
    - The gradient (m) falls between 0.98 and 1.02
    - The intercept (b) lies between ±0.3.
    - The correlation ($R^2$) is greater than 0.9995
13. Reject the calibration if the above criteria are not met. If the calibration fails perform a leak check (section6.4.5), check zero air scrubbers or check troubleshoot guide for possible errors (section 7).

## 4.4  NO₂ Converter efficiency

The efficiency of the $NO_2$ converter can affect $NO_X$ readings, the converter efficiency must be measured to:

- Ensure the efficiency is at an adequate level (96% or higher)
- Correct measurements for the losses introduced by the converter inefficiency

To measure and correct $NO_2$ converter efficiency the following steps should be followed:

1. Enter Main menu → Calibration menu and set the $NO_2$ Converter efficiency field to 100%, return to main menu
2. Supply the instrument with 90% full scale span gas
3. Allow the  instrument to stabilize then record both the NO reading as $[NO]_{ORIG}$ and $NO_2$ reading as $[NO_2]_{ORIG}$
4. Turn on the $O_3$ generator in the Gas Phase Titration system and produce sufficient $O_3$ to generate 80% of full scale $NO_2$

> **Note:** The $NO_2$ concentration must not exceed 90% of the original NO concentration from step 2

5. Allow the  instrument to stabilize then record both the NO reading as $[NO]_{FINAL}$ and $NO_2$ as $[NO_2]_{FINAL}$
6. Calculate the $NO_2$ converter efficiency from the following equation:

$$EFF_{CONV} = \frac{D[NO_2]}{D[NO]} \times 100 = \frac{[NO_2]_{FINAL} - [NO_2]_{ORIG}}{[NO]_{ORIG} - [NO]_{FINAL}} \times 100$$

**Equation 4 Calculation for converter efficiency**

7. If the $NO_2$ converter efficiency is above 96%, enter the Main menu → Calibration menu → Converter efficiency and enter in the number obtained in Equation 4.
8. If the converter efficiency is below 96% then the converter must be replaced (pt; H011105).

## 4.5  NH₃ Converter efficiency

The efficiency of the $NH_3$ converter can affect $NH_3$ readings, the converter efficiency must be measured to:

- Ensure the efficiency is at an adequate level (86% or higher)
- Correct measurements for the losses introduced by the converter inefficiency

To measure and correct $NH_3$ converter efficiency the following steps should be followed:

1. Enter Main menu → Calibration menu and set the $NH_3$ Converter efficiency field to 100%, return to main menu
2. Supply the instrument with 90% full scale $NH_3$ span gas
3. Allow the  instrument to stabilize then record both the NOx reading as C[NOx] and $NH_3$ reading as C[NH₃]
4. Calculate the $NH_3$ converter efficiency from the following equation:

$$EFF_{CONV} = \frac{C[NH_3]}{C[NO]} \times 100$$

**Equation 5 Calculation for NH₃ converter efficiency**

5.  If the NH$_3$ converter efficiency is above 86%, enter the Main menu →
    Calibration menu → NH3 Converter efficiency and enter in the number
    obtained in Equation 5.
6.  If the NH$_3$ converter efficiency is below 86% then the converter may require
    servicing.

## 4.6  Precision check

A precision check is a Level 2 calibration. This means that the instrument has a
known concentration, or zero air, run through it and an observation of the
instruments concentration is made with no adjustment. A precision check can be
performed either manually or automatically.

## *4.7  Pressure calibration*

The pressure calibration involves a two point calibration, one point under vacuum and another point at ambient pressure. To perform a pressure calibration the following steps must be completed

> **Note:** The vacuum calibration must be performed first when performing a pressure calibration

### Vacuum

1. Open instrument (section 2.1)
2. Disconnect the ozone generator connector from the ozone assembly (Figure 8)
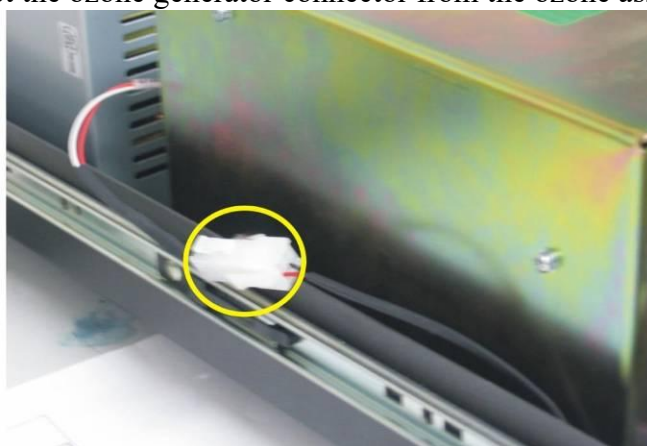


**Figure 8 Ozone generator cable**

3. Remove the tubing connecting the dryer to the exhaust line and block the exhaust line T-piece (see Figure 9).
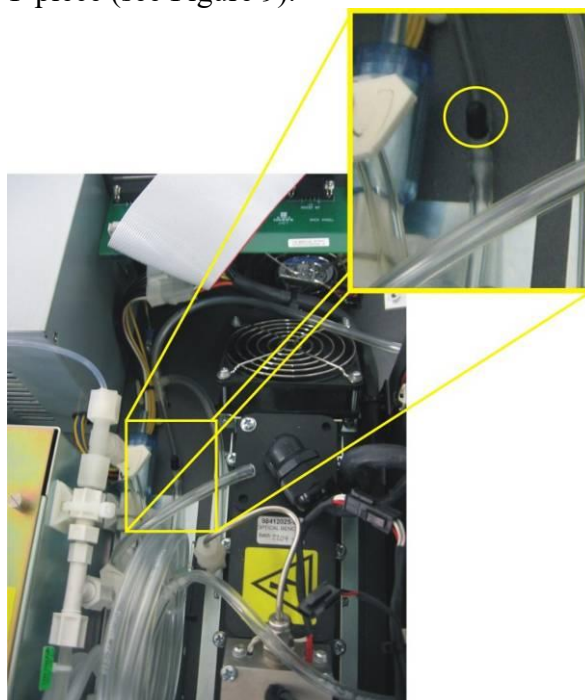


**Figure 9 Blocking exhaust T-piece**

4. Disconnect the tubing connecting the valve manifold to the Ozone generator and place the barometer on the valve manifold (see Figure 10).

**Figure 10 Position of Barometer placement (valve manifold)**

5.  Connect vacuum source to Exhaust port of analyzer, block the sample port and switch vacuum source on.
6.  Enter Calibration menu → Pressure Calibration and select pressure (vacuum pressure) then select the unit of pressure being used (torr etc)
7.  The screen will display three horizontal bar (Figure 11) the first (Amb) is for the ambient pressure sensor, the second (Manifld) is for the pressure sensor in the valve manifold and the third (Cell) is for the pressure sensor
8.  Ensure that the pressure is stable (arrows are not moving up and down the bar.


**Figure 11 Pressure menu**

9.  Select the set option (activate buttons) the Current Pressure window will open
10. Using the keypad, input the current pressure reading on the meter.
11. Press the "Accept" button to calibrate pressure sensors

**Ambient**
1.  Disconnect external pump (remove exhaust or turn off pump), if internal pump is fitted
2.  Enter the main menu → Calibration menu → Pressure calibration
3.  Select ambient (ambient pressure) then select the unit of pressure being used (torr etc)
4.  The screen will display three horizontal bars (Figure 11) the first (Amb) is for the ambient pressure sensor, the second (Manifld) is for the pressure sensor in the valve manifold and the third (Cell) is for the cell pressure sensor
5.  Ensure that the pressure is stabile (arrows are not moving up and down the bar.
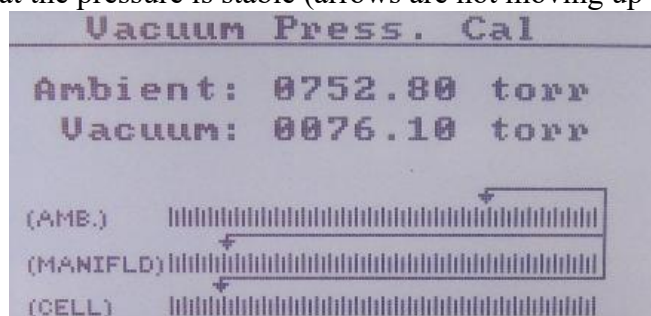6.  Select the set option (activate buttons) the Current Pressure window will open
7.  Using the keypad, input the current pressure reading on the pressure meter in ambient air.
8.  Press the "Accept" button to calibrate pressure sensors

# 5   Communication

The Serinus analyzer has four methods of communication. Each communication method is used in specific situations for data download, instrument control or both. The Serinus can perform communication through 4 different paths (RS232, USB, 25 pin Digital/Analog input/output or TCP/IP network (optional). The Serinus also contains an additional program, the Serinus Communicator, that allows data download and remote activation from a PC.
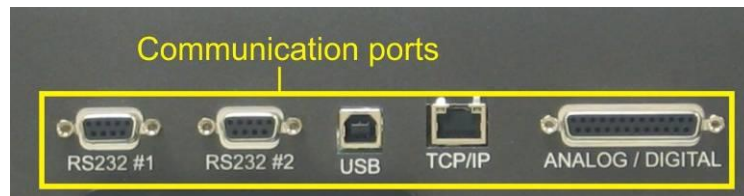

**Figure 12 Communication ports**

## 5.1  RS232 Communication

### RS232 #1
This port is designed to be used in tandem with a Termination Panel allowing the Serinus instrument to work as a datalogger. This function is an optional extra and must be purchased from Acoem.

### RS232 #2
RS232 communication is the most reliable way to access data from instrument. RS232 port #2 should be connected to a computer, datalogger or in a daisy chain configuration (multiple analyzers connected via the same RS232 cable).

Uses the following protocols
      EC9800 protocol (Appendix B – EC9800 Protocol)
      Bavarian protocol (Appendix C – Bavarian Protocol)
      Advanced protocol

## 5.2  USB Communication

### USB
This port is good for downloading data quickly via a laptop and for onsite diagnostics and maintenance.

## 5.3  TCP/IP Network Communication

### TCP/IP (optional)
This port is best used for remote access and real-time access to instruments when a network is available to connect with.

## Installation
1.   If **Device Installer** is not installed on your PC, download it from
    http://www.lantronix.com/device-networking/utilities-tools/device-installer.html

2.  The Serinus analyzer must be configured to allow network use, this is done through directly connecting it with a PC. Using a crossover Ethernet cable, connect the cable from the Ethernet port on the Serinus to a free Ethernet port on the PC.

> **Note:** This step requires a free Ethernet port on the PC.  If Ethernet port is being used to connect to the network, stop all network activities and disconnect the cable.

3.  Wait until the connection between the Serinus and the PC gives the status "Limited or no Connectivity" as seen on the PC.  This should take a few minutes.

4.  Open *Device Installer*.  If a message box comes up asking you to view a TCP/IP tutorial (Figure 13), click No.
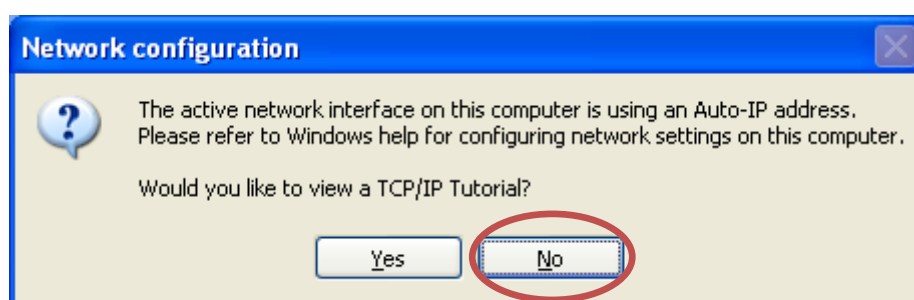


**Figure 13 Device Installer pop up window**

5.  When initial search has completed, access the XPort-03 device listed on the right-hand pane (Figure 14) by double-clicking on it.  This will bring up its details.
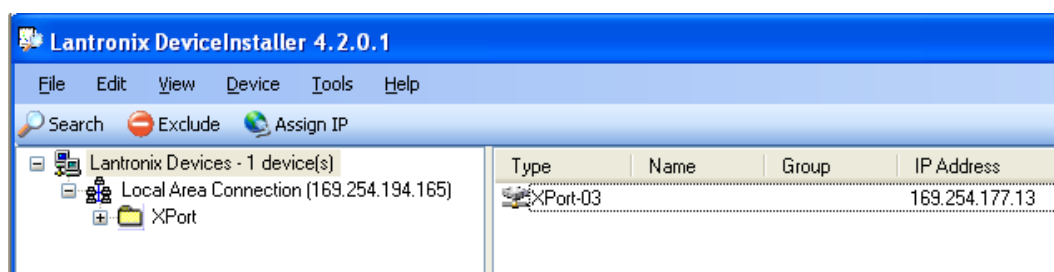


**Figure 14 Device Installer XPort-03**

6.  Click the "Telnet Configuration" tab and click "Connect" (Figure 15).  Leave the IP address and port as is.  Afterwards, press Enter to enter Setup Mode.  This will list the various parameters set up in the Serinus and will give you menu options to change them.
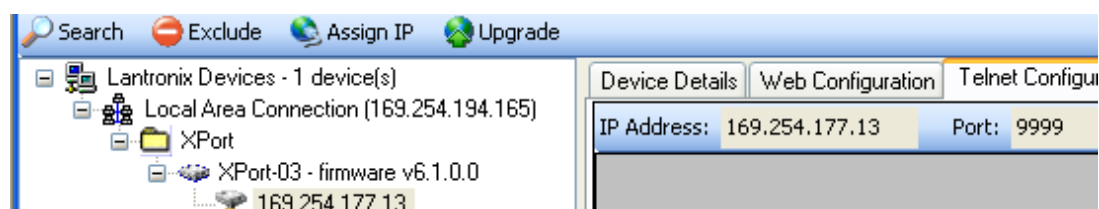


**Figure 15 Device Installer - Telnet Configuration**

7.  On the "Change Setup" menu, Press 1 and then "**Enter**" to open the Channel 1 setup (below).

```
                    Change Setup:
              0 Server

              1 Channel 1

              3 E-mail

              5 Expert

              6 Security

              7 Defaults

              8 Exit without save

              9 Save and exit           Your choice ? 1
```

8.  Change the settings to match those in brackets below as they appear.  The value in brackets indicates its current configuration.  If the value should be left unchanged, simply press Enter without any value being entered (below).

```
              Baudrate (38400) ?

              I/F Mode (4C) ?

              Flow (00) ?

              Port No (32785) ?

              ConnectMode (C0) ?

              Send '+++' in Modem Mode  (Y) ?

              Auto increment source port  (N) ?

              Remote IP Address : (000) .(000) .(000) .(000)

              Remote Port  (0) ?

              DisConnMode (00) ?

              FlushMode   (00) ?

              DisConnTime (00:00) ?:

              SendChar 1  (00) ?

              SendChar 2  (00) ?
```

**Settings available during Channel 1 setup**

9.  When returned to the "Change Setup" menu, press 9 then Enter to save the settings.

## 5.4  Digital/Analog communication

### External I/O port
The 25 Pin Analog/Digital port on the rear of the analyzer sends and receives analog/digital signals to other devices. These signals are commonly used to activate gas calibrators or for warning alarms.

### Analog Outputs
The analyzer is equipped with three analog outputs Voltage 0-5V or Current settable 0-20,2-20,4-20 mA

### Analog Inputs

The Analyzer is also equipped with three analog inputs with resolution of 15 bits plus polarity. Input voltage 0-5 V

### Digital Status Inputs

The analyzer is equipped with 8 logic level inputs for the external control of the Analyzer such as Zero/Span sequences. Each input has a terminating resistor which can be either PULL UP or PULL DOWN. This is set using the Jumper JP1 on the Back Panel printed circuit board.

### Digital Status Outputs

The analyzer is equipped with 8 open collector outputs which will convey instrument status conditions warning alarms such as no flow, sample mode, etc. Two of the digital outputs can be set so that there is +5V or +12V available on the 25 pin connector for control purposes.

In the default jumper locations (Figure 16) these two outputs will function normally as open collector outputs. If moved to the position closer to the 25 pin connector then DO 0 will supply +12V and DO 1 will supply +5V. These supplies are limited to about 100mA.
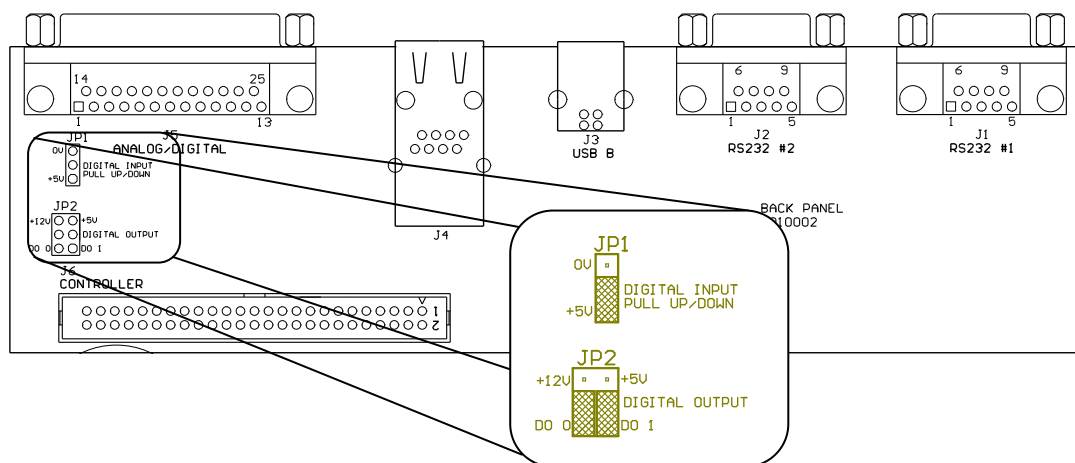


**Figure 16 Serinus 25 pin microprocessor board (with default jumpers highlighted)**
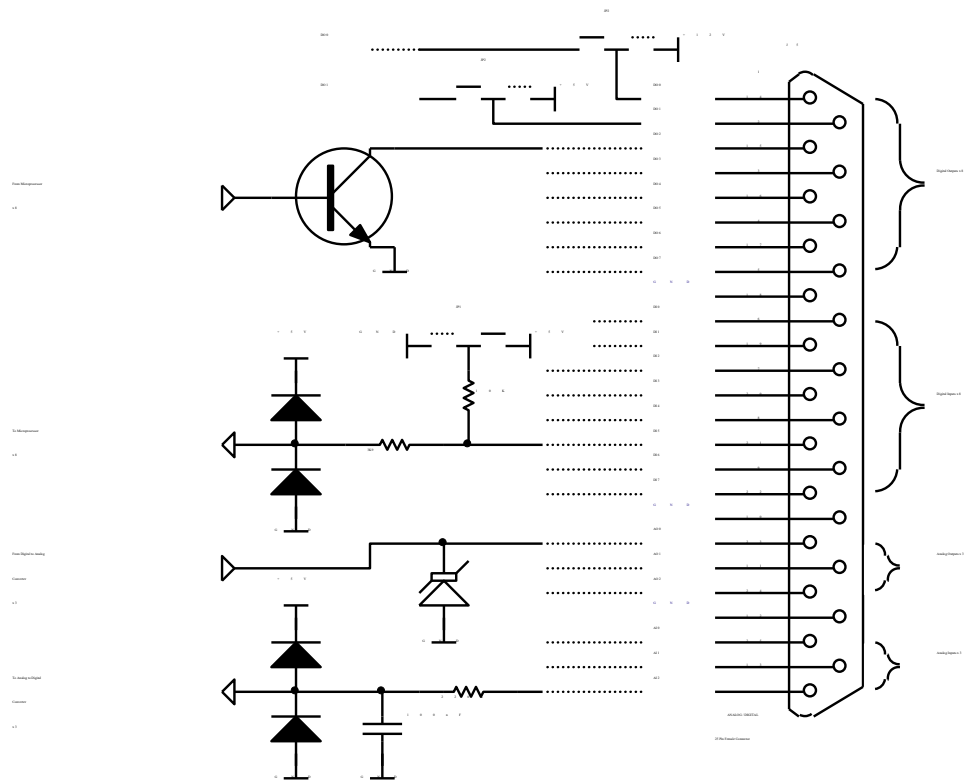
**Figure 17 External 25pin I/O individual pin descriptions**

> **Warning:** The Analog and Digital Inputs and Outputs are rated to CAT I, meaning that they should be less than 12VDC. Exceeding these voltages can permanently damage the instruments and void warranty

## 5.5  Serinus downloader program

The Serinus Downloader program is designed to allow the user to acquire data directly from the analyzer and control it remotely. The Serinus downloader program has four main windows; **"Settings"** where configurations are made to communicate with the analyzer, **"Data"** where data is downloaded into a spreadsheet and **"Remote Screen"** where the analyzer can be controlled directly and "Remote Terminal" which is a diagnostic tool used to check instrument operation and parameter values.

### 5.5.1  Settings

Within this window both the data format setting and analyzer communications settings are defined. There are two icons in the main header, they are **Save Settings** (which saves the current settings as default) and Cancel changes

### Output

| | |
|---|---|
| **Ouput file:** | Enter in the destination (folder) including file name (extension must be .txt) for the data to be downloaded into |
| **Date Format:** | Enter in the date format that data will be written as (within the text file). |

Date must be separated by forward slashes, commas and time by colon. and must contain:

| | |
|---|---|
| Year | yyyy |
| Month | MM |
| Day | dd |
| Hour | HH |
| Minute | mm |
| Second | ss |

The date can be used for one of three activities

| | |
|---|---|
| Append Data | Add data onto the end of the current entries within the text file |
| Overwrite Data | Always create new text file rather than adding to existing file |
| Prompt User | Displays a window that prompts user to overwrite data, if no is selected data will be appended to current .txt file |

## Connection
The user must select the type of connection that the computer is connect to the analyzer with. This is chosen in the **"Connection Type"** field and consists of:

**Direct Serial connection:**
Used when the analyzer is connected directly to PC via serial port
    **Port →**      Choose which port on the PC the Serinus is attached to
    **Baud Rate →**  Select the baud rate with which communication will take place (must match the baud rate set on the analyzer see the Serial Communications section)

**Network Connection:**
Used when the analyzer is being connected via a network.
    **IP Address →**  Enter the IP address of the analyzer as described in Acoem technote: TEC 0045
    **Port →**      Enter the port number of the analyzer as described in Acoem technote: TEC 0045

**USB Connection:**
Used when the analyzer is connected directly to PC via the USB connection
    **Analyser →**  A drop down list will display all analyzers that the downloader program can connect to, the user must select the appropriate analyzer number matching that of the analyzer connected to.

## Analyzer
**Analyzer ID:**
Enter the analyzer ID found in the "Main Gas ID" field (Main Menu → Communications → Serial Communications)

> **Note**: Only relevant for a direct serial connection
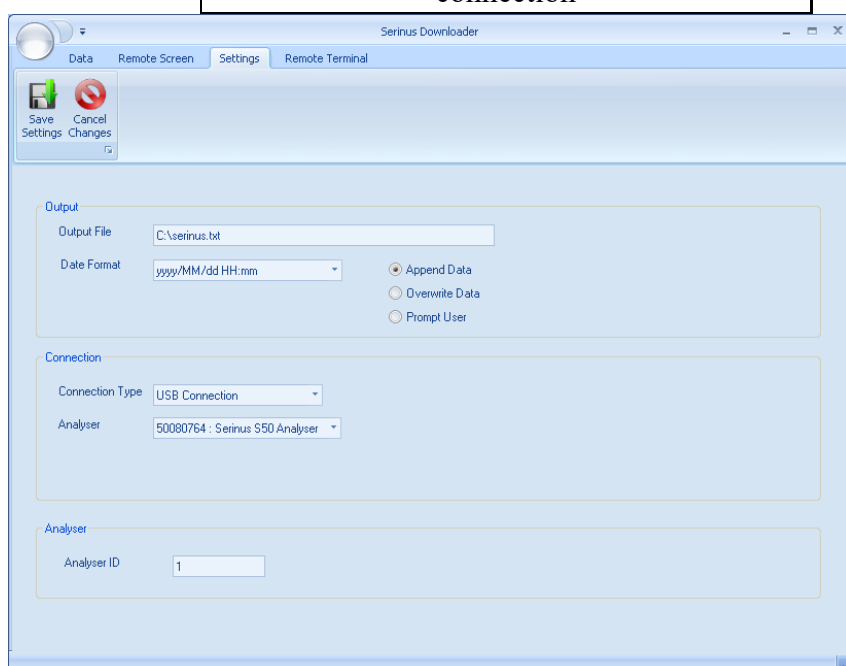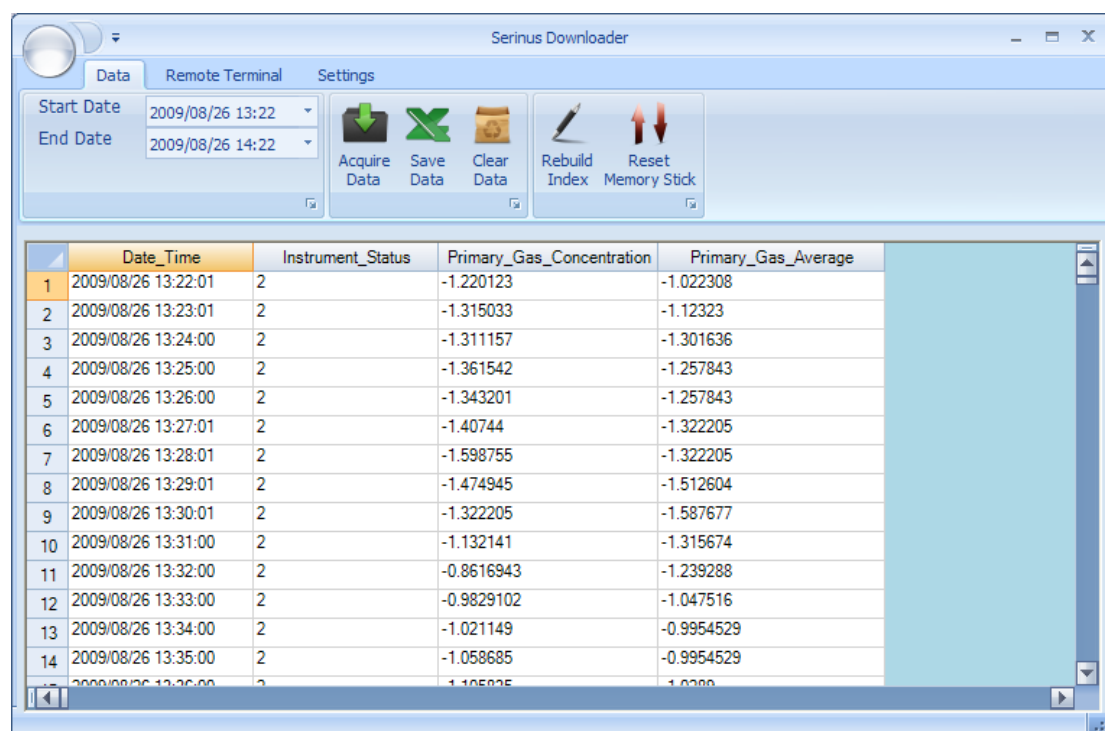


**Figure 18 Serinus downloader - settings tab**

## 5.5.2 Data

The Data window consists mainly of a spreadsheet with rows (numeric) and columns (labeled as per parameter). The amount of data to be uploaded into the spreadsheet is determined by the start and end date range on the left side of the main menu bar. The other features in the menu bar are:

- **Acquire data**        This button acquires data from the analyzer (within the date ranges) and displays on screen along with saving as a text file
- **Save data**        Saves the data into excel file format
- **Clear Data**        Deletes data from the screen
- **Rebuild index**        This function is used when the downloader is unable to access data. A common reason for this is a corruption or deletion of the index.dat file (on removable USB stick) or data in the text file has been deleted. Rebuilding the index will create new index files and allow all current data to be accessed.
- **Reset Memory stick**  Resets the memory stick, this is used if the instrument is having problems detecting the stick.



**Figure 19 Serinus Downloader – Data tab**

### 5.5.3  Remote screen

The remote screen tab allows the user to connect to the Serinus instrument and control it remotely. The screen has all the same buttons as the Serinus gas analyzer and is used as virtual interface with the instrument. The screen is a screenshot and not an automatically updated feed; the refresh button will need to be used when tracking changes in parameters.

- By clicking the green "Connect" button in the top left hand corner, the remote terminal session will begin.
- The session can be terminated at anytime by pressing the red "Disconnect" button
- The screen can be updated by clicking the "refresh screen" button. This must be used
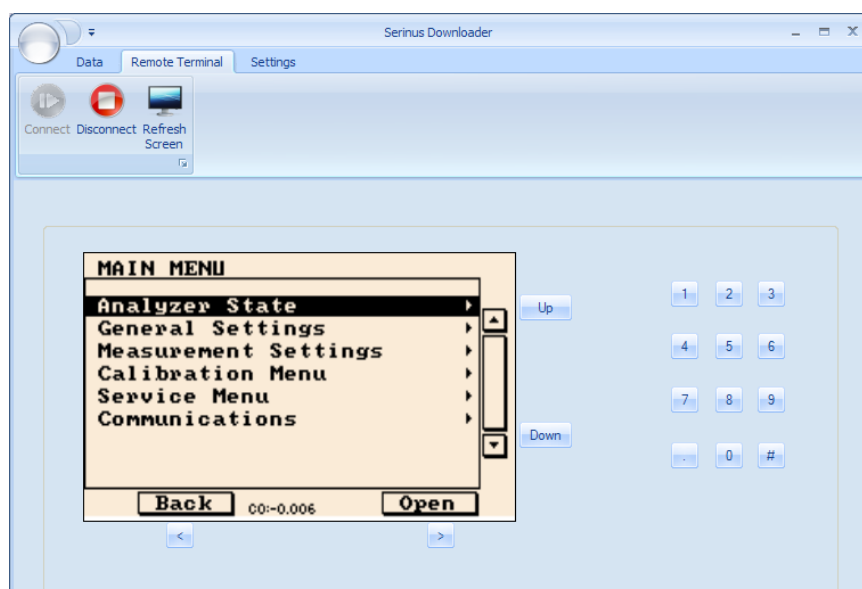


**Figure 20 Serinus Downloader – Remote Screen tab**

### 5.5.4  Remote terminal

The remote terminal tab is a diagnostic tool used to check instrument operation and parameters. The remote terminal is used in a similar way to "ping" a computer; it is used to ensure communications are working properly. Firstly the Downloader program must be connected to the instrument and the green connect button in the top left hand corner must be clicked. The remote terminal tab consists of 3 different sections:

- Advanced Protocol
  Within this section the user selects the parameter number (from within the advanced protocol) then clicks the get button to receive that parameters value
- EC9800 Protocol
  Within this section a command can be sent to the instrument using the EC9800 protocol. Simply type in the text command in the field and click the send button.
- Received Data
  This field contains the value or the parameter that has been requested. Values can be cleared by pressing the clear button
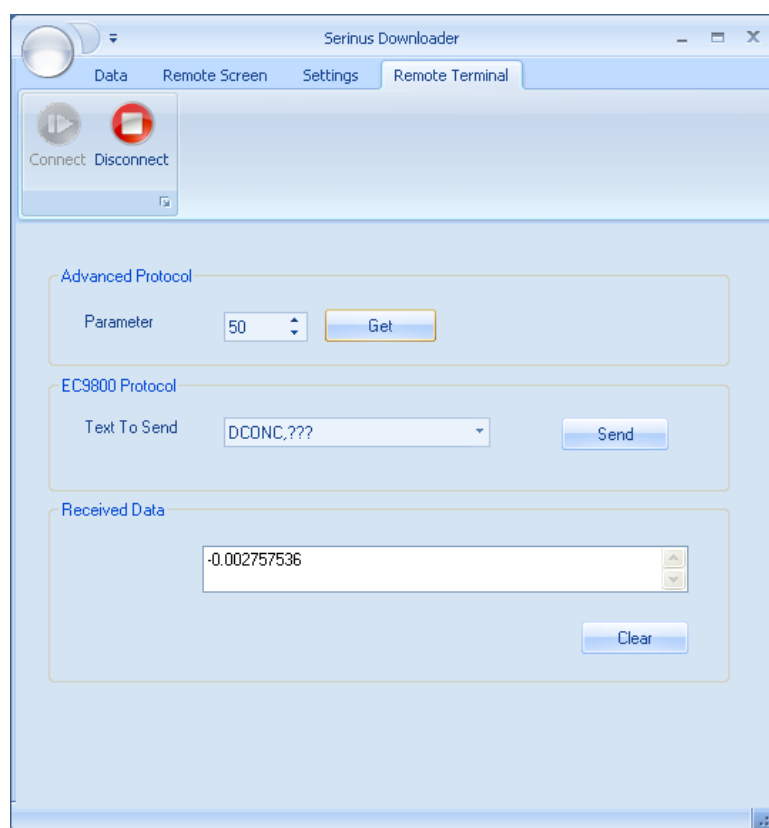


**Figure 21 Serinus downloader - Remote Terminal tab**

# 6 Service

> **Note: After removing power from the Serinus 44 the exhaust must be maintained for 15 minutes. This is necessary to purge all of the ozone preventing its build up and combustion with charcoal (in exhaust scrubber).**

> **Note: The Serinus 44's internal ozone destroyer removes near 100% of ozone in exhaust air (<20ppb remains). An additional charcoal scrubber should be attached to exhaust if lower levels of ozone emission within exhaust are necessary.**

## 6.1 Pneumatic diagram
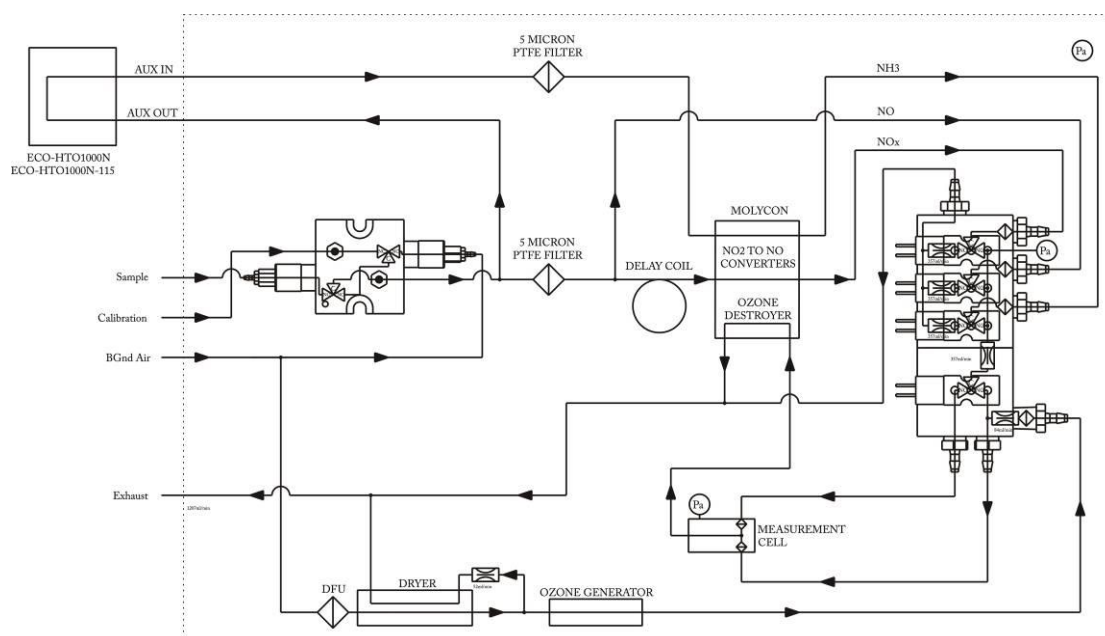


**Figure 22 Pneumatic diagram**

## 6.2 Maintenance tools

To perform general maintenance on the Serinus 44 the user will require the following equipment:

- Digital multimeter (DMM)
- Computer or remote data terminal and connection cable for RS232 communication
- Pressure transducer (absolute) and connection tubing, calibrated in torr
- Flow meter (1 slpm nominal)
- Minifit extraction tool
- Orifice removal tool
- 1.5mm hex key
- Assortment of 1/4" and 1/8" tubing and fittings
- Test zero air source

- Test span gas source
- Leak tester

## 6.3  Recommended maintenance schedule

**Table 1 Maintenance schedule**

| Interval * | Task performed | Page |
|---|---|---|
| Weekly | Check inlet particulate filter, replace if full/dirty | 56 |
| | Check sample inlet system for moisture or foreign materials. Clean if necessary | |
| | Perform precision check | |
| Monthly | Check fan filter, clean if necessary | 57 |
| | Perform span calibration | 35 |
| | Check date and time is correct | 22 |
| 6 Monthly | Check the Converter efficiency | 39 |
| | Perform multi-point calibration check | 37 |
| Yearly | Replace DFU filter | 57 |
| | Replace sintered filter and orifice (only if necessary) | 57 |
| | Perform a pressure check | 58 |
| 2 years | Clean Reaction Cell | 60 |

* Suggested intervals for maintenance procedure are a guide only and may vary with sampling intensity and/or environmental conditions.

## 6.4  Maintenance procedures

> **Note: After removing power from the Serinus 44 the exhaust must be maintained for 15 minutes. This is necessary to purge all of the ozone preventing its build up and combustion with charcoal (in exhaust scrubber).**

> **Note: The Serinus 44's internal ozone destroyer removes near 100% of ozone in exhaust air (<20ppb remains). An additional charcoal scrubber should be attached to exhaust if lower levels of ozone emission within exhaust are necessary.**

### 6.4.1  Particulate filter replacement

1.   Disconnect the external pump
2.   Slide open (Figure 23) to access the particulate filter (located in front right hand corner
3.   Unscrew the filter cap (bright blue) by turning it counterclockwise
4.   Remove the filter plunger from the casing, place finger on tubing connector  and pull to the side
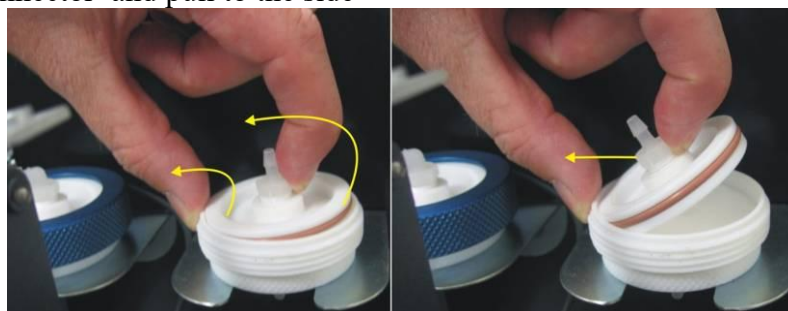

**Figure 23 Removing plunger**

5.   Remove old filter, wipe down plunger with damp cloth and insert new filter
6.   Replace plunger, screw cap on and reconnect the pump
7.   Close instrument and perform a quick leak check (section 6.4.5)
8.   Resume monitoring

### 6.4.2  Clean fan Filter

1. Turn off fan
2. Remove outer filter casing and filter (Figure 24)
3. Clean filter by blowing with compressed air (if available) or shaking vigorously
4. Replace filter and filter casing


**Figure 24 Removing fan filter**

### 6.4.3  DFU Replacement

1. Turn off analyzer and remove power
2. Remove Kynar nut from the end of the DFU  by turning anti-clockwise (looking from DFU side)
3. Replace DFU and ensure that the flow is in the correct direction (arrows points toward Kynar nut)
4. Tighten kynar nut clockwise

### 6.4.4  Sintered filter Replacement

The sintered filter is used to prevent contaminants blocking the sample orifice. Sintered filters should be changed per year
1. Turn off the analyzer and disconnect the pump
2. Disconnect the tubing from the T-piece on top of the measurement cell (Figure 25)
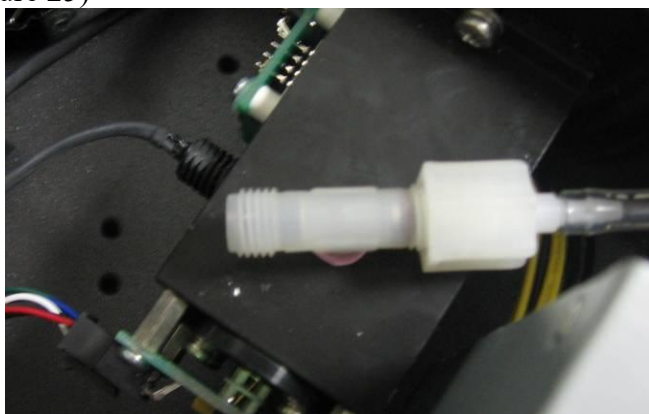

**Figure 25 Measurement cell T-piece**

3. Unscrew the T-piece form the cell (anti-clockwise)

4.    Once the t-piece has been removed use the orifice/filter removal tool to remove either the orifice and/or filter
5.    Orifice and filter maybe exchanged with new ones or cleaned as needed.
6.    Replace the filter and/or orifice in the correct part of the T-piece and replace the T-piece as before.
7.    Perform a calibration

## 6.4.5  Quick Leak test

This procedure is designed to determine if the instrument pneumatics has a leak, this initial check. If the instrument passes the check then no further leak checks are needed, if it fails a full leak check will be required.

1.    Enter main menu → Diagnositcs → Valve menu and set valve sequencing to off. Then open all the valves in that menu
2.    Plug both the "Sample port", "Calibration port" and the "DFU filter" inlet inside the instrument (see Figure 26 below)



**Figure 26 Plugged sample and calibration ports**

3.    Enter the main menu → analyzer state menu →  pressure menu and compare the   ambient pressure to the cell pressure
4.    Allow 1-2 minutes for the pressures to stabilize, check that the gas flow = 0, if this is not the case then there is a leak
5.    If the two pressures are within 10% of each other  then the leak check has passed.
6.    If the pressures fluctuate with channel switching or are more than 10% different, perform pressure calibration (section 4.7), after this is completed repeat quick leak check, if this again fails perform advanced leak check (section 6.4.6).

## 6.4.6  Advanced leak check

If a leak is suspected a more intensive leak check can be performed.
1.    Continue from the setup in the quick leak check.
2.    Connect a pump to the exhaust port with a shut off valve (pump side) and a vacuum gauge (exhaust port side) between the two
3.    Ensure that the shut off valve is open then turn on the pump (1-2 minutes) and create a vacuum.
4.    Close the shut off valve and measure the vacuum. If the vacuum slowly drops (pressure rises) then a leak is present
5.    Open each valve individually, leaving the other two closed, and using the pneumatic diagram determine the location of the leak
6.    When the location of the leak has been determined check all tubing and fittings to make sure that they are attached appropriately and have no splits or cracks

## 6.4.7  Replace PMT desiccant packs

---

**Caution**
**Because the PMT is extremely sensitive to light, it is essential that before opening the PMT assembly to make sure that the analyzer is switched off.**
**In addition, even when the analyzer is switched off is very important to cover the PMT at all times so that no direct light reaches its window.**

---

1.    Turn the analyzer off and disconnect power.
2.    Using a Phillips head screwdriver, remove the desiccant pack access cap from the PMT housing. Refer to 1 in Figure 27
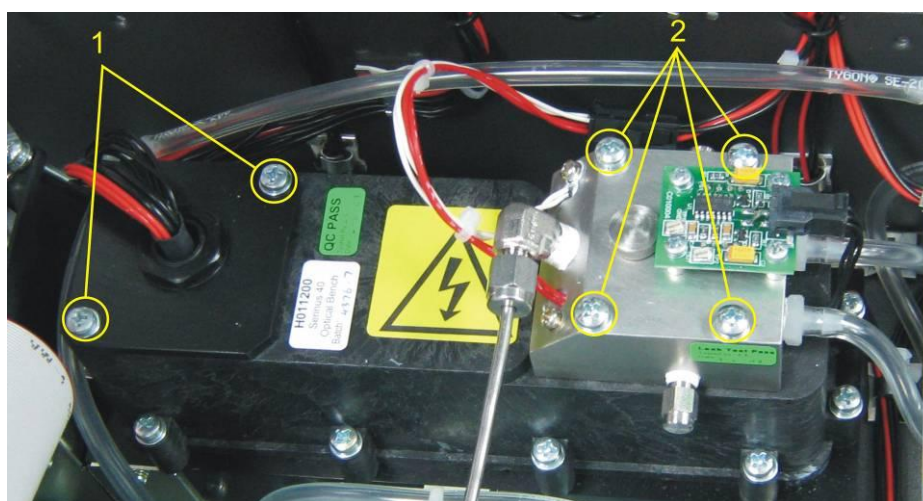


**Figure 27 Opening the Reaction cell or PMT access cap**

3.  Remove the old desiccant packs, located on top and below the PMT, to the left of the access cap. Replace old packs with new ones, Do not attempt to dry and reuse the old packs.
4.  Inspect the inside of the PMT housing (by touch or with an inspection mirror) to check for moisture inside the housing. If moisture is detected inside the housing the desiccant pack replacement interval should be decreased.
5.  Replace the desiccant cap on optical bench and secure with two screws.
6.  Reconnect power and restart the analyzer.

## 6.4.8  Clean reaction cell

As $O_3$ reacts with the contaminants in the air it will begin to deposit a film on the walls and optical filter within the cell. This will result in decreased sensitivity of the analyzer and increase the gain required to read NO. The reaction cell should be cleaned periodically to remove deposits and restore sensitivity.

| **Caution** |
| --- |
| Take extreme care not to damage the pressure transducer assembly on top of the reaction cell. |

1.  Turn off the analyzer and disconnect the pump.
2.  Disconnect the electrical and pneumatic fittings from the reaction cell, remove the four screws that secure the cell to the PMT housing, and remove the reaction cell from the PMT housing. Refer to 2 in Figure 27

| **Caution** |
| --- |
| Because the PMT is extremely sensitive to light, it is essential that before opening the PMT assembly to make sure that the analyzer is switched off.<br>In addition, even when the analyzer is switched off it is very important to cover the PMT at all times so that no direct light reaches its window. |

3.  Turn the reaction cell upside down and remove the four screws fastening the optical filter from the cell.
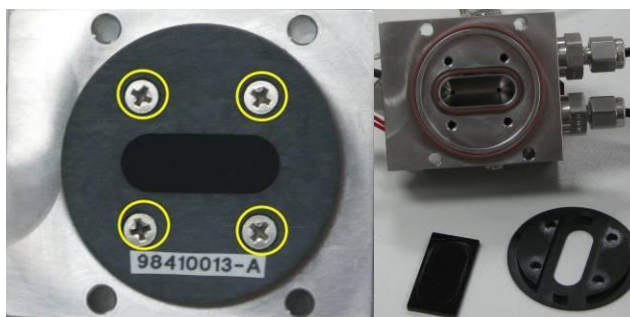

**Figure 28 Optical filter removal and cleaning**

4.  Clean the filter and the inside of the cell with high purity isopropyl alcohol
5.  Reassemble the reaction cell in reverse order of the above steps.
6.  Recalibrate the analyzer.

### 6.4.9  Pressure sensor check

Flow checks are needed to ensure that the pressure sensor is accurately measuring pressure inside the instrument

1.  Remove the exhaust and sample tubing from the back of the analyzer
2.  After 5-10 minutes observe the pressure reading in the "cell" (section 3.5.2.3)
3.  Compare the Serinus pressure sensor measurement to the current ambient pressure from an external calibrated sensor. Ensure that they are reading the same ± 3 TORR (± 0.4 kPa)
4.  If no external pressure sensor is available, compare the serinus "cell" pressure to the "ambient" pressure (section 3.5.2.3). Ensure that they are reading the same ± 3 TORR (± 0.4 kPa)
5.  If the readings are outside this level then perform a Pressure calibration (section 4.7)

## 6.5  Parts list

Below is a list of the replaceable parts of the Serinus 44. Some of these parts will not need replacing and other consumables will need constant replacing. See below for information on yearly consumable kits available from Acoem.

**Table 2 Parts List**

| Part Description | Part Number |
| --- | --- |
| **Spare parts** | |
| Tube, side-on, photomultiplier | H011203 |
| Heater and thermistor assembly | C020073 |
| LCD and interface assembly | C010010 |
| PCA, controller | C010001 |
| Power supply, Serinus | P010003 |
| Filter, optical, reaction cell | H011205 |
| Heater/thermocouple assembly Molycon | C020072 |
| Heater/thermistor assembly | C020073 |
| Ozone generator and housing assembly | H011107 |
| Valve manifold assembly | H010013-01 |
| Power supply optical bench | H011211-02 |
| Cooler, thermoelectric kit | H011211-03 |
| Thermistor assembly kit | H011211-04 |
| Dryer assembly, Permapure | H011106 |
| Extraction tool, Filter and Orifice | H010046 |
| PCA pressure sensor assembly | H010031 |
| Fitting, Kynar, elbow 1/8 NPT - 1/8 barb (3 required) | F030005 |
| Fitting, Kynar, male connector 1/8NPT - 1/8 barb (2 required) | F030006 |
| Male elbow, Tapered Threads, 1/8T-1/8NPT, SS | F030025 |
| Plug Test Lamp | H010026 |
| Serinus 44 User Manual | M010034 |
| Fitting, Kynar, elbow 1/8NPT - 1/8 barb (3 required) | F030005 |
| Fitting, Kynar, male connector 1/8NPT - 1/8 barb (2 required) | F030006 |
| Filter element, 5 micron, consumable (50 each) | F010004 |
| Gasket Pressure Sensor | H010037 |

| Serinus 44 Maintenance Kit (includes consumables below) | E020203 |
|---|---|
| Filter, Sintered (2 required) | F010004 |
| O- ring 0.364ID X 0.070W (5 required) | O010010 |
| Filter unit disposable | F010005 |
| O-ring, Desiccant access cap | O010022 |
| O-ring, Orifice and filter (8 required) | O010012 |
| O-ring, reaction cell housing | O010017 |
| O- ring 1/4ID X 1/16W, viton (5 required) | O010015 |
| O-ring, reaction cell-optical filter (6 required) | O010016 |
| Nylon washer-Spacer Heat Shield (2 required) | F050040 |
| O-ring 5/32ID X 1/16W, viton (10 required) | O010013 |
| O- ring 1 11/16ID X 3/32W viton (2 required) | O010014 |
| O-ring, Opt bench assembly | O010018 |
| O-ring 3/16ID X 3/32W, EP | O010019 |
| O-ring 5/8ID X 3/32W, EP | O010020 |
| Spring Compression SS, 0.24 | H010040 |
| Desiccant, 5 gram pack (2 required) | C050014 |
| O-ring, Test lug | O010021 |
| Washer Neoprene-Spacer Heat Shield (2 required) | F050041 |
| Filter sintered W/O-ring groove (5 required) | H010047-01 |
| O-ring BS015, viton (7 required) | O010023 |
| Tygon tubing ¼ x 1/8 (3ft) | T010011 |
| Silicone heatsink compound | C050013 |
| Other consumables (not listed in maintenance kit) | |
| Filter paper Teflon 47MM pack of 50 | F010006-01 |
| Filter paper Teflon 47MM pack of 100 | F010006 |
| Molycon assembly, $NO_2$ to NO convertor | H011105 |
| Orifice, 4 mil | H010043-02 |
| Orifice 8 mil (2 required) | H010043-06 |
| Tube/Spring assembly, $O_3$ Generator | H011120 |
| Orifice 3 mil | H010043-01 |
| External pump repair kit (suite 607 pump) | P031001 |

## 6.6  Updating firmware

**USB memory stick update**

1. Turn instrument off
2. Place USB memory stick with new firmware on the Front panel USB port
3. Turn instrument on and immediately press the hash key multiple times until the following screen appears

> Vx.x Bootloader
> Press „1"to enter Bootloader

4. Press 1 to enter the Bootloader menu
5. Select option 3, (Upgrade from USB memory stick) press 3 on keypad
6. Press 9 to start the analyzer with new firmware

# 7    Troubleshooting

**Table 3 Troubleshoot list**

| Error Message/ Problem | Cause | Solution |
|---|---|---|
| Zero Flow | Multiple | Troubleshoot 7.1 |
| Reset Detection | | Upgrade firmware |
| Electronic zero adjust | Faulty zero air or pneumatics | Troubleshoot 7.2 |
| 12 Voltage supply failure | Power supply has failed | Replace power supply |
| Flow block temp | Faulty electronics | Replace flow block |
| Sample pressure Too high or too low | Loss of calibration | Too high = Re-calibrate pressure sensors, Too low = Check calibration and sample flow |
| Sample flow not at 1.0 SLPM | Loss of calibration | Check/replace sintered filter, check pump, check valves, re- calibrate sample flow |
| Unstable zero/span | Zero air source, span source, leaky sample/measure valve | Leak check valves, leak check pneumatics and gas delivery system, replace zero air scrubbers, confirm sample pressure/flow are correct and have stable readings. |
| Unable to span | Confirm NO source is accurate. | 1. Check for leaks (repair any leaks). 2. Ensure you are using a NO transfer standard that has a valid certificate, check other components of span delivery are not faulty |
| Noisy readings/ low span | Multiple | See Troubleshoot 7.3 |
| Zero drift | Leak | Perform leak test (section 6.4.6) |
| Converter temp Failure | Multiple | See Troubleshoot 7.4 |
| Flow block temp failure | Multiple | See Troubleshoot 7.5 |
| Reaction cell temp failure | Multiple | See Troubleshoot 7.6 |

## 7.1  Zero Flow
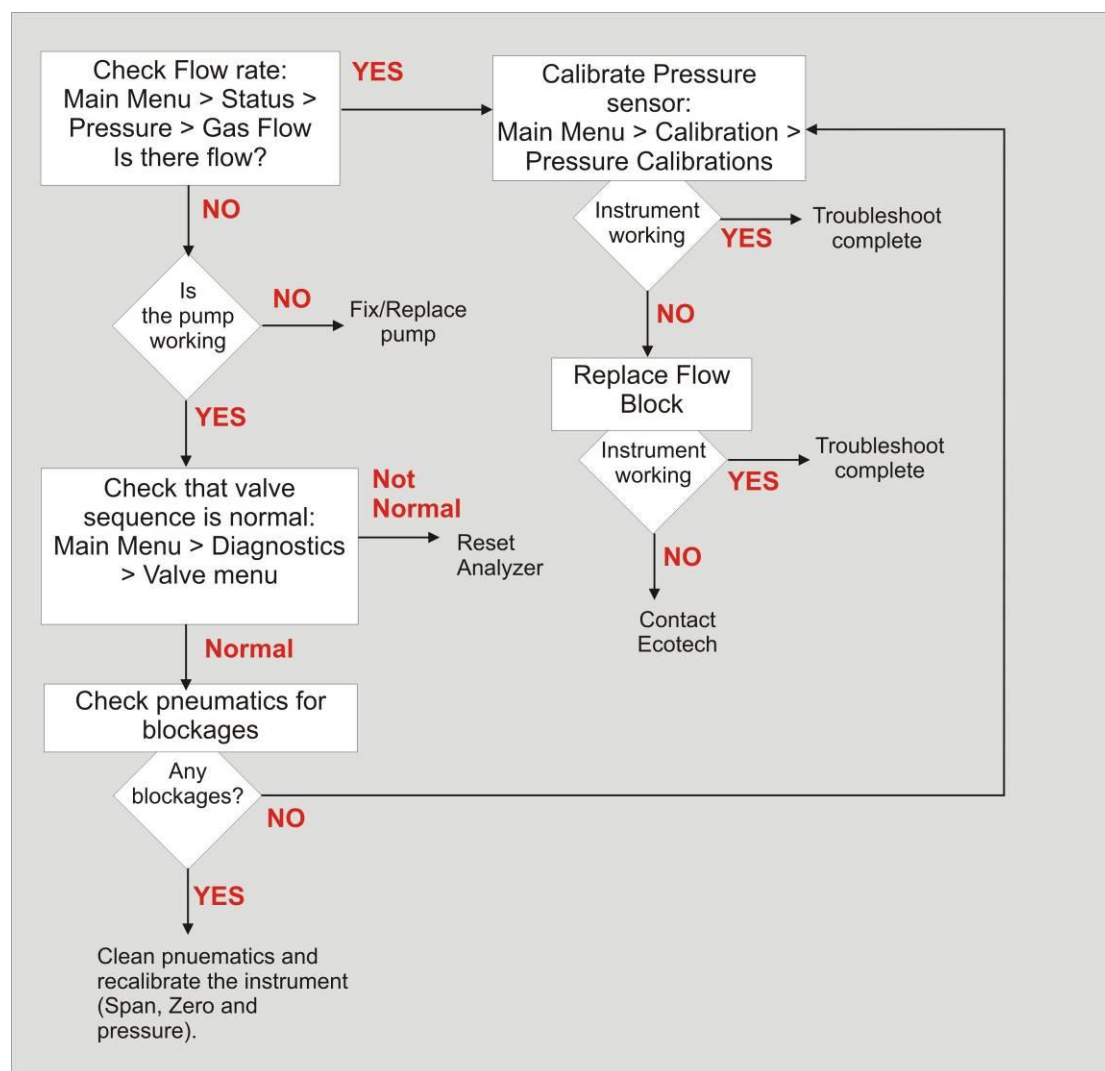


## 7.2  Electronic Zero adjust
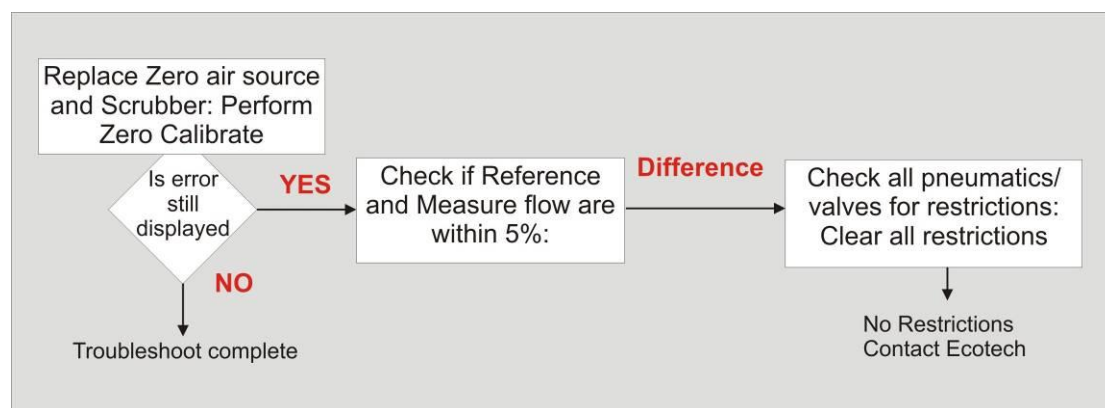
## 7.3  Noisy readings

**Table 4 Noisy readings troubleshoot**

| Cause | Solution |
|---|---|
| Gain too high | 1. Leak check (repair any leaks) |
|  | 2. Clean optical filter in reaction cell |
| Cell pressure too high (>280 torr) | 1. Leak check (repair any leaks) |
|  | 2. Replace pump (internal or external) and recalibrate |
| PMT temperature too high (>18ºC) | Replace optical cell assembly |
| Unstable ozone generator | Substitute Ozone generator with known working generator. If instrument now works replace ozone generator. |

## 7.4  Converter temperature failure
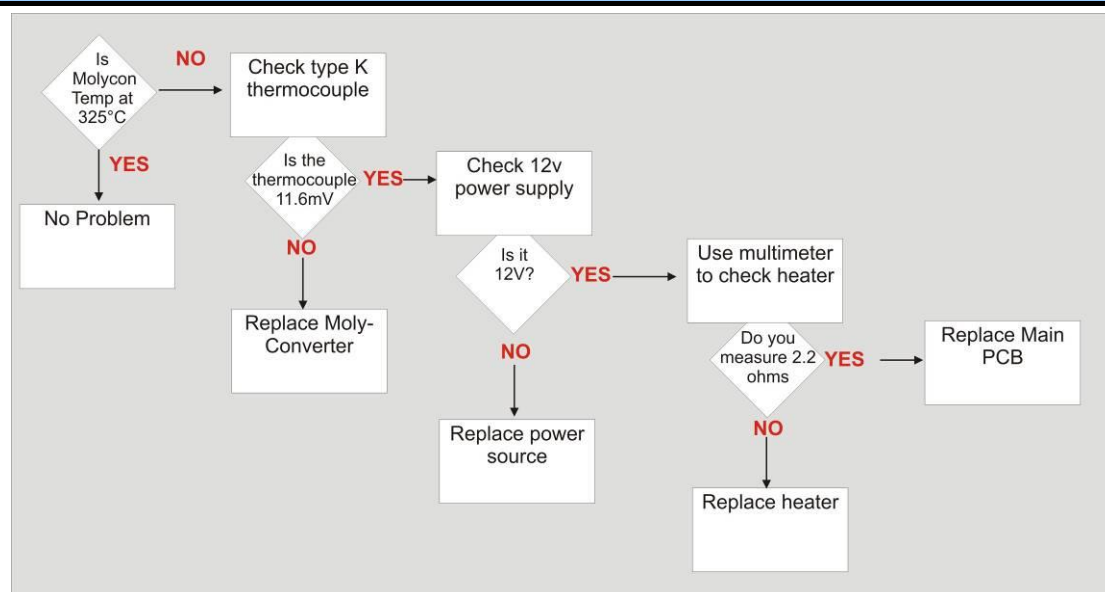
## 7.5   Flow block temperature failure
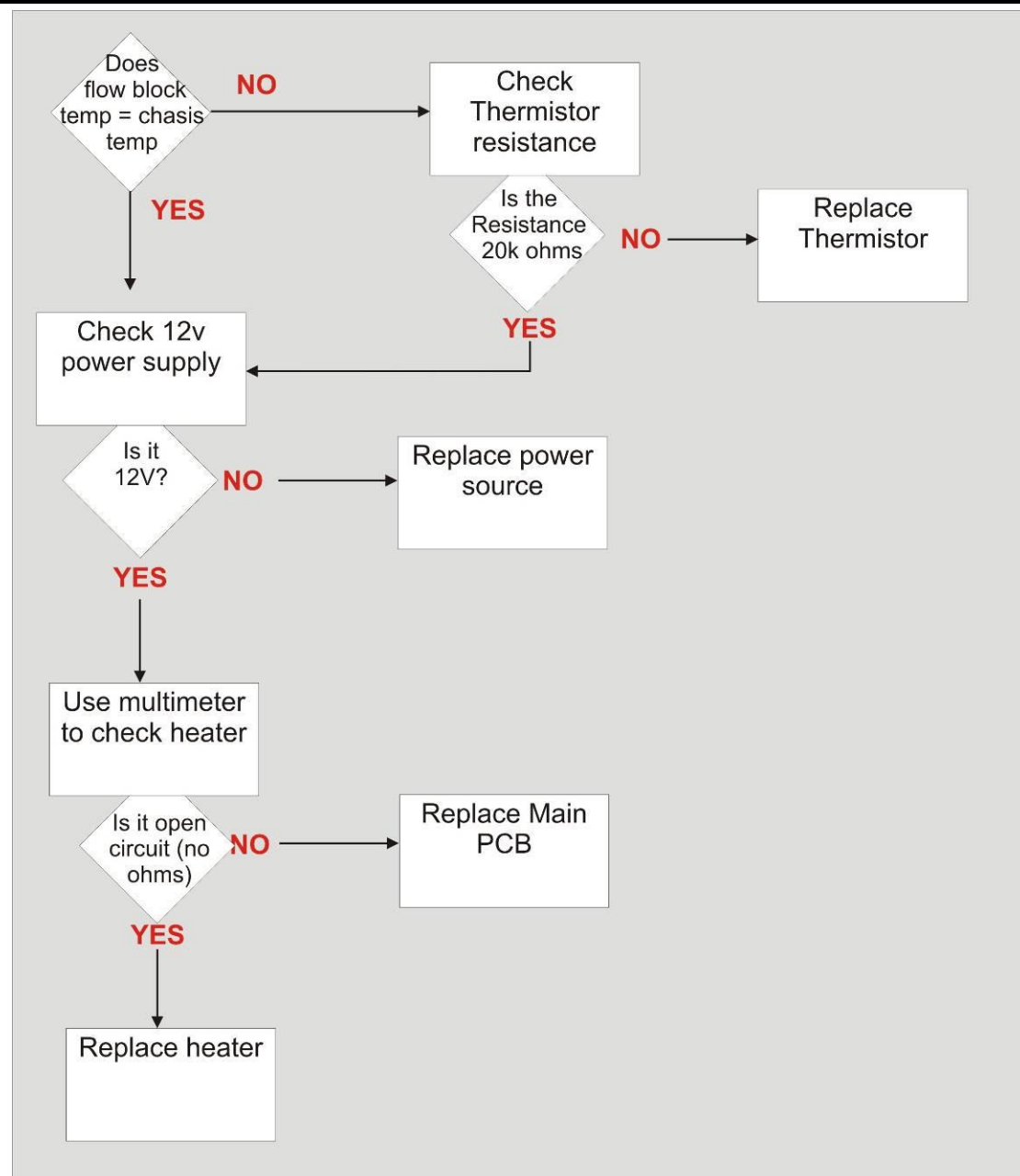
## 7.6   Reaction cell temperature failure
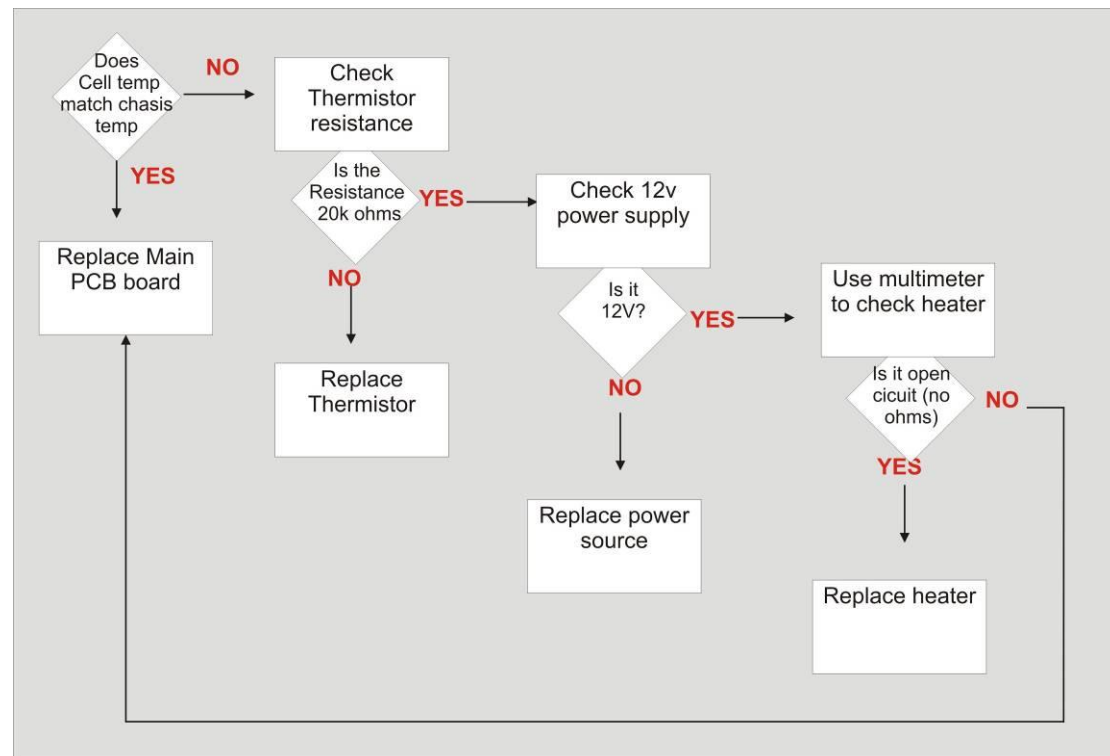
# 8   Optional Extras

## 8.1  Rack mount kit

The rack mount kit is necessary for installing the Serinus 10 into a 19" rack. The Serinus 10 is 4RU in height, to install in the rack follow these steps.

**Installing the instrument**

1. Remove the rubber feet from the analyzer (if attached)
2. Install the two H shaped instrument brackets onto the left and right side of the rack securely with M6 bolts (two at the back and two at the front) shown circled in .



**Figure 29 Installation of rack mount brackets**

3. Insert the instrument lid (without the instrument) into the rack and attach to the already installed instrument brackets with M6 bolts, shown circled in .
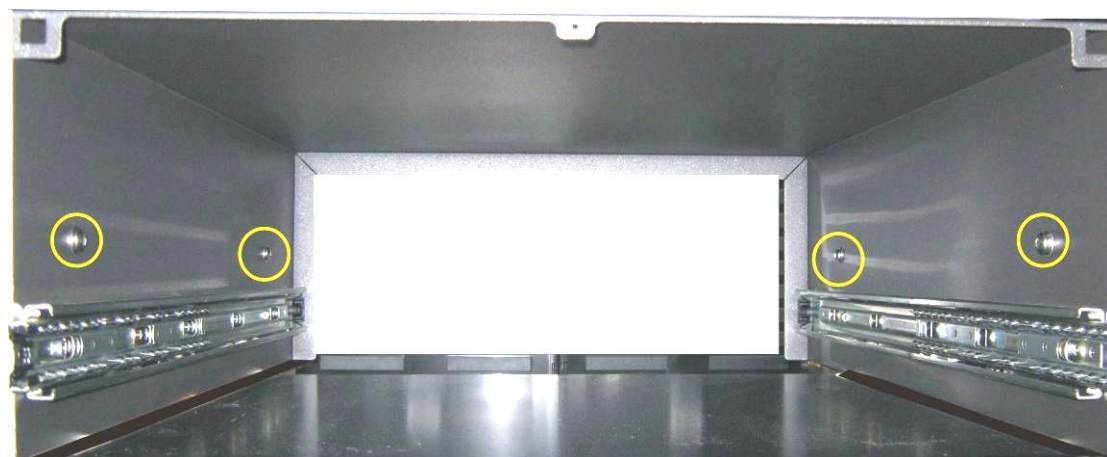


**Figure 30 Installation of lid to rack mount brackets**

4. Check that the instrument lid is not bowed (bent), if there is a bow adjust bracket and lid bolts until the lid is square, and bolts are tight.
5. Now carefully insert the instrument into the rack by placing the instrument slides into the lid slides, ensure that the rack slide locks engage (Figure 31) on each side (you will hear a click) and gently slide the instrument into the rack.

> **Note:** Ensure both sides of the slide are attached
> to the lid slides before pushing into rack

## Removing the instrument

1. To remove the instrument first "push" instrument out of rack giving access to the slides
2. Find the rack slide lock labelled push (Figure 31) and push it in whilst sliding the instrument out of the rack, complete this for both sides before carefully removing instrument
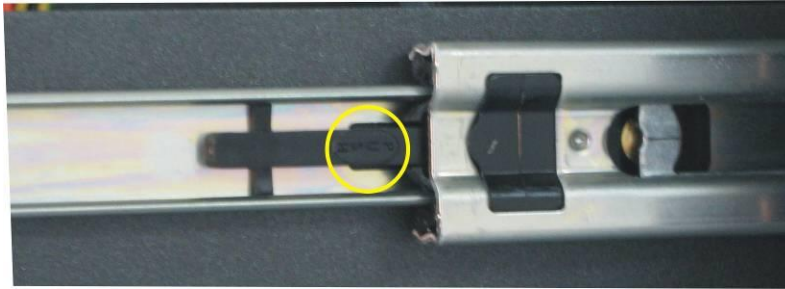


**Figure 31 Rack slide lock**

3. Unscrew lid by removing M6 bolts shown in
4. Slide lid back on to instrument ready for transport or storage

## *8.2  Pressurised zero/span valve*

> **Note:** This is NOT intended as a source for calibrating the instrument. This should only be used as an operational check of the instrument's zero point and single upscale point (recommended as 80% of full scale)

### 8.2.1  Single pressurized calibration option

The internal pressurised calibration valves are already installed within the analyzer (Figure 32) as either a zero or span (either $NH_3$ or $NO_X$) calibration source, thus no other connections need to be made.

**Operation of single calibration option**

When using the pressurised calibration option either a high pressure zero or span bottle should be connected to the "Press Cal #1" port on the back of the analyzer.

1. Ensure gas cylinder is fitted with an appropriate gas regulator with shut off valve.
2. Connect a line of 1/8" stainless steel tubing between the gas cylinder and the analyzer "Auxiliary port" inlet.

> **Note:** This connection may need to be retightened during this operation.

3. Open the cylinder main valve and adjust the regulator to 15 psig or 1 bar
4. Open the regulator shutoff valve and leak test.
5. Temporarily place a flow meter on the "calibration" port inlet (used as a vent).
6. Enter the calibration menu (Main Menu → Calibration Menu)
7. Change "Set Cal Port" to External
8. Select either Span or Zero under the "Cal Mode" option depending on which calibration check is being performed. This will initiate the pressurized calibration.
9. Open the cylinder shutoff valve, adjust the regulator pressure until the flow on the vent line (Calibration port) is between 0.5 and 1 lpm.

> **Note:** Do not exceed 2 bar of pressure, if this occurs a leak may exist

**Return to normal operation**

1. Set Cal. Mode → Measure.
2. Remove the flow meter on the calibration port and connect a ¼" vent line to port.
3. Reconnect instrument fittings and place in original set up
4. The instrument is now in normal operation mode.
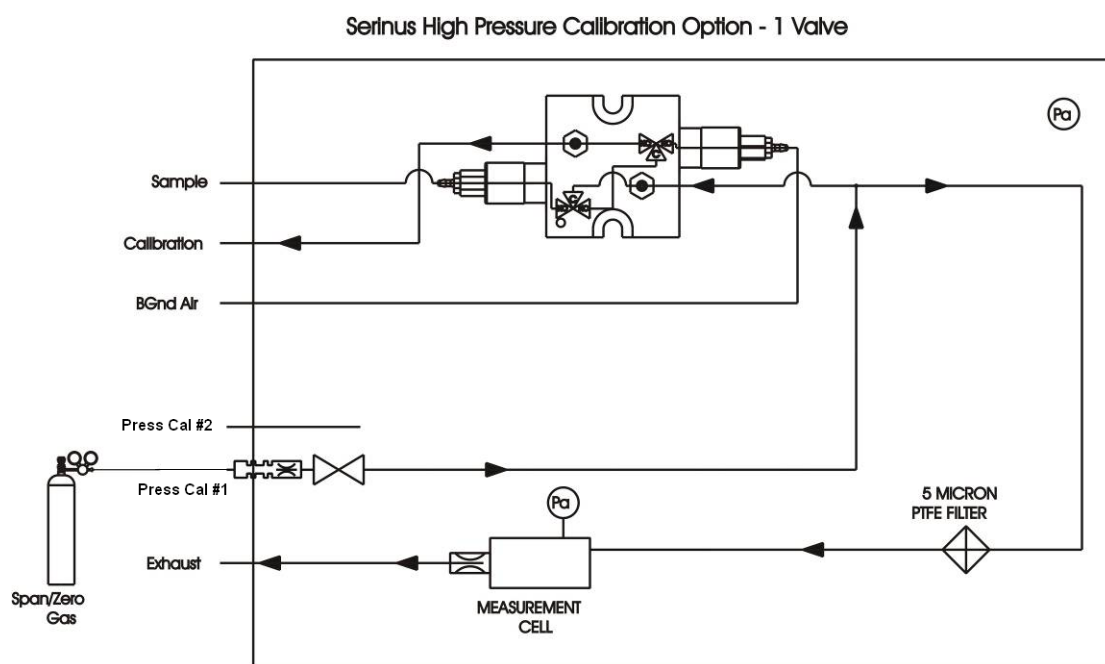
**Figure 32 Single high pressure calibration option**

## 8.2.2 Dual pressurized calibration option

The dual internal pressurised calibration valves are already installed within the analyzer (Figure 33) as a zero and span calibration source, thus no other connections need to be made.

### Operation of dual calibration option

When using the pressurised calibration option a high pressure zero bottle should be connected to the "Press Cal #1" port and a high pressure span bottle connected to the "Background" port on the back of the analyzer.

1. Ensure gas cylinder is fitted with an appropriate gas regulator with shut off valve.
2. Connect a line of 1/8" stainless steel tubing between the appropriate gas cylinder and the analyzer inlet port.

> **Note:** This connection may need to be retightened during this operation.

3. Open the Main Valve and adjust the regulator to 15 psig or 1 bar
4. Open the regulator shutoff valve and leak test.
5. Temporarily place a flow meter on the "Press Cal #2" port (used as a vent).
6. Change "Set Cal Port" to External (Main Menu → Calibration Menu) then select either span or zero under the "Cal Mode" option depending on which calibration check is being performed. This will initiate the pressurized calibration.
7. Open the cylinder shutoff valve; adjust the regulator pressure until the flow on the vent line (Calibration port) is between 0.5 and 1 lpm.

> **Note:** Do not exceed 2 bar of pressure, if this occurs a leak may exist

**Return to normal operation**

1. Set Cal. Mode → Measure.
2. Remove the flow meter on the calibration port and connect a ¼" vent line to port.
3. Reconnect instrument fittings and place in original set up
4. The instrument is now in normal operation mode.
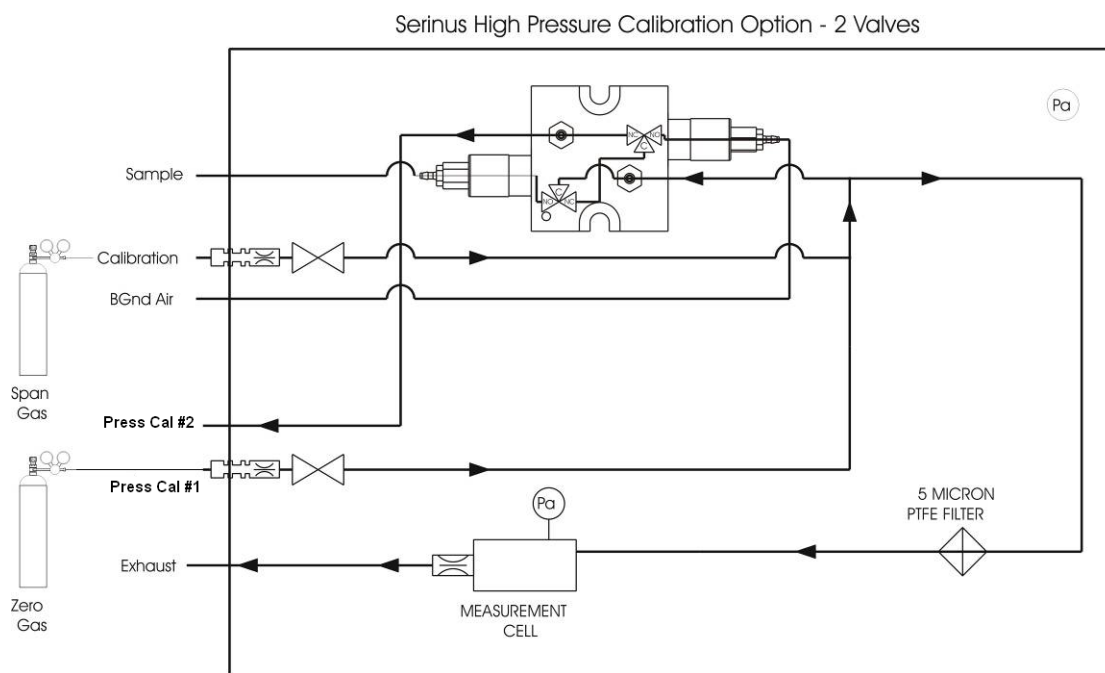


**Figure 33 Dual high pressure calibration option**

# Appendix A Advanced Protocol Parameter List

> **Note:** Parameters are for all Serinus analyzers and may not be applicable to an individual analyzer.

**Table 5 Advanced Protocol Parameter list**

| # | Description | Notes |
|---|---|---|
| 0 | Sample / Cal Valve | 0=Sample, 1=Cal/Zero |
| 1 | Cal / Zero Valve | 0=Zero, 1=Cal |
| 2 | Internal Span Valve | 0=Closed, 1=Open |
| 3 | Spare Valve 1 | 0=Closed, 1=Open |
| 4 | Spare Valve 2 | 0=Closed, 1=Open |
| 5 | Spare Valve 3 | 0=Closed, 1=Open |
| 6 | Spare Valve 4 | 0=Closed, 1=Open |
| 7 | NOx Measure Valve | 0=NO, 1=NOx |
| 8 | NOx Bypass Valve | 0=NO, 1=NOx |
| 9 | NOx Background Valve | 0=Closed, 1=Open |
| 10 | Valve Sequencing | 0=Off, 1=On |
| 11 | LCD Contrast Pot | 0=Lightest, 255=Darkest |
| 12 | SO2  REFERENCE ZERO Gain  Pot | S50  Reference ZERO POT |
| 13 | CO Measure Gain Pot | S30 Measure Gain Adjust |
| 14 | CO Reference Gain Pot | |
| 15 | CO Test Measure Pot | SEE 149. EXISTS |
| 16 |  & PMT HIGH VOLTAGE Pot | High Voltage Controller Pot for PMT S50 & S40 |
| 17 | SO2  Lamp  ADJ  Pot | S50 Lamp Adjust Pot |
| 18 | O3  Lamp  ADJ  Pot | S10 Lamp Adjust Pot |
| 19 | O3 ZERO  Measure Pot: Coarse | S10 Signal Zero (coarse) |
| 20 | O3 ZERO  Measure Pot: Fine | S10 Signal Zero (fine) |
| 21 | PMT  Fan  Pot | PMT fan speed controller Pot |
| 22 | Rear  Fan  Pot | CHASSIS Fan speed control POT |
| 23 | PUMP SPEED Motor Driver Pot: Fine | INTERNAL Pump speed fine POT |
| 24 | PUMP SPEED Motor Driver Pot: Coarse | INTERNAL Pump speed coarse POT |
| 25 | Analogue input 0 | SO2 REFERENCE SIGNAL |
| 26 | Analogue input 1 | CO REFERENCE SIGNAL |
| 27 | Analogue input 2 | O3 REFERENCE SIGNAL |
| 28 | Analogue input 3 | SO2 & O3 LAMP CURRENT |
| 29 | Analogue input 4 | FLOW BLOCK PRESSURE |
| 30 | Analogue input 5 | CELL PRESSURE |
| 31 | Analogue input 6 | AMBIENT PRESSURE |
| 32 | Analogue input 7 | RAW ADC CALIBRATION INPUT |
| 33 | Analogue input 8 | MFC1 NOT USED |
| 34 | Analogue input 9 | CONCENTRATION DATA |
| 35 | Analogue input 10 | MFC2 NOT USED |
| 36 | Analogue input 11 | MFC3 NOT USED |
| 37 | Analogue input 12 | EXTERNAL ANALOG INPUT 0 |
| 38 | Analogue input 13 | EXTERNAL ANALOG INPUT 1 |

| 39 | Analogue input 14 | EXTERNAL ANALOG INPUT 1 |
|----|----|----|
| 40 | Analogue input 15 | MFC0 NOT USED |
| 41 | CO Measure Pot : Coarse | S30 Measure ZERO Coarse adjustment Pot |
| 42 | CO  Measure  Pot: Fine | S30 Measure ZERO Fine adjustment Pot |
| 43 | SO2 Measure  SIGNAL Gain  Pot | SO2 Measure Signal Gain Pot |
| 44 | SO2  REFERENCE  Gain  Pot | SO2 Reference Signal Gain Pot |
| 45 | SO2 SIGNAL ZERO | SO2 Measure Zero Pot |
| 46 | O3 SIGNAL GAIN POT | O3 INPUT SIGNAL GAIN POT |
| 47 | Test Pot | Test Pot for all the analysers |
| 48 | NOX  Signal GAIN  Pot | PMT signal input gain control FOR NOX |
| 49 | PGA Gain | 1, 2, 4, 8, 16, 32, 64, 128 |
| 50 | Primary Gas Concentration | Current value on front screen |
| 51 | Secondary Gas Concentration | Current value on front screen(if applicable eg NOx |
| 52 | Calculated Gas Concentration | Gas 3 (eg:NO2) |
| 53 | Primary Gas Average | Average of the readings(for Gas1) of the last n minutes where n is the averaging period |
| 54 | Secondary Gas Average | |
| 55 | Calculated Gas Average | |
| 56 | Instrument Gain | |
| 57 | Main Gas ID | |
| 58 | Aux Gas ID | |
| 59 | Decimal Places | |
| 60 | Noise | |
| 61 | Gas 1 Offset | |
| 62 | Gas 3 Offset | |
| 63 | Flow Temperature | |
| 64 | Lamp Current | |
| 65 | Digital Supply Voltage | Digital Supply voltage (should always read close to 5 volts) |
| 66 | Concentration Voltage | |
| 67 | PMT High Voltage | High Voltage reading for PMT |
| 68 | Ozonator Status | 0=Off, 1=On |
| 69 | Control Loop | |
| 70 | Diagnostic  Mode | |
| 71 | Gas Flow | |
| 72 | Gas Pressure | |
| 73 | Ambient Pressure | |
| 74 | 12V Supply Voltage | The 12 volt Power supply voltage |
| 75 | Cell Temperature | |
| 76 | Converter Temperature | |
| 77 | Chassis Temperature | |
| 78 | Manifold Temperature | |
| 79 | Cooler Temperature | |
| 80 | Mirror Temperature | |
| 81 | Lamp Temperature | |
| 82 | O3 Lamp Temperature | |
| 83 | Instrument Status | |

| 84 | Reference Voltage | |
|---|---|---|
| 85 | Calibration State | 0 = MEASURE<br>1 = CYCLE<br>2 = ZERO<br>3 = SPAN |
| 86 | Primary Raw Concentration | (before NOx background and gain) |
| 87 | Secondary Raw Concentration | (before NOx background and gain) |
| 88 | NOx Background Concentration | (before gain) |
| 89 | Calibration Pressure | |
| 90 | Converter Efficiency | |
| 91 | Multidrop Baud Rate | |
| 92 | Analog Range Gas 1 | |
| 93 | Analog Range Gas 2 | |
| 94 | Analog Range Gas 3 | |
| 95 | Output Type Gas 1 | 1=Voltage<br>0=Current |
| 96 | Output Type Gas 2 | 1=Voltage<br>0=Current |
| 97 | Output Type Gas 3 | 1=Voltage<br>0=Current |
| 98 | Voltage Offset /Current Range Gas1 | 0=0% or 0-20mA<br>1=5% or 2-20mA<br>2=10% or 4-20mA |
| 99 | Voltage Offset /Current Range Gas2 | 0=0% or 0-20mA<br>1=5% or 2-20mA<br>2=10% or 4-20mA |
| 100 | Voltage Offset /Current Range Gas3 | 0=0% or 0-20mA<br>1=5% or 2-20mA<br>2=10% or 4-20mA |
| 101 | Full Scale Gas 1 | 5.0 Volt Calibration value for Analog Output 1 |
| 102 | Full Scale Gas 2 | 5.0 Volt Calibration value for Analog Output 2 |
| 103 | Full Scale Gas 3 | 5.0 Volt Calibration value for Analog Output 3 |
| 104 | Zero Adjust Gas 1 | 0.5 Volt Calibration value for Analog Output 1 |
| 105 | Zero Adjust Gas 2 | 0.5 Volt Calibration value for Analog Output 2 |
| 106 | Zero Adjust Gas 3 | 0.5 Volt Calibration value for Analog Output 3 |
| 107 | Negative 10V Supply | |
| 108 | NA | |
| 109 | NA | |
| 110 | Instrument State | |
| 111 | CO Linearisation Factor A | |
| 112 | CO Linearisation Factor B | |
| 113 | CO Linearisation Factor C | |
| 114 | CO Linearisation Factor D | |
| 115 | CO Linearisation Factor E | |
| 116 | Instrument Units | 0= PPM<br>1=PPB<br>2=PPT<br>3=mG/M³<br>4=µG/M³ |

| | | |
|---|---|---|
| | | 5=nG/M³ |
| 117 | Background Measure Time | In seconds |
| 118 | Sample Fill Time | In seconds |
| 119 | Sample Measure Time | In seconds |
| 120 | Aux Measure Time | In seconds |
| 121 | Aux Sample Fill Time | In seconds |
| 122 | Background Fill Time | In seconds |
| 123 | Zero Fill Time | In seconds |
| 124 | Zero Measure Time | In seconds |
| 125 | Span Fill Time | In seconds |
| 126 | Span Measure Time | In seconds |
| 127 | Span Purge Time | In seconds |
| 128 | Background Pause Time | In seconds |
| 129 | Background Interleave Factor | In seconds |
| 130 | Calibration Pressure 2 | |
| 131 | AUX Instrument Gain | |
| 132 | Background voltage | |
| 133 | AUX Background Voltage | |
| 134 | O3 Generator Output | PPM |
| 135 | O3 Generator On/Off | |
| 136 | Calibration Point 1 | PPM |
| 137 | Calibration Point 2 | PPM |
| 138 | Calibration Point 3 | PPM |
| 139 | Calibration Point 4 | PPM |
| 140 | Calibration Point 5 | PPM |
| 141 | Desired Pump Flow | SLPM |
| 142 | Actual Pump Flow | SLPM |
| 143 | Set Lamp Current | % |
| 144 | Lamp Current | mA |
| 145 | Cycle Time | Minutes |
| 146 | CO Cooler  Pot | CO Cooler voltage adjustment POT |
| 147 | CO Source  Pot | CO Source voltage adjustment POT |
| 148 | CO MEASURE Test  Pot 0 | CO MEASURE TEST POT |
| 149 | CO REFERENCE Test  Pot 1 | CO REFERENCE TEST POT |
| 150 | O3 REF Average | S10 Background Average |
| 151 | PTF Gain 0 | Pressure Temperature Flow Compensation Factor for first gas |
| 152 | PTF Gain 1 | Pressure Temperature Flow Compensation Factor for second gas in dual gas analyzers. |
| 153 | Inst. Cell Pressure | Instantaneous cell pressure |
| 154 | Manifold Pressure | Valve  Manifold Pressure |
| 155 | Cell Gas 1 Pressure | Cell Pressure for Gas 1 |
| 156 | Cell Gas 2 Pressure | Cell Pressure for Gas 2 |
| 157 | Cell Bgnd Pressure | Cell Pressure when in Background |
| 158 | Reserved | |
| 159 | Reserved | |
| 160 | Reserved | |
| 161 | Temperature Units | 0 = "ºC", |

| | | |
|---|---|---|
| | | 1 = "ºF",<br>2 = "ºK", |
| 162 | Pressure Units | 0 = "torr",<br>1 = "psi",<br>2 = "mbar",<br>3 = "atm",<br>4 = "kPa" |
| 163 | Averaging Period | 0 = "  1 Min",<br>1 = " 3 Mins",<br>2 = " 5 Mins",<br>3 = "10 Mins",<br>4 = "15 Mins",<br>5 = "30 Mins",<br>6 = "  1 Hr",<br>7 = "  4 Hrs",<br>8 = "  8 Hrs",<br>9 = " 12 Hrs",<br>10 = " 24 Hrs" |
| 164 | Filter Type | NO FILTER = 0,<br>KALMAN FILTER = 1,<br>10 SEC FILTER = 2,<br>30 SEC FILTER = 3,<br>60 SEC FILTER = 4,<br>90 SEC FILTER = 5,<br>300 SEC FILTER = 6,<br>ADPTIVE FILTER =7 |
| 165 | NO2 Filter | 0 = Disabled, 1 = Enabled |
| 166 | Background Interval | 0 = "24 Hrs",<br>1 = "12 Hrs",<br>2 = "8 Hrs",<br>3 = "6 Hrs",<br>4 = "4 Hrs",<br>5 = "2 Hrs",<br>6 = "Disable" |
| 167 | Service  Baud | 0 = " 1200 bps",<br>1 = " 2400 bps ",<br>2 = " 4800 bps ",<br>3 = " 9600 bps ",<br>4 = "14400 bps ",<br>5 = "19200 bps ",<br>6 = "38400 bps " |
| 168 | Multidrop Baud | 0 = " 1200 bps",<br>1 = " 2400 bps ",<br>2 = " 4800 bps ",<br>3 = " 9600 bps ",<br>4 = "14400 bps ",<br>5 = "19200 bps ",<br>6 = "38400 bps " |
| 169 | Service Port (COM 1) Protocol | 0 = "  EC9800",<br>1 = "Bavarian", |

| | | 2 = "Advanced" |
|---|---|---|
| 170 | Multidrop Port (COM 2)  Protocol | 0 = "  EC9800",<br>1 = "Bavarian",<br>2 = "Advanced" |
| 171 | Gas1 Over Range | The Upper Concentration Range when Over-Ranging is enabled for Analog Output 1 |
| 172 | Gas2 Over Range | The Upper Concentration Range when Over-Ranging is enabled for Analog Output 2 |
| 173 | Gas3 Over Range | The Upper Concentration Range when Over-Ranging is enabled for Analog Output 3 |
| 174 | Gas1 Over Ranging | 0 = Over Ranging Disabled<br>1 = Over Ranging Enabled   (Gas1) |
| 175 | Gas2 Over Ranging | 0 = Over Ranging Disabled<br>1 = Over Ranging Enabled   (Gas2) |
| 176 | Gas3 Over Ranging | 0 = Over Ranging Disabled<br>1 = Over Ranging Enabled   (Gas3) |
| 177 | Heater Set Point | Cell Heater Set Point |
| 178 | PMT HV Ctrl POT | PMT High Voltage Controller POT |
| 179 | PMT Test LED POT | PMT Test LED intensity controller POT |
| 180 | Last Power Failure Time | Time Stamp of the Last power fail (4 byte time stamp)<br><br>Bit 31:26   ----   Year    (0 – 99)<br>Bit 25:22   ----   Month  ( 1 – 12)<br>Bit 21:17   ----   Date    (1 – 31)<br>Bit 16:12   ----   Hour   (00 – 23)<br>Bit 11:06   ----   Min    (00 – 59)<br>Bit 05:00   ----   Sec    (00 – 59) |
| 181 | Instantaneous Manifold Pressure | Instantaneous Manifold Pressure in S40 analyzers (no filter) |
| 182 | Calibration Pressure 2 | |
| 183 | Gas 4 ($NH_3$) Concentration | |
| 184 | Gas 5 ($N_X$)Concentration | |
| 185 | Gas 4 ($NH_3$) Average Concentration | |

# Appendix B – EC9800 Protocol

**DCONC**

| | |
|---|---|
| **Function** | Sends the current instantaneous concentration data to the serial port. |
| **Format** | DCONC,{<DEVICE I.D.>}{TERMINATOR} |
| **Device response** | {GAS}<SPACE>{STATUS WORD}<CR><LF> |

All numbers are in floating point format. The STATUS WORD indicates the instrument status in hex using the following format:

Bit 15  = SYSFAIL (MSB)
Bit 14  = FLOWFAIL
Bit 13  = LAMPFAIL
Bit 12  = CHOPFAIL
Bit 11  = CVFAIL
Bit 10  = COOLERFAIL
Bit 9    = HEATERFAIL
Bit 8    = REFFAIL
Bit 7    = PS-FAIL
Bit 6    = HV-FAIL
Bit 5    = OUT OF SERVICE
Bit 4    = instrument is in zero mode
Bit 3    = instrument is in span mode
Bit 2    = unused
Bit 1    = SET$\rightarrow$PPM selected, CLEAR$\rightarrow$MG/M3
Bit 0    = reserved (LSB).

**DSPAN**

| | |
|---|---|
| **Function** | Commands the unit under test to enter the span mode and stay there. |
| **Format** | DSPAN,{<DEVICE I.D.>}{TERMINATOR} |
| **Device response** | <ACK> if the unit under test is able to perform the command, <NAK> if not. |

**DZERO**

| | |
|---|---|
| **Function** | Commands the unit under test to enter the zero mode and stay there. |
| **Format** | DZERO,{<DEVICE I.D.>}{TERMINATOR} |
| **Device response** | <ACK> if the unit under test is able to perform the command, <NAK> if not. |

**ABORT**

| | |
|---|---|
| **Function** | Commands the addressed device to abort the current mode and return to the measure mode. |
| **Format** | ABORT,{<DEVICE I.D.>}{TERMINATOR} |
| **Device response** | <ACK> if the unit under test is able to perform the command, <NAK> if not. |

| **RESET** | |
|---|---|
| **Function** | Reboots the instrument (software reset). |
| **Format** | RESET, {<DEVICE I.D.>}{TERMINATOR} |
| **Device response** | <ACK> |

# Appendix C – Bavarian Protocol

Bavarian Network Command Set Format
All Bavarian Network commands follow the command format as specified in this section. The specific Bavarian commands and their function are described in section

Bavarian Network Command Format: <STX><TEXT><ETX><BCC1><BCC2>
Where:
<STX>           = ASCII Start Of Transmission = 02 hex
<TEXT>          = ASCII text maximum length of 120 characters
<ETX>           = ASCII end of transmission = 03 hex
<BCC1>          = ASCII representation of block check value MSB
<BCC2>          = ASCII representation of block check value LSB.
The block check algorithm begins with 00 Hex and exclusive-OR each ASCII character from <STX> to <ETX> inclusive. This block check value is then converted to ASCII format and sent after the <ETX> character.

Examples
The following is an example of a valid Bavarian data request for an instrument that has an I.D. of 97:
<STX>DA097<EXT>3A
The block check calculation is best shown by the following table:

| Character | Hex Value | Binary | Block Check |
|-----------|-----------|--------|-------------|
| <STX> | 02 | 0000 0010 | 0000 0010 |
| D | 44 | 0100 0100 | 0100 0110 |
| A | 41 | 0100 0001 | 0000 0111 |
| 0 | 30 | 0011 0000 | 0011 0111 |
| 9 | 39 | 0011 1001 | 0000 1110 |
| 7 | 37 | 0011 0111 | 0011 1001 |
| <ETX> | 03 | 0000 0011 | 0011 1010 |

The binary value 0011 1010 corresponds to the hex value 3A. This value in ASCII forms the last two characters of the data request message. Please note that the I.D. of 97 is sent as the sequence 097. All I.D. strings must have 3 digits and the user should always pad with ASCII zero characters.
This is an example of a valid command to put the unit in the manual span mode if the instrument has an I.D. of 843:
<STX>ST843 K<ETX>52
The block check operation is best shown with the following table:

| Character | Hex Value | Binary | Block Check |
|-----------|-----------|--------|-------------|
| <STX> | 02 | 0000 0010 | 0000 0010 |
| S | 53 | 0101 0011 | 0101 0001 |
| T | 54 | 0101 0100 | 0000 0101 |
| 8 | 38 | 0011 1000 | 0011 1101 |
| 4 | 34 | 0011 0100 | 0000 1001 |
| 3 | 33 | 0011 0011 | 0011 1010 |
|   | 20 | 0010 0000 | 0001 1010 |
| K | 4B | 0100 1011 | 0101 0001 |
| <ETX> | 03 | 0000 0011 | 0101 0010 |

The binary block check value is 0101 0010 which is the hex value 52 as shown at the end of the command string.

# Appendix C – Pneumatic Diagram